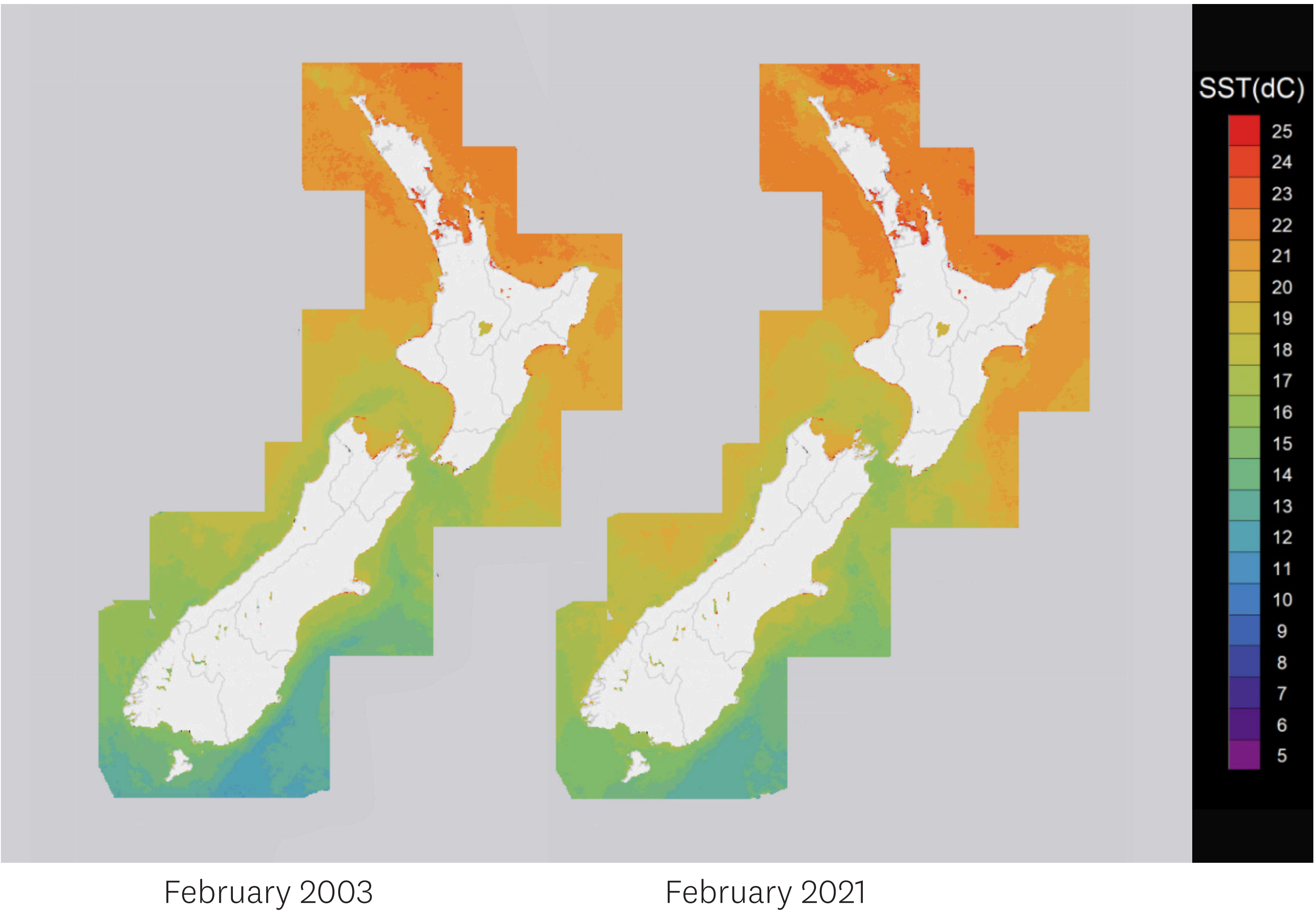
Working Paper 2021/14

The Role of Ocean Water Temperature in Climate Change Policy: A New Zealand King Salmon case study

Figure 1: Mean sea surface temperature (SST) levels



MCGUINNESS INSTITUTE
TE HONONGA WAKA

Title *Working Paper 2021/14 – The Role of Ocean Water Temperature in Climate Change Policy: A New Zealand King Salmon case study*

This paper forms part of the Institute's ReportingNZ, ClimateChangeNZ and OneOceanNZ projects.

Citation Please cite this publication as:

McGuinness Institute (2021). *Working Paper 2021/14 – The Role of Ocean Water Temperature in Climate Change Policy – A New Zealand King Salmon case study*. [online] Available at: https://www.mcguinnessinstitute.org/publications/working-papers [Accessed date].

Copyright © McGuinness Institute Limited November 2021
ISBN 978-1-990013-58-4 (paperback)
ISBN 978-1-990013-59-1 (PDF)

This document is available at www.mcguinnessinstitute.org and may be reproduced or cited provided the source is acknowledged.

Author McGuinness Institute

Research team includes Lucy Witkowski, Arne Larsen, Eilish Cartysquires

Designers Dana King and Sophie Wells

Editors Johanna Knox

For further information
McGuinness Institute
Phone (04) 499 8888
Level 1A, 15 Allen Street
PO Box 24222
Wellington 6011
New Zealand
www.mcguinnessinstitute.org

Disclaimer The McGuinness Institute has taken reasonable care in collecting and presenting the information provided in this publication. However, the Institute makes no representation or endorsement that this resource will be relevant or appropriate for its readers' purposes and does not guarantee the accuracy of the information at any particular time for any particular purpose. The Institute is not liable for any adverse consequences, whether direct or indirect, arising from reliance on the content of this publication. Where this publication contains links to any website or other source, such links are provided solely for information purposes and the Institute is not liable for the content of any such website or other source.

Publishing The McGuinness Institute is grateful for the work of Creative Commons, which inspired our approach to copyright. Except where otherwise noted, this work is available under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International Licence. To view a copy of this licence visit: creativecommons.org/licenses/by-nc-nd/4.0

Contents

List of Appendicies

List of Figures

1.0 Introduction

This working paper sits under two of the Institute's Research Projects: *OceanNZ* and *ClimateChangeNZ*.

In the face of climate change, businesses will need to become agile through improving measurement, engaging early with strategic issues, and disclosing emerging risks and opportunities to investors and other stakeholders.

This paper illustrates how changes in ocean water temperature have been discussed by experts and policy makers, from 2012 (when climate change was not seen as significant), to today (when it is now a key determinant impacting financial viability). The aim of this paper is to contribute to a wider discussion on how New Zealand might improve the quality of ocean water temperature data in order to deliver timely, effective and durable resource management decisions.

The recent consent hearing considering New Zealand King Salmon's *Application to establish a new salmon farm within a 1,000 ha site located approximately 5 kilometres due north of Cape Lambert* began in October 2021 and will continue in December 2021. It raises the issue of the rise in water temperature and, more importantly, how water temperature is measured and reported.

1.1 Background

The New Zealand salmon farming industry is both a victim and a villain in terms of climate change. New Zealand King Salmon (NZKS) is no exception. It is a victim in that it is one of the first companies having to reconsider its business model: rising temperatures mean the salmon farms need to be moved to cooler water, and existing farms will become stranded assets. It is a villain because it imports large amounts of feed from Australia and Chile and exports 50% of its product to overseas destinations, creating a significant carbon footprint.

Oceans are a public asset; they are owned by the public, rather than individuals or companies. The closest model of private ownership for oceans is a consent provided to individuals or companies to use water space. Currently, NZKS does not pay for the use of water space for its existing consented farms in the Marlborough Sounds, which is inconsistent with the pricing strategies in other countries.

Arguably this current application, if successful, leads to a form of private ownership of a public resource because it gives rights to use the water space, at the exclusion of all other parties, for a period of 35 years. It is the length of time, the 35 years, that make the application relevant in terms of climate change, in particular the extent ocean water temperature will change between the years 2021 and 2056. It is this latter point that is explored in this working paper.

2.0 Methodology

NZKS, and the wider discourse in the Marlborough Sounds, provides a case study to illustrate the need for a universally agreed way to measure and report ocean water temperatures, whether at the surface or below. This work is important as it illustrates a problem that faces New Zealand's aquaculture industries as well as New Zealand's ocean management more broadly. A failure in establishing an agreed reporting framework for ocean water temperature will result in poor investment decisions, poor resource management and a poor outcome for current and future generations.

Importantly, the spatial term 'offshore' has created confusion and misunderstandings at the recent NZKS application hearing (U190438, also known as Blue Endeavour). A number of government agencies and regional councils share the responsibility for managing activities in New Zealand's 'offshore waters'. Offshore waters between 0 – 200 nautical miles include both our Exclusive Economic Zone and Continental Shelf and our territorial waters.

All aquaculture in the Marlborough Sounds, including all existing salmon farms and the recent application (U190438) are in the Territorial Sea Baseline between the low water mark up to 12 nautical miles, being part of the 'offshore waters'. So effectively, this recent application is not significantly different from any other application in this part of the coastal marine area. In contrast, an application beyond the 12 nautical miles zone would mean a fundamental new approach.

Another working paper in the series is *Working Paper 2021/15 – Looking for a taxonomy for Aotearoa New Zealand's oceans*. *Working Paper 2021/15* aims to understand whether a common taxonomy of ocean management terms exists, and where inconsistencies in terminology arise, by undertaking a scoping of oceans literature. A taxonomy is a comprehensive classification system with a hierarchy of key terms to enable researchers to consistently analyse and compare data in a meaningful way over time.

These working papers collate and illustrate the impacts of climate change on public policy, which will then be canvassed in our upcoming 2058 report: *Report 18 – A Climate Change Strategy for Aotearoa New Zealand*.

2.1 Method

Step 1: Find Files

The research focussed on four groups of documents:

Group 1: NZKS applications (see Appendix 1)

- NZKS Application U190438 (Blue Endeavor);
- NZKS Application for a [fresh]water Conservation order [at Takaka Hatchery for smolt];
- NZKS 2017 Relocation proposal; and
- NZKS 2013 Board of Inquiry.

Appendix 1 documents were found by doing searches on the Marlborough District Council and the Environmental Protection Agency website using the filters for resource consent number, such as 'U190438' 'submission' and 'NZKS'.

Group 2: Marlborough District Council hearings (see Appendix 2)

- MDC Variation 1 and 1A of the Proposed Marlborough Environment Plan (PMEP).

Appendix 2 documents were found on the Marlborough District Council website, relating to Variation 1 and 1A for inclusion in the Proposed Marlborough Environment Plan. Variation 1A provides additional provisions specifically for finfish farming.

Group 3: MPI reports (see Appendix 3)

- MPI Aquaculture report;
- MPI reports on salmon deaths; and
- MPI reports on the 2017 salmon investigation report (search for contained zones).

Appendix 3 documents were found on the Ministry for Primary Industries website by doing searches for the term 'aquaculture strategy' and 'salmon mortality'.

Group 4: Selected reports and articles (see Appendix 4)

- Selected NIWA reports relating to Marlborough Sounds and its water temperatures; and

Selected articles and reports related to Marlborough Sounds and its water temperatures.

Appendix 4 documents were found by doing a wider search of documents relating to the NZKS submissions as well as ocean water temperatures in the Marlborough Sounds.

What was excluded:

This process provided hundreds of files to sort through, all relating to water temperature in the Marlborough Sounds. Given the number of documents, the research excluded the following:

- NZKS application to change Conditions 36 and 40 of Coastal Permit U140294 (Waitata) and Coastal Permit U140296 (Ngamahau).
- Other NZKS applications not listed above.
- A in-depth review of other reports and articles was not undertaken.

Step 2: Sort files using the word 'temperature'

The next step was to begin sorting through the files in order to determine which related to water temperature and which did not. This was done by individually opening up each file and doing a search for the term 'temp'. We used 'temp' instead of 'temperature' to ensure that no graphs or figures that mentioned temperature in shorthand were missed.

The files were then sorted into folders of 'does contain temperature' and 'does not contain temperature'. Files that did contain temperature were then checked again to ensure that the use of the word temperature was in the context of the water in the Marlborough Sounds. For example, this process removed the *Evidence of Peter Rough*, who used temperature as a way of describing land, not water temperature.

Step 3: Compile excerpts

Excerpts that contained the word temperature were copied into the appropriate table by date of publication and name of document (as uploaded on the official website). Note that the date of publication is often different from the date of upload so, for the reader's convenience, the upload date has been used in Appendix 1A.

If a document contained more than one mention of temperature, each mention was copied into an individual row to ensure that everything was clear.

In most cases, footnotes and endnote numbers were removed from excerpts for the ease of the reader, however links were also provided to help readers go to the document directly.

2.2 Limitations

Due to the method of copying and pasting from documents, this includes risk of human error. Given this, each excerpt was checked twice by different staff to ensure accuracy of each excerpt.

As files had to be manually downloaded, there is possibility that some excerpts may have been unintentionally excluded.

Some files did not allow for text searching due to them being scanned and uploaded documents, therefore Adobe Acrobat was used to convert files to become searchable text files. Because of this there is the possibility that some excerpts may have been unintentionally excluded.

Audio files were excluded. There is one exception (See Appendix 1A, Number 2 – Oral submission of Wendy McGuinness, Expert, Hearing of Application for Resource Consent U190438 – NZKS Co Limited – Blue Endeavour, 22 October 2021, transcript provided through personal communications with Marlborough district Council (Marlborough)).

3.0 Results

At the hearing on Friday 22 October 2021, Commissioner Rob Enright and Wendy McGuinness both understood the trigger to be 17°C. However, Commissioner Enright believed the trigger of 17°C referred to the temperature at which fish normally get stressed (no matter what the depth), see discussion in Appendix 1A, Row 2. In contrast, McGuinness thought the trigger of 17°C referred to the surface temperature of the ocean (the SST) and that if the skin of the surface of the ocean was 17°C the fish would become stressed. This was possibly due to McGuinness being at other hearings where an assumption was made that 17°C SST indicated the temperature where salmon become stressed.

3.1 What we know

Below is a brief discussion on the following groups of documents searched, showcasing by example what the documents tell us about how water temperature has been used in the public policy processes.

3.1.1 NZKS applications

2021 Application U190438 (Blue Endeavour) (Appendix 1A)

- NZKS are struggling to farm inshore, and the business model is likely to be more challenged as the planet warms. This has resulted in NZKS being 'forced to look for cooler waters', outside the inshore waters of the Marlborough Sounds. (See Appendix 1A, Row 30).
- Higher ocean water temperatures increase fish disease and mortality and decrease fish growth once the water temperature reaches a certain level. Diggles for NZKS states: ['the increased water currents and depths, together with the reduced chances of disease outbreaks occurring in the first place due to better water quality and lower average water temperatures in Cook Strait.'] (see Appendix 1A, Row 99), and Knight for NZKS states: ['The report of Dr Ben Diggles notes that stress on cultured fish can affect their health and this could result in a greater potential for disease and mortality.'] (see Appendix 1A, Row 85).
- Kenepuru and Central Sounds Residents Association state: ['Part of the NZKS story with this application is that this site will avoid the high summer sea temperature problem by being located in deeper open waters. As far as we can ascertain the only actual sea temperature data from the Cape Lambert site provided by NZKS is from monitoring between begin October 2018 until 25 January 2019. As can be seen from the graph, the surface temperature can even exceed 19°C at times in January, while at a depth of 10 m, the temperature reaches 17°C.'] (see Appendix 1A, Row 37).

2018 Application for a [fresh]water Conservation Order [at Takaka Hatchery for smolt] (Appendix 1B)

- Appendix 1B makes clear that a relatively consistent year-round temperature of 12°C is the ideal temperature for salmon rearing. The implications are that a closed land-based system could deliver optimal temperatures (see Appendix 1B, Row 1).

2017 Relocation proposal (Appendix 1C)

- Appendix 1C shows that in 2017 the Panel decided: ['Whether climate change does cause those significant long-term temperature rises in Pelorus Sound has yet to be shown empirically, so we do not consider the Plan Change Proposal can be refused on that ground'] (see Appendix 1C, Row 1).

  The problem with this view is that if the data is not collected, it is impossible to show empirically that the evidence of climate change exists. NZKS now argues, three years later, that climate change is impacting their business model so significantly that they are being 'forced to look for cooler waters', outside the inshore waters of the Marlborough Sounds (see Appendix 1A, Row 30). If the lack of empirical data (to support the view that climate change does cause significant long-term temperature rises) is able to be construed as supporting the status quo in 2017, how can a lack of the same empirical data in 2021 lead to a change in the status quo (going outside the inshore waters) - this seems illogical.

2012 Board of Inquiry (Appendix 1D)

- At the 2012 Board of Inquiry, it was rare for the discussion to refer to water temperature in any detail. Generally the narrative was very unspecific, e.g. 'sea temperature change', 'sea water temperature' (e.g. Appendix 1D, Rows 26 & 27, Row 44) or 'average daily water temperature' (provided by Preece on behalf of NZKS, see Appendix 1D, Row 73). Even graphs fail to refer to the depth the temperature was taken (e.g. Appendix 1D, Row 63).
- The NIWA maps, which used SST data, are an exception (e.g. Appendix 1D, Row 64, Row 65).
- There are some narratives that are confusing, but also raise issues around what depth salmon prefer to swim at. For example, in Appendix 1D, Row 71, provided by Preece on behalf of NZKS: 'Water depth at the site ranges from 28–30m, and water flow is categorised as 'low' to 'moderate' with an average mid-water current speed of 8.4 cm/s. Over an annual period, 5m deep, daily ocean water temperatures averaged over recent years fall between ~12-17.5°C' (Waihinau Bay, para 49). This may mean that, 5m below the surface, the annual temperature was between 12°C and 17.5°C. If we are to take this as correct, this would mean the surface temperature (the SST) might have been between 14°C and 19.5°C. This illustrates that the decision making to date has failed to seek out or consider useful comparable temperature data over time.
  New Zealand needs to develop decision-useful water temperature data.
- There is also an issue of timely and comparable data, especially given that climate change is impacting water temperature very quickly. In 2012, the Board of Inquiry was provided data for very short and often very unique times of the year (e.g. not averaged). For example, one graph provided by Gillard on behalf of NZKS shows the temperature records from 1 December 2009 to 30 April 2010 (see Appendix 1D, Row 80) and another, provided by Knight on behalf of NZKS, shows the temperature records from 24 July 2008 to 21 August 2008 (see Appendix 1D, Row 88). Please note neither of these temperature graphs state whether this is surface (SST) records or if not, at what depth. Further, these graphs only cover short periods of time, whereas we know that change should be measured and averaged over a number of years to be useful and comparable (using the same times of the year). In this case, one graph uses summer months and the other uses winter months.
- To add to the confusion, one of NZKS's experts introduces a 'surface temperature' that is not a surface temperature. See Appendix 1D, Row 92. The Figure notes that the surface means a temperature from 'the top metre'. The expert then goes on to note 'Deep' is 9m at Tory Channel and 25m at Wedge Point. Although this is not terribly useful, it does illustrate an important observation – that the water temperature in the Tory Channel is not influenced by depth: the difference between 1m and 9m/25m is not significant. However, this is likely to be because of the current from the coast, which we now know (based on the cover) is decreasing in volume (see Figure 3).
- Based on the above, we now consider the evidence on temperature provided to the Board of Inquiry was of a very poor standard.

3.1.2 Marlborough District Council hearings

2020 MDC Variations 1 and 1A (Appendix 2)

- SST may measure more than just the skin of the ocean. The MDC consulation document states: ['Thus, satellite measurements of water-temperature typically amount to measurements of temperature in the upper few tens of cm of the water-column.'] (see Appendix 2A, Row 5).
- A submission by Clova Bay Residents Association Incorporated states: 'The depth profile of temperature is nearly uniform in late winter: perhaps a little cooler at the surface than at the bottom, but again the time series plots show this better. The warming in spring is confined to the top 10 m or so of the water column, but as summer progresses this warm layer thickens and eventually occupies the full depth,

down to the 40 m shown in the figures.' [and] The model's temperature bias in summer in Pelorus Sound is thought to be a result of the amplitude of the seasonal cycle in SST in Cook Strait being too low. This might be a result of a bias in the surface heat flux formulation (which is based on coarse-resolution data from a global-scale model) or maybe excessive **tidal mixing in the areas with high tidal current speeds in Cook Strait** (see Figure 3-8 below). ... A noticeable feature of the temperature time series at the four deeper sites in Figure3-2 is that the near-surface is warmer than the water below in summer, but cooler by as much as 1-2 °C in winter. Given that water expands as it warms, a lower surface temperature can only be maintained if the surface water is less saline, and the salinity data presented below confirm that this is the case. This phenomenon of a cool surface water layer in winter was noted in Beatrix Bay by Sutton and Hadfield (1997) and appears to be a ubiquitous feature in Pelorus Sound.' [bold added] (See Appendix 2B, Row 13).

- Climate change, in particular, changes in sea temperatures, is resulting in a number of submitters seeking for Variation 1A to be withdrawn. A submission by Marine Farming Association Inc and Aquaculture New Zealand states: '(g) There are substantial environmental changes affecting the Marlborough Sounds. In addition to changes from terrestrial sources, climate change is having a significant influence on sea temperatures across New Zealand. It is predicted that sea temperatures will rise ahead of air temperature, with the oceans taking up more than 90% of the excess heat of the climate system. By attempting to fix everything in place, Variation 1A does not provide for adaptation to climate change.' (See Appendix 2B, Row 19).
- MDC have been collecting monthly temperature profiles (based on Friends of Onapua Bay Inc), (see Appendix 2C, Row 1).

3.1.3 MPI reports

- Appendix 3A notes that selective breeding can help counter the negative impacts of rising temperatures. However, this requires further clarity as it implies it may be possible, not that it has proven to be the case.
- Appendix 3B explains that water temperature plays a major role in creating a bacterium (T. maritimum) that grows in salt water environments in temperatures between 15°C and 35°C (see Appendix 3B, Row 5), leading to increased mortality. It does not grow in freshwater, hence land-based farming would not be vulnerable to that risk.

This report led to the development of contained zones to contain bacteria. This should be revisited given NZKS's application U190438 (Blue Endeavour), discussed in Appendix 1A, is considering using a range of farms in the vicinity of the proposed two farms. We are also unaware of this discussion in terms of the variations being considered by MDC.

3.1.4 Selected reports and articles

Appendix 4A [Row 1] indicates that the SST between February (hottest) and August (coldest) is approximately 5°C. It is not clear what time period this refers to, but it will be pre-2016.

- Appendix 4B contains a range of detail that is in the public arena. Perhaps the most useful, in comparison with all the data provided to commissioners, is this statement by the Chief Executive of NZKS: 'King salmon prefer temperatures between 12 and 17 degrees Celsius, but the farms have been warmer than usual since early December, and one farm has been consistently over 19°C at a depth of 5 metres for the last three weeks'. This may imply that all the temperatures recently provided by NZKS are at 5m, but the reality is we do not know (and that is the key concern).

Given all of the above analysis of the evidence, the question remains whether the trigger of 17°C is at SST, or at a depth below the surface (e.g. 5m, 9m, 25m or deeper again). Below we summarise what we do not know and what we suspect.

3.2 What we do not know

There is uncertainty over the water temperature where NZKS is planning to farm salmon (in water offshore but still within the Marlborough Sounds).

The excerpts are less than clear when it comes to the following questions.

Question 1: How long can salmon swim in 17°C before: (i) growth slows, (ii) they get a disease or (iii) they die?
Discussion: The trigger point (the certain temperature) is unclear, as indicated by the excerpts in the appendices by NZKS expert evidence. For example, in Appendix 1A, Row 101, Diggles for NZKS states: ['exceed 16°C for extended periods during summer'], in Appendix 1A, Row 85 Knight for NZKS states: ['avoiding temperature extremes >16°C'], and in Appendix 1A, Row 122 ['18°C is used as a worst-case summertime temperature, with observed temperatures typically 17°C or less'].

The only indication of the difference in temperature between the surface and where salmon are likely to swim, before the commissioners (to our knowledge), is in the Kenepuru and Central Sounds Residents Association submission. Here they indicate the difference between SST and a depth of 10m is about 2°C. See Appendix 1A, Row 37 ['the surface temperature can even exceed 19°C at times in January, while at a depth of 10 meter [sic], the temperature reaches 17°C']. If this is the case, any SST at about or above 19°C, in the location being proposed by NZKS, would mean their business model will be severely challenged. That is why the presentation by Hanneke Kroon at the consent hearing in October was so relevant. The NIWA maps she presented (repeated on the cover of this working paper), indicate that 19°C SST in February may be possible in the proposed location (either now or in the near future). This is why it is important for water temperature testing to be carried out on site.

Question 2: What is the impact of depth on water temperature, in terms of the new location being proposed under this application? For example, if SST is 17°C, is that sufficient to trigger the three impacts (in Quesiton 1 above)?

Question 3: How much colder are the new proposed sites' SST, and how do they differ from inshore sites?

Question 4: How might currents impact SST on the proposed sites in the next 35 years (particularly given the size of the green illustrated on the map on the cover – repeated and highlighted below in black)?

Question 5: Is SST a useful term or should other types of water temperature measures be developed to assist commissioners to make resource decisions, the industry and bankers make investment decisions and the wider public make community decisions?

Question 6: What quality of data, over what timeframe, with what level of independence, should be presented to commissioners by applicants wanting to use water space?

Question 7: What type of conditions or limitations could be put in place by commissioners and councils to measure and manage the risks of changes in water temperature?

Discussion: The Institute had assumed that SST was the gold standard, and that surface water temperature could be assumed to be the standard measure when NZKS and their experts mentioned water temperature. Given the hearing, we now suspect this is not the case and that there has been a lack of discipline in its use, not only at this hearing, but at previous hearings.

Use of differing and imprecise terminology is creating an unnecessary level of uncertainty. For example, a number of times in Appendix 1A there is mention of actual sea temperatures but no mention of the depth they have been taken at; in Appendix 1A, Row 54, Preece for NZKS states ['sea temperatures'] and in Row 81, Knight for NZKS states ['summer temperatures of 18°C']. Examples where the type of temperature and actual temperature are listed together, providing the reader with clarity, are rare. For example, in Appendix 1A, Row 53, Preece for NZKS states ['sea surface temperature ranging from 17-25°']. However, this does indicate, from NZKS perspective, that if the sea surface temperature was found to be 17° at the Cape Lambert site (as suggested by Kenepuru and Central Sounds Residents Association), the proposal is not feasible.

3.3 What we suspect

- The water will warm more quickly than expected. Currently, there is mention of a rise of 0.2 to 0.4 degrees every ten years, but it looks as though this may speed up in the short-term. See Figures 2 and 3 below.
- The water may warm more quickly than predicted as the mass that will be supporting that water temperature is decreasing over time. That can be seen by the green mass in 2002 getting significantly smaller by 2021. This is arguably similar to an iceberg: the bigger the mass, the slower the melt, and once the mass gets small, the mass can melt very fast. This should ideally be explored by experts in the field. In particular, the impact on the Tory Channel may be particularly significant.

Figure 2: NIWA Mean Surface Temperatures for the Marllborough Sounds from 2004, 2012 and 2020

The images are from the 'NIWA Timeseries' GIS database (https://gis.niwa.co.nz/portal/home). They show the average Sea Surface Temperature (SST) (°C) for the month of February.

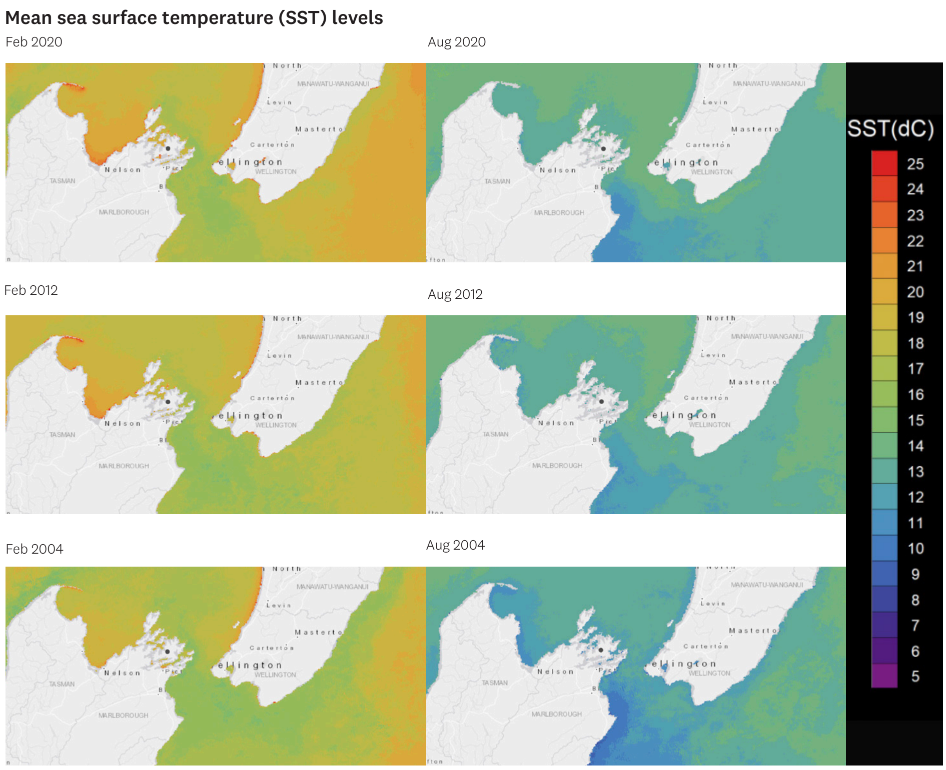
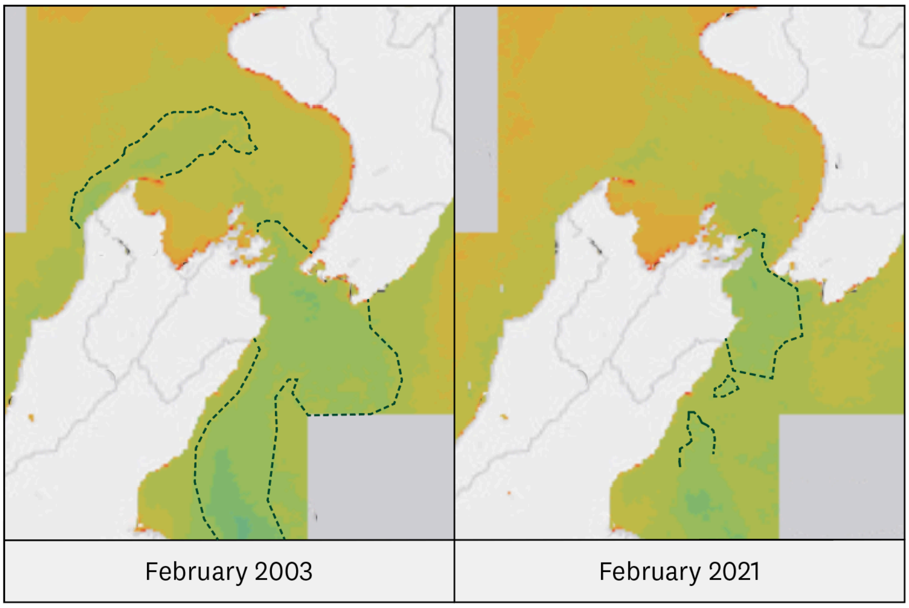


Figure 3: NIWA's figure (the cover image adjusted) to illustrate how water below 15°C is shrinking and now isolated from the currents along the eastern face of the South Island.



4.0 Recommendations

Recommendation 1: Commissioners request that all ocean water temperature data be provided by the applicant and by experts in such a way that is accurate, comparable, useful and independently verifiable.

This will enable the commissioners, the submitters, and the general public to understand the extent to which changes in ocean water temperature from climate change is impacting on NZKS's business model, the health of salmon and the health of the wider ecological environment. Ocean water temperature is dependent on the inclusion of multiple characteristics to ensure accuracy, comparability and independence. In this case, comparing water temperature over time or between salmon farms requires reporting on the (i) location, (ii) time of day, (iii) day of the year, (iv) the tide and (v) the depth, as well as specifying who undertook the research using what measurement tools. More information is needed on the sea temperatures at the Cape Lambert site in order to determine if Kenepuru and Central Sounds Residents Association concerns are correct.

Investors, bankers, insurance companies, and those undertaking resource management decisions should expect to be able to access and rely on useful data that can be compared over time and between existing and potential farm sites. Work is urgently required in this space.

Recommendation 2: Commissioners request clarification of the point at which sea surface temperature (SST) is likely to trigger (i) decreases in salmon growth, (ii) increases in disease and (iii) increases in salmon mortality.

For example, is it at a sea surface temperature of say (i) 17°C, (ii) 18°C or (iii) 19°C, or is it salmon swimming between 5m and 10m below a sea surface temperature of say (i) 17°C, (ii) 18°C or (iii) 19°C, or is it salmon swimming between 10m and 25m below a sea surface temperature of say (i) 17°C, (ii) 18°C or (iii) 19°C? This question should be answered relatively easily given the company's experience at farming king salmon in the Marlborough Sounds. Our concern is that without this clarity, decisions are likely to be incorrect and may lead to consents being issued without adequate profits being earned. Profits will be necessary to ensure conditions are actioned or in the worst case, to prevent the cost of farms being disestablished being paid for out of the public purse.

Recommendation 3: The new Oceans Secretariat should undertake an urgent project to improve the quality of ocean water temperature data, its collection, management and environmental impacts.

The time to collect data and develop the skills, expertise, and the language to benchmark and manage climate change impacts is now. The newly established Oceans Secretariat, comprising officials from the Department of Conservation, Ministry for Primary Industries and the Ministry for the Environment, should lead this work. We suggest the Oceans Secretariat should call on the assistance of NIWA, to produce guidance on reporting ocean water temperature data and record impacts, not only publishing changes in ocean water temperature but its impact on disease and mortality rates (per salmon farm), impacts on shellfish (per farm) and on marine mammals more generally. Data is urgently required to help commissioners, investors, bankers, stakeholders, consultations, policy analysts, councils, the courts and NGOs consider, report, respond and manage climate change impacts.

This work could be funded and managed by the new Minister for Oceans and Fisheries, David Parker. The new portfolio includes the management of New Zealand's fisheries (including aquaculture), providing for use while ensuring sustainability of those resources for the benefit of New Zealand as a whole, and responsibility for oceans policy.

Key for appendices:

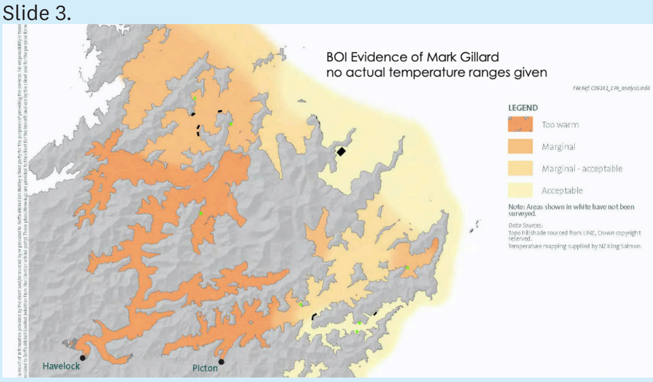
Excerpts that are mentioned in Section 3 of this paper are highlighted in green.

Degrees Celsius or [°C] are highlighted in red.

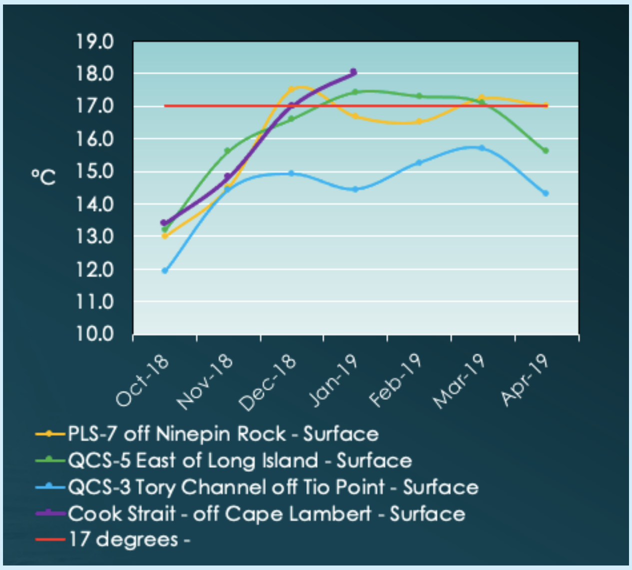
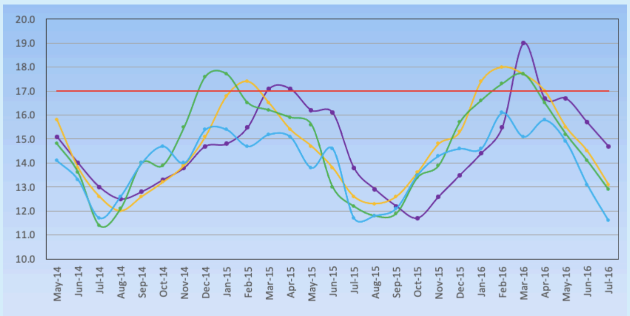
Sea surface temperature or **(SST)** are highlighted in red and are bold.

Every row contains the word temp, temerature or SST. References are by Appendix #, followed by Row #.

Appendix 1: NZKS applications and submissions

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
1	29 Oct 2021	Applicant - Supplementary Brief - B Kaye-Blake (3.8MB) Record: 21236091 05 Nov 2021	Table A4 ES and related MEA categories used in this study, p. 80. Water regulation: Water absorption during rainfall and release in dry times. Temperature and flow regulation for plant and animal species.
2	22 Oct 2021	Oral submission of Wendy McGuinness, Expert, Hearing of Application for Resource Consent U190438 – NZKS Co Limited – Blue Endeavour, 22 October 2021, transcript provided through personal communications with Marlborough district Council (Marlborough)	Transcript from verbal presentation of Wendy McGuinness. 6:50:50 ENRIGHT: Thank you. And we have looked at a little bit more in that and I noticed that **surface temperature**, and Mr Preece did state that the salmon would be down lower and the **sea surface** does warm up during the summer. 6:51:06 MCGUINNESS: And my question is, and I am not sure, whether the 17 degrees that they talk about as the borderline is the surface or not. So they talk about, and I could find the quote for you - 6:51:22 ENRIGHT: It doesn't matter whether it's on the surface or whether it's down low, it's where the salmon is in the water column. So if it's... There's a range within which salmon can survive quite nicely. And if they're in that water range where it's above 17 degrees they will get stressed. So it depends where, you know... 17 [degrees] is a stressor for the fish.
3	22 Oct 2021	Applicant evidence - proposed consent conditions dated 22 October 2021 (624.6KB) Record: 21227399 22 Oct 2021	Endnote 14, (PDF p. 19). During each six hour period 15 m surface integrated, and Van Dorn water samples will be collected from 3 depths (surface, 15 m and 30 m) and tested for a range of nutrients (e.g. total nitrogen [TN], total phosphorus [TP], total ammoniacal nitrogen [TAN], urea, nitrate) and chlorophyll-a. In addition, CTD casts will be undertaken to measure dissolved oxygen (DO) and other water properties (e.g. chlorophyll-a and temperature) at different depths and a sample of the phytoplankton communities at the site.
4	21 Oct 2021	Applicant evidence - proposed consent conditions dated 22 October 2021 (624.6KB) Record: 21227399 22 Oct 2021	Endnote 14, (PDF p. 19). Water samples should be collected at each site at least three times within half of a tidal cycle (i.e. spread across the six-hour period). Replicates of water samples (at least two) should be taken. Pseudo-replicates (replicates within a single sample) for assessment of variation associated with sample handling and laboratory processing should also be considered for at least one site in a survey. CTD casts for salinity, temperature, DO and turbidity at each site should also be collected.
5	21 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association - PowerPoint v2 (9.6MB) Record: 21226095 21 Oct 2021	Slide 3. 

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)

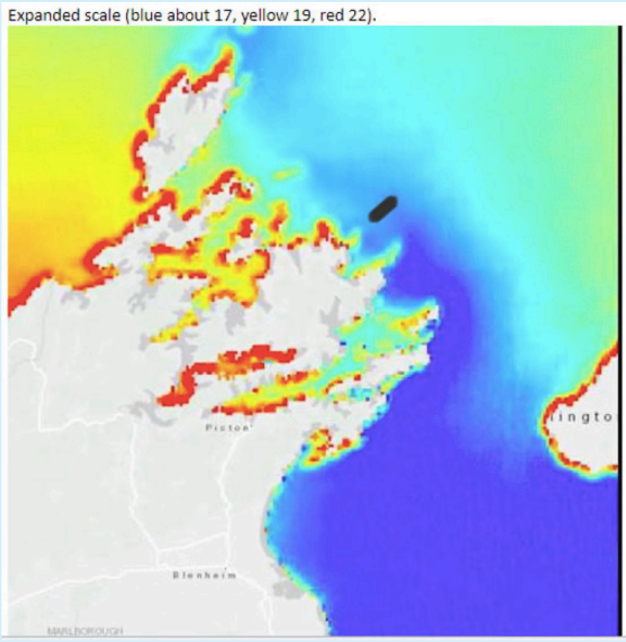
Number	Date on document	Name of document and Date uploaded	Excerpt from document
6	21 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association - PowerPoint v2 (9.6MB) Record: 21226095 21 Oct 2021	Slide 5. Comparison of Sea temperatures inside Marlborough Sounds with Cook Strait - off Cape Lambert - Oct 2018 and Jan 2019 
7	21 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association - PowerPoint v2 (9.6MB) Record: 21226095 21 Oct 2021	Slide 6. **Sea surface temperature** comparison - MDC monitoring data 

<table>
<tr><th colspan="4">Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)</th></tr>
<tr><th>Number</th><th>Date on document</th><th>Name of document and Date uploaded</th><th>Excerpt from document</th></tr>
<tr><td>8</td><td>21 Oct 2021</td><td>Hearing submission - Kenepuru and Central Sounds Residents Association - PowerPoint v2 (9.6MB)
Record: 21226095
21 Oct 2021</td><td>Slide 8.
Niwa – Cook Strait 2002 – 2020
February mean SST (°C)

Enlargement of previous NIWA picture
Supplied by Niall Broekhuizen - NIWA

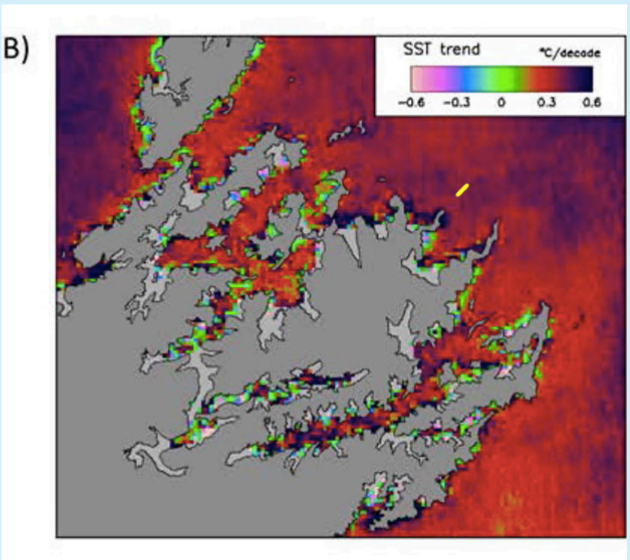
Note the colours indicating the Sea Surface Temperature are different from the previous picture.

Blue = 17 °C
Yellow = 19 °C
Red = 22 °C

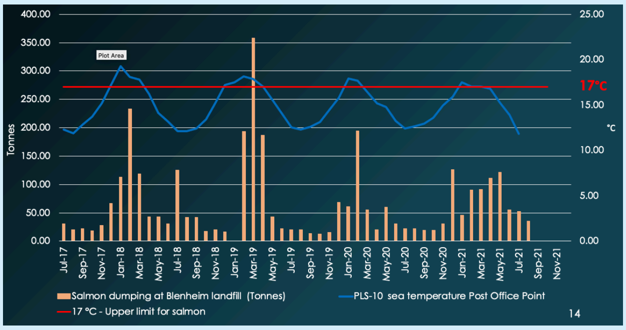
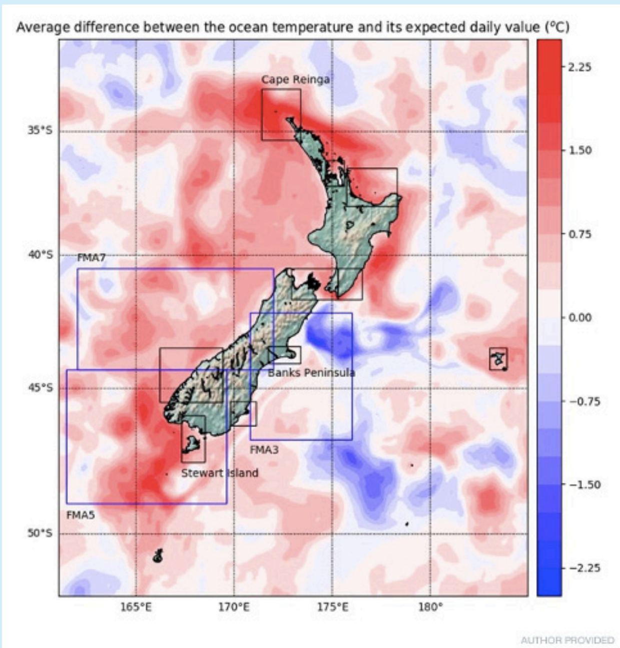

</td></tr>
<tr><td>9</td><td>21 Oct 2021</td><td>Hearing submission - Kenepuru and Central Sounds Residents Association - PowerPoint v2 (9.6MB)
Record: 21226095
21 Oct 2021</td><td>Slide 9.
Sea Surface Temperature increase per decade

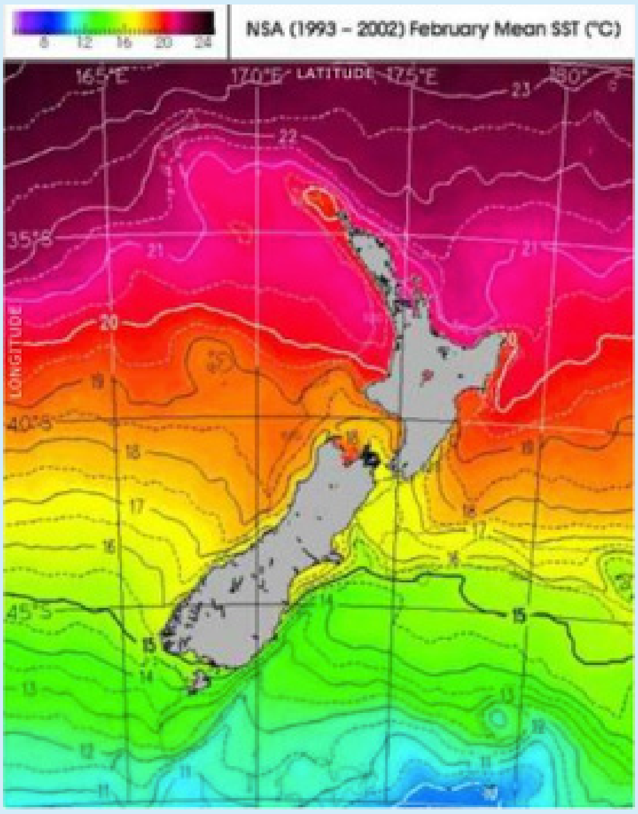
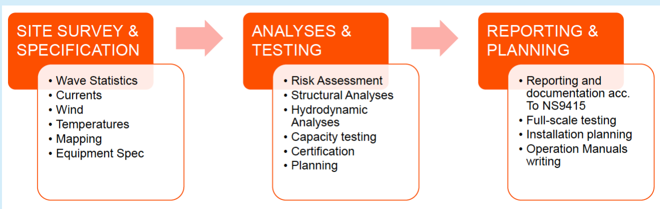
Niall Broekhuizen, David R. Plew, Matt. H. Pinkerton & Mark. G. Gall (2021).

Sea temperature rise over the period 2002–2020 in Pelorus Sound, New Zealand – with possible implications for the aquaculture industry.


</td></tr>
</table>

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)

Number	Date on document	Name of document and Date uploaded	Excerpt from document
10	21 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association - PowerPoint v2 (9.6MB) Record: 21226095 21 Oct 2021	Slide 14. Salmon dumping at landfill and corresponding sea temperature at Pelorus Sound entrance – data supplied by MDC 
11	21 Oct 2021	Submitter evidence - Aquaculture New Zealand - New Zealand Farmed Salmon Welfare Standards 2021 (6MB) Record: 21226061 21 Oct 2021	Chapter 2.b, p. 6. Stocking density is one of a range of parameters (like water temperature and dissolved oxygen) that can act together to affect the welfare of farmed salmon.
12	21 Oct 2021	Submitter evidence - Aquaculture New Zealand - New Zealand Farmed Salmon Welfare Standards 2021 (6MB) Record: 21226061 21 Oct 2021	Chapter 3.g, p. 8. To reduce the risk of water quality affecting fish welfare: • At a minimum temperature and DO must be measured and maintained at appropriate levels at all times where possible to ensure a reduced risk of fsh stress
13	20 Oct 2021	Submitter PowerPoint presentation - Marlborough Environment Centre (12.8MB) Record: 21225420 20 Oct 2021	Slide 24. Marine heatwaves MBIE Moana Project's research for 2021 shows Cape Lambert is in a red zone, most vulnerable to sea temp rise. So far for 2021 sea temps here were 1C-1.5C warmer than normal. Has the impact of marine heat waves due to climate change been factored in by NZKS when selecting the Cape Lambert site?  Temperature anomaly in relation to 25 years of climate data. The boxes show the regions where detailed analysis and detection of marine heatwaves is carried out.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
14	20 Oct 2021	Submitter PowerPoint presentation - Marlborough Environment Centre (12.8MB) Record: 21225420 20 Oct 2021	Slide 25. Effects of Climate Change • “Climate change is the key driver for this application” • For a 35-year consent application, there should be a rigorous analysis of climate change effects, not just a few comments in the planner report. • Should also be more recent data. The sea temperature chart in Mr Preece’s operational evidence uses data from 1993-2002. 
15	15 Oct 2021	Applicant evidence – Powerpoint presentation – M Søreide (3.5MB) Record: 21224384 20 Oct 2021	Page 4. Design Basics/Process, Cages, Nets, Mooring. • Design is based on requirements from NS4915. 
16	18 Oct 2021	Applicant legal submissions - S Gepp speaking notes (192KB) Record: 21222331 18 Oct 2021	Paragraph 1, p. 2. a. Salmon farming requires cool, clean water. Sea temperature is rising. Climate change is a key drive of the move to open ocean aquaculture. Several submitters raise concerns re effects of climate change – far from being overlooked, for NZ King Salmon climate change is a lived reality that cannot be disregarded.
17	15 Oct 2021	Applicant’s Legal Submissions (926KB) Record: 21220802 15 Oct 2021	Paragraph 5, p. 4. Warming sea temperatures decrease the areas in the Marlborough Sounds available for salmon farming and will lead to decreased salmon production until eventually the Pelorus Sound will become too warm to farm salmon year-round.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
18	15 Oct 2021	Applicant's Legal Submissions (926KB) Record: 21220802 15 Oct 2021	Paragraph 63, pp. 22–23. In any event, Mr Preece explains that the farms recommended by the Panel (with the exception of Tio Point in Tory Channel) have since been assessed as not suitable for year-round salmon farming in the longer term given the observed increases in seawater temperature over the last few years.
19	14 Oct 2021	Applicant's Rebuttal Evidence - M Preece (413.2KB) Record: 21220685 15 Oct 2021	Paragraph 22, p. 7. Salmon are ectothermic (they rely on external factors to regulate their body temperature). Salmon grow and convert feed most efficiently at their thermal optimum. When the water temperature is too cold or too warm, salmon growth may be slower. A warming climate may make cold farm locations better suited to growing salmon. As discussed in my evidence-inchief, I believe the temperature profile at Blue Endeavour will be ideal for growing salmon.
20	15 Oct 2021	Applicant's Legal Submissions (11.8MB) Record: 21220663 15 Oct 2021	Paragraph 5, p. 4. Warming sea temperatures decrease the areas in the Marlborough Sounds available for salmon farming and will lead to decreased salmon production until eventually the Pelorus Sound will become too warm to farm salmon year-round.
21	15 Oct 2021	Applicant's Legal Submissions (11.8MB) Record: 21220663 15 Oct 2021	Paragraph 63, pp. 22–23. In any event, Mr Preece explains that the farms recommended by the Panel (with the exception of Tio Point in Tory Channel) have since been assessed as not suitable for year-round salmon farming in the longer term given the observed increases in seawater temperature over the last few years.
22	14 Oct 2021	Applicant Rebuttal Evidence (3.2MB) Record: 21220661 15 Oct 2021	Paragraph 59, (PDF p. 18). I agree that sea temperature will likely affect the decay rate of particles. As the water temperatures at the Blue Endeavour site are likely to be slightly warmer (although not by a lot, as the water at the site in Norway during the referenced study was around ca. 14°C during one of the surveys), I would expect the decay rate to be slightly higher.
23	14 Oct 2021	Applicant Rebuttal Evidence (3.2MB) Record: 21220661 15 Oct 2021	Paragraph 61, (PDF p. 18). The decay rate as it relates to the 12.5 g/m^2 contour is discussed in Dr Smeaton's rebuttal evidence at paragraph 14 (in response to Dr Broekhuizen's comments). Dr Smeaton defers to me as to whether decay will differ considerably between Blue Endeavour and Tory Channel. Given that the temperature profiles between those two locations will be relatively similar, the metabolic rates and therefore particle decay, should also be relatively similar.
24	14 Oct 2021	Applicant Rebuttal Evidence (3.2MB) Record: 21220661 15 Oct 2021	Paragraph 22, (PDF p. 59). Salmon are ectothermic (they rely on external factors to regulate their body temperature). Salmon grow and convert feed most efficiently at their thermal optimum. When the water temperature is too cold or too warm, salmon growth may be slower. A warming climate may make cold farm locations better suited to growing salmon. As discussed in my evidence-inchief, I believe the temperature profile at Blue Endeavour will be ideal for growing salmon. profile at Blue Endeavour will be ideal for growing salmon.
25	14 Oct 2021	Hearing Legal Submission - McGuinness Institute (202.2KB) Record: 21220543 14 Oct 2021	Paragraph 21, p. 4. In addition to the project's potential impact on climate change, addressed above, the Institute is concerned about the projects vulnerability to climate change. New Zealand is in a climate emergency and climate change presents significant risk to New Zealand's fisheries and aquaculture operations. Physical risks include: rising sea levels, more frequent and severe storms, rising water temperatures, and more.
26	14 Oct 2021	Applicant's Rebuttal Evidence - B Knight (1.4MB) Record: 21220492 14 Oct 2021	Paragraph 10, p. 4. Mr Schuckard raises a relevant concern about the cumulative effects of climate change. At current rates of warming this appears to between 0.1-0.2°C per decade in the region of the proposal (see Sutton and Bowen 2019). Over a 30-year consent period, at the higher end of the existing temperature trend, this would equate to a warming of 0.6°C and greater than historic rates of warming might plausibly increase this up to a 1°C increase over 30 years.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
27	14 Oct 2021	Applicant's Rebuttal Evidence (2.4MB) Record: 21220482 14 Oct 2021	Paragraph 10, p. 21. Mr Schuckard raises a relevant concern about the cumulative effects of climate change. At current rates of warming this appears to between 0.1-0.2°C per decade in the region of the proposal (see Sutton and Bowen 2019). Over a 30-year consent period, at the higher end of the existing temperature trend, this would equate to a warming of 0.6°C and greater than historic rates of warming might plausibly increase this up to a 1°C increase over 30 years.
28	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 13, p. 2. Looking at the broader picture, human activity has already impacted much of the Marlborough Sounds and created a story of loss – whales, blue cod, scallops, wild mussel beds, kelp forests. These losses will continue with increasing sedimentation, intensive aquaculture, and rising sea temperatures. For these reasons it is crucial that resource management decisions pay heed to protecting what we have left. The Cape Lambert area is one of the few remaining untouched parts of the Sounds.
29	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 29, p. 4. Marine ecosystems are changing and coming under more pressure from increasing sea temperatures. The same issue is limiting where open ocean salmon farms may be able to be installed around the New Zealand coast. And consumers are asking more questions about the pollution footprint of salmon farming – the waste must go somewhere, and the ocean is not an infinite repository for industrial waste.
30	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 77, p. 12. As the effects of climate change are felt around the world, sea temperatures in the Outer Marlborough Sounds are already rising above the ideal conditions for growing salmon. Mass mortalities in Pelorus Sound over recent years have been blamed on higher water temperatures and forced the company to look for cooler waters.
31	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 79, p. 12. Yet as shown in the evidence of Kenepuru and Central Sounds Residents Association, MDC monitoring data records water temperatures for the Cape Lambert area above 16C from March-June in 2015, and the same in 2016. That's eight out of 24 months. Sea temperatures are still going up and this trend will continue over the 35-year consent term.
32	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 81, p. 13. While this is bad news for salmon farmers, it's even worse for the wider marine ecosystems. The marine environment is already suffering from sea temperature rise and would also have to absorb the extra nutrient load from the Cape Lambert salmon farm.
33	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 85, p. 13. MEC submits that land-based RAS would provide better long-term environmental and business outcomes than establishing a large farm in an exposed part of the outer Sounds, where water temperatures are rising, and storm conditions are growing in severity.
34	14 Oct 2021	Hearing Submission - Marlborough Environment Centre (265.7KB) Record: 21220453 14 Oct 2021	Paragraph 90, p. 14. One of the new farms, Kopaua/Richmond, has suffered high sea temperatures, seabed enrichment and high fish mortalities. It is now being proposed for use only part of the year, as a nursery and harvesting site for Cape Lambert.
35	14 Oct 2021	Hearing submission - Aquaculture New Zealand - G Hooper (316.7KB) Record: 21220295 14 Oct 2021	Paragraph 22, (PDF p. 6). Farming in the open ocean will assist the industry to purposefully adapt to a changing climate, with greater risks of marine heatwaves, ocean acidification and rising sea temperatures. The Aotearoa Circle16 concludes that the seafood sector already faces challenging climate-related risks that warrant urgent and decisive action, grounded in the best available knowledge.

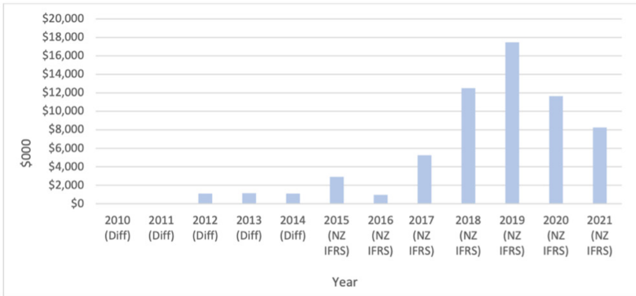
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
36	14 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association (806.4KB) Record: 21220279 14 Oct 2021	Paragraph 5, p. 2. Since then NZKS has had second thoughts about wanting more farms in the Pelorus Sound. The assurances given to the BOI back in 2012, that the Waitata Reach had the required year round low water temperatures, required for successful salmon farming, proved to be incorrect. Cue ongoing high mortality rates in the BOI Pelorus farms.
37	14 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association (806.4KB) Record: 21220279 14 Oct 2021	Paragraphs 11–18, pp. 3–4. From the onset of the BOI, it became apparent to the Association that salmon farming in the Pelorus Sound faced an intractable physical problem. Too often and for too long the water temperatures in the Pelorus Sound equal or exceed the critical 17 degrees threshold. At this point farmed King (Chinook) salmon become stressed, because they cannot regulate their body temperature. Eventually they stop eating and start to die in unacceptably large numbers. Pelorus Sound: Sadly for NZKS (and its fish) their expectation that salmon farming would be successful here, has been proven wrong. For a NZKS farm extension consent application hearing (November 2018) involving one of the BOI high flow farms (Waitata) the Association, in the absence of farm specific mortality data being available, calculated the mortality in the 2018/2019 monitoring period for this farm as over 40% by biomass! This is not sustainable environmental management, nor is it acceptable for animal health, disease risk, biosecurity risk and other issues. Further, NZKS knew the risk as at the BOI they categorized the water temperatures in the main channel of the Pelorus Sound as marginal. Sea Temperatures at the Cape Lambert Site: Part of the NZKS story with this application is that this site will avoid the high summer sea temperature problem by being located in deeper open waters. As far as we can ascertain the only actual sea temperature data from the Cape Lambert site provided by NZKS is from monitoring between begin October 2018 until 25 January 2019. As can be seen from the graph, the surface temperature can even exceed 19°C at times in January, while at a depth of 10 meter, the temperature reaches 17°C. Due to the blue and green coloured dots used in the graph, it is hard to distinguish between the surface and the -10m measurements. The January 2019 temperatures are hardly reassuring, but it must be noted that there was that summer a marine heatwave in the Tasman Sea, with elevated water temperatures 1.5°C above normal. This was the same year that 40% mortality was calculated for the Waitata farm in the Pelorus. According to the Cawthron report the temperatures shown were not representative of typical conditions for this region. We compared the Cape Lambert site temperatures with three locations in the Marlborough Sounds. As can be seen, the Cape Lambert site is at least as warm as the entrance of the Pelorus or the Queen Charlotte Sound and much warmer than the Tory Channel entrance. The deeper water will not help the farmed salmon much, as the net pens have 15m long sides, followed by a cone shaped bottom. The graph shows the Marlborough Sounds locations for a few more months, but only Tory Channel remains below 17°C for the whole summer.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
37	14 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association (806.4KB) Record: 21220279 14 Oct 2021 (continued)	Additional Temperature data: The Marlborough District Council (MDC) monitors up to 23 sites from 2013 onwards, in reaction to the BOI, who noticed the complete lack of any environmental monitoring with incredulity. Initially Port Gore was included in the monitoring, but dropped when the Supreme Court did not allow a salmon farm there. The monitoring location was in the middle of the entrance, between Cape Lambert and Cape Jackson. The graph shows that the temperature profile of Port Gore is more akin to the Pelorus or the Queen Charlotte Sound entrance, with summer temperatures exceeding the 17°C mark. It bears no resemblance to the Tory Channel temperature profile. Increasing Sea Temperatures? According to MetOcean Solutions the sea temperatures in New Zealand are increasing. NIWA has publically stated that the Tasman Sea is warming rapidly and is supplying warm sea currents in New Zealand's direction. Niall Broekhuizen and others from NIWA have done an in-depth analysis of the sea temperatures in the Pelorus Sound and how they have changed over time. Multiple data series at different locations in the Pelorus Sound, spanning four decades, were analysed. The conclusion is that the sea temperatures are rising in the Pelorus and the main cause for this is the warming of the Tasman Sea. Higher than average sea temperatures in winter lead to marine heat waves during the summer. It is clear from the maps that the warming effect stretches far into Cook Strait and that the Cape Lambert site is also exposed to the warming Tasman Sea currents. The satellite data indicate that warming has been more rapid in Cook Strait than inside the Sounds. Why all this emphasis on sea temperature? Due to the global warming of the earth, marginal areas for growing salmon will only become warmer and at some stage unsuitable for salmon farming. From a Part Two RMA perspective we do not believe that the utilization of this site for an activity that is so marginal is an efficient use of this high value public space.
38	14 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association(806.4KB) Record: 21220279 14 Oct 2021	Paragraph 19, p. 4. Elevated sea temperatures for ongoing periods stresses salmon because they cannot regulate their body temperature. The farmed salmon cannot take evasive action either. Stressed fish are more susceptible to disease. Salmon diseases and diseased salmons has plagued NZKS for the last 10 years.
39	14 Oct 2021	Hearing submission - Kenepuru and Central Sounds Residents Association (806.4KB) Record: 21220279 14 Oct 2021	Paragraph 29, p. 6. The landfill data has been used to plot the seawater temperature in combination with the dumped salmon waste (in tonnes) per month and shows the correlation between the two. There is a clear increase in dumped salmon waste with increasing sea temperatures, but the salmon mortality increase happens some weeks after the sea temperature increase. This is to be expected, as the salmon mortality increases as a consequence of longer periods of seawater temperatures exceeding the 17°C mark.
40	8 Oct 2021	Submitter evidence - Department of Conservation - N Broekhuizen (1.6MB) Record: 21215966 08 Oct 2021	Paragraph 40, p. 8. Hydrodynamic models are used to generate spatially and temporally resolved fields of: (a) horizontal- and vertical water movements (currents), (b) temperature and salinity. Loosely speaking, they operate by partitioning the spatial domain across numerous tessellating 'grid cells'. The instantaneous state within each grid-cell is characterized by five state-variables (three orthogonal velocity components, temperature and salinity) and the temporal evolution of this state is governed by five corresponding coupled differential equations. These differential equations are too complex to permit analytical solution. Instead, numerical methods are used to develop approximations to the time-evolution of the current velocity components, temperature and salinity under the combined influences of wind, fresh- and salt-water inputs, net thermal inputs, internal density gradients, local friction etc.

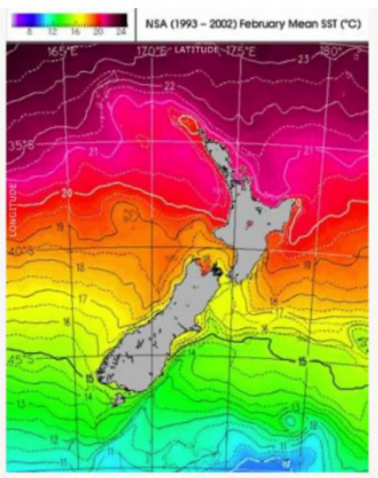
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
41	8 Oct 2021	Submitter evidence - Department of Conservation - N Broekhuizen (1.6MB) Record: 21215966 08 Oct 2021	Paragraph 114, p. 32. Given the strong influence that temperature has upon microbial growth rates, one might anticipate lesser resuspension during the summer months (all else being equal). Since microbially induced degradation rates are also likely to be faster in summer, this implies that there may be some seasonality in the extent and intensity of the footprint of incremental organic matter.
42	8 Oct 2021	Submitter evidence - Department of Conservation - N Broekhuizen (1.6MB) Record: 21215966 08 Oct 2021	Endnote 9, p. 36. For cold-blooded species such as salmon, metabolic rates tend to rise as temperatures rise. Until the temperatures rise above those that induce stress, this implies that fish will have a greater appetite (and, if this is sated, generate faeces at a greater rate). Microbes will also tend to process waste more rapidly – such that the benthic oxygen demand per unit of sedimented organic matter will tend to increase in the summer.
43	8 Oct 2021	Submitter evidence - Department of Conservation - N Broekhuizen (1.6MB) Record: 21215966 08 Oct 2021	Paragraph 149, p. 47. Under favourable conditions, phytoplankton biomass can double in 1-2 days. They will continue growing until conditions become unfavourable (they have exhausted the nutrient supply, light levels drop too low, water temperatures drop too low or grazer-induced mortality becomes too high). It seems probable that, when conditions are favourable, peak phytoplankton biomass will arise around 2-5 days downstream of the pens.
44	8 Oct 2021	Submitter evidence - Department of Conservation - A Baxter (2.9MB) Record: 21215964 08 Oct 2021	Paragraph 37, p. 7. In my view, several inter-related biophysical factors help shape the natural character of the coastal environment and are relevant for considering the biophysical status or condition of an area. These are broadly grouped into abiotic (physical environment) and biotic (biological environment) features: • Abiotic features: natural substrates; geology; environmental complexity; water quality; and physical processes (e.g., tides, currents, exposure, temperature, salinity, sedimentation, etc).
45	8 Oct 2021	Submitter evidence - Department of Conservation - A Baxter (2.9MB) Record: 21215964 08 Oct 2021	Paragraph 65, p. 14. MacDiarmid et al. (2012) concluded that ocean acidification (from increased CO2 in the atmosphere) is by far the greatest threat to marine ecosystems. The next most significant threat was rising sea temperatures (due to climate change). Some other global threats also ranked highly, including changes in ocean currents (5th=), increased storminess (5th=), and sea level rise (8th=). All these threats are global in origin and effect and cannot be properly addressed through local/regional management measures.
46	8 Oct 2021	Submitter evidence - Ministry for Primary Industries Evidence (961KB) Record: 21215927 08 Oct 2021	Paragraph 4.6, p. 3. Open ocean aquaculture in this context means those farming areas may be in the territorial sea or the exclusive economic zone, outside of the more sheltered bays and harbours where salmon farms have traditionally been located. Due to the sea temperature requirements for salmon farming, this growth is likely to occur in the eastern areas of the South Island, and off the coast of Stewart Island.
47	8 Oct 2021	Submitter evidence - Ministry for Primary Industries Evidence (961KB) Record: 21215927 08 Oct 2021	Paragraph 6.11, p. 6. In the context of salmon farming, supporting the industry to adapt to climate change requires enabling farming in ways that manage the impact of increasing sea temperatures on farm operations. This can include farming in cooler waters more suited to Chinook salmon, along with farming models that avoid the highest temperature peaks of certain sites.

<table>
<tr><th colspan="4">Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)</th></tr>
<tr><th>Number</th><th>Date on document</th><th>Name of document and Date uploaded</th><th>Excerpt from document</th></tr>
<tr><td>48</td><td>8 Oct 2021</td><td>Submitter evidence - McGuinness Institute (3.8MB)
Record: 21215900
08 Oct 2021</td><td>Paragraph 22, fig. 7, (PDF p. 36).
Figure 7 illustrates the level of mortalities. There have been several events, some of which are thought to be generated by rising water temperatures due to climate change.
…

Figure 7: Fish health events (mortalities) net of insurance proceeds ($000)



</td></tr>
<tr><td>49</td><td>8 Oct 2021</td><td>Submitter evidence - R Schuckard for Friends of Nelson Haven and Tasman Bay, Guardians of the Sounds, Kenepuru and Central Sounds Residents Association and Marlborough Environment Centre (692.2KB)
Record: 21215889
08 Oct 2021</td><td>Page 6.
Higher water temperatures are causing significant thermal stress for salmon operations resulting in a declining productivity.</td></tr>
<tr><td>50</td><td>8 Oct 2021</td><td>Submitter evidence - R Schuckard for Friends of Nelson Haven and Tasman Bay, Guardians of the Sounds, Kenepuru and Central Sounds Residents Association and Marlborough Environment Centre (692.2KB)
Record: 21215889
08 Oct 2021</td><td>Page 22.
Climate-induced changes in salinity, temperature and mixing, which all influence both oxygen conditions and species mean that hypoxia (low oxygen concentration) tolerance will be of importance. Climate change is a rather new phenomenon and it is only relatively recently that we are seeing attempts to integrate more and more of the consequences of this new reality.</td></tr>
<tr><td>51</td><td>8 Oct 2021</td><td>Submitter evidence - R Schuckard for Friends of Nelson Haven and Tasman Bay, Guardians of the Sounds, Kenepuru and Central Sounds Residents Association and Marlborough Environment Centre (692.2KB)
Record: 21215889
08 Oct 2021</td><td>Page 22.
The effects of large-scale climate warming are causing long-term variations in oxygen content and saturation as an observed increase in temperature has led to a general decrease in oxygen solubility of water masses. Mitigation of effects should reflect the realities of an uncertain future and we should not take comfort from the poorly known assimilation capabilities of the marine environment to date.</td></tr>
<tr><td>52</td><td>1 Oct 2021</td><td>Applicant evidence 22 - M Preece (1MB)
Record: 21211014
04 Oct 2021</td><td>Paragraph 44, (PDF p. 9).
The key factors required for optimum growth of King salmon are good water flows, water depth of around 100m and water temperature which ranges from 12-16°C. Ideal growth occurs within this temperature range; on either side of this range a deterioration in performance is observed.</td></tr>
</table>

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
53	1 Oct 2021	Applicant evidence 22 - M Preece (1MB) Record: 21211014 04 Oct 2021	Paragraph 46, (PDF p. 10). a. North Island: water temperatures are too high, and this region is outside the natural range of King salmon in New Zealand; b. Tasman and Golden Bays: Water temperatures are too high, with average summer **sea surface temperature** ranging from 17-25°C in both these bays; c. Admiralty Bay: Water temperatures are too high, with average summer **sea surface temperature** ranging from 17-25°C. This, in conjunction with low water current flows, mean this bay is considered unsuitable for farming salmon; ... e. Akaroa Harbour: water temperatures are suitable; however, this harbour is already the site of a boutique salmon farming operation, in the only area (the outer third of the harbour) that has flows and depths suitable for small scale salmon farming. The exposed waters near the entrance also preclude further development;
54	1 Oct 2021	Applicant evidence 22 - M Preece (1MB) Record: 21211014 04 Oct 2021	Paragraph 48, (PDF p. 12). The increasing sea temperatures observed in the Marlborough Sounds (0.2- 0.4°C per decade), leave very few new areas in the Marlborough Sounds available for salmon farming.
55	1 Oct 2021	Applicant evidence 22 - M Preece (1MB) Record: 21211014 04 Oct 2021	Paragraph 52, (PDF p. 13). (i) Temperature is a key factor. Admiralty Bay and west to Tasman Bay are simply too warm for salmon aquaculture on a year-round basis. The farm needs to be located in a place which is exposed to the cooler currents coming from the east coast of the South Island.
56	1 Oct 2021	Applicant evidence 22 - M Preece (1MB) Record: 21211014 04 Oct 2021	Paragraph 59, (PDF p. 16). (b) Water depth: siting the blocks of pens over areas of around 80-100m depth, minimises the refraction of waves and reduces the stresses on structures; (c) Water temperature: optimising water temperature ensures healthy salmon and good growth. The cool waters from the Southland Current contribute to the water temperatures in Cook Strait being cooler than those in the Marlborough Sounds (Appendix MAP5b);
57	1 Oct 2021	Applicant evidence 22 - M Preece (1MB) Record: 21211014 04 Oct 2021	Appendix MAP5: environmental parameters which assisted in site selection, (PDF p. 56). (b) Average sea surface temperatures for February 1993-2002.[41] 

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
58	2 Oct 2021	Applicant evidence 20 - B Munro (3.3MB) Record: 21210904 04 Oct 2021	Paragraph 4.72, p. 57. Having considered the Proposal in the context of this theme, I am of the opinion that: a. The aquaculture industry is a primary industry. I understand from the evidence of Mr Preece that salmon are sensitive to increases in temperature. A trend of increasing temperature has been recorded in New Zealand waters in recent years, including the Pelorus Sounds. The Proposal enables NZ King Salmon to adapt to the effects of climate change and, as I understand from Ms McCowan's evidence, to enable an environmental outcome that is consistent with the Company's focus on sustainability.
59	2 Oct 2021	Applicant evidence 20 - B Munro (3.3MB) Record: 21210904 04 Oct 2021	Paragraph 7.41, p. 81. Section 7(i) requires that the Council have particular regard to the effects of climate change. Mr Preece highlights that the warming coastal water temperature caused by climate change is a reason for why the Proposal is being advanced. In this regard, climate change is one of the drivers behind NZKS seeking deeper, cooler water temperatures.
60	2 Oct 2021	Applicant evidence 20 - B Munro (3.3MB) Record: 21210904 04 Oct 2021	Paragraph 7.45, p. 82. A key component of sustainable management is, in my opinion, enabling people and communities to provide for their social, economic and cultural wellbeing, and for their health and safety. There is little question in my mind, given the evidence of Mr Preece that the Proposal is, as things stand, an important response to warming water temperatures and thus is of importance to the future of salmon farming activity in New Zealand. This wider activity is also, I understand from Dr Kaye-Blake's evidence, of importance to the social and economic wellbeing of many within Marlborough. Given this, I am of the opinion that should the Proposal proceed, it is very likely to benefit many people and communities.
61	2 Oct 2021	Applicant evidence 20 - B Munro (3.3MB) Record: 21210904 04 Oct 2021	Footnote 12, (PDF pp. 164–165). [To be summarised by Knight] Once a Blue Endeavour farm block reaches near-peak biomass, two intensive field surveying trips should be undertaken, one on each of the ebb and flood tides. This would occur over approximately two six-hour periods, beginning immediately after the turn-of the tide. During each six hour period 15 m surface integrated, and Van Dorn water samples will be collected from 3 depths (surface, 15 m and 30 m) and tested for a range of nutrients (e.g. total nitrogen [TN], total phosphorus [TP], total ammoniacal nitrogen [TAN], urea, nitrate) and chlorophyll-a. In addition, CTD casts will be undertaken to measure dissolved oxygen (DO) and other water properties (e.g. chlorophyll-a and temperature) at different depths and a sample of the phytoplankton communities at the site.
62	2 Oct 2021	Applicant evidence 20 - B Munro (3.3MB) Record: 21210904 04 Oct 2021	Footnote 12, (PDF p. 165). Water samples should be collected at each site at least three times within half of a tidal cycle (i.e. spread across the six-hour period). Replicates of water samples (at least two) should be taken. Pseudo-replicates (replicates within a single sample) for assessment of variation associated with sample handling and laboratory processing should also be considered for at least one site in a survey. CTD casts for salinity, temperature, DO and turbidity at each site should also be collected.
63	2 Oct 2021	Applicant Evidence (8.2MB) Record: 21210869 04 Oct 2021	Paragraph 4.72, p. 57. (PDF p. 94). Having considered the Proposal in the context of this theme, I am of the opinion that: a. The aquaculture industry is a primary industry. I understand from the evidence of Mr Preece that salmon are sensitive to increases in temperature. A trend of increasing temperature has been recorded in New Zealand waters in recent years, including the Pelorus Sounds. The Proposal enables NZ King Salmon to adapt to the effects of climate change and, as I understand from Ms McCowan's evidence, to enable an environmental outcome that is consistent with the Company's focus on sustainability.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
64	2 Oct 2021	Applicant Evidence (8.2MB) Record: 21210869 04 Oct 2021	Paragraph 7.41, p. 81 (PDF p. 118). Section 7(i) requires that the Council have particular regard to the effects of climate change. Mr Preece highlights that the warming coastal water temperature caused by climate change is a reason for why the Proposal is being advanced. In this regard, climate change is one of the drivers behind NZKS seeking deeper, cooler water temperatures.
65	2 Oct 2021	Applicant Evidence (8.2MB) Record: 21210869 04 Oct 2021	Paragraph 7.45, (PDF p. 119. A key component of sustainable management is, in my opinion, enabling people and communities to provide for their social, economic and cultural wellbeing, and for their health and safety. There is little question in my mind, given the evidence of Mr Preece that the Proposal is, as things stand, an important response to warming water temperatures and thus is of importance to the future of salmon farming activity in New Zealand. This wider activity is also, I understand from Dr Kaye-Blake's evidence, of importance to the social and economic wellbeing of many within Marlborough. Given this, I am of the opinion that should the Proposal proceed, it is very likely to benefit many people and communities.
66	2 Oct 2021	Applicant Evidence (8.2MB) Record: 21210869 04 Oct 2021	Footnote 12, (PDF pp. 200–201). [To be summarised by Knight] Once a Blue Endeavour farm block reaches near-peak biomass, two intensive field surveying trips should be undertaken, one on each of the ebb and flood tides. This would occur over approximately two six-hour periods, beginning immediately after the turn-of the tide. During each six hour period 15 m surface integrated, and Van Dorn water samples will be collected from 3 depths (surface, 15 m and 30 m) and tested for a range of nutrients (e.g. total nitrogen [TN], total phosphorus [TP], total ammoniacal nitrogen [TAN], urea, nitrate) and chlorophyll-a. In addition, CTD casts will be undertaken to measure dissolved oxygen (DO) and other water properties (e.g. chlorophyll-a and temperature) at different depths and a sample of the phytoplankton communities at the site.
67	2 Oct 2021	Applicant Evidence (8.2MB) Record: 21210869 04 Oct 2021	Footnote 12, (PDF p. 201). Water samples should be collected at each site at least three times within half of a tidal cycle (i.e. spread across the six-hour period). Replicates of water samples (at least two) should be taken. Pseudo-replicates (replicates within a single sample) for assessment of variation associated with sample handling and laboratory processing should also be considered for at least one site in a survey. CTD casts for salinity, temperature, DO and turbidity at each site should also be collected.
68	1 Oct 2021	Applicant evidence 17 - P Taylor (1.7MB) Record: 21210384 01 Oct 2021	Paragraph 17, p. 3. The Cawthron water column (Report 3313) and water column modelling (Report 3479) reports produced for this application are relevant to the pelagic habitat. They provide what is described as mainly uniform information on temperature, salinity, and turbidity at the BE site, which reflects the results of the 1980 study.
69	1 Oct 2021	Applicant evidence 17 - P Taylor (1.7MB) Record: 21210384 01 Oct 2021	Endnote 7, p. 6. Information was available on bathymetric features, circulation, water column dynamics and links with El Niño, which provided insight into nutrient transport, temperature and light regimes, and potential levels of productivity within an extended area outside Pelorus Sound see WFR §2.1.1 and §2.1.2.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
70	1 Oct 2021	Applicant evidence 17 - P Taylor (1.7MB) Record: 21210384 01 Oct 2021	Paragraph 31, p. 7, 8–9. The following are key features of the pelagic habitat within the study area: (c) Results showed that waters out to almost 25 km (the area around the BE site) were tidally mixed with no strong temperature or salinity stratification either vertically or horizontally ... (h) The initial water column report also provides information on temperature, salinity, and turbidity at the BE site which were shown to be mostly uniform with depth and having nutrient levels referred to as "unremarkable and within the range of concentrations measured at an existing farm in Port Gore". The diatoms taken in water samples indicated "a moderately-nutrient enriched and well-mixed water column". Such uniformity in environmental variables, particularly temperature, reflects the early study.
71	1 Oct 2021	Applicant evidence 17 - P Taylor (1.7MB) Record: 21210384 01 Oct 2021	Appendix B: A Brief General Description of the Pelagic Habitat, p. 49. The principal abiotic characteristics of a pelagic habitat include its physical characteristics such as temperature, light and turbidity, pressure (which is directly related to depth), current speeds, turbulence, and sound, and its water chemistry such as salinity, pH, dissolved oxygen concentration, and nutrient concentrations. The variables salinity and temperature define the density of a water body and its potential for stratification and stability (i.e., its resistance to vertical mixing) (Cloern 1991a, from Gibbs 1993). These features can strongly affect planktonic processes within the water body.
72	30 Sep 2021	Applicant evidence 18 - T Dempster (533KB) Record: 21210333 01 Oct 2021	Paragraph 28, (PDF p. 8). Farmers will develop and adapt specific protocols to minimise waste feed at their site through time based on experience and monitoring. This includes trigger points for reducing or stopping feeding based on environmental conditions, such as strong current periods where feed may be rapidly washed sideways in the pen and away from feeding fish and known upper temperature and lower dissolved oxygen thresholds that lead to lower appetite levels.
73	30 Sep 2021	Applicant evidence 18 - T Dempster (533KB) Record: 21210333 01 Oct 2021	Paragraph 30, (PDF pp. 8–9). In appetite-based feeding control, fish are fed specific levels of feed as a percentage of their body weight per day, based on tables that predict appetite with inputs on fish size, within-pen biomass, and environmental variables such as temperature and dissolved oxygen levels.
74	30 Sep 2021	Applicant evidence 18 - T Dempster (533KB) Record: 21210333 01 Oct 2021	Paragraph 46, (PDF p. 13). The specific study design would need to be tailored to the site, budget, and local expertise, but in general terms, and to address the two key factors identified above, the monitoring protocol should involve the following: (a) Several sampling periods spread over a full year and/or production cycle to capture seasonal and production cycle effects. Peak feeding should be expected across the summer months when water temperatures are warmest. This period should be adequately sampled as this is when greatest waste feed should occur;
75	30 Sep 2021	Applicant evidence 16 - M Smeaton (2.9MB) Record: 21210332 01 Oct 2021	Paragraph 89, (PDF p. 45). The fact that Atlantic salmon have a lower FCR does not mean that King salmon will create more faeces from a given amount of feed. It means that King salmon are less efficient at turning feed into biomass. FCR also considers the energy expenditure of the fish and is affected by other factors such as oxygen stress, temperature fluctuations, fish health, and fish size (Petrell et al. 2000).

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
76	30 Sep 2021	Applicant evidence 14 - N Keeley (12.7MB) Record: 21210329 01 Oct 2021	Footnote 3, p. 1, (PDF p. 92). Peak biomass refers primarily to single year class farming where finfish biomass peaks toward the end of the grow-out phase, and therefore on a 12-18 month cycle, depending on size at stocking, and whether any fallowing is required subsequent to cycle. If the farm is stocked under a multi-year-class arrangement, then peak biomass may not be so apparent, in which case it may occur annually and potentially in sync with regional scale sampling (targeting a summer period when water temperatures and metabolic activity are maximised).
77	30 Sep 2021	Applicant evidence 14 - N Keeley (12.7MB) Record: 21210329 01 Oct 2021	Chapter 4.1, p. 16, (PDF p. 107). Consequently, the initial sampling of these biogenic habitats should occur annually in and be standardised to the summer season when weather conditions are most likely to be conducive to sampling. This will also reduce the impact of seasonality on the baseline data. As described in section 3.2 and following best practice this will be in summer during periods of maximal enrichment (deposition) and effects area likely to be the strongest during warmer temperatures.
78	30 Sep 2021	Applicant evidence 14 - N Keeley (12.7MB) Record: 21210329 01 Oct 2021	Chapter 5.3, p. 23, (PDF p. 114). The interval between monitoring surveys needs to be large enough to allow for time for change to manifest, but small enough that effects are detected before they potentially become severe or irreversible. Baseline monitoring surveys should be carried out in summer when algae growth is most prolific, seawater temperatures are at a maximum, and monitoring is most feasible.
79	30 Sep 2021	Applicant evidence 14 - N Keeley (12.7MB) Record: 21210329 01 Oct 2021	Ageing based on growth rings, p. 1, (PDF p. 148). The shells of many bivalve molluscs are characterised by growth marks on the surface or in the microstructure of the shell, usually with wide bands of active shell deposition alternating with narrower bands of little or no growth (Silina 2012). These alternating growth phases usually reflect changes in environmental conditions, particularly temperature, salinity, or food supply.
80	30 Sep 2021	Applicant evidence 14 - N Keeley (12.7MB) Record: 21210329 01 Oct 2021	Preliminary ageing of the Waitata specimens, p. 3, (PDF p. 150). In contrast to the indication from the Waitemata Harbour surveys, Hopkins' (2002) data from Doubtful Sound suggest that the Waitata individuals are around one year old (Table 1). This difference is unlikely to relate to differences in water temperature between Waitemata Harbour and Doubtful Sound because faster growth would be expected at higher temperatures. The spring-autumn range recorded at 14 m depth in Doubtful Sound was 13.4–16.1 °C (Hopkins 2002). Average sea-surface temperatures around Auckland range from 13.8 °C in August and September to 22.8 °C in February.
81	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 61, (PDF p. 25). (b) Dissolved oxygen estimates consider maximum summer temperatures of 18°C, i.e. the highest oxygen-use period of the year, with an assumption of large king salmon swimming speeds of 36.5 cm/s.
82	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 80, (PDF p. 37). Nevertheless, such effects may be significant to the cultured fish, or drifting marine biota in combination with other stressors (low dissolved oxygen or high temperatures) within/beside the net pens.
83	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 81, (PDF p. 38). McManaway Rocks is the closest ecologically significant site. It is likely that Blue Endeavour will reduce DO by a small amount and may slightly increase concentrations of nitrogenous compounds (e.g. nitrate and ammonium). Combined with a shifting baseline of warmer temperatures, the potential for synergistic (i.e. additive) effects from many small changes are possible … McManaway Rocks is also included as a water column monitoring site, consequently a record of temperature, DO, TN, ammonium and chlorophyll-a will be recorded monthly at the site.

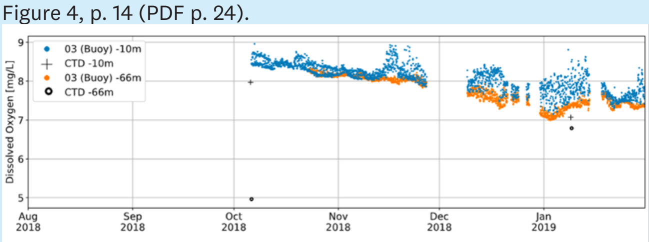
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
84	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 96, (PDF p. 46). In the case of finfish farming where high densities of cultured fish can occur at times (e.g. up to 25kg/m^3 near to harvest), fish respiration can reduce DO concentrations below background levels (see for example Hartstein et al 202166). The degree of respiration by the cultured fish can be calculated as a function of the fish size, temperature and activity (i.e. swimming speed)(Stewart & Ibarra 1991).
85	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 109, (PDF pp. 52–53). Nevertheless, the combination of high concentrations of ammonium, lowered DO and high temperatures could create synergistic stresses on the cultured Salmon. The report of Dr Ben Diggles notes that stress on cultured fish can affect their health and this could result in a greater potential for disease and mortality. Specifically, his report noted that: "In the case of salmonids, this means maintaining dissolved oxygen levels above 6 mg/L (preferably above 6.5 mg/L), reducing temperature and salinity fluctuations and avoiding temperature extremes (>16°C) and exposure to sediment and pollutants (Ellard 2015)."
86	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 110, (PDF p. 53). However, given that such modelling estimates contain some uncertainty, monitoring of the key water column properties of temperature and dissolved oxygen, along with the density and health of the cultured fish (e.g. disease and mortality records) are still recommended to ensure that potential stressors can be managed, should any issues be detected.
87	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Paragraph 119, (PDF pp. 55–56). I note that the operative Marlborough Sounds Resource Management Plan and the proposed Marlborough Environment Plan (MEP) both provide a limited suite of water quality standards for coastal waters designed to ensure suitability for shellfish gathering (SG class). These standards relate to: (a) Temperature, which must not be changed by more than 3 degrees C.
88	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 2, p. 5, (PDF p. 84). The model transports water and other constituents (e.g. salt, temperature, turbulence) through the use of triangular volumes (connected 3-D polyhedrons). SCHISM has been used extensively within the scientific community, where it forms the backbone of operational systems used to nowcast and forecast estuarine water levels, storm surges, velocities, water temperature and salinity.
89	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 2.1.1, p. 5–6, (PDF pp. 84–85). This function provides thinner and less variable surface layer. 50 vertical layers are used in the present configuration, with vertical stretching factors of 6 for the surface (θ_s) and 2 for the bottom (θ_b). Atmospheric forcing was provided by the Climate Forecast System Reanalysis (CFSR) which is provided by National Center for Atmospheric Research (NCAR). This includes the variables 10 m winds, air temperature, relative humidity, precipitation rate, downward short and long wave radiation and sea level pressure.
90	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Glossary, (PDF p. 110). Conductivity-temperature-depth (CTD) instrument – a profiling instrument that can be lowered from a boat to measure salinity (through conductivity), temperature and depth (through a pressure sensor). Other sensors are often attached to measure other properties, such as turbidity, chlorophyll-a, light and dissolved oxygen.

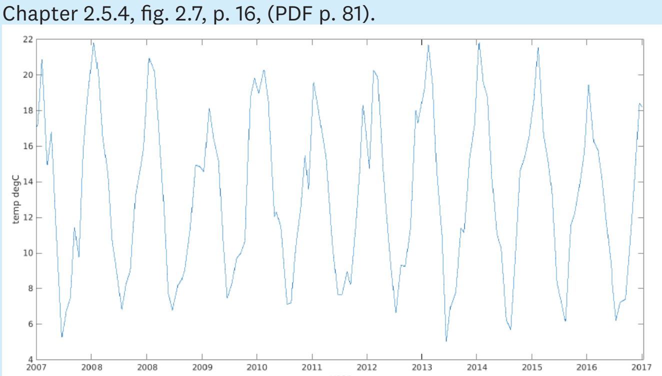
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
91	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 4.1, p. 8–9 (PDF pp. 119–120). Prior to commencing operations at the site, baseline data for at least a year will be collected near the centre of the site. Baseline monitoring will cover the following: ... • profiling data including salinity, temperature and dissolved oxygen (DO). Some of these measurements (e.g. DO, chlorophyll-a, salinity and temperature) will be able to be taken throughout the water column using a conductivity-temperature-depth (CTD) profiling instrument.
92	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 4.2.1, p. 12 (PDF p. 123). Year-round monthly monitoring of dissolved oxygen (DO) for the entire water column will be undertaken downstream at 250m from the end of each block of pens and at the site boundary with a conductivity-temperature-depth (CTD) instrument. Salinity, temperature, and turbidity will also be collected.
93	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 4.2.2, p. 13 (PDF p. 124). Replicates of water samples (at least two) will be taken. Pseudo-replicates (replicates within a single sample) for assessment of variation associated with sample handling and laboratory processing should also be considered for at least one site in a survey. CTD casts for salinity, temperature, DO and turbidity at each site will also be collected.
94	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 4.2.2, p. 13 (PDF p. 124). Conductivity-temperature-depth (CTD) instrument casts for salinity, temperature, DO and turbidity at each monitoring station (including the net pen sites) will also be collected for the entire water column.
95	30 Sep 2021	Applicant evidence 10 - B Knight (8.2MB) Record: 21210328 01 Oct 2021	Chapter 4.2.3, p. 13 (PDF p. 124). In addition, CTD casts will be undertaken to measure dissolved oxygen (DO) and other water properties (e.g. chlorophyll-a and temperature) at different depths.
96	30 Sep 2021	Applicant evidence 9 - D Clement (2.3MB) Record: 21210327 01 Oct 2021	Paragraph 67, (PDF p. 14). In terms of humpback whales, their migratory routes are assumed to be socially and culturally driven (e.g. calves learn migratory paths from their mothers) rather than environmentally driven (e.g. water temperatures). While whales can be naturally curious and inquisitive, particular age classes (i.e. Mothers with Calves) can be sensitive to disturbance and additional noise.
97	30 Sep 2021	Applicant evidence 1 - B K Diggles (503.8KB) Record: 21210315 01 Oct 2021	Paragraph 64, (PDF p. 19). In each case, the NZ-RLOs and T. maritimum were also detected in apparently healthy fish. The fact that the RLOs were only associated with disease and skin ulcers at the two farming sites with highest water temperatures, suggests that the disease process was probably multifactorial and related to suboptimal environmental conditions (i.e. water temperatures > 16°C) and other husbandry related factors such as waterborne dispersal of stinging nematocysts from marine pests during net cleaning activities at the low flow sites.
98	30 Sep 2021	Applicant evidence 1 - B K Diggles (503.8KB) Record: 21210315 01 Oct 2021	Paragraph 66, (PDF p. 19). Based on the information described in paragraphs 63-65 above, I considered that the likelihood of the disease agent being released from the wild into seapens in the Cook Strait north of the Marlborough Sounds was High. This was due to the fact that wild marine fishes in the Marlborough Sounds are likely to be the main reservoir hosts for these bacteria, and they transmit the disease to cultured salmon under certain environmental conditions (high water temperatures) that permit establishment of infection.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
99	30 Sep 2021	Applicant evidence 1 - B K Diggles (503.8KB) Record: 21210315 01 Oct 2021	Paragraph 68, (PDF p. 20). In the Disease Risk Assessment Report I chose a worst case scenario where I assumed New Zealand strains of Piscirickettsia-like bacteria are highly virulent (until proven otherwise) and require a relatively low infectious dose to infect susceptible fish. Even so, considering the proposed offshore location of the salmon farming site if seapens are located in the Cook Strait north of the Marlborough Sounds in water depths of 70 to 110 meters, the risk of backspill infection occurring would be greatly reduced due to the increased dilution factors from the increased water currents and depths, together with the reduced chances of disease outbreaks occurring in the first place due to better water quality and lower average water temperatures in Cook Strait.
100	30 Sep 2021	Applicant evidence 1 - B K Diggles (503.8KB) Record: 21210315 01 Oct 2021	Paragraph 77, (PDF p. 22). In the case of salmonids, this means maintaining dissolved oxygen levels above 6 mg/L (preferably above 6.5 mg/L), reducing temperature and salinity fluctuations and avoiding temperature extremes (>16°C) and exposure to waterborne irritants, sediment and pollutants.
101	30 Sep 2021	Applicant evidence 1 - B K Diggles (503.8KB) Record: 21210315 01 Oct 2021	Paragraph 87, (PDF p. 26). All evidence suggests this opportunistic disease agent is endemic in New Zealand wild fishes (though the identity of the reservoir species is unknown at this time), and it has emerged to become problematic only in salmon farmed at suboptimal locations where water temperatures exceed 16°C for extended periods during summer, with resultant drops in oxygen availability that stress fish and thus expose them to increased risk of disease.
102	30 Sep 2021	Applicant evidence 1 - B K Diggles (503.8KB) Record: 21210315 01 Oct 2021	Paragraph 89, (PDF pp. 27–28). Some of the submissions, such as the one from the New Zealand Sport Fishing Council (NZSFC), referred to disease outbreaks and concern for the welfare of farmed fish. For example, the NZSFC stated that NZ King Salmon "have a history of mass deaths in their current farms. With rising water temperatures the risk of disease is increased. King Salmon Co. have historically been reluctant, along with MPI, to release to the public any details about the causes of the mass deaths. This withholding of information is a concern."
103	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Paragraph 43, p. 11. • The application is safe-guarding against seasonal temperature changes, utilising the benefits of the open ocean's optimum conditions for improved animal welfare, and environmental and social impacts.
104	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Appendix 6: U190438 – Summary of Submissions, row 11, p. 43. Safe guarding against seasonal temperature changes, utilising the benefits of the open ocean's optimum conditions for improved animal welfare, and environmental and social impacts.
105	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Appendix 6: U190438 – Summary of Submissions, row 15, p. 43. The proposal will improve biosecurity. Safe guarding against seasonal temperature changes, utilising the benefits of the open ocean's optimum conditions for improved animal welfare.
106	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Appendix 6: U190438 – Summary of Submissions, row 22, p. 45. The proposal is not situated in an area close to land, ensuring no landscape issues and the open ocean's water flow and temperature ensure a large amount of salmon to be reared with minimal benthic impact.
107	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Appendix 6: U190438 – Summary of Submissions, row 36, p. 48. The application has a range of benefits over the current inshore method, including improved biosecurity, reduction of seasonal temperature changes, improved animal welfare and reduction of environmental and community impacts.
108	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Appendix 6: U190438 – Summary of Submissions, row 41, p. 49. The application's monitoring of the sea temperature data is incomplete which provides uncertainty.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
109	24 Sep 2021	Council's evidence - P Johnson - Planning (3.7MB) Record: 21205549 24 Sep 2021	Appendix 6: U190438 – Summary of Submissions, row 54, p. 53. The inevitable impacts of climate change will increase sea temperatures resulting in increased disease and fish mortality.
110	24 Sep 2021	Council's evidence - P Wilson - water quality (361.5KB) Record: 21205520 24 Sep 2021	Chapter 9, p. 18–19. Routine monitoring that may include monthly sampling and high – frequency sensors, including, but not limited to, the following water quality parameters. (i) Total nitrogen; (ii) Nitrate-nitrite nitrogen; (iii) Total ammoniacal nitrogen; (iv) Chlorophyll-a; (v) Phytoplankton species and abundance; and (vi) **Temperature**, salinity, and pH as supporting variables.
111	12 Dec 2019	Council's evidence - M Morrison - demersal fish and biogenic habitats (648.3KB) Record: 21205389 24 Sep 2021	Chapter 3.3, p. 15. Assessing the international literature, Taylor & Dempster (2019) commented that fish families of fisheries value that aggregate around farms include carangids (trevally's), mugilids (mullets) and sparid's (page 26), and that these families are also present around current Marlborough Sounds farms. The snapper (Chrysophrys auratus, sparid) fisheries stock that encompasses the Marlborough Sounds (SNA7) has increased considerably in biomass since the late 2000s, following several strong recruitment year classes (Langley 2018). Warming sea temperatures are also thought to be favouring snapper and other temperate species such as kingfish (Seriola lalandii), both of which are being seen in higher abundance further south in New Zealand than in the past. Kingfish are attracted to structure, with recreational anglers often fishing close to navigation buoys and the crests of submerged rocky reefs to target them. Trevally (Pseudocaranx dentex) are also likely to benefit from warming sea temperatures, and often associate with structures. The kahawai (Arripis trutta) from the family Arripididae also a species that may congregate around offshore fish farms. In terms of the Mugilids (mullets), two species occur in New Zealand. The yellow-eyed mullet (Aldrichetta forsteri) is ubiquitous around the New Zealand coast, especially in estuaries, though there is a decline in abundance and occurrence with increasing latitude (Francis et al. 2011). It has a coastal neustonic larval phase (occurs on the surface waters of the ocean), before moving inshore to recruit into sheltered shallower water systems, especially estuaries. Adults occur in coastal waters, although their offshore and depth distribution limits are poorly known. The second mullet species in New Zealand, the grey mullet (Mugil cephalus) also has an initial offshore larval phase (which is largely unknown), before recruiting into estuaries which are thought to be obligate (required) in its life history. Adults range widely in their distribution, including through low slope gradient freshwater systems, estuaries, and off surf beaches. Grey mullet reach their southern limit at the top of the South Island, and while small population pockets occur, including in the Sounds, they are not common in this region. However, this is likely to change with warming sea temperatures. Collectively, snapper, trevally, kingfish, and kahawai are all species that may come to associate with the proposed fish farm at some level, and whose abundances in the wider ecosystem are/may also be increasing with warmer water temperatures.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
112	12 Dec 2019	Council's evidence - M Morrison - demersal fish and biogenic habitats (648.3KB) Record: 21205389 24 Sep 2021	Chapter 3.3, p. 15. Warming sea temperatures are also thought to be favouring snapper and other temperate species such as kingfish (Seriola lalandii), both of which are being seen in higher abundance further south in New Zealand than in the past. Kingfish are attracted to structure, with recreational anglers often fishing close to navigation buoys and the crests of submerged rocky reefs to target them. Trevally (Pseudocaranx dentex) are also likely to benefit from warming sea temperatures, and often associate with structures. ... Grey mullet reach their southern limit at the top of the South Island, and while small population pockets occur, including in the Sounds, they are not common in this region. However, this is likely to change with warming sea temperatures. Collectively, snapper, trevally, kingfish, and kahawai are all species that may come to associate with the proposed fish farm at some level, and whose abundances in the wider ecosystem are/may also be increasing with warmer water temperatures.
113	24 Sep 2021	Council's evidence - J Oldman - benthic and water quality modelling (437.6KB) Record: 21205346 24 Sep 2021	Paragraph 46, (PDF pp. 8–9). The application assumes that the relationship developed by Smith (2006) between nitrogen and phytoplankton can be used to predict what happens "on average" to phytoplankton based on what happens "on average" to nitrogen. The relationship between water column nitrogen and phytoplankton is highly variable (e.g., Cloern, 2001, Kelly, 2008, Redalje, 2010). Even simplified multiple-regression models (that take into variations in nutrient load, current speed, water temperature, day-length and solar radiation to predict water column effects) can be used with some success to predict water column effects of marine farms (Møhlenberg et al., 2018) but generally only within the first few hundred of metres of a farm and the "skill" of such models is relatively low.
114	9 Sep 2021	Additional information on depositional modelling - Dr Smeaton (9 September 2021) (873.1KB) Record: 21194063 13 Sep 2021	Chapter 6, (PDF p. 13). The fact that Atlantic salmon have a lower FCR does not mean that King salmon will create more faeces from a given amount of feed. It means that King salmon are less efficient at turning feed into biomass. FCR also considers the energy expenditure of the fish and is affected by other factors such as oxygen stress, temperature fluctuations, fish health, and fish size (Petrell et al. 2000).
115	27 Aug 2021	Cawthron - Recommendations for a Seabed Management Plan for 'Blue Endeavour' salmon farming area report No. 3490-Amended (3.2MB) Record: 21183217 30 Aug 2021	Footnote 17, p. 28, (PDF p. 40). Peak biomass refers primarily to single year class farming where biomass peaks toward the end of the grow-out phase, and therefore on a 12-18 month cycle, depending on size at stocking, and whether any fallowing is required subsequent to cycle. If the farm is stocked under a multi-year-class arrangement, then peak biomass may not be so apparent, in which case it may occur annually and potentially in synch with regional scale sampling (targeting a summer period when water temperatures and metabolic activity are maximised.
116	27 Aug 2021	Cawthron - Recommendations for a Seabed Management Plan for 'Blue Endeavour' salmon farming area report No. 3490-Amended (3.2MB) Record: 21183217 30 Aug 2021	Appendix 2, pp. 51–52, (PDF pp. 63–64). Monitoring and management: The Modelling–Ongrowing fish farms–Monitoring (MOM) method: ... The model incorporates environmental information (e.g. depth, current, concentrations of oxygen and ammonium, and annual temperature cycles), and production information (e.g. net pen size and orientation, maximum fish density per unit area, feed composition, feeding rate; Stigenbrant et al. 2004).
117	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.5, p. 9, (PDF p. 19). In the case of finfish farming where high densities of cultured fish can occur at times (e.g. near to harvest), fish respiration can reduce DO concentrations below background levels. The degree of respiration by the cultured fish is a function of the fish size, temperature and activity (i.e. swimming speed). Increases in temperature and activity are associated with higher oxygen use. On the contrary, larger fish use less oxygen per unit mass (i.e. they are more efficient). In an open pen system, the use of oxygen is balanced by a replenishment of oxygen from outside of the pens.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
118	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 3.3, p. 13, (PDF p. 23). Dissolved oxygen (DO) was measured using optical sensors mounted to a conductivity-temperature-depth (CTD) instrument and to a buoy at depths of 10 and 66 m.
119	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Figure 4, p. 14 (PDF p. 24).  Figure 4. Time series of dissolved oxygen at the proposed site expressed as absolute concentration for dates with supporting temperature and salinity data available from October 2018 to January 2019. Black crosses and circles indicate dissolved oxygen concentrations from CTD casts for comparison with the buoy instruments. Sourced from Newcombe et al. (2020).
120	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 4.3, p. 24, (PDF p. 34). In general, king salmon take in less oxygen per gram of body weight as they get larger, although at any age they tend to use more oxygen under increasing temperature and activity.
121	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 4.3, pp. 24–25 (PDF pp. 34–35). Based on the model of Stewart and Ibarra (1991), I calculated oxygen consumption rates for large fish as was calculated in Newcombe et al. (2020). For the large fish, an average fish size of 3.5 kg (i.e. harvest-sized fish), a temperature of 18 °C and a swimming velocity of 36.5 cm/s was assumed.
122	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Footnote 24, p. 25 (PDF p. 35). The respiration rate per kg of fish increases as the temperature increases and the fish size decreases. 18 °C is used as a worst-case summertime temperature, with observed temperatures typically 17 °C or less.
123	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 5.2.2, p. 40, (PDF p. 50). The largest (44%) peak case change could result in a reduction to below 60% DO saturation, which may be stressful for any animals interacting with the pen environment of the farmed salmon (e.g. zooplankton or larval fish). However, such a change would likely only occur for a short period of time (e.g. < 1 hour) around the change of the tide. In addition, as these calculations assume a near maximum density of fish (22 kg/m^3) and warm summer water temperatures (18 °C).
124	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 5.2.2, p. 40, (PDF p. 50). These estimates may be overestimations for most of a year and in reality I think the 44% reduction would be unlikely to be observed beside the net pen due to the replenishment processes that are not modelled and the difficulty of all of those factors aligning (e.g. temperature, density and tidal state).
125	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.1, p. 7, (PDF p. 72). The model transports water and other constituents (e.g. salt, temperature, turbulence) through the use of quadrilateral and triangular volumes (connected 3-D polyhedrons).
126	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.1, p. 7, (PDF p. 72). SCHISM has been used extensively within the scientific community where it forms the backbone of operational systems used to nowcast and forecast estuarine water levels, storm surges, velocities, water temperature and salinity.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
127	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.5.1, p. 14, (PDF p. 79). The open-boundary residual velocities, water elevations, salinity and temperature were prescribed from a 3D ROMS model domain of central New Zealand at 3-hour interval.
128	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.5.2, p. 14, (PDF p. 79). Within SCHISM temperature nudging is available by means of analysis nudging (Newtonian relaxation). The nudging allows the model state to be reconciled with observations in four dimensions. For this project, **sea surface temperatures** within the SCHISM model domain was nudged using available satellite data from the 1-km resolution MODIS dataset and the 0.05-deg resolution Operational **Sea Surface Temperature** and Sea Ice Analysis (OSTIA) with the nudging weighted to the order of 1-day.
129	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.5.3, p. 14, (PDF p. 79). WRF reanalysis prognostic variables such as wind velocity, atmospheric pressure, relative humidity, surface temperature, long and short wave radiation and precipitation rate were used at hourly intervals to provide air-sea fluxes to force SCHISM domain.
130	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.5.4, p. 15, (PDF p. 80). Temperature of the Pelorus river was derived by averaging the water temperature from the Wairau river and Motueka river.
131	27 Aug 2021	Cawthron - Updated water quality modelling report No. 3479 (7.6MB) Record: 21182887 29 Aug 2021	Chapter 2.5.4, fig. 2.7, p. 16, (PDF p. 81).  Figure 2.7. Time series of the river temperature used for the Pelorus river from 2007 to 2017. This time series was obtained by averaging the temperature from the Wairau and Motueka river flows.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
132	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Chapter 3.3, pp. 16–18. Near bottom water temperature was measured by Cawthron between 2003 and 2011 using the temperature sensor from the RDI and SonTek ADCP with a sampling period of 30 min. **Near bottom (5 m above sea bed) and near surface (10 m below sea surface) temperature** and salinity were measured by NIWA between 2012 and 2013 in the Queen Charlotte Sounds (QCS) and the Tory Channel. These water properties were measured using the ADCP temperature and salinity sensor, a Hobo temperature logger and the Microcat logger. A map and a summary of the ADCP configuration for the Cawthron and the NIWA campaign are presented in Figure 3.3 and Table 3.4, respectively.

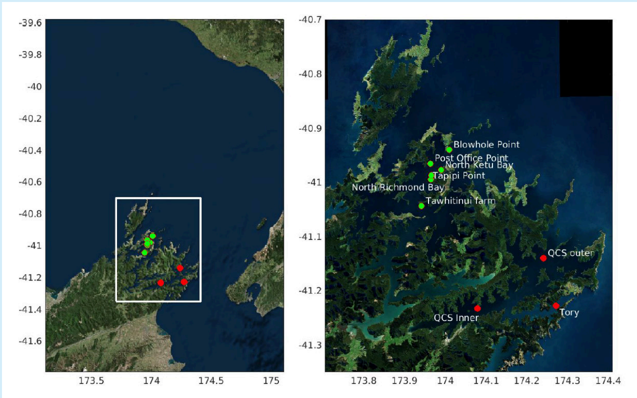
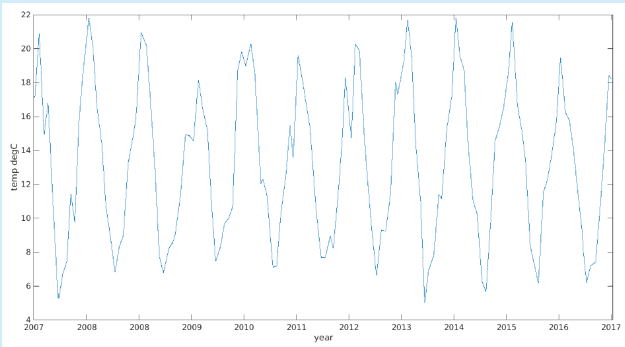
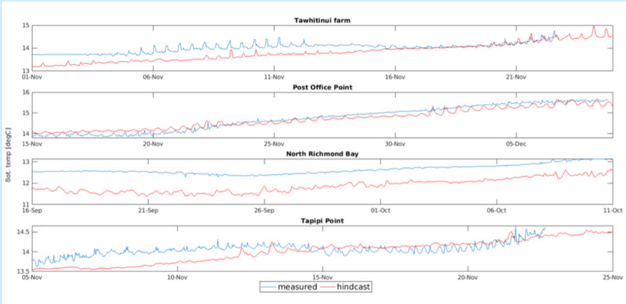
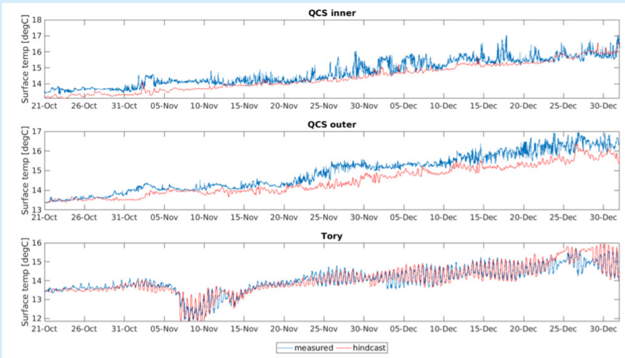
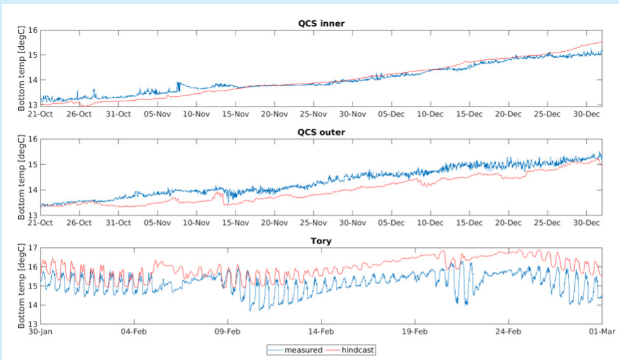


Figure 3.3 Aerial photo of the Cook Strait (left) and the Marlborough Sounds (right) showing the sites were temperature/salinity were measured by Cawthron (green dots) and NIWA (red dots).

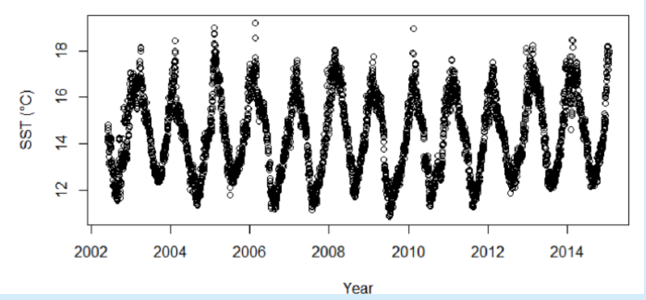
Table 3.4 Durations, location coordinates and approximate water depths of instruments use in the water property measurements.

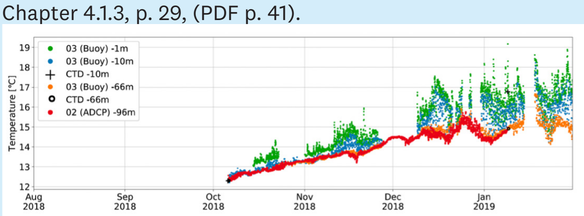
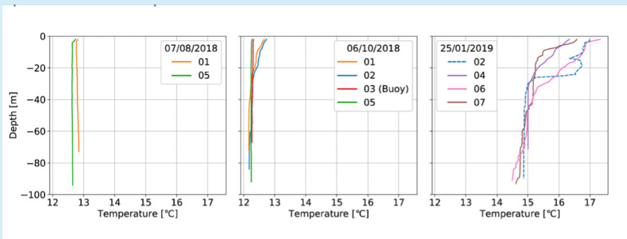
Site	Owner	Instrument	Latitude (WGS84)	Longitude (WGS84)	Depth (m)	Start	End	Measurement		Level	
								Temp	Salinity	Bottom	Surface
Blowhole Point	Cawthron	RDI	-40.9397	174.0096	50.2	23/11/2010	22/12/2010	✓		✓	
Post Office Point	Cawthron	Sontek	-40.9650	173.9636	50.2	26/01/2010	26/02/2010	✓		✓	
North Ketu Point	Cawthron	RDI	-40.9773	173.9895	33.2	20/10/2010	13/11/2010	✓		✓	
Tapipi Point	Cawthron	Sontek	-40.9872	173.9658	38.6	20/10/2010	24/11/2010	✓		✓	
North Richmond Bay	Cawthron	Sontek	-40.9946	173.9641	35.4	20/10/2010	13/10/2010	✓		✓	
Tawhitinui	Cawthron	RDI	-41.0435	173.9415	50.2	20/10/2010	22/11/2010	✓		✓	
QCS Inner	NIWA	Sontek	-41.2324	174.0786	46.4	28/06/2012	22/01/2013	✓	✓	✓	✓
QCS Outer	NIWA	RDI	-41.1397	174.2406	47.8	28/06/2012	22/01/2013	✓	✓	✓	✓
Tory Channel	NIWA	RDI	-41.2277	174.2716	47.9	28/06/2012	17/05/2013	✓	✓	✓	✓

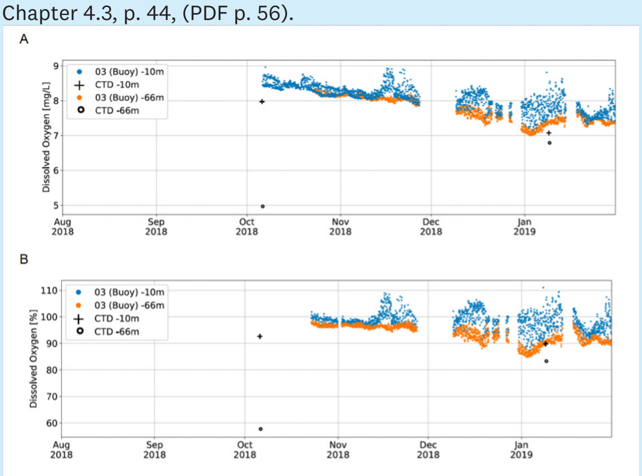
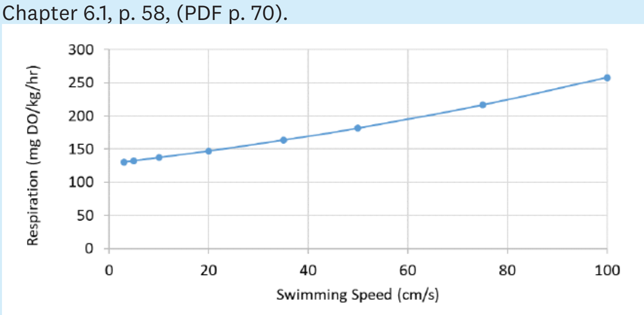
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
133	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Chapter 4.5, p. 25. 4.5.1 Hydrodynamic forcing Tidal boundary conditions for the SCHISM model were derived from constituents defined from a 1- year Regional Ocean Modelling System (ROMS Haidvogel et al. 2008) model domain of central New Zealand with approximately 3.5-km horizontal resolution. The tidal velocities were interpolated in 3D assuming a logarithmic profile. The open-boundary residual velocities, water elevations, salinity and temperature were prescribed from a 3D ROMS model domain of central New Zealand at 3-hour interval. 4.5.2 Temperature forcing Within SCHISM temperature nudging is available by means of analysis nudging (Newtonian relaxation). The nudging allows the model state to be reconciled with observations in four dimensions. For this project, **sea surface temperatures** within the SCHISM model domain was nudged using available satellite data from the 1-km resolution MODIS dataset and the 0.05-deg resolution Operational **Sea Surface Temperature** and Sea Ice Analysis (OSTIA) with the nudging weighted to the order of 1-day.
134	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Chapter 4.5.4, p. 27. Only the Pelorus River was included in the study. Even though smaller rivers exist in the sounds, they only have minimal impact on the Sounds hydrodynamics. The final flow from the Pelorus river was obtained by adding the measured flow from Bryants station (downloaded from NIWA's hydro Web Portal6) and the flow from the Rai river (courtesy of Marlborough district council) (See Figure 4.7). To include other rivers inputs (i.e flow from Kaituna river) the final flow were scaled up by 16 % (Knight 2012). Temperature of the Pelorus river was derived by averaging the water temperature from the Wairau river and Motueka river.
135	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Figure 4.8, p. 28. Time series of the river temperature used for the Pelorus river from 2007 to 2017. This time series was obtained by averaging the temperature from the Wairau and Motueka river flows. 

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
136	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Figure 5.20, p. 54. Comparison of bottom temperature measured (blue) and modelled (red) in PS at four sites by the ADCP sensors during November 2010 to December 2010. 
137	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Figure 5.21, p. 55. Comparison of surface temperature measured (blue) and modelled (red) in QCS at three sites during October 2012 to December 2012. 
138	Mar 2019	Hindcast hydrodynamic modelling report - March 2019 (7.6MB) Record: 21182885 29 Aug 2021	Figure 5.22, p. 56. Comparison of bottom temperature measured (blue) and modelled (red) in QCS at three during November 2012 to March 2013. 
139	9 Aug 2021	Application (Amended) - 12 - Draft Evidence Dr B Diggles, DigsFish Services - Biosecurity (Fish Disease) (582.5KB) Record: 21172835 11 Aug 2021	Paragraph 64, (PDF p. 19). In each case, the NZRLOs and T. maritimum were also detected in apparently healthy fish. The fact that the RLOs were only associated with disease and skin ulcers at the two farming sites with highest water temperatures, suggests that the disease process was probably multifactorial and related to suboptimal environmental conditions (ie. water temperatures > 16°C) and other husbandry related factors such as waterborne dispersal of stinging nematocysts from marine pests during net cleaning activities at the low flow sites.

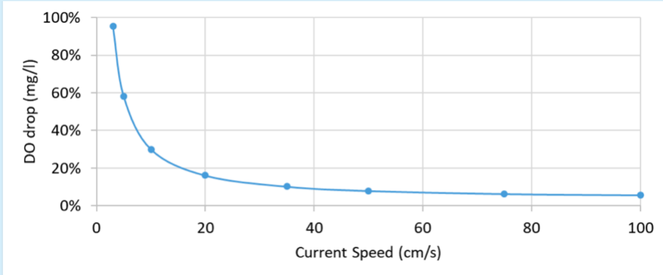
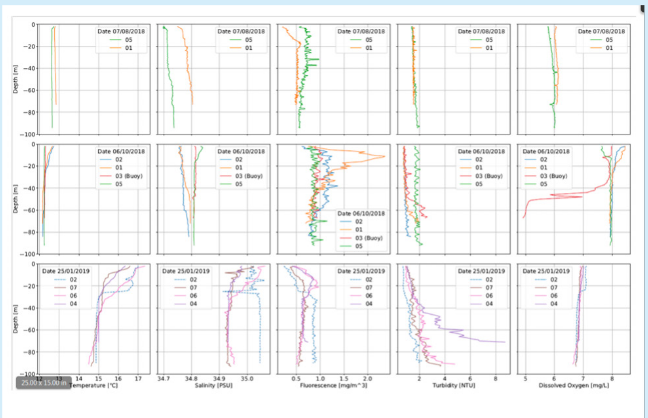
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
140	9 Aug 2021	Application (Amended) - 12 - Draft Evidence Dr B Diggles, DigsFish Services - Biosecurity (Fish Disease) (582.5KB) Record: 21172835 11 Aug 2021	Paragraph 66, (PDF pp. 19–20). This was due to the fact that wild marine fishes in the Marlborough Sounds are likely to be the main reservoir hosts for these bacteria, and they transmit the disease to cultured salmon under certain environmental conditions (high water temperatures) that permit establishment of infection.
141	9 Aug 2021	Application (Amended) - 12 - Draft Evidence Dr B Diggles, DigsFish Services - Biosecurity (Fish Disease) (582.5KB) Record: 21172835 11 Aug 2021	Paragraph 68, (PDF p. 20). In the Disease Risk Assessment Report I chose a worst case scenario where I assumed New Zealand strains of Piscirickettsia-like bacteria are highly virulent (until proven otherwise) and require a relatively low infectious dose to infect susceptible fish. Even so, considering the proposed offshore location of the salmon farming site if seapens are located in the Cook Strait north of the Marlborough Sounds in water depths of 70 to 110 meters, the risk of backspill infection occurring would be greatly reduced due to the increased dilution factors from the increased water currents and depths, together with the reduced chances of disease outbreaks occurring in the first place due to better water quality and lower average water temperatures in Cook Strait.
142	9 Aug 2021	Application (Amended) - 12 - Draft Evidence Dr B Diggles, DigsFish Services - Biosecurity (Fish Disease) (582.5KB) Record: 21172835 11 Aug 2021	Paragraph 77, (PDF pp. 22–23). In the case of salmonids, this means maintaining dissolved oxygen levels above 6 mg/L (preferably above 6.5 mg/L), reducing temperature and salinity fluctuations and avoiding temperature extremes (>16°C) and exposure to waterborne irritants, sediment and pollutants. It would be reasonably expected that all these water quality objectives would more likely be achievable at offshore farm sites in the Cook Strait north of the Marlborough Sounds in water depths of 70 to 110 meters, than inside the Marlborough Sounds.
143	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Executive Summary, p. i, (PDF p. 5). Our assessment is largely based on reviews of published literature and draws on knowledge from long-term monitoring of existing salmon farms in the Marlborough Sounds. To improve our understanding of the local water column environment, we carried out field surveys comprising deployment of Acoustic Doppler Current Profilers (ADCPs), measurements of salinity, temperature, turbidity, nutrients, oxygen and chlorophyll-a, and phytoplankton counts in water samples collected in the proposed farm area.
144	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Executive Summary, p. i, (PDF p. 5). • Results of field surveys confirmed that the water column in the proposed farm area is relatively uniform with respect to variations of temperature, salinity and turbidity with depth.
145	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 2.1, p. 5, (PDF p. 17). Offshore sites such as that considered in this assessment provide multiple advantages in terms of environmental effects on the water column over near-shore sites. They provide good conditions for turbulent mixing and strong currents, thereby increasing the rate of dilution and dispersal of farm-derived wastes (Welch et al. 2019). Because they are in deeper open waters, they are likely to have cooler water temperatures than more protected near-shore waters.
146	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.1, p. 7, (PDF p. 19). During most of the time, the water column in the Strait is well-mixed. Stratification does occur and is strongest in summer causing temperature to vary by as much as 3 °C with depth (Stevens et al. 2019).
147	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.2, p. 8, (PDF p. 20). The available data show the following characteristics over the monitoring period: • a generally well-mixed water column, with little variation of temperature and salinity with depth • temperature range (approximate): 12.5–17 °C

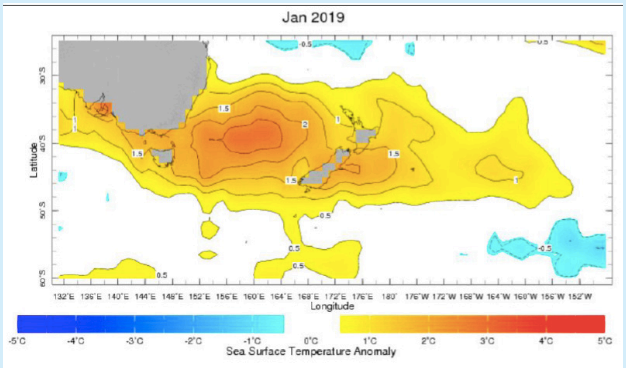
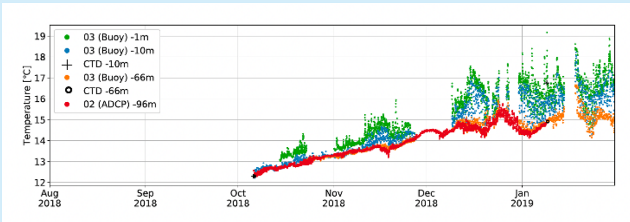
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
148	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.2, p. 8, (PDF p. 20). Seasonal patterns (other than temperature) were not apparent in the data – however this may be in part due to an inability of monthly samples to accurately reflect time-integrated conditions.
149	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.2, p. 10, (PDF p. 22). On a larger scale, water temperature and dynamics of upwelling in greater Cook Strait were investigated by Chiswell et al. (2017). This study reports upwelling of cool water in the Kahurangi Shoals, on the upper west coast of the South Island. This cool water then moves through the greater Cook Strait to Cook Strait itself. Surface temperature in the greater Cook Strait, estimated from satellite imagery and from a Regional Ocean Modelling System, also showed an effect of cool waters from the eastern side of Cook Strait moving into the area to the north and east of the Marlborough Sounds, i.e. incorporating the area considered in the present report. Monthly averages of six years of data showed that this relatively cool body of water sitting to the north and east of the Marlborough Sounds was most apparent from late spring to autumn. In the colder months, water temperatures were more homogenous across the greater Cook Strait (Chiswell et al. 2017). The mean monthly temperature occurred in February, when surface waters north of the Marlborough Sounds averaged approximately 17 °C (Chiswell et al. 2017).
150	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.2, p. 10, (PDF p. 22). Long-term (13 years) **sea surface temperature** data available for a single site in outer Port Gore (taken from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery) show that temperatures > 18 °C were uncommon and rarely exceeded 19 °C (Figure 4, reproduced from Taylor et al. 2015). The lowest temperatures varied between 11 °C and 12 °C every year.
151	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.2, p. 10, (PDF p. 22).  **Figure 4. Sea surface temperature (SST)** for outer Port Gore derived from MODIS satellite data (Lat: -40.98306°, Long: 174.2602°). Adapted from Taylor et al. (2015).
152	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 3.2, p. 10, (PDF p. 22). Remotely-sensed chlorophyll-a concentrations were also calculated monthly for the greater Cook Strait by Chiswell et al. (2017). As for temperature, six years of satellite data were used for this calculation.
153	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.1.3, p. 28, (PDF p. 40). Water temperature, salinity and turbidity provide important information about the vertical density structure of the water column within the proposed farm area. The seasonal variation of these factors affects the carrying capacity of the environment and thus we consider them here. In theory, it is possible that small changes in temperature could occur due to energy losses associated with the metabolic heat loss of large numbers of farmed salmon, frictional losses from current/structure interactions or electrical/mechanical energy inputs from equipment used at the site (Gillespie et al. 2011) …

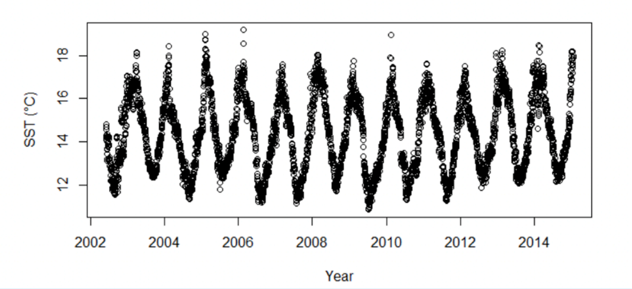
Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
154	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.1.3, p. 28, (PDF p. 40). Continuous temperature and salinity measurements were taken from thermistors/thermometers (1 m, 10 m, and 66 m) and salinity meters (10 m and 66 m) moored on a buoy at Station 3. Temperature and salinity data were also collected using similar instrumentation at Station 2 (96 m). Conductivity, temperature, and depth (CTD) casts were carried out on three occasions (7 August 2018; 6 October 2018; 25 January 2019) at 7 stations within the proposed farm area.
155	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.1.3, p. 28, (PDF p. 40). Water temperature steadily increased from approximately 12.5 °C in early October (Figure 14). As the water warmed, the temperature became increasingly variable across different depths, and within a given depth. By the end of January 2019, temperature ranged between a high of 19 °C in surface waters and 14.5 °C at 66 m (the deepest sensor, on the ADCP at Station 2, was removed in early January).
156	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.1.3, p. 29, (PDF p. 41).  Figure 14. Time series of water temperature at stations 2 and 3 from 6 October 2018 to 25 January 2019. Black symbols indicate temperatures from CTD casts.
157	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.1.3, p. 30, (PDF p. 42). The CTD casts through the water column reflect the same pattern of increasingly high and variable water temperatures into summer. Below approximately 30 m, temperatures were relatively stable with depth. A temperature increase from 12–13 °C in August and October to approximately 15 °C in January is also evident in the profiles (Figure 15).  Figure 15. Variation of temperature with depth at 7 stations on 7 August 2018, 6 October 2018 and 25 January 2019. Station 02 is dashed in January to indicate that this cast was taken on 9 January 2019.
158	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.1.3, p. 30, (PDF p. 42). The highest temperatures recorded in the survey (approximately 19 °C) are higher than those reported by Broekhuizen (2015) and the means modelled by Chiswell et al. (2016). This is likely due to the high number of measurements recorded by the moored instrumentation (buoy data were not averaged) and the fact that, in the summer of 2018/19, New Zealand waters were affected by a 'marine heat wave' with average surface water temperatures about 1.5 °C higher than normal (Appendix 6). This undoubtedly affected measurements presented here, and hence these results may not be representative of typical conditions in the region.

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
159	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.3, p. 43, (PDF p. 55). During the monitoring period, DO concentrations at station 3 ranged from 7.0 to 8.9 mg/L (Figure 23). The monitoring data indicate a decreasing trend in DO concentrations over time which is mainly due to the waters warming into the summer period (colder waters can hold more oxygen than warmer waters). Percent saturation data were available for a slightly shorter time period as their calculation from absolute concentrations requires temperature and salinity data that were not available for some periods during deployment.
160	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 4.3, p. 44, (PDF p. 56).  Figure 23. Time series of dissolved oxygen at station 3 expressed as absolute concentration (A) and percent saturation for dates with supporting temperature and salinity data available (B) from October 2018 to January 2019. Black symbols indicate dissolved oxygen concentrations from CTD casts.
161	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 6.1, p. 58, (PDF p. 70). Fish respire—reducing DO concentrations, and exhaling carbon dioxide (CO_2) into the water. The degree of respiration is a function of the fish size, temperature and activity (i.e. swimming speed). In general, king salmon respire less per gram of body weight as they get larger and respire more under increasing temperature and activity.
162	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 6.1, p. 58, (PDF p. 70). Oxygen consumption was estimated based on the model information provided in Stewart and Ibarra (1991) for a variety of swimming velocities based on currents measured at the site (Figure 29). The model also assumes a fish size of 3,500 g (a harvest-sized fish) and a temperature of 18 °C.
163	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 6.1, p. 58, (PDF p. 70).  Figure 29. Calculated respiration rate per kg of biomass per hour for a range of swimming speeds for 3.5 kg Chinook salmon at a temperature of 18 °C, based on data provided in Stewart and Ibarra (1991).

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)

Number	Date on document	Name of document and Date uploaded	Excerpt from document
164	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Footnote 20, p. 58, (PDF p. 70). The respiration rate per kg of fish increases as the temperature increases and the fish size decreases. 18 °C is used as a worst-case maximum temperature, with observed temperatures typically 17 °C or less.
165	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 6.1, p. 59, (PDF p. 71).  Figure 30. Estimated relative dissolved oxygen decreases downstream of the net pen for given ambient current speeds at the proposed farm site assuming average background DO concentrations of 8 mg/L. Calculations assume no mixing with the surrounding water, a temperature of 18 °C and fish are 3.5 kg in size.
166	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Chapter 8.1, p. 65, (PDF p. 77). The proposed farm site is located in 60–110 m water depth in an area of strong water currents (mean mid-depth current speeds = 40 cm/s). The water column in the area is subject to strong vertical mixing and horizontal transport causing little variation in temperature and salinity with depth.
167	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Appendix 2. Methods and data collected in the field surveys, p. 82, (PDF p. 94). • Water column profiles were collected on 7 August 2018, 6 October 2018 and 25 January 2019 at a number of sampling stations. A CTD (conductivity, temperature, depth) instrument was fitted with additional instruments for the collection of data on fluorescence, dissolved oxygen concentration, and turbidity.
168	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Appendix 2. Methods and data collected in the field surveys, p. 82, (PDF p. 94). Temperature and salinity • timeseries from buoy at Station 3 (1 m [ADCP], 10 m, 66 m) • timeseries from ADCP at Stations 2 (96 m) • water column profiles (surface to seabed) at a range of stations (three timepoints).
169	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Appendix 6, p. 88, (PDF p. 100). Depth profiles of temperature, salinity, fluorescence, turbidity and dissolved oxygen used for comparison of cast and moored data collected at stations in the proposed farm area on three sampling occasions. 

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
170	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Paragraph 64. The fact that the RLOs were only associated with disease and skin ulcers at the two farming sites with highest water temperatures, suggests that the disease process was probably multifactorial and related to suboptimal environmental conditions (ie. water temperatures > 16°C) and other husbandry related factors such as waterborne dispersal of stinging nematocysts from marine pests during net cleaning activities at the low flow sites.
171	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Appendix 7, P. 89, (PDF p. 101). **Sea surface temperature** anomaly for New Zealand in January 2019.  Source: International Research Institute for Climate and Society (https://iri.columbia.edu/?bbox=bb%3A131.23%3A-60.03%3A211.83%3A-24.86%3Abb).
172	26 Feb 2020	Revised Water Column Assessment, Cawthron Report No. 3313 (February 2020) Record: 21172802 11 Aug 2021	Appendix 8, P. 90, (PDF p. 102). Time series of temperature, salinity, fluorescence, turbidity and dissolved oxygen used for comparison of cast and moored data collected at stations in the proposed farm area. 
173	21 Oct 2019	Acoustic Monitoring Report (1.4MB) Record: 19240165 25 Oct 2019	Chapter 4.0, p. 19. To develop a reliable propagation model, detailed knowledge is required on a range of oceanographic and other physical data (e.g. depth, bottom type, salinity, temperature, etc), almost all of which has already been collected as part of the assessment of effects for these sites (Elvines et al. 2019; Newcombe et al. 2019).

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
174	16 Dec 2019	Notification Package (Part 1 of 4)(29.7MB) Record: 19232981 16 Oct 2019	Chapter 3.2, p. 9, (PDF p. 225). Long-term (13 years**)** **sea surface temperature** data available for a single site in outer Port Gore (taken from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery) show that temperatures > 18 °C were uncommon and rarely exceeded 19 °C (Figure 4, reproduced from Taylor et al. 2015). The lowest temperatures varied between 11 °C and 12 °C every year.  Figure 3. **Sea surface temperature (SST)** for outer Port Gore derived from MODIS satellite data (Lat: -40.98306°, Long: 174.2602°). Adapted from Taylor et al. (2015).
175	5 Jul 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Chapter 3, p. 4, (PDF p. 16). In addition, NZ King Salmon needs the ability to adapt to the effects of climate change. Sea temperatures have been well above the long term average over the past two summers.
176	5 Jul 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Chapter 4.1, pp. 4–5, (PDF pp. 16–17). “Offshore sites such as that considered in this assessment provide multiple advantages in terms of environmental effects on the water column over near-shore sites. They provide good conditions for turbulent mixing and stronger currents thereby increasing the rate of dilution and dispersal of farm-derived wastes (Welch et al. 2019). Because they are located in deeper open waters, they are likely to have cooler water temperatures than more protected near-shore waters, and lower water temperatures can be favourable for fish health and survival.”
177	26 Jun 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Chapter 3.2.1, p. 24, (PDF p. 131). Deposition of farm-derived organic material is the primary driver of seabed impacts associated with salmon farming. The physical characteristics of the farm site and attributes of the farms themselves influence the accumulation of this organic material (Keeley & Taylor 2011; MacDiarmid et al. 2013; Anderson et al. 2019). The flushing potential and environmental assimilation of farm wastes at a given site are largely dictated by water depth and current speed, and to a lesser extent, seasonal factors such as water temperature (Keeley & Taylor 2011). Increased flushing not only reduces local biodeposition and sedimentation, but also increases oxygenation of sediments (Findlay & Watling 1997).
178	Jun 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Executive Summary, p. i, (PDF p. 209). Our assessment is largely based on reviews of published literature and draws on knowledge from long-term monitoring of existing salmon farms in the Marlborough Sounds. To improve our understanding of the local water column environment, we carried out field surveys comprising deployment of Acoustic Doppler Current Profilers (ADCPs), measurements of salinity, temperature, turbidity, nutrients, oxygen and chlorophyll-a, and phytoplankton counts in water samples collected in the proposed farm area.
179	Jun 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Executive Summary, Magnitude and significance of assessed effects, p. i, (PDF p. 209). Results of field surveys confirmed that the water column in the proposed farm area is relatively uniform with respect to variations of temperature, salinity and turbidity with depth …

Appendix 1A: 2021/22 Application U190438 (Blue Endeavour)			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
180	Jun 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Chapter 3.1, p. 7, (PDF p. 223). During most of the time, the water column in the Strait is well-mixed. Stratification does occur and is strongest in summer causing temperature to vary by as much as 3 °C with depth (Stevens et al. 2019).
181	Jun 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Chapter 3.2, p. 8, (PDF p. 224). The available data show the following characteristics over the monitoring period: • a generally well-mixed water column, with little variation of temperature and salinity with depth • temperature range (approximate): 12.5–17 °C
182	Jun 2019	Notification Package (Public) (1.6MB) Record: 19232107 15 Oct 2019	Chapter 3.2, p. 9, (PDF p. 225). On a larger scale, water temperature and dynamics of upwelling in greater Cook Strait were investigated by Chiswell et al. (2017). This study reports upwelling of cool water in the Kahurangi Shoals, on the upper west coast of the South Island. This cool water then moves through the greater Cook Strait to Cook Strait itself. Surface temperature in the greater Cook Strait, estimated from satellite imagery and from a Regional Ocean Modelling System, also showed an effect of cool waters from the eastern side of Cook Strait moving into the area to the north and east of the Marlborough Sounds, i.e. incorporating the area considered in the present report. Monthly averages of six years of data showed that this relatively cool body of water sitting to the north and east of the Marlborough Sounds was most apparent from late spring to autumn. In the colder months, water temperatures were more homogenous across the greater Cook Strait (Chiswell et al. 2017). The mean monthly temperature occurred in February, when surface waters north of the Marlborough Sounds averaged approximately 17 °C (Chiswell et al. 2017).
183	8 Oct 2019	Application (4 out of 4) (21MB) Record: 19231436 14 Oct 2019	Chapter 3.2, p. 5, (PDF p. 70). Elevated temperature: High temperature is a major factor involved in susceptibility to disease. Disease organisms also tend to multiply more rapidly at higher temperature.

Appendix 1B: 2018 Application for a [fresh]water Conservation Order [at Takaka Hatchery for smolt]			
Number	**Date of document**	**Name of document**	**Excerpt from text**
1	21 Apr 2020	Affidavit of Mark John Gillard in support of notice of motion. Link	Paragraph 21, p. 4, (PDF p. 10). Other parameters of water quality from the Springs are very good. Although its hardness is relatively high, we can manage that. It is some of the clearest freshwater in the southern hemisphere and has a relatively consistent year-round temperature of approximately 12°C, an ideal temperature for salmon rearing.

Appendix 1C: 2017 Relocation proposal			
Number	**Date of document**	**Name of document**	**Excerpt from text**
1	Jul 2017	Report and Recommendations of the Marlborough Salmon Farm Relocation Advisory Panel Link	Page 119. In respect of Policy 3(2) many comments stressed that climate change may well cause sea temperatures in the long term to rise above those that can provide a relatively stress-free environment for NZ King Salmon which ideally should be reared in waters below 17 degrees Celsius. Whether climate change does cause those significant long-term temperature rises in Pelorus Sound has yet to be shown empirically, so we do not consider the Plan Change Proposal can be refused on that ground.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
1	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 19, (PDF p. 97). Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, temperature, turbidity and dissolved oxygen (DO) at the following locations: Pelorus Sound (for Waitata, Richmond, Tapipi, Kaitira and White Horse Rock); Queen Charlotte Sound (for Kaitapeha, Ruaomoko and Ngamahau); Port Gore (for Papatua):
2	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 21, (PDF p. 99). Monitoring in order to determine compliance with the WQS in Condition 52. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 77c. ... Targeted water column surveys to quantify the localised effect of the farm on surrounding water quality, for the purpose of obtaining information regarding farm-specific, near-farm mixing properties in order to provide a context for evaluating compliance with the EQS - WQS in Condition 52. This shall involve a series of fine-scale surveys in the vicinity of the farm (within 1km from the net pens) measuring: salinity, temperature, chlorophyll a, turbidity, dissolved oxygen (DO), nutrient concentrations (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), phytoplankton composition and biomass along transects that move away from the farm and span potential nutrient gradients.
3	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 19, (PDF p. 165). Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at the following locations: Pelorus Sound (for Waitata and, Richmond,); Queen Charlotte Sound/Tory Channel (for Ngamahau); Port Gore (for Papatua):
4	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 21, (PDF p. 167). Monitoring in order to determine compliance with the WQS in Condition 52. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 77c. ... Targeted water column surveys to quantify the localised effect of the farm on surrounding water quality, for the purpose of obtaining information regarding farm-specific, near-farm mixing properties in order to provide a context for evaluating compliance with the EQS - WQS in Condition 52. This shall involve a series of fine-scale surveys in the vicinity of the farm (within 1km from the net pens) measuring: salinity, clarity, temperature, chlorophylla, turbidity, dissolved oxygen (DO), nutrient concentrations (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), phytoplankton composition and biomass along transects that move away from the farm and span potential nutrient gradients.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
5	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices [Link]	Page 14, (PDF p. 191). Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at the following locations: i. Near-farm locations within 1km from the net pens; ii. Locations within Port Gore that are expected to have the greatest potential for marine farm-related cumulative enrichment effects (particularly where marine farms are located in proximity to one another and/or as indicated by spatially explicit nutrient modelling or other modelling considered necessary by the Peer Review Panel in accordance with Condition 65a); iii. Locations further away from the marine farm in Port Gore that are expected to have progressively lesser marine farm-related cumulative enrichment effects (as indicated by spatially explicit nutrient modelling or other modelling considered necessary by the Peer Review Panel in accordance with Condition 85a); iv. Locations that are identified as being of high ecological value; and v. Near the entrances to Cook Strait.
6	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices [Link]	Page 16, (PDF p. 193). Monitoring in order to determine compliance with the WQS in Condition 40. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 58c. ... Targeted water column surveys to quantify the localised effect of the marine farm on surrounding water quality, for the purpose of obtaining information regarding marine farmspecific, near-farm mixing properties in order to provide a context for evaluating compliance with the EQS - WQS in Condition 40. This shall involve a series of fine-scale surveys in the vicinity of the marine farm (within 1km from the net pens) measuring: salinity, clarity, temperature, chlorophyll a, turbidity, dissolved oxygen (DO), nutrient concentrations (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), phytoplankton composition and biomass along transects that move away from the marine farm and span potential nutrient gradients. The surveys shall be undertaken at least twice per year and continued for at least two years after the marine farm has reached stable maximum feed discharge levels and no future increases are proposed.
7	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices [Link]	Page 14, (PDF p. 222). Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at the following locations:

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
8	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 16, (PDF p. 224). Monitoring in order to determine compliance with the WQS in Condition 44. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 63c. ... Targeted water column surveys to quantify the localised effect of the marine farm on surrounding water quality, for the purpose of obtaining information regarding marine farmspecific, near-farm mixing properties in order to provide a context for evaluating compliance with the EQS - WQS in Condition 44. This shall involve a series of fine-scale surveys in the vicinity of the marine farm (within 1km from the net pens) measuring: salinity, clarity, temperature, chlorophyll a, turbidity, dissolved oxygen (DO), nutrient concentrations (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), phytoplankton composition and biomass along transects that move away from the marine farm and span potential nutrient gradients. The surveys shall be undertaken at least twice per year and continued for atleast two years after the marine farm has reached stable maximum feed discharge levels and no future increases are proposed.
9	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 14, (PDF p. 255). Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at the following locations:
10	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 16, (PDF p. 257). Monitoring in order to determine compliance with the WQS in Condition 44. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 63c. ... Targeted water column surveys to quantify the localised effect of the marine farm on surrounding water quality, for the purpose of obtaining information regarding marine farmspecific, near-farm mixing properties in order to provide a context for evaluating compliance with the EQS - WQS in Condition 44. This shall involve a series of fine-scale surveys in the vicinity of the marine farm (within 1km from the net pens) measuring: salinity, clarity, temperature, chlorophyll a, turbidity, dissolved oxygen (DO), nutrient concentrations (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), phytoplankton composition and biomass along transects that move away from the marine farm and span potential nutrient gradients.
11	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 14, (PDF p. 288). Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at the following locations:

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
12	22 Feb 2013	Board of Inquiry New Zealand King Salmon Plan Change Requests and Applications for Resource Consents Volume two – appendices Link	Page 16, (PDF p. 290). Monitoring in order to determine compliance with the WQS in Condition 44. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, clarity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 62c. ... Targeted water column surveys to quantify the localised effect of the marine farm on surrounding water quality, for the purpose of obtaining information regarding marine farm specific, near-farm mixing properties in order to provide a context for evaluating compliance with the EQS - WQS in Condition 44. This shall involve a series of fine-scale surveys in the vicinity of the marine farm (within 1km from the net pens) measuring: salinity, clarity, temperature, chlorophyll a, turbidity, dissolved oxygen (DO), nutrient concentrations (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), phytoplankton composition and biomass along transects that move away from the marine farm and span potential nutrient gradients.
13	2012	Statement of evidence of Neil David Hartstein Link	Paragraph 14, (PDF p. 5). There appears to be no scenario based modelling to take into account inter-annual variability within the proposed farm production areas. Model runs presented in the latest 2185 report are for the winter and early spring period only. Of particular importance is that high temperatures and at times low winds found during summer time, these types of conditions have not been considered. Late Spring/ Summer time is usually when there is a higher risk for algae blooms i.e. Those observed in Big Glory Bay (granted in Stewart Island but a useful New Zealand example). Generally there is more environmental stress in and around the farms in summer due to higher water temperatures and lower oxygen; hence from a sustainability and carry capacity point of view this period of time needs to be addressed in any predictive modelling study for an application of this size.
14	2012	Statement of evidence of Neil David Hartstein Link	Paragraph 17. I believe the issues regarding salinity and temperature that have been discussed by other peer reviews i.e. Nialls Broekhuizen and at caucusing, and has been sufficiently addressed in the latest version of the calibration report (2185), it thus needs no further comment.
15	2012	Statement of evidence of Neil David Hartstein Link	Paragraph 25. Our review of the scientific literature shows numerous occurrences advocating for the complexity of this carbon to chlorophyll-a ratio which varies with parameters such as light availability, nutrient availability, temperature, etc. (Finenko et al., 2003; Li et al., 2010; Geyder, mcintyre and Kana, 1998; Wang et al., 2009; Cloern, Grenz and Vidergar-Lucas, 1995 ; Sathyendranath et al., 2009)
16	2012	Statement of evidence of Neil David Hartstein Link	Paragraph 43. The Mike 3 three dimensional model allows for computation of baroclinic density based on continuous update from the varying temperatures and salinity. Given there is additionally very little to no available data on these parameters (Gibbs etc al 1991 Proctor, R. Et al. 1998 Heath, R.A. 1974 provide some insights but nothing conclusive) , crude estimations could lead to detrimental effects on the actual results. It was therefore chosen to leave these parameters constant, with reference values of 35 PSU for salinity and 15 degrees for the temperature (during a summer run scenario looking at oxygen respiration and nutrients a temperature of 18 degrees was used). While data review section has shown temperatures to change significantly in time, density driven currents (requiring baroclinic modelling with computation of density variations, instead of barotropic) are estimated to have more influence than a global change of density would. Moreover, tides and wind have no correlation with density.

Appendix 1D: 2013 Board of Inquiry			
Number	Date of document	Name of document	Excerpt from text
17	2012	Statement of evidence of Neil David Hartstein Link	Paragraph 59. The wind forcing hydrodynamic scenario was used to examine a worst case for DO depletion in and around 4 farm sites in central Pelorus Sounds over a 4 month spring and summer period (period of potentially lower wind and higher temperatures). Figures 34 & 35 indicate that there can be considerable reduction of DO in and around the proposed lease areas. The plots presented here are a worst case showing minimum oxygen levels. Such levels will have local scale impacts to the aquatic ecosystem in the upper parts of the water column, with levels temporarily falling below chronic (<5.0mg/L) USEPA Values, and certainly below those that are optimum for fish growth and survival. While it is not expected that this reduction will have any adverse impacts on the wider aquatic ecosystem, there will be some localised impact within Pelorus Sound.
18	2012	Submission to: The Board of Enquiry, New Zealand King Salmon Proposal: Sustainably Growing King Salmon - Marlborough Recreational Fishers Association, Soundfish, Mr Des Boyce Link	Paragraph 15.3. The most significant features of open-sea aquaculture are that all waste material is rapidly and effectively dispersed, and water temperatures can be selected for optimal growth.
19	18 Oct 2012	Annexure B NZKS proposed conditions – closing version 18/10/12 Link	Page 19. Water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, temperature, turbidity and dissolved oxygen (DO) at the following locations: Pelorus Sound (for Waitata, Richmond, Tapipi, Kaitira and White Horse Rock); Queen Charlotte Sound (for Kaitapeha, Ruaomoko and Ngamahau); Port Gore (for Papatua):
20	18 Oct 2012	Annexure B NZKS proposed conditions – closing version 18/10/12 Link	Page 21. Monitoring in order to determine compliance with the WQS in Condition 52. Throughout the term of the consent this shall include long-term water column monitoring for nutrient (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP) and chlorophyll a concentrations, phytoplankton composition and biomass, salinity, temperature, turbidity and dissolved oxygen (DO) at locations stipulated in Condition 77c.
21	16 Oct 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Pages 20–21. MR GARDNER-HOPKINS: Do you accept, in terms of appropriateness, that the Ruaomoko and Kaitapeha sites are more efficient producers of salmon than most of the other sites because of the cooler temperatures and higher water flows? MS CAMERON: I believe that is the case. MR GARDNER-HOPKINS: And so those sites are likely to have better feed conversion ratios? MS CAMERON: I will take your word for it. MR GARDNER-HOPKINS: I think there may be some evidence on it. But would you accept that mortalities at those sites, because of those conditions, cooler temperatures/higher flows, are likely to be lower than at other sites?
22	16 Oct 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 3938 (PDF p. 109). MR NOLAN ...“the Council has deliberately taken a neutral stance ...” for the reasons you gave earlier, and that was the paragraph we looked at there, and we’ve already – and it talks about the 59 species in the next paragraph, which we’ve discussed, and of course we’ve heard from Mr Gillard, who is the expert salmon farmer, about how their company now wishes to secure more space and has done from about the mid-2000s, and from based on their learning’s [sic] they’re looking for high flow, cooler temperature sites, and you’re aware of all that from the evidence.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
23	12 Oct 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 86. MS DAWSON: No. It was all to do with the biological needs of the fish. How they change depending on temperature for example of the water, different stages of their life cycle. The various sort of pluses and minuses that they have to work with in feeding fish who are natural beings and that around the – there are sort of levels of uncertainty – not uncertainty but pluses and minuses that come around dealing with natural things in a natural environment. He gave evidence on this. There's no point in me repeating it.
24	9 Oct 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 3310 (PDF p. 36). PROFESSOR LEADER: Likewise in China, there are presently more than 3,000 open ocean pens growing a wide range of organisms from fish to algae using a design imported from Norway. And Chang Chee Hong summarises, "But further development of the aquaculture industry, must take a holistic approach to culturing technologies, socioeconomic, natural resources and the environment, so that sustainability can be achieved. The most significant features of open sea aquaculture are that all waste material is rapidly and effectively dispersed and water temperatures can be selected for optimal growth."
25	21 Sept 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 2291 (PDF p. 15). MS ALLAN: I think just because there is no direct linking evidence doesn't mean that there isn't actually a connection, and I think there is a risk associated with it which shouldn't be overlooked, we haven't done anything on this scale. And you would see in my evidence as well too the issue of temperature, in terms of Pelorus, and also climate change in terms of a 35 year consent.
26	20 Sep 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 65. MR GARDNER-HOPKINS: You mention a number of risk factors at your paragraph 1.5.2 and you refer to disease, sea temperature change, storms, natural disasters and the like. And you have suggested in that discussion at least a 15 percent discount rate should be applied to reflect this? MR OFFEN: Well, as the minimum, absolutely. MR GARDNER-HOPKINS: As a minimum. So, at least a 15 percent. And that is based on experience assessing new projects, facing new ground and risks.
27	20 Sep 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 66. MR GARDNER-HOPKINS: So, you mentioned I think sea temperature change as a risk factor. Are you aware of whether or not there is any evidence in these proceedings that the sea temperature will rise within the 35 year consent period ... MR OFFEN: No, I am not. I have not attempted to work out whether these risks will transpire. The point is simply that there has not been any analysis undertaken in that regard at all ... MR GARDNER-HOPKINS: Well ... MR OFFEN: ... by New Zealand King Salmon.
28	19 Sep 2012	Cage Farming Aquaculture 2011/2012 Link	Page 5. Strong Polarcirkel PIM Brackets Extensive use of PE (Polyethylene) in our PIM (Pressure Injection Moulded) brackets eliminates corrosion, minimizes expensive and difficult maintenance, and substantially increases cage lifespan compared to steel brackets. This is especially important in areas with high salinity, warm water temperatures and choppy seas.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
29	19 Sep 2012	Cage Farming Aquaculture 2011/2012 Link	Page 11. Environmental monitoring and logging Oxygen-, temperature- and current sensors are fully integrated in akvacontrol. All sensor data are displayed in real time and logged For further analysis. This allows for optimal feeding at all times. Technical and environmental alarm functions Predefined alarms (high current, low oxygen, high temperature, feed system and technical errors). Alarm output to site alarm (flashing light/siren) and/or via SMS/text messaging.
30	19 Sep 2012	Cage Farming Aquaculture 2011/2012 Link	Page 14. To know the environmental data as temperature, oxygen and current speed are factors that are important inputs when feeding fish. In the Akvasmart CCS Feed System all these factors can be set to automatically control or adjust the feeding. All environmental data will be logged and can be used in further analyses either in akvacontrol or in Fishtalk. Temperature - the foundation for all feeding regimes and growth models. The Akvasmart Temperature Sensor is a reliable and robust sensor that can be submerged at desired depths. Accurate real time readings are displayed and logged by the akvacontrol Feed System software. Akvacontrol can calculate the expected daily feed amount based on feed tables with measured temperature data. The Akvasmart Temperature Sensor is connected to the Akvasmart CCS Feed System either by connection to the Akvasmart CCS Selector Valve or via the CAP network.
31	7 Sep 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 48. MR SAGAR: It is an area below 60 degrees south so they have got water temperatures – just to put it into perspective here, it has got water temperatures of zero to one degrees centigrade, it is the open ocean, it is influenced by pack ice and there is no fresh water influence in that area at all, it is well away from any land. And this is rather in contrast I think to the Marlborough Sounds which is, as we know, embayments which has got intrusions of fresh water and detritus from the land and we have got rainfall as well, and the water temperatures are usually above 10 degrees centigrade. And then within Beatrix Bay (ph 4.21) we know that 85 percent of the suspended matter in the water column is detritus and a lot of that comes from land based sources. In other words, I think we have got two entirely different –well, I know we have got two entirely different ecosystems here and it is totally inappropriate to take the data from the Weddell Sea and just transpose it into the Marlborough Sounds situation and say this is how king shag hunting depth will change with increases in chlorophyll-a concentration.
32	30 Aug 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 26. DR HADFIELD: The vertical mixing in the original – well, in fact I didn't examine the original model as reported in May 2012 very closely, but I am assured by Mr Knight and others that there were problems with that model and those problems were fixed by limiting the vertical diffusivity. And I've got quite a detailed discussion of the issues on that in my peer review report. So we have a turbulence model that generates a vertical diffusivity which then, in terms of the gradients, it's controlled by the gradients of velocity and temperature and solidity. And it calculates a vertical diffusivity which is then used to mix material vertically, and Mr Knight has limited the vertical diffusivity because the model was too diffusive.

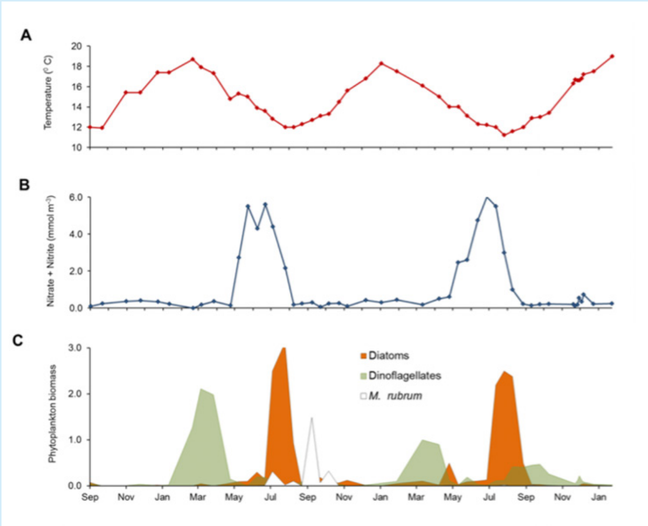
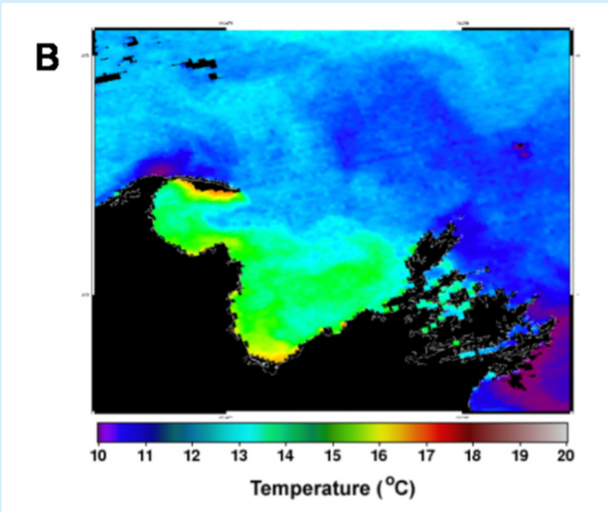
Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
33	30 Aug 2012	Transcript of proceedings Board of Inquiry New Zealand King Salmon proposal Link	Page 386. DR LONGDILL: The first thing you want to do when you are modelling farms such as this would be replicate the physical processes, the hydrodynamics. So we are talking there about the movement of water, tidal currents, river forcings, temperatures (INDISTINCT 1.12), oceanic processes. That is the first thing. That has been done in this example in a three dimensional sense, which is the best you have got available.
34	Aug 2012	Statement of rebuttal evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful Algal blooms for the New Zealand King Salmon Company Limited (Cawthron Institute) Link	Executive Summary. (E) Several submitters have drawn attention to the fact that the Cawthron evidence does not address the issue of climate change and its potential effect on HAB incidence and the effect of salmon farm effluents. It is acknowledged that increases in sea temperatures in the future may have an important effect on the phytoplankton ecology in the Sounds, but what these effects might be are unpredictable and any projections at this stage would simply be speculation. As Hallegraeff et al. (2012)4 acknowledge, "Prediction of the impact of global climate change on marine phytoplankton is fraught with uncertainty." Seawater warming in the Sounds could provide conditions conducive to HABs or equally well result in the reduction of natural oceanic nutrient inputs to the Sounds and hence a much less productive environment than it is presently.
35	Aug 2012	Statement of rebuttal evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful Algal blooms for the New Zealand King Salmon Company Limited Link	Paragraph 33. In paragraph 6 (p2) Mr Miller makes the statement: "There remains the possibility that a combination of the elevation of nitrogen levels in the waters of the Sounds combined with water temperature rise and wider distribution of formerly rare dinoflagellates could lead to persistent algal blooms within the Sounds." I disagree with some of this statement but not all. As referred to in the Executive Summary, we do not know what will happen to phytoplankton communities in the Sounds as a result of a rise in sea temperatures. Temperature rise could either increase or decrease natural nutrient inputs, although it is likely to enhance summer thermal stratification and provide an environment more conducive to the growth of flagellates. As a result I do agree that it is possible that over time some formerly rare nuisance species may extend their range throughout the Sounds. However, I believe that whether or not this happens will not be determined by the presence or absence of the salmon farms. Persistent algal blooms are unlikely as they are by their nature usually episodic events.
36	Aug 2012	Statement of rebuttal evidence of Mark Anthony Preece for the New Zealand King Salmon Co. Limited Link	Paragraph 15.2, p. 29. Fish welfare is important to NZ King Salmon. We need to ensure our fish receive sufficient feed across their life cycle. The changes in temperature and other environmental conditions can alter feed consumption by up to 15%. For this reason we occasionally need flexibility to exceed our maximum feed levels by up to 15%. This margin allows us to ensure fish welfare is maintained in years when salmon survivability is unusually high.
37	Aug 2012	Statement of rebuttal evidence of Mark Anthony Preece for the New Zealand King Salmon Co. Limited Link	Paragraph 17.2, p. 30. To expand upon that point, Crail Bay is a warm site. Fish which are exposed to warm temperatures reduce feeding which reduces growth and increases feed conversion.
38	Aug 2012	Statement of rebuttal evidence of Mark Anthony Preece for the New Zealand King Salmon Co. Limited Link	Paragraph 17.7, p. 31. Ultimately, NZ King Salmon will utilise Crail Bay as an area where new farming techniques can be tried. As one would expect from a former mussel farm site, this is a site with low economic efficiency, very small production and a site which, due to its high temperatures, has poorer feed conversion than colder sites.
39	Aug 2012	Cultural Impact Assessment for New Zealand King Salmon proposals to Board of Inquiry Prepared for Te Ātiawa Manawhenua ki te Tau Ihu Trust Link	Page 14. The proposed activity is sea-temperature-sensitive and the Ruaomoko and Kaitapeha sites are sites of known high tidal flow and at times, challenging sea conditions. That is, Te Ātiawa considers these sites to be weather event vulnerable. Climate change has the potential to affect water temperature, water levels and sea conditions in these locations potentially exacerbating navigational safety issues.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
40	Aug 2012	Statement of evidence of Rob Shuckard A Link	Page 7. Definition of poorly located farms – The Marlborough Sounds as a semi enclosed water body is marginally suitable for finfish farming due to temperature and confinement.
41	Aug 2012	Statement of evidence of Rob Shuckard August 2012 Link	Paragraph 3.12, p. 13. Lack of ecosystem knowledge, in combination with declining diversity of life-forms, will make adaptation to changing environmental conditions in the future more challenging. To maintain bio-diversity is to maintain our future options. The future challenges to already degrading coastal habitats will be exacerbated by predicted climate change and its impact on algal blooms (Al-Ghelani, 2005). Climate-induced changes in salinity, temperature and mixing, which all influence both oxygen conditions and species' hypoxia tolerance will be of importance. Climate change is a rather new phenomenon and only recently, planners attempt to integrate more and more the consequences of this new reality. The impacts of eutrofication, independent on the source of the flux, will be significantly influenced by this new reality. Both changes in climate forcing and nutrient loadings are aspects of global change that is expected to profoundly impact coastal hypoxia through more stratified water conditions. Planning towards these realities is not reflected in planning matters. The effects of large-scale climate warming are causing long-term variations in oxygen content and saturation as an observed increase in temperature has led to a general decrease in oxygen solubility of water masses. Mitigation of effects should reflect the realities of an uncertain future and we should not take comfort from the poorly known assimilation capabilities of the marine environment to date.
42	Aug 2012	Statement of evidence of Rob Shuckard August 2012 Link	Paragraph 5.14, p. 21. So in addition to anthropogenic nutrient inputs, global warming with rising temperatures may increase the release of dissolved organic matter from soil and alter vegetation cover, which may in turn elevate nutrient and organic matter export.
43	Aug 2012	Statement of evidence of Rob Shuckard August 2012 Link	Paragraph 5.20, p. 24. The degree to which marine ecosystems may support pelagic- or benthic food chain has been shown to vary across natural and anthropogenic gradients in e.g., temperature and nutrient availability. Moreover, such external forcing may not only affect the flux of organic matter, but could trigger large and abrupt changes, i.e., trophic cascades and ecological regime shifts, which once having occurred may prove potentially irreversible. A potential regime shift from pelagic to benthic regulatory pathways has been reported in Kattegat (Denmark) as a possible first sign of recovery from eutrophication likely triggered by drastic nutrient reductions (involving both nitrogen and phosphorus), in combination with climate-driven changes in local environmental conditions (e.g., temperature and oxygen concentrations) (Lindegren et al. 2012)
44	Aug 2012	Statement of evidence of Rob Shuckard August 2012 Link	Paragraph 6.11, pp. 33–34. The period from 2-13 January, 1989, a Harmful Algal Bloom developed in Big Glory Bay, Stewart Island. Fish kills occurred and the weather was characterised by warm air and sea water temperatures, long daylight hours, light to moderate winds from an easterly quarter and an episode of intense rainfall. These conditions would result in runoff from the catchment being retained within the bay resulting in fertilization of the water and contributing towards the establishment of a stable stratified water column. These conditions were clearly suitable for the development of a flagellate dominated population. Conversely the same period the following year was characterised by cool air and sea water temperatures, the same day-length (but probably lower solar radiation), and moderate to strong winds from the west accompanied by intense cool rainfall.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
45	Aug 2012	Statement of evidence of Rob Shuckard August 2012 Link	Paragraph 10.16, p. 58. Water temperature and dive depth influence the cost of diving but foraging parameters of shags are most strongly influenced by the availability of prey. Even a small reduction in prey density will prevent birds meeting their energy requirements (Grémillet et al. 1999). A reduction of prey density of only 25% results in search time increase of 50%-100%. If prey density decreases to 50%, females will fail to reach the foraging efficiency of 1.0, irrespective of temperature or diving depth.
46	Aug 2012	Statement of evidence of Rob Shuckard August 2012 Link	Paragraph 10.19, p. 60. Between 16300 and 30600 tonnes of feed are potentially released if the NZKS applications and others under appeal do go ahead. An assumed average feed use of 23.500 tonnes per annum will result in a monthly nitrogen releases of between 40 and 130 tonnes, where the spike of nitrogen release through feces will take place during the warmest temperatures of the year (between December and April).
47	10 Aug 2012	Statement of evidence in chief of Andrew Stephen Baxter for the Minister of Conservation in relation to Marine ecology and natural character Link	Paragraphs 5, 5.2. I consider several inter-related biophysical factors contribute to the natural character of the coastal environment. These biophysical elements reflect the direction provided by policy 13(2) of the nzcps and can be broadly grouped as follows: abiotic features: natural substrates, geology; environmental complexity, water quality, and physical processes (e.g. Tides, currents, waves, salinity, temperature and sedimentation).
48	10 Aug 2012	Statement of evidence in chief of Andrew Stephen Baxter for the Minister of Conservation in relation to Marine ecology and natural character Link	Paragraphs 7, 7.2. Natural biotic patterns in the marine environment form a three dimensional ecological picture due to differences in marine community structure and function associated with: distance along-shore and changes in variables such as shelter/exposure, substrate composition, tidal and current patterns, salinity, turbidity levels, sedimentation and temperature. Local features such as bays, headlands, reef systems, tidal passages, estuaries, offshore algal beds and biogenic reefs add diversity and complexity to biotic patterns.
49	10 Aug 2012	Statement of evidence in chief of Andrew Stephen Baxter for the Minister of Conservation in relation to Marine ecology and natural character Link	Paragraph 62. 62. Physical processes include such factors as: 62.1 tidal change; 62.2 currents, both tidal and wind driven; 62.3 salinity changes; 62.4 temperature gradients; 62.5 sedimentation patterns; 62.6 wave action; and 62.7 turbidity, water clarity and light penetration.
50	10 Aug 2012	Statement of evidence in chief of Andrew Stephen Baxter for the Minister of Conservation in relation to Marine ecology and natural character Link	Paragraph 66. Biotic patterns manifest themselves in all directions in three-dimensional space. There is a "vertical" zonation offshore into deeper water; i.e. From intertidal beaches and reefs, down to offshore reefs and beyond to gravels, sands and mud. There are broad changes along the coast in response to differences in variables such as shelter/exposure, substrate composition, tidal and current patterns, salinity changes, turbidity levels, sedimentation and temperature. Local features such as headlands, bays, reef systems, tidal passages, estuaries, offshore algal beds and biogenic reefs (e.g. Bryozoan and horse mussel beds) all add diversity and complexity. Along-shore biotic patterns may manifest themselves over tens of kilometres depending on the geomorphology of the coast and the adjoining marine environment.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
51	10 Aug 2012	Statement of evidence in chief of Andrew Stephen Baxter for the Minister of Conservation in relation to Marine ecology and natural character Link	Paragraph 72. The Marlborough Sounds' marine environment is shaped by a number of broad environmental gradients which traverse the length and breadth of the sounds and strongly influence the biotic and abiotic features we see today including: 72.1 wave exposure; 72.2 tidal influence (currents, tidal height and water exchange); 72.3 turbidity; 72.4 sedimentation; 72.5 temperature; 72.6 salinity; 72.7 natural substrates; and 72.8 depth.
52	10 Aug 2012	Evidence from the East Bay Conservation Society Incorporated 10 August 2012 Link	Paragraph 35, p. 12. The Otanerau farm was established in 1989 on what Cawthron classify as a low-moderate flow site. The farm has not been in continuous use since that time. We recall the structures disappeared for at least a year, possibly two, at the time the Proposed MSRMP was notified in 1995. Our understanding from speaking with former employees working on the farm is that it was not performing as well as Regal Salmon (the then owners) hoped and fish were getting sick. The latter was possibly related to over-warm water temperatures during the summer months. Since the reestablishment of the farm on the site, fish stock have been moved to the Te Pangu farm from late December to mid-late April to avoid the effects of the warmer water temperature in Otanerau Bay during those months. This farm is therefore effectively fallowed for three to four months each year.
53	Aug 2012	Statements of evidence of Helmut J. Janssen for Sustain our sounds inc. Claudia Janssen Link	Paragraph 4, p. 39. Fish-farming suitability mapping by John Gillard demonstrates that temperatures in the Sounds are marginal at best and generally too warm. Naturalised salmon's northernmost distribution limit is the Awatere river. Paragraph 5, p. 39. Consensus on climate change predictions are that temperatures are on the rise. This will place considerably more stress on an already stressed caged fish in marginal temperatures.
54	Aug 2012	Statements of evidence of Helmut J. Janssen for Sustain our sounds inc. Claudia Janssen Link	Page 61. Conclusion Applicant's evidence reports a permanence of HAB cysts and an increase of habs in the Sounds over the past decades and that water temperatures of proposed sites are at best marginal for Salmon. Considering a probable further increase of water temperature due to global warming, in addition to significant fossil-fuelled Nr pollution, a further intensification of habs and a phase-shift away from the Sounds' ecosystems capacity to support life is not just logical, but a highly probable and significant adverse effect of irreversible long-term impact.
55	Jul 2012	Statement of evidence of Danny Michael Boulton for sustain our sounds inc. - In relation to tourism and recreational effects For the New Zealand King Salmon co. Limited Proposal July 2012 Link	Paragraph 27. Biophysical factors including geology, tide, currents, sedimentation, temperature, salinity and variation in wave exposure and depth have created a highly complex marine environment. This physical complexity has resulted in a unique assemblage of species, habitats and communities. No other coastal area in New Zealand exhibits this enormous range of habitat complexity.

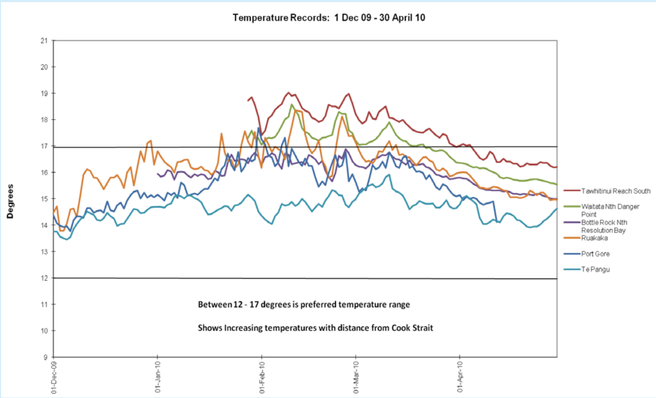
Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
56	22 Jun 2012	Statement of evidence of Andrew Christopher Clark in relation to demand, efficiency, and ownership of New Zealand King Salmon Co Limited Link	Page 9. This is attributable to the decision to discontinue farming Crail Bay, together with a below average production season (which occurs from time to time). In that regard, salmon farming is no different to most other agricultural industries in that there are seasons of relative abundance and less productive seasons. This can be due to a whole range of factors such as temperatures, storms, the presence of predators etc, and as a consequence supply has certain variability. The elevated mortalities we are experiencing at Waihinau (which we are investigating, thoroughly) have also reduced our productivity for the 2012/13 year.
57	22 Jun 2012	Statement of evidence of Andrew Christopher Clark in relation to demand, efficiency, and ownership of New Zealand King Salmon Co Limited Link	Page 12. However, the Crail Bay sites have very small production capacity (as stated above, currently around 500mt, although if that farm was economic and we had continued to farm that site we may have been able to increase the productivity slightly) and are in low-flow water areas with warm summer temperatures, so are far from ideal for farming salmon (Mr Gillard has explained the temperature and water flow issues in detail in his evidence). In short, Crail Bay is uneconomic except in years with high selling price and even so it needs careful management to ensure good growth and minimise mortalities.
58	22 Jun 2012	Statement of evidence of Andrew Christopher Clark in relation to demand, efficiency, and ownership of New Zealand King Salmon Co Limited Link	Page 18. As Mr Gillard has explained in his evidence, NZ King Salmon and other companies have exited sites over the years, due to their proving too difficult and uneconomic to farm. These include Port Ligar, Hallam Cove, Crail Bay (NZ Marine Farms) and NZ King Salmon recently mothballing Crail Bay. It will be clear from Mr Gillard's evidence that lower flow, higher temperature, sites face significant difficulties for salmon. They are not as productive and face higher mortalities.
59	Jun 2012	Statement of evidence of Paul Robert Taylor in relation to the pelagic habitat, pelagic finfish and sharks for the New Zealand King Salmon Co. Limited Link	Appendix A, para 3, p. 44. The principal abiotic characteristics of a pelagic habitat include its physical characteristics such as temperature, light and turbidity, pressure (which is directly related to depth), current speeds, turbulence, and sound, and its water chemistry such as salinity, ph, dissolved oxygen concentration, and nutrient concentrations. The variables salinity and temperature define the density of a water body and its potential for stratification and stability (i.e., its resistance to vertical mixing). These features can strongly affect planktonic processes within the water body.
60	Jun 2012	Statement of evidence of Benjamin Keith Diggles in relation to risks from disease for the New Zealand King Salmon Co. Limited Link	Page 31. Studies of the dynamics of Bonamiosis in flat oysters have shown that stressors such as mechanical disturbance, and rapid temperature changes can elevate B. Exitiosa infections (Hine et al. 2002).
61	Jun 2012	Statement of evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful algal blooms for the New Zealand King Salmon Co. Limited Link	Paragraph 14. Blooms are the result of the transient dominance by one or a few species over others, due to favourable physical (e.g. Salinity/temperature), chemical (e.g. Nutrients) or biological (e.g. Life cycle behaviours) factors that enhance their growth.
62	Jun 2012	Statement of evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful algal blooms for the New Zealand King Salmon Co. Limited Link	Paragraph 16. Most HAB species are flagellates, i.e. They belong to a number of different taxonomic groups that have whip-like flagella which enable them to swim and rapidly change position within the water column in response to light, nutrients, temperature and salinity gradients.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
63	Jun 2012	Statement of evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful algal blooms for the New Zealand King Salmon Co. Limited Link	Figure 1, p. 12, (PDF p. 17). Seasonal changes in (A) water column temperature, (B) nutrients (nitrate + nitrite), and (C) phytoplankton biomass in the Marlborough Sounds. This figure is based on observational data from Tennyson Inlet, Pelorus Sound but these patterns are typical of processes in other embayments throughout the Sounds. The patterns are generally maintained from year to year although the timing, magnitude and species involved vary. 
64	Jun 2012	Statement of evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful algal blooms for the New Zealand King Salmon Co. Limited Link	Figure 3, p. 18, (PDF p. 23). B) Satellite image of **sea surface temperatures** showing cold (~ 10°C), high nitrate, upwelling water off the east coast of the Marlborough Sounds on 18 Feb 2012.). 
65	Jun 2012	Statement of evidence of Angus Lincoln Mackenzie in relation to water column effects: harmful algal blooms for the New Zealand King Salmon Co. Limited Link	Paragraph 54. These upwelling phenomena have been associated with northwest winds resulting from a negative phase of ENSO (Zeldis et al., 200860). However other field and satellite observations of **sea surface temperature** (mackenzie unpub.) Clearly show that upwelling also occurs under positive phase (La Nina) conditions and the frequency and mechanism of these events has yet to be properly identified.

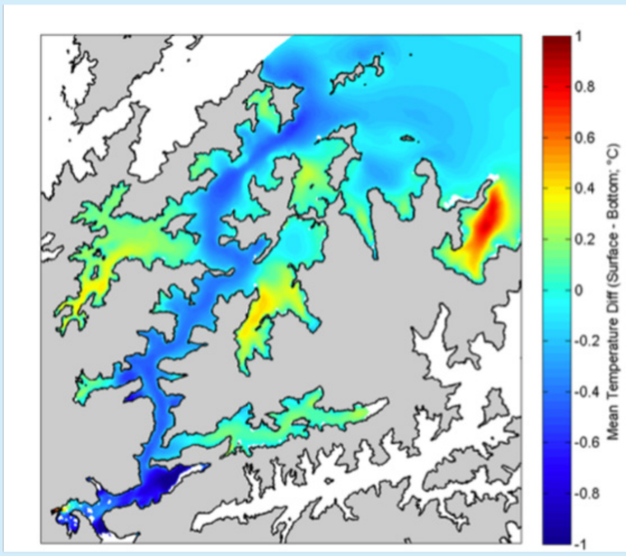
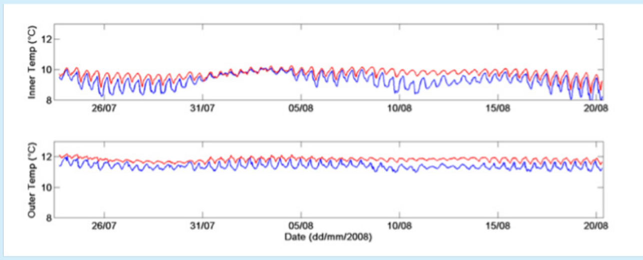
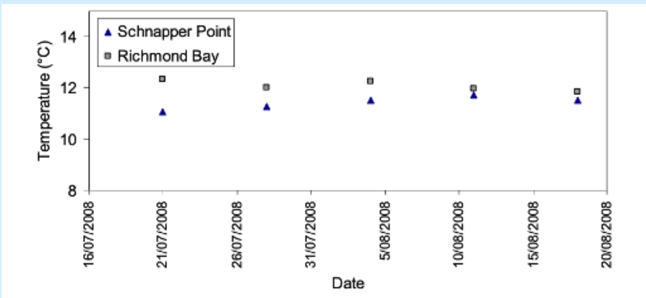
<table>
<tr><th colspan="4">Appendix 1D: 2013 Board of Inquiry</th></tr>
<tr><th>Number</th><th>Date of document</th><th>Name of document</th><th>Excerpt from text</th></tr>
<tr><td>66</td><td>Jun 2012</td><td>Supplementary document of appendices – for the evidence of Nigel Brian Keeley provided in relation to benthic impacts for the New Zealand King Salmon Co. Limited Link</td><td>Paragraph 4.5.1, pp. 21–22.
Ideally the stations should be coordinated with benthic monitoring stations as outlined in Section 4.4 of this report. Seawater concentrations of nutrients (NH4-N, NO3-N, NO2-N and TN) will be analysed in discrete, remotely-collected samples from mid-water depths at each station. Depth profiles of salinity, temperature, chlorophyll a, turbidity and dissolved oxygen will be measured in situ at the same stations using a submersible sensor array.
...
Table 10. Summary of farm-scale monitoring methods.
<table>
<tr><td>Timing:</td><td colspan="2">Two surveys/farm during summer period of maximum feed application</td></tr>
<tr><td>Location:</td><td colspan="2">All proposed farms</td></tr>
<tr><td>Sampling stations:</td><td colspan="2">Cage site (×2), 50m (×3), 150 m (×3), Reference site (×1)</td></tr>
<tr><td>Sampling methods:</td><td>Sampling</td><td>Parameters</td></tr>
<tr><td></td><td>- Duplicate discrete samples at mid-cage depths</td><td>- Nutrients (NH_4-N, NO_3-N, NO_2-N, TN) & phytoplankton biomass (chl a concentration)</td></tr>
<tr><td></td><td>- In situ profiling throughout water column</td><td>- Salinity, temperature, chl a, turbidity, DO</td></tr>
</table></td></tr>
<tr><td>67</td><td>Jun 2012</td><td>Supplementary document of appendices – for the evidence of Nigel Brian Keeley provided in relation to benthic impacts for the New Zealand King Salmon Co. Limited Link</td><td>Paragraph 4.5.2, pp. 22–23.
Comparative stations will also be surveyed at locations where minimal farm enrichment effects are expected. Seawater concentrations of nutrients (NH4-N, NO3-N, NO2-N, TN, DRP, TP and Si) and phytoplankton species and abundance will be analysed in depth-integrated samples at each station. Depth profiles of salinity, temperature, chlorophyll a, turbidity and dissolved oxygen will be measured in situ at the same stations using a submersible sensor array. Surveys will be undertaken at a minimum of three times per year to focus on mid-summer periods of highest feed application rates and periods associated with winter/spring and autumn phytoplankton maxima.
...
Table 11 Summary of wide-scale monitoring methods.
<table>
<tr><td>Timing:</td><td colspan="2">At least 3 surveys (Nov-Feb, Aug/Sep, Apr/May)</td></tr>
<tr><td>Location:</td><td colspan="2">At least 6 stations in each sound</td></tr>
<tr><td>Sampling methods:</td><td>Sampling</td><td>Parameters</td></tr>
<tr><td></td><td>- Duplicate integrated water column</td><td>- Nutrients (NH_4-N, NO_3-N, NO_2-N, TN, DRP, TP and Si) & phytoplankton species and abundance</td></tr>
<tr><td></td><td>- In situ profiling throughout water column</td><td>- Salinity, temperature, chl a, turbidity, DO</td></tr>
</table></td></tr>
<tr><td>68</td><td>Jun 2012</td><td>New Zealand King Salmon Aquaculture Biosecurity Protocol – Annexure to Mark Anthony Preece Link</td><td>Page 2.
Elevated temperature: High temperature is a major factor involved in susceptibility to disease. Disease organisms also multiply rapidly at higher temperature.</td></tr>
<tr><td>69</td><td>Jun 2012</td><td>Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link</td><td>Ruakaka Farm, para 40, p. 12.
The site, the oldest of NZ King Salmon's farms, is characterised by water depths of around 35m and low current flows (average mid-water flow of 3.7 cm/s). Over an annual period, water temperatures at this site range from ~11-18°C. Salmon are raised in 20 steel sea pens (20mx20m) at this site.</td></tr>
<tr><td>70</td><td>Jun 2012</td><td>Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link</td><td>Forsyth Bay, para 44, p. 13.
The farm at Forsyth Bay was originally developed by Southern Ocean Seafoods in 1994. Water depths at the site are around 35m and as with Ruakaka, current flows are classified as 'low' (average mid-water flow of 3.1 cm/s) and average daily water temperatures averaged over recent years fall between ~12-17.5°C.</td></tr>
<tr><td>71</td><td>Jun 2012</td><td>Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link</td><td>Waihinau Bay, para 49.
Water depth at the site ranges from 28- 30m, and water flow is categorised as 'low' to 'moderate' with an average mid- water current speed of 8.4 cm/s. Over an annual period, 5m deep, average daily water temperatures averaged over recent years fall between ~12-17.5°C.</td></tr>
</table>

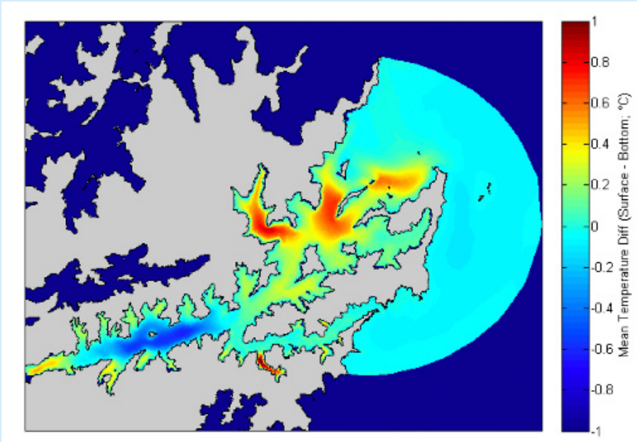
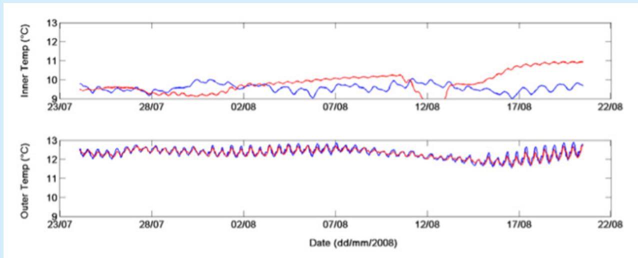
Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
72	Jun 2012	Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link	Otanerau Farm, para 54. Water depth at this site ranges from 37m-39m and current flows are characterised as 'low' to 'moderate' with an average mid-water current speed of 6 cm/s. Average daily water temperatures averaged over recent years fall between ~11.5-18°C, but due to the consistently higher warmer temperatures in summer at this site, salmon are only grown here for nine months of the year (April to January).
73	Jun 2012	Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link	Te Pangu, para 58. Water depth at this site ranges from 27-31m, with 'high' mid-water current water flows averaging 15 cm/s, and water temperatures average daily water temperatures averaged over recent years fall between ~11.5–15.5 °C.
74	Jun 2012	Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link	Clay Point, para 64. This site is located in water depths ranging from 30m-40m and it has the highest water velocities of all of NZ King Salmon's farms with average mid-water flows of 19.6 cm/s. The high water flows, and cooler water temperatures (~10.5-16°C) compared to farms in Pelorus and Queen Charlotte Sounds make this site ideal for growing salmon.
75	Jun 2012	Brief of evidence of Mark Anthony Preece in relation to farm operation detail for the New Zealand King Salmon Co. Limited Link	Crail Bay, para 68. The farms are located in water depths ranging from 19m-31m, and with 'low' mid-water current flows ranging from 2.5-3.5cm/s and water temperature ranging from 11-20°C.
76	Jun 2012	Brief of evidence of Mark John Gillard in relation to site selection and consultation for the New Zealand King Salmon Co. Limited Link	Paragraph 20. The first critical matters are the key appraisals of the physical characteristic required for salmon to successfully grow (rather than perform poorly or possibly die). These are primarily: i. Water temperature - salmon prefer cooler waters and usually grow best in water temperatures between approximately 12 to 17°C; ii. Water depth - which preferably should be at least 30 metres and ideally 40 metres or more; iii. High current - it is generally preferable to grow salmon in areas of high current. Water depth and current can impact on temperature, but are also important in terms of "flushing" by-products from the farm area. It is not an exact science. For example, some warm sites that are at the marginal temperature of 17°C (or even just over in the summer), can be managed if they are for example stocked at times to avoid warm temperatures especially with smolt during their first year in seawater. Our existing site at Waihinau Bay falls into this category, although we have farmed this site for over 20 years we do still experience difficulties with our autumn mortality event.
77	Jun 2012	Brief of evidence of Mark John Gillard in relation to site selection and consultation for the New Zealand King Salmon Co. Limited Link	Paragraph 28. The difficulties with low flow sites generally stem from flow, temperature and depth, which are often related. Slowly moving water has more time to heat up from sunlight. It can stratify, trapping warmer water near the surface. This can add to the already stressful conditions on low flow sites. In contrast, fast moving water brings water from deep cool reservoirs such as Cook Strait. Water moving at speed can be more turbulent which results in water being brought up from depth which has less exposure to sunlight and accordingly heat.
78	Jun 2012	Brief of evidence of Mark John Gillard in relation to site selection and consultation for the New Zealand King Salmon Co. Limited Link	Paragraph 29. Given that King Salmon can generally only thrive in waters less than 17°C, farming in low flow areas creates particular problems when farming in summer months.

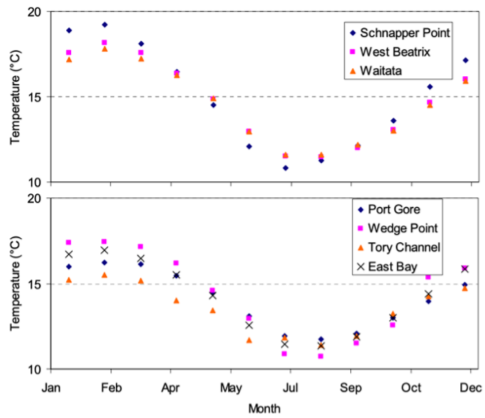
Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
79	Jun 2012	Brief of evidence of Mark John Gillard in relation to site selection and consultation for the New Zealand King Salmon Co. Limited Link	Paragraph 56. The areas considered in the overall assessment but ruled out include: a. The North Island: Temperatures generally too high, and this region is outside the natural range of King Salmon in New Zealand. b. Tasman and Golden Bays: Water temperatures are too high. ... j. Admiralty Bay: Marginal water temperatures in conjunction with low water current flows mean this Bay is considered unsuitable for farming salmon.

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
80	Jun 2012	Brief of evidence of Mark John Gillard in relation to site selection and consultation for the New Zealand King Salmon Co. Limited [Link]	Paragraphs 66–71, pp. 27–29. Map 3 shows the broad maximum temperatures of the Sounds. Marginal, shown in the medium orange represents a temperature of around 17ºC. That is about the limit for which we would farm salmon, and from our knowledge of Waihinau and Forsyth we know water in the medium orange colour can get up to 18.0 ºC in the summer (The long term average for Waihinau is 17.5ºC). The darker orange is almost certainly too warm. The lighter orange and yellow shadings are more ideal. As you might expect, the deep Cook Strait waters are cool and so areas more exposed to the Cook Strait will be cooler, with the waters of the inner sounds warmer. The temperature of the water depends on other factors such as water depth, flows, and degree of stratification and temperature of other sources of water such as rivers and streams. Map 3 demonstrates that salmon farming is likely to be unsuccessful in either the “inner” Pelorus or Queen Charlotte Sounds. In respect of our proposal sites, it shows that the Waitata Reach sites in the Pelorus are “marginal” from a water temperature perspective. Papatua is better and Ngamahau, Ruaomoko and Kaitapeha sites are the preferred sites in terms of temperature. Figure 1 below shows record of temperatures for the period 1 Dec 2009 to 30 April 2010. Data loggers were used to record the data for each of these sites. The Te Pangu data (blue-green line) is from the salmon farm and shows the temperature profile for that period for Tory Channel. Tory Channel has an excellent temperature profile as a result of excellent flushing from Cook Strait as a result of the cool current that runs up the east coast of the South Island. The Ruakaka data is from the salmon farm in Ruakaka Bay (orange line), NZ King Salmon has demonstrated that it is able to successfully farm on this location, the temperature is generally within the preferred range with some levels for short periods in summer to 18ºC. Ruakaka is further from Cook Strait than either the Bottle Rock North-Resolution Bay or Te Pangu sites. I understand that the Ruakaka farm is influenced by the large water body to the south and east but is moderated by the influence of water from Tory Channel. Bottle Rock- North Resolution Bay (purple line) is in the main Queen Charlotte channel near Long Island. This plot shows an elevated (but acceptable) level especially through late January 2010 to mid March 2010. This site is further from the influence of Cook Strait and is therefore warmer during summer than Tory Channel. The Port Gore (blue line) data has been obtained from Melville Cove in Port Gore. This Bay is relatively sheltered with low water flows; the temperatures are generally acceptable but more variable over the mid January 2010 to early March 2010. The Tawhitinui Reach South (red line) and Waitata Nth Danger Point (green line) sites are both in the Pelorus Sound. It is clear that both sites exhibit temperatures above the preferred 17oc and the site most distant from the entrance to Pelorus Sound/Cook Strait (Tawhitinui Reach South) has the highest and for part of the year unacceptable temperatures. The Tawhitinui Reach South site is within the area identified in Map 3 as too warm. The Waitata North Danger Point site is in outer Port Ligar and possibly influenced by that water body. Temperatures are slightly elevated not too dissimilar to the Ruakaka site. This site is within the area identified as marginal in Map 3. **Figure 1: Temperature Records 1 December 2009 to 30 April 2010** 

Appendix 1D: 2013 Board of Inquiry			
Number	Date of document	Name of document	Excerpt from text
81	Jun 2012	Brief of evidence of Mark John Gillard in relation to site selection and consultation for the New Zealand King Salmon Co. Limited Link	Paragraph 74. So, on just the criteria of temperature and exposure, much of the Sounds is not suitable for salmon farming. Map 5 shows those parts of the Sounds that are not suitable for salmon farming based on temperature and exposure alone.
82	Jun 2012	Statement of evidence of Paul James Barter in relation to greywater discharges to coastal water for the New Zealand King Salmon Co. Limited Link	Paragraph 29. Changes in coastal water temperature are a natural phenomenon and generally occur as a result of seasonal, or even diurnal, fluctuations in solar radiation. More rapid and acute changes can occur from upwelling of cooler subsurface waters, inputs from cold freshwater sources like rain or snow melt and even heated inputs from hot springs or hydrothermal vents. While most marine organisms are well adapted to these types of changes, acute variations of several degrees Celsius or more in water temperature can have a marked, and sometimes lethal, effect on individuals as well as more subtle effects on aquatic ecosystems.
83	Jun 2012	Statement of evidence of Paul James Barter in relation to greywater discharges to coastal water for the New Zealand King Salmon Co. Limited Link	Paragraph 31. The assessment showed that greywater from showering would be the likeliest source of increased temperature and the temperature of the discharge could be as high as 40°C with flows of 10 litres per minute for the duration of the shower.
84	Jun 2012	Statement of evidence of Paul James Barter in relation to greywater discharges to coastal water for the New Zealand King Salmon Co. Limited Link	Paragraph 32. Firstly the discharge water from the heat exchanger was the same temperature (i.e. 40°C) as the 'worst-case' NZ King Salmon greywater..... Results of this study showed that the temperature effect was significantly attenuated within 6 m from the discharge point with the change from ambient temperature generally less than 2°C. In other words, a comparative discharge that was 80 times the volume of the proposed NZ King Salmon discharge(s) did not have an effect on temperature outside a few metre radius of the discharge point.
85	Jun 2012	Statement of evidence of Paul James Barter in relation to greywater discharges to coastal water for the New Zealand King Salmon Co. Limited Link	Paragraph 33. On this basis, I consider that the greywater discharge will have a negligible effect on the temperature of the receiving waters within a metre or two of the discharge point.
86	Jun 2012	Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link	Paragraph 3.1.2. Model boundary water temperatures were determined using the mean of dynamic near boundary modelled temperatures (determined by solar forcing and air temperature within the model domain) and predefined BRAN temperature timeseries data to allow for yearly variation. This was implemented in the model through the use of a 'nudging factor' (set at 0.5) for the models.

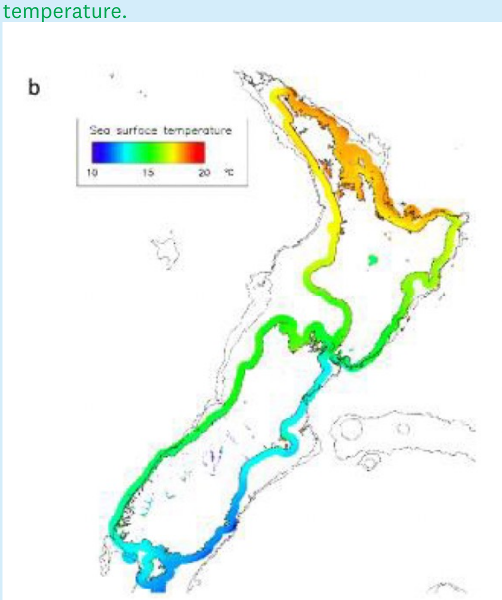
Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
87	Jun 2012	Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link	Paragraph 4.1.3., p. 26, (PDF p. 38). Figure 15. 28 day mean of differences in water temperature (top panel) and salinity (bottom panel) between the surface and bottom of the water column in outer Pelorus Sound. The results demonstrate strong, salinity-driven stratification in the inner sound near the Pelorus River over the period 24 July to 21 August 2008, a period of moderate rainfall and some high river flows. Note that cooler surface temperature differences are driven by the Pelorus River which was parameterised with a constant 10 °C. 
88	Jun 2012	Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link	Paragraph 4.1.3., p. 27, (PDF p. 39). Figure 16. Modelled surface and bottom layer salinity (Salt) and temperatures (Temp) in the inner Pelorus Sound (Kenepuru Entrance; NZMG: 2581594E, 5997845N) and outer Pelorus Sound (Waitata Reach; NZMG: 2590719E, 6025046N) over the period the 24 July to 21 August 2008. 
89	Jun 2012	Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link	Paragraph 4.1.3., p. 28, (PDF p. 40). Figure 17. Observed weekly depth averaged salinity and temperature at an inner Pelorus Sound (Schnapper Point) and an outer Pelorus Sound (Richmond Bay) Site for the modelled period (NIWA unpublished data). 

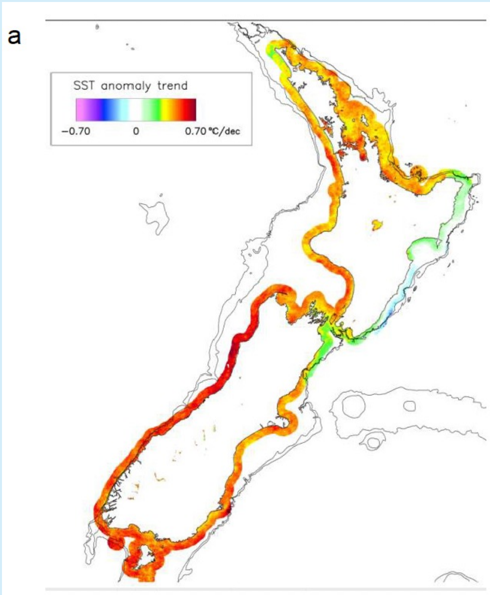
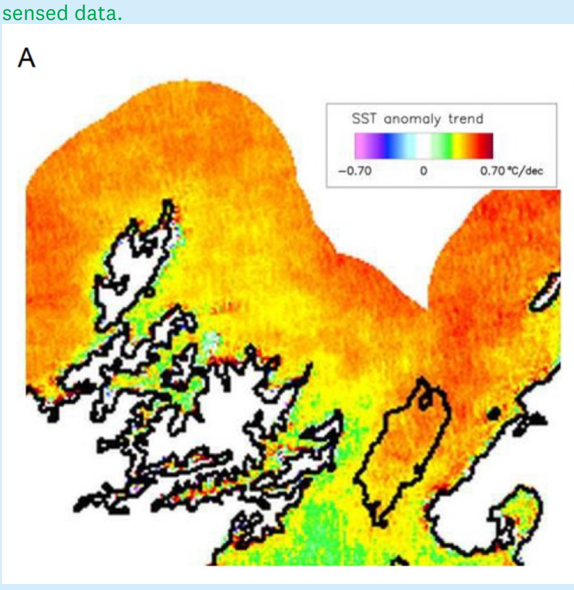
<table>
<tr><th colspan="4">Appendix 1D: 2013 Board of Inquiry</th></tr>
<tr><th>Number</th><th>Date of document</th><th>Name of document</th><th>Excerpt from text</th></tr>
<tr><td>90</td><td>Jun 2012</td><td>Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link</td><td>Paragraph 4.2.3., p. 42, (PDF p. 54).
Figure 33. 28-day mean of surface minus lower water column temperature (top map) and salinity (bottom map) differences in Queen Charlotte Sound over days 60 to 88 of the model run.

</td></tr>
<tr><td>91</td><td>Jun 2012</td><td>Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link</td><td>Paragraph 4.2.3., p. 43, (PDF p. 55).
Figure 34. Modelled surface and bottom layer salinity (Salt) and temperatures (Temp) in the inner Queen Charlotte Sound (Wedge Point, NZMG: 2595415E, 5994759N) and outer Queen Charlotte Sound (Tory Channel, NZMG: 2610346E, 5995577N) over the period the 24 July to 21 August 2008.

</td></tr>
<tr><td>92</td><td>Jun 2012</td><td>Supplementary document of appendices – for the Evidence provided by Benjamin Robert Knight in relation to Water column effects for the New Zealand King Salmon Co. Limited Link</td><td>Paragraph 4.2.3.
Table 9. Summarised temperature and salinity data for Tory Channel and Wedge Point for the years 2003 to 2005 (NIWA unpublished data). Surface data is form the top metre of both sites, 'Deep' data is from 9 m in Tory Channel and 25 m at Wedge Point.
<table>
<tr><th></th><th></th><th colspan="2">Salinity (PSU)</th><th colspan="2">Temperature (°C)</th></tr>
<tr><th>Site</th><th>Statistic</th><th>Surface</th><th>Deep</th><th>Surface</th><th>Deep</th></tr>
<tr><td>Tory Channel</td><td>Min.</td><td>34.15</td><td>33.72</td><td>10.08</td><td>10.01</td></tr>
<tr><td>Tory Channel</td><td>Max.</td><td>35.09</td><td>35.91</td><td>12.94</td><td>12.74</td></tr>
<tr><td>Tory Channel</td><td>Mean</td><td>34.39</td><td>34.67</td><td>11.70</td><td>11.59</td></tr>
<tr><td>Tory Channel</td><td>Count</td><td>29</td><td>18</td><td>32</td><td>26</td></tr>
<tr><td>Wedge Point</td><td>Min.</td><td>33.80</td><td>34.20</td><td>10.94</td><td>10.97</td></tr>
<tr><td>Wedge Point</td><td>Max.</td><td>35.74</td><td>35.91</td><td>12.23</td><td>12.09</td></tr>
<tr><td>Wedge Point</td><td>Mean</td><td>34.39</td><td>35.09</td><td>11.46</td><td>11.41</td></tr>
<tr><td>Wedge Point</td><td>Count</td><td>18</td><td>19</td><td>20</td><td>19</td></tr>
</table></td></tr>
<tr><td>93</td><td>Jun 2012</td><td>NZ King Salmon Plan Change Requests and Resource Consent Applications Planning Report Link</td><td>Paragraph 68, p. 14.
c. Targeted water column surveys for the purpose of quantifying the localised effect of individual farms on surrounding water quality. This shall involve a series of fine-scale surveys in the vicinity of the farm (and reference areas) over a two year period, measuring: salinity, temperature, chlorophyll, turbidity, dissolved oxygen (DO), nutrient concentrations, phytoplankton composition and biomass along transects that move away from the farm and span potential nutrient gradients.</td></tr>
</table>

Appendix 1D: 2013 Board of Inquiry			
Number	**Date of document**	**Name of document**	**Excerpt from text**
94	Mar 2012	Plan Change and Resource Consents for New Water Space - Social Impact Assessment prepared for New Zealand King Salmon by Taylor Baines & Associates Link	Endnote 18. Due to relatively warm water temperatures, the salmon farm at Otanerau Bay operates only nine months of the year. During January-March, the Otanerau Bay salmon farm is not farmed.
95	3 Nov 2011	Recommendation of the EPA to the Hon Kate Wilkinson, Minister of Conservation Link	Paragraph 12. Salmon farming requires sites with particular characteristics including deep water, good water currents and consistently cool temperatures. These characteristics are restricted to particular areas of the Marlborough Sounds.
96	Aug 2011	The New Zealand King Salmon Company Limited: Assessment of Environmental Effects – Water Column Link	Page 7. Seawater temperatures in inner Pelorus Sound are alternatively warmer in summer and cooler in winter than outer Sound waters reflecting the shallow, low salinity conditions in the inner Sound and the moderating influence of Cook Strait in the outer Sound.
97	Aug 2011	The New Zealand King Salmon Company Limited: Assessment of Environmental Effects – Water Column Link	Page 9. The Marlborough Sounds are temperate with water column temperatures generally ranging between 10 and 20°C depending on the time of year and location (see Appendix 4).
98	Aug 2011	The New Zealand King Salmon Company Limited: Assessment of Environmental Effects – Water Column Link	Page 78, (PDF p. 88). **Appendix 4. Unpublished data from CTD surveys**  **Figure 4.1.** Mean monthly depth-averaged column temperatures at MSQP monitoring sites in Pelorus Sound (upper), Port Gore and Queen Charlotte Sound (lower) for the period .

Appendix 2: Aquaculture Variations 1 and 1A

Appendix 2A: Aquaculture Variations – Variations 1 and 1A (Consultation Documents) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
1	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page i, (PDF p. 5). Using the available historical data, we found no evidence of a correlation between chlorophyll anomalies and expansion of the marine farming industry (as determined by area of approved marine farms measured at bay scale). In contrast, there is evidence that inter-annual fluctuations in river flow are correlated with the anomalies and it is possible that rising sea temperatures may also play a role.
2	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Endnote 6, p. 4, (PDF p. 12). The cell-specific chlorophyll content can vary through time in response to fluctuations in temperature, light, nutrients etc. Filtration should take place as soon after the water-sample has been gathered as practical.
3	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 5, (PDF p. 13). More recently, sensors have been developed to measure fluorescence in intact water samples. A suitable light source is used to briefly illuminate the water sample and a sensor measures any subsequent fluorescence. The sensors can be preprogrammed to measure fluorescence at high frequency (e.g. every few seconds). The fluorescence sensor is usually mounted alongside other sensors (e.g. temperature, salinity, turbidity, dissolved oxygen) to allow simultaneous monitoring of several important water properties.
4	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 8, (PDF p. 16). Diatoms tend to contain more chlorophyll per unit cell carbon than other taxa and dinoflagellates tend to contain less than other taxa—but there is a lot of overlap amongst taxa. Indeed, the absolute and relative chlorophyll content varies through time at the level of an individual phytoplankter—being influenced by the ambient light intensities, nutrient concentrations and temperatures that the plankter has experienced over preceding hours/days (e.g. Geider et al. 1998).
5	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Endnote 7, p. 8, (PDF p. 16). The efficiency with which even pure water absorbs electromagnetic radiation depends upon the wavelength of the radiation. Water absorbs infra-red (heat) radiation more efficiently than it absorbs visible light. Thus, satellite measurements of water-temperature typically amount to measurements of temperature in the upper few tens of cm of the water-column. In contrast, measurements made in the visible spectrum (e.g. measurements of chlorophyll) typically amount to measurements across the upper few metres. Since the concentrations of coloured solutes and particulates (which also influence absorption) can fluctuate day-to-day at a location, the depth across which measurements extend can vary day-to-day at any one location.
6	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 15, (PDF p. 23). Ultimately, a simulation model consists of: Aug 2020 1. State variables (quantities that characterise the state of the system: e.g. water temperature, salinity, water velocities, nutrient and phytoplankton concentrations etc.) 2. Process descriptions (equations describing the rates of state change as functions of the present state of the system [incl both internal state and state at the boundaries]). Some process descriptions (such as those describing the evolution of water temperature and water motion) derive from well understood fundamental relationships. Others (notably those relating to many of the biological processes) are better described as 'theoretically plausible but merely empirically determined relationships'.

Appendix 2A: Aquaculture Variations – Variations 1 and 1A (Consultation Documents) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
7	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 19, (PDF p. 27). Collectively, these studies indicate: (i) chlorophyll (and indeed, particulate organic matter in general) is usually present in lesser quantities within/immediately downstream of mussel farms than upstream of them (but sometimes, the reverse has been observed), (ii) the difference appears to fall back towards zero within tens to a few hundred metres of the downstream edge of the farm, (iii) the magnitude of difference can be very variable across time at any one farm and across farms. When depletion has been observed, it has tended to be greater at times of the year when phytoplankton are expected to be growing only slowly (higher summer—when inorganic nutrients are scarce, and mid-winter when temperature and light-levels are low).
8	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 26, (PDF p. 34). Figure 5a illustrates the 1997–2018 average of satellite-sensed near-surface chlorophyll in the coastal strip around New Zealand. The averages sit around 0.3-1.5 mg chl m-3 around most of New Zealand. Figure 5b illustrates the corresponding average satellite-sensed near-surface temperatures—which range from around 11 °C up to around 18 °C. Figure 5b … (b) near-surface satellite-sensed temperatures around New Zealand (reproduced from figures 3-10 of Pinkerton et al. (2018b)). The time-average periods are 1997–2018 for chlorophyll and 1981–present for temperature. 

Appendix 2A: Aquaculture Variations – Variations 1 and 1A (Consultation Documents) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
9	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Pages 26–27, (PDF pp. 34–35). Figure 6 illustrates the estimated 1997–2018 time-trends for (a) satellite-sensed temperature and (b) satellite-sensed chlorophyll concentrations around the New Zealand coastline. Sea-surface temperatures have tended to rise around all parts of the coastline. Warming has been most rapid along the west coast of the South Island and least rapid around the SE flank of the North Island and the open, east coast of Marlborough. Conversely, the chlorophyll concentration has been downward around much (but not all) of New Zealand's coastline including the western and central region of Cook Strait. Figure 6a Plots illustrating the long-term trend (Sen slope) for deseasoned monthly satellite-sensed temperature and satellite-sensed chlorophyll concentrations (adapted from figures 3-14 of Pinkerton et al. (2018b)). Trends are calculated for the 2002–2018 period. 
10	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Figure 7, p. 28, (PDF p. 36). Long-term trends (Sen's slopes) for (a) near-surface temperature and (b) near-surface chlorophyll in the Cook Strait region using satellite sensed data. 

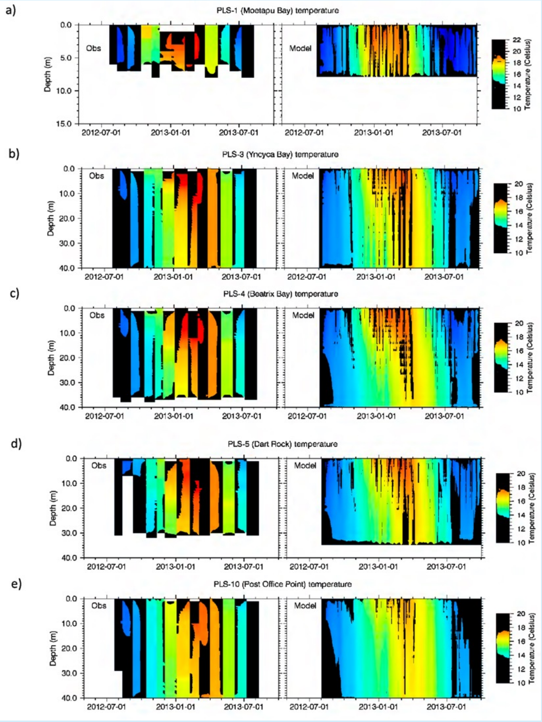
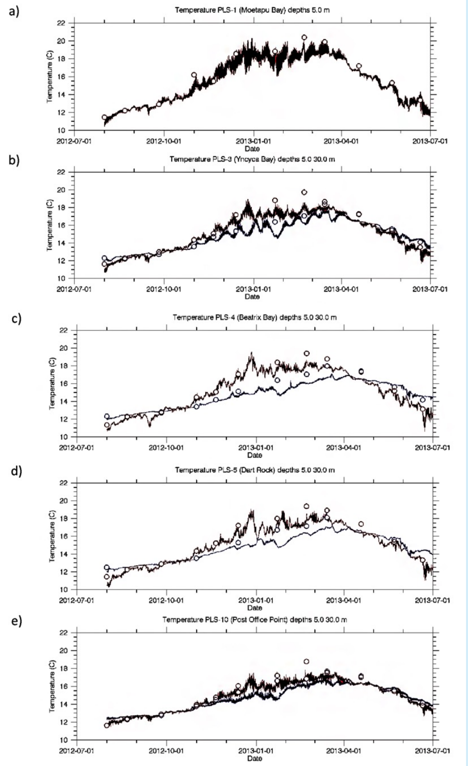
Appendix 2A: Aquaculture Variations – Variations 1 and 1A (Consultation Documents) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
11	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 32, (PDF p. 40). NIWA is applying Generalized Additive Models (GAMs) to explore the correlations between deseasoned chlorophyll concentration (i.e. differences between instantaneous chlorophyll concentration and the long-term average for the time of year) and candidate explanatory variables (including anomalies of time-averaged river flow, water temperature, ENSO-state, wind stress, and bay-scale area of approved mussel farms). Preliminary indications are that the approved area of mussel farms is not retained as a useful explanatory variable (of chlorophyll fluctuations and long-term decline) in the optimal GAMs17.
12	Aug 2020	10. Measuring mussel farming effects on plankton in the Marlborough Sounds 23/03/2021	Page 33, (PDF p. 41). In the absence of controlled, experimental manipulations, the GAM analysis (or any alternative one) can only exploit the realised environmental time-series for chlorophyll, temperature, total area of approved marine farms, river flow, study ID, etc. Thus, our GAM analysis is analogous to a correlation analysis and it is worth repeating the aphorism 'correlation need not imply causation'.
13		11. NZIER - Economic contribution of marine farming in the Marlborough region 23/03/2021	Page 9, (PDF p. 17). New Zealand salmon production has reduced from about 12,800 tonnes in 2012 to 10,800 tonnes in 2014. While warmer water temperatures contributed to higher fish mortality rates in some bays in the Marlborough Sounds, a greater impact has come from changes in fish husbandry to lower density that reduces mortality and improves the premium quality of the flesh.
14	Aug 2013	14. Overview of Ecological Effects Aquaculture 23/03/2021	Page 16. The capacity of the environment to disperse and assimilate finer mussel farm biodeposits is largely determined by water depth and current speeds, although the carrying capacity of the environment may also vary seasonally in relation to the factors, such as water temperature. Increased flushing not only reduces localised sedimentation and accumulation of organic matter, it also increases oxygen delivery to the sediments allowing for more efficient breakdown of organic material.
15	Aug 2013	14. Overview of Ecological Effects Aquaculture	Page 25. For example, in the New Zealand summer of 2010/11 an OsHV-1 strain was identified as a cause of 50 to 80 percent die-off of oyster spat in most North Island Pacific oyster farms. It appears this virus may have been present in New Zealand waters since at least 1991, where it caused mass mortality of oysters in a hatchery in the Mahurangi Harbour, but did not manifest in farmed or wild stocks until 2010, possibly triggered by stress related to unusually high summer water temperatures. Until that time there were no documented serious parasites or pathogens of Pacific oysters from the 30-year history of farming this species in New Zealand.
16	Aug 2013	5. Chapter 3 - Benthic effects review of ecological effects of aquaculture 23/03/2021	Page 8. The capacity of the environment to disperse and assimilate farm wastes is primarily a function of water depth and current speeds, although assimilative capacity may also vary seasonally in relation to factors such as water temperature. Water depth and current speeds affect the extent of flushing, therefore, they are the primary attributes that modify both the magnitude and spatial extent of seabed effects.
17	Aug 2013	5. Chapter 3 - Benthic effects review of ecological effects of aquaculture 23/03/2021	Page 23. The capacity of the environment to disperse and assimilate mussel farm biodeposition is largely determined by water depth and current speeds (i.e. flushing capacity), although the assimilative capacity of the environment may also vary seasonally in relation to factors such as water temperature. Increased flushing not only reduces localised sedimentation and accumulation of organic matter (Hartstein & Rowden 2004), it also increases oxygen delivery to the sediments, allowing for more efficient breakdown (i.e. mineralisation) of organic material (Findlay & Watling 1997).

Appendix 2A: Aquaculture Variations – Variations 1 and 1A (Consultation Documents) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
18	Nov 2013	6. Keeley - Quantifying and predicting benthic enrichment lessons learnt from southern temperate aquaculture systems 23/03/2021	Pages 210–211, (PDF pp. 234–235). A better understanding of the role of the dynamic and complex bacterial communities that are an important but poorly understood component of the benthic ecology (Bissett et al. 2007) may help explain these anomalies in the temporal cycles. It is likely that temperature / season also played a role by influencing metabolic rates (including that of the bacterial communities) and near-bottom oxygen levels.
19	Jun 2019	7. Best Management Practice Guidelines for Salmon Farms in Marlborough 23/03/2021	Page 35. Fish stocking and harvesting strategies also vary considerably between farms, but historically the summer months have been associated with the highest feed use. Mid to late summer also generally coincides with highest water temperatures and hence highest benthic mineralisation rates and oxygen consumption, and therefore benthic impacts.
20	Feb 2018	2. Draft - Boffa Miskell, 2018. Existing marine farms in Outstanding Overlays. Appropriateness of marine farms in the Marlborough Sounds. 18/12/2020	Page 25. The Marlborough Sounds' marine environment is diverse, notable for its connections to Cook Strait and its highly convoluted form of interconnected sounds, inlets, bays, reaches, and channels with numerous islands, stacks, headlands and reefs. Several physical variables (e.g. shelter/exposure, temperature, salinity, turbidity/ sedimentation, depth, substrate, tides and currents) create overlapping layers of complexity to the Sounds' marine environment. Aquaculture tends to be located within western parts of the Sounds (i.e. concentrated in Pelorus Sound).
21	Feb 2018	2. Draft - Boffa Miskell, 2018. Existing marine farms in Outstanding Overlays. Appropriateness of marine farms in the Marlborough Sounds. 18/12/2020	Page 78. Opportunities for re-organising existing aquaculture outside of outstanding areas should also be encouraged as part of a district wide assessment for the location of aquaculture. Factors other than landscape and natural character, such as water quality, water temperature, ecology and navigation should all be documented to encourage a balance between the ongoing appropriate location of aquaculture and landscape protection in the Marlborough Sounds.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
1	Feb 2021	Submission 102 - McGuinness Institute 04/05/2021	Page 6. (iii) … In reality, the uncertainty is being driven by concerns by NZKS about its business model, and in particular the rising of water temperatures in the Marlborough Sounds.
2	Feb 2021	Submission 102 - McGuinness Institute 04/05/2021	Page 17. It is important that any decisions made going forward take into consideration climate change. Given that NZKS has indicated their business model is being challenged by rising water temperatures, it acts as a warning that the total ecosystem in the Marlborough Sounds will come under increasing stress in the short term. For example, removing farms (rather than increasing areas farmed), is likely to remove stress on an already stressed system. Looked at this way, salmon farming is the canary in the coalmine. If an ecosystem is being stressed, the goal should be to destress it.
3	Feb 2021	Submission 102 - McGuinness Institute 04/05/2021	Page 21. (iii) … (b) The Exposed: Climate change and infrastructure report (January 2019) discussed a maturity index framework. The proposed variations and plan indicate that MDC has a long way to go before getting to a 'making progress' level. We appreciate this is hard work, but climate change is not simply about sea level risk and 'adaptation' – it is also about water temperature risk, acidification, biodiversity risk and the all-important 'mitigation'. See the table below.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
4	Feb 2021	Submission 102 - McGuinness Institute 04/05/2021	Page 25. Further evidence of this is the fact that the '19. Climate Change' in the proposed plan does not mention salmon farming (or finfish) being challenged by warmer temperatures caused by climate change21 (nor its section 32 evaluation of climate change)22, yet variation 1A and its 'Section 32 Evaluation' promote finfish farming as being an important contributor to the local and regional economy (page 32) but with minimal mention of climate change.
5	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 1, p. 15, (PDF p. 112). Regions of slow currents are more likely to incur benthic impacts and receive less food. Waite (1989) identified slow current speed, low food concentration, high salinity and high temperature as factors that may limit feeding and growth of P. canaliculus.
6	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 3, para 4.5, p. 17, (PDF p. 186). It is not appropriate to base the majority of impact assessments and farm management on chlorophyll a measurement – the composition of the phytoplankton is likely to be far more important, which has been shown to be reliant on nutrient species, stratification, water temperature, etc. (Ross et al., 1998).
7	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 10, (PDF p. 257). Stratification in Pelorus Sound is generally driven by salinity. In summer time, when river flows are generally low, warmer surface temperatures can strengthen stratification. In winter, surface salinities can be sufficiently low to allow the surface water to become cooler than that of deeper waters.
8	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 11, (PDF p. 258). The hydrodynamic model produces summer-time water temperatures which are a bit too low. Since phytoplankton and zooplankton physiology is temperature dependent, this (or possibly incorrect parameterisation of the temperature dependence) could have subtle influences upon emergent population growth rates and standing stocks.
9	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 18, (PDF p. 265). ROMS is a fully 3 dimensional model and is able to simulate the currents forced by tides and wind, as well as the effects of density differences caused by variations in temperature and salinity.
10	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 21, (PDF p. 268). For the 1994-1995 and 1997-1998 periods, lateral boundary data for the Cook Strait simulations was taken from an implementation of ROMS for the New Zealand region, forced by six-hourly surface fluxes, essentially repeating the work of Rickard, Hadfield and Roberts (2005). In either case the purpose of the Cook Strait model was to generate realistic temperature, salinity and currents at the entrance to Pelorus Sound.
11	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 22, (PDF p. 269). Surface heat fluxes in both the Cook Strait and Pelorus Sound models were calculated using data (6- hourly averages) from a global atmospheric analysis system called the NCEP Reanalysis (Kalnay, Kanamitsu et al. 1996), with a heat flux correction term that causes the model **sea surface temperature (SST)** to be nudged towards observed **SST** (the NOAA Optimum Interpolation 1/4° daily **SST** dataset (Reynolds, Smith et al. 2007)). The heat flux correction prevents the modelled **SST** from departing too far from reality due to any biases in the surface fluxes, but has a negligible effect on day-to-day variability.
12	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, para 2.54, p. 26 (PDF p. 273) Beginning in July 2012, Marlborough District Council with NIWA support has measured monthly vertical profiles of temperature and salinity with a CTD (conductivity-temperature-depth) instrument at 11 sites (Figure 2-7) in Pelorus Sound. (At 7 of these sites water quality samples were also collected, see Section 4.4.) The CTD data are compared with hydrodynamic model output in Section 3.1.1.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
13	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, para 3.1.1, pp. 27–29, (PDF pp. 274–276). Figure 3-1 shows the temperatures measured by the monthly CTD surveys as colour plots against time and depth axes, along with comparable model data. (However note that the way the CTD data are graphed suggests the temperature is uniform throughout the month, but in fact it only applies to a period of an hour or so, and there is considerable within-month variability in the actual temperatures, just as there is in the model.) The panels of Figure 3-1 show 5 sites from inner to outer Pelorus Sound: PLS-1 (Moetapu Bay) in Mahakipawa Arm, PLS-3 (Yncyca Bay) in Popoure Reach; PLS- 4 (Beatrix Bay); PLS-5 (Dart Rock) in western Tawhitinui Reach; and PLS-10 (Post Office Point) in Waitata Reach. Site locations are shown in Figure 2-7. At all the sites there is a clear seasonal variation in near-surface temperature, from 10–12 °C in late winter to 18–20 °C in late summer. At the sites in the inner Sound the winter minimum is lower and the summer maximum higher than in the outer Sound: the time series plots below will show this more quantitatively. The depth profile of temperature is nearly uniform in late winter: perhaps a little cooler at the surface than at the bottom, but again the time series plots show this better. The warming in spring is confined to the top 10 m or so of the water column, but as summer progresses this warm layer thickens and eventually occupies the full depth, down to the 40 m shown in the figures. Overall, Figure 3-1 suggests that the variation of temperature with depth and time agrees well between the model and the CTD measurements, with the obvious limitation that the CTD data are monthly snapshots. Figure 3-2 is a comparison of the temperature measured by the CTD with co-located model data- like Figure 3-1 above—but in this case the data are plotted as time series from two depths, 5 and 30 m. At the innermost and shallowest site, PLS-1 (Figure 3-2a), where there are no 30 m data, the 5 m modelled temperature agrees with the CTD data (bearing in mind the limitations of the CTD data). At all other sites there is good agreement between the model and the measurements in winter and early spring, but from late spring to late summer, the model is biased low by 1-1.5 °C. However the difference in temperature between the two depths remains about right. The model's temperature bias in summer in Pelorus Sound is thought to be a result of the amplitude of the seasonal cycle in **SST** in Cook Strait being too low. This might be a result of a bias in the surface heat flux formulation (which is based on coarse-resolution data from a global-scale model) or maybe excessive tidal mixing in the areas with high tidal current speeds in Cook Strait (see Figure 3-8 below). A noticeable feature of the temperature time series at the four deeper sites in Figure3-2 is that the near-surface is warmer than the water below in summer, but cooler by as much as 1-2 °C in winter. Given that water expands as it warms, a lower surface temperature can only be maintained if the surface water is less saline, and the salinity data presented below confirm that this is the case. This phenomenon of a cool surface water layer in winter was noted in Beatrix Bay by Sutton and Hadfield (1997) and appears to be a ubiquitous feature in Pelorus Sound.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
13	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021 (continued)	**Figure 3-1: Observed and modelled temperature profiles** Temperature versus time and depth from monthly CTD casts (left) and model (right) for 5 sampling locations shown in Figure 2-7: a) PLS-1; b) PLS-3; c) PLS-4; d) PLS-5; e) PLS-10.  **Figure 3-2: Observed and modelled temperature time series** Temperature at two depths (blue lower, red upper) from monthly CTD casts (symbols) and model (lines) for 5 sampling locations shown in Figure 2-7: a) PLS-1; b) PLS-3; c) PLS-4; d) PLS-5; e) PLS-10. 

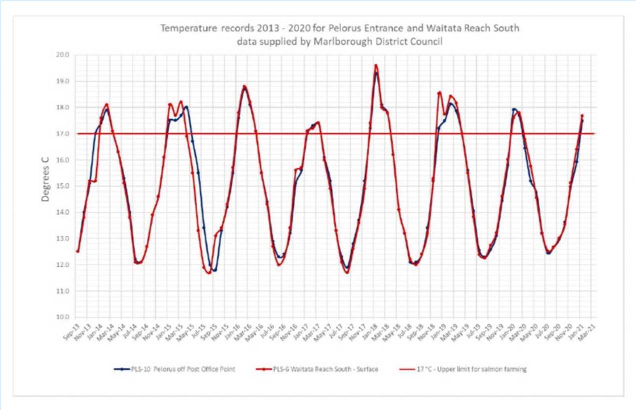
Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
14	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 52, (PDF p. 299). The model's salinity and temperature agree well with observations. The model does tend to under- predict summer temperatures by 1-1.5 °C, however the difference in water temperature between surface and near bed remains about right. This may indicate a deficiency in the model's surface heat flux formulation, which was derived from a global, coarse resolution atmospheric model, or maybe excessive tidal mixing in Cook Strait. However, the model allows stratification to develop to approximately the right extent in Pelorus Sound suggesting that vertical mixing processes are resolved sufficiently well.
15	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, pp. 107–108, (PDF pp. 354–355). The combination of higher summertime water temperatures (permitting greater specific filtration rates by the mussels) and higher summertime seston concentrations imply that the rates of ingestion and faeces/pseudofaeces production are several times greater in summer than in winter. ... Ammonium excretion tends to be highest in summer reflecting the influence of water temperature upon basal respiration, and the fact that fish are growing most rapidly at that time of year.
16	26 Feb 2021	Submission 90 - Clova Bay Residents Association Incorporated 27/04/2021	Attachment 8, p. 113, (PDF p. 360). [T]he hydrodynamic model is yielding summertime water temperatures which are a bit too low. Since phytoplankton and zoo plankton physiology is temperature dependent, this (or possibly incorrect parameterisation of the temperature dependence) could have subtle influences upon emergent population growth rates and standing stocks. We emphasize that the temperature effects that are mediated through physiological changes are likely to be small. As a rule of thumb, the rates at which physiological processes proceed approximately double for each 10 °C temperature increment[38]. Thus, the fact that simulated summertime water temperatures are approximately one °C too low implies that all temperature-dependent rates (primarily, ingestion (hence, egestion) and respiratory excretion) will be underestimated by about 5-10% [38] This is a rule-of-thumb that applies within an ectothermic organism's 'tolerable temperature range'. At more extreme (low or high) temperatures, the rates will drop rapidly toward zero due to temperature-induced damage to enzymes and cell structures. Differing functional forms (and/or coefficient values) have been adopted to describe the temperature dependencies of the various planktonic growth processes and mussel/fish ingestion, egestion and respiration processes (see appendices) but none imply a temperature- dependence that is markedly different from two-fold for ten degrees.
17	N/A	Submission 83 - Friends of Nelson Haven and Tasman Bay Inc 27/04/2021	Page 2. Warmer waters will not only have an impact on the natural world, aquaculture industry itself is also not immune to a changing coastal environment. Biodiversity response of our coastal environment to climate change is likely negative and aquaculture productivity itself is also not immune to a changing coastal environment. Mussel value may decline in the future due to warmer waters. Total annual production of Greenshell Mussels nationwide has been static at about 90,000 tonnes, but this tonnage was harvested from 2,600 ha in 2006, while in 2019 5,500 ha was required for this volume. Higher water temperatures are also causing significant thermal stress for salmon operations with declining productivity. About 8000 tonnes was produced around 2011, similar to the 2018 harvest but now including three newly operational farms. Most of the salmon farms have major issues with compliance and mortalities (or disease), calling into question the appropriateness of this industry in warmer coastal waters.

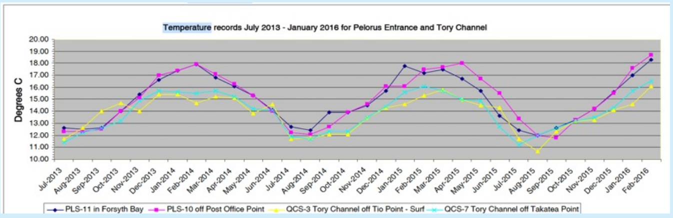
Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
18	N/A	Submission 83 - Friends of Nelson Haven and Tasman Bay Inc 27/04/2021	Page 18. Modelling studies of shag species has provided insight into interaction between shags and their environment. Water temperature and dive depth very much influence the energetic cost of diving but foraging parameters of shags are most strongly influenced by the availability of prey. Even a small reduction in prey density will prevent Great Cormorants meeting their daily energy requirements65. A reduction of prey density of only 25% resulted in an increase of search time of 50%-100%. If prey density decreases to 50%, females will fail to reach the foraging efficiency of 1.0, irrespective of temperature or diving depth. Foraging birds have to meet efficiency 1.0 to survive under given conditions.
19	26 Feb 2021	Submission 72 - Marine Farming Association Inc and Aquaculture New Zealand 27/04/2021	Paragraph 28. In respect of **Variation 1A**, the MARINE FARMING ASSOCIATION INCORPORATED and AQUACULTURE NEW ZEALAND seek that that Variation be withdrawn in its entirety for the following reasons: ... (g) There are substantial environmental changes affecting the Marlborough Sounds. In addition to changes from terrestrial sources, climate change is having a significant influence on sea temperatures across New Zealand. It is predicted that sea temperatures will rise ahead of air temperature, with the oceans taking up more than 90% of the excess heat of the climate system.By attempting to fix everything in place, Variation 1A does not provide for adaptation to climate change.
20	26 Feb 2021	Submission 72 - Marine Farming Association Inc and Aquaculture New Zealand 27/04/2021	Schedule 1, para 55. In contrast, there is evidence that inter-annual fluctuations in river flow are correlated with the chlorophyll anomalies and it is possible that rising sea temperatures may also play a role.
21	26 Feb 2021	Submission 67 - Peter Martin 27/04/2021	(PDF page 3). Our understanding of the FAMAs suggests that when finfish farms in the Outer Pelorus/Te Hoiere fail to operate within their consents (likely as temperatures are too high), other aquaculture will take that space, and MDC will offer more space in the open water CMUs.
22	26 Feb 2021	Submission 57 - The New Zealand King Salmon Co Ltd 27/04/2021	Paragraph 19, pp. 4–5. (f) There are substantial environmental changes affecting the Marlborough Sounds. In addition to changes from terrestrial sources climate change is having a significant influence on sea temperatures across New Zealand. It is predicted that sea temperatures will rise ahead of air temperature, with the oceans taking up more than 90% of the excess heat of the climate system. [11] Pörtner, H. O., Roberts, D. C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., & Weyer, N. (2019). IPCC special report on the ocean and cryosphere in a changing climate. IPCC Intergovernmental Panel on Climate Change: Geneva, Switzerland, 1(3). [Summary for Policy Makers A.2].
23	26 Feb 2021	Submission 57 - The New Zealand King Salmon Co Ltd 27/04/2021	Paragraph 21, pp. 5–6. NZ King Salmon has responded to environmental change and will continue to do so: (a) It will continue to produce significant volumes of salmon from Tory Channel, which tends to be more than two degrees cooler than other parts of the Marlborough Sounds. This temperature differential provides the best conditions for growing salmon; ... (e) It is developing ways of farming which are more tolerant to higher temperatures or do not need to be at sea in the hotter months; ... ... (h) The Crail Bay farm in particular is an ideal research farm as we develop technology and under selective breeding will provide insight against warmer temperatures. NZ King Salmon is constantly seeking to improve the genetic stock of its salmon, and to breed for tolerance to higher temperatures;

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
24	N/A	Submission 53 - Te Ohu Kaimoana 27/04/2021	Page 7. It is clear that any proposal must recognise and take into account the warming of the waters in the Sounds and provide a long-term solution that will allow sustainable salmon farming ventures that operate within acceptable environmental limits. Necessarily this must consider the role of all sites currently consented, the proposed new sites (and surrendering of some as a result), the manner in which each these could operate for the ranges of temperature based off existing technology and effective management measures to ensure fish health, and for the scenarios of both with or without the Blue Endeavour site. To ensure that consideration is robust, more field data is being collected.
25	26 Feb 2021	Submission 34 - Clifford Bay Marine Farms Ltd 27/04/21	Paragraph 15, (PDF p. 3). This relief is sought in order to future proof the Marlborough mussel industry from climate change. It seeks that consideration be given to the expected effects of the global warming crisis. Water flows into the Marlborough Sounds from Australia, with the result that the water temperature rises slightly annually. The water in CMU 8 comes from the Antarctic and is on average 4 degrees cooler. Sites such as this will be vital for the industry as the environment continues to change.
26	17 Jan 2021	Submission 2 - Neil McLennan 27/04/21	Page 6. Industry records of marine farm productivity provide the best dataon "mussel food" quantity and quality change over time. Mussel farm productivity is known to vary with seawater temperature and location (e.g. localized water movement) as well.
27	17 Jan 2021	Submission 18 - Richard and Christine Wright 27/04/21	Page 2. We write in opposition of the proposed salmon farm to be relocated to Horseshoe Bay in Pelorus Sound. We own the house in Horseshoe Bay and note when this site was first suggested, it was stated that there were no houses in this bay, which is incorrect. We are strongly opposed for the following reasons – • There are already nine mussel farms in the bay which take up the majority of the coastline of the bay. One of which appears to be on or very close to the proposed site of the salmon farm. We attach a map showing the mussel farms in the bay • We understand that there have been high mortality rates (40% in 2018) in Waitata salmon farm and can see no reason why this site would be less as the water temperature will be higher here than Waitata. • We understand that salmon farms can increase the likelihood of algal blooms which will have an effect on the shellfish in the bay. • We are concerned for the increase in seals and sharks that the salmon farm will attract. • We are concerned for the damage that the salmon farm will have on the seabed and marine life on this site.
28	N/A	Submission 111 - Te Ātiawa Manawhenua Ki Te Tau Ihu Trust 27/04/2021	Paragraph 22, (PDF p. 6). Climate Change: Is there adequate relevant science around the farming of shellfish and ocean acidification and related effects on calciferous organisms? Rising and unreliable peak summer temperatures are also a climate change issue for the Sounds – data / information / knowledge: Appropriate specific response in Variation 1?
29	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Page 2. The Association submits in opposition to these proposals and believes they should be declined. A primary driver for our opposition is that sea water temperatures in these areas are unsuitable (too warm too often for too long) for the sustainable farming of King Salmon. The Association wishes to be heard at the public hearing and will be represented.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
30	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Page 3. Board of Inquiry: … The evidence from a senior NZKS employee Mr Gilliard as to key criteria for successful salmon farming was enlightening. He saw seawater temperature as critical criteria1. To our surprise the Pelorus /Waitata thermocline mapping he put up and talked to indicated that this area was marginal in terms of desirable seawater temperatures. Unfortunately, for whatever reason, in making its decision this admission and its consequences for animal health and disease risk passed the BOI panel by. Concurrently it had emerged that an existing NZKS salmon farm – Waihinau - had suffered an intense summer mortality event. The BOI permitted cross-examination but NZKS expert witnesses were not forthcoming to the Association as the to the whys or any detail of this event.
31	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Page 4. The Panel's report: The Association decided, given the clear adverse effects from this proposal, it had no choice but to participate in this one sided process and obtained expert advice in conjunction with other community groups on likes of adverse impacts on Landscape and Natural Character values and the insignificant economic value of the proposals for the Nelson and Marlborough regional economies. We also deployed what we had leant since the BOI on the adverse impacts of sea temperatures and disease and mortality related events. In relation to the latter point the Panel largely dismissed these concerns on the grounds it had not received any evidence as to long term sea temperature rises in the Pelorus Sound
32	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Page 5. NZKS Waitata Extension Application: The Association along with other community groups contested a poorly thought out and deeply flawed 2019 application by NZKS to extend its Waitata farm pen area from that granted by the BOI. This was against a background of two severe mortality spikes in NZKS Pelorus farms linked to warm sea temperatures over the summers of 2017/18 and 2018/19. In due course the hearing Commissioner declined the application.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
33	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Pages 6–7. 6. Sea Water Temperatures trends in the Pelorus As previously noted the BOI process brought to our attention the likelihood of elevated summer seawater temperatures preventing sustainable farming of King Salmon in the Waitata/Pelorus area. Concurrently there was a significant mortality event at an existing NZKS farm – Waihinau. We decided to investigate matters further. One of the outcomes has been our monitoring of seawater temperatures using Council-monitoring data. Bearing in mind the upper range of the preferred temperature we attach as Schedule One a graph showing seawater temperatures at the monitoring point at the Pelorus entrance (Post Office point). Note the time the temperature sits above the 17 degree bound. We put a similar graph to the Panel. The Panel's view on Climate Change: However as noted the Panel back in 2017 decided that it had received no empirical evidence as to long term sea water change as a result of climate change or otherwise and thus could not see an issue for the proposed activities. As can be seen from the Schedule One graph, Nature, in the following summer (2017/2018) slammed the issue home with a pronounced temperature spike. Some commenters were keen to label this event as an abnormal one off event. So again Nature rubbed the point home with another elevated seawater temperature spike the following summer (2018/2019). The point is of course that even on a medium term basis the area is inappropriate for additional salmon farms - contrary to what Council and Variation 1A assumes. Latest Science – Warming Sea temperatures: To put adverse thermocline matter in further focus, we note a very recent refereed scientific paper in the New Zealand Journal of Marine and Freshwater Research. The authors directly attempted to identify trends in terms of sea temperature rise in Pelorus Sound over the period 2002 – 202013. The paper concludes in its discussion at page 12 that the data sets reviewed provide convincing evidence that the waters of the Pelorus Sound have warmed over the study period. The paper notes further that summertime water temperatures in the Sound already climb above those at which King salmon exhibit symptoms consistent with thermal stress and additional warming will further reduce the suitability of these waters for salmon farming.
34	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Page 7. 7. Placement of FAMAs in Inappropriate Areas – Mortality and Disease risk ... Now we have the Council adopting without any real examination the recommendations of the advisory Panel report whose myopic view of the existence and consequences of unsuitable current sea temperatures (and likely rising ones) were exposed within a short time of the release of its report. Of particular note has been the saga of disease and fish mortality spikes as Nature rams home the fact that in the medium term any further increase in King Salmon farming in the Waitata Reach and Pelorus Sound is inappropriate.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
35	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Page 8. In essence the Panel was confident that the new BOI sites and the proposed new farm locations they were now recommending in the Waitata Reach/Pelorus were the desired high flow cool sites that would not suffer these events. Unfortunately this “blind eye” approach ignores a physical fact. The water temperature is more or less the same everywhere in this area. As noted, almost immediately the Panel’s confidence that cool high flow sites would solve any issues was proved wrong. More Mortality Spikes: Based on our ongoing monitoring of sea temperatures we were aware that the summers of 2017/2018 and 2018/2019 produced higher temperatures for a longer period. Media reports confirmed mortality was high. By this stage NZKS was a listed NZX company and some overall mortality data was publicly available. Not farm specific though.
36	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule One, p. 16. Temperature Time Graph Series for Pelorus Sound 
37	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 19. 20. Based on my experience, there are two overarching critical matters to consider in determining whether it is feasible to farm salmon productively: a. The first critical matters are the key appraisals of the physical characteristic required for salmon to successfully grow (rather than perform poorly or possibly die). These are primarily: i. Water temperature - salmon prefer cooler waters and usually grow best in water temperatures between approximately 12 to 17 °C; ii. Water depth - which preferably should be at least 30 metres and ideally 40 metres or more; iii. High current - it is generally preferable to grow salmon in areas of high current. i. Water depth and current can impact on temperature, but are also important in terms of "flushing" byproducts from the farm area. It is not an exact science. For example, some warm sites that are at the marginal temperature of 17 °C (or even just over in the summer), can be managed if they are for example stocked at times to avoid warm temperatures especially with smolt during their first year in seawater.

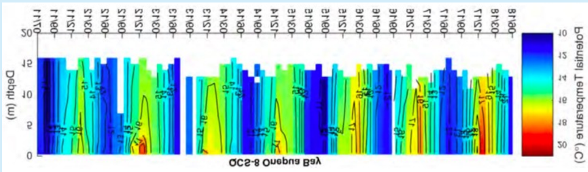
Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
38	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 20. Figure 1. 2014 and 2015 Average Monthly Temperatures in Outer Pelorus Sound and Tory Channel  The Pelorus is significantly warmer than Tory Channel and the average monthly temperatures in the summer are above the ideal temperature range of 12 – 17 °C for king salmon. In the Marlborough Sounds, Tory Channel, from a temperature point of view, provides the best growing conditions forsalmon, exhibiting the correct water temperature, good depth and high current flow.
39	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 21. Chinook (King) Salmon farming (the species favored by NZKS) is < 1% of total salmon farming in the world, Unfortunately this means there is not much data available on the web about the specific requirements of Chinook. Coho Salmon come closest. However, there seems little disagreement that Chinook Salmon grow best when temperatures are in the range of 12–17 °C, while water currents have to be sufficient to disperse wastes and provide a continuous supply of well-oxygenated water. Chinook (King) Salmon remain in seawater for 15–18 months and are harvested after reaching 3.5–4.0 kg. Coho Salmon tolerate a wide array of oceanic conditions but grow best when temperatures are in the range of 9–15 °C, and water currents are sufficient to disperse wastes and provide a continuous supply of well-oxygenated water. Our research suggests that stocking densities at harvest should not exceed 8–12 kg/m³. Coho Salmon remain in seawater for 10–12 months and are harvested after reaching 2.5–3.5 kg. Best management practices dictate that a seafarm should contain only a single year class of fish. This practice reduces the risk of disease transmission to arriving smolts. Atlantic Salmon seem to grow best in sites where water temperature extremes are in the range 6–16 °C, and salinities are close to oceanic levels (33-34 per cent). Water flows need to be sufficient to eliminate waste and to supply well oxygenated water (approximately 8 ppm).
40	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, pp. 21–22. Our research shows that: Because [sic] water temperature affects the health of individual fish, it also affects entire populations and species assemblages. Temperature may directly affect salmonids in obvious ways, or indirectly through interaction with other important variables. (Dunham et al. 2001). For example: – Given sufficient magnitude and time, high temperatures can cause weight loss, disease, competitive displacement by species better adapted to the prevailing temperature, or death (Sullivan et al. 2000). – When fish are stressed by any one process, they are less able to deal with other stressors. Salmonids already stressed by high water temperature will be less able to deal with a second stressor (e.g., **toxic pollutant, pathogen). Warmer temperatures often increase the infection rate or virulence of fish pathogens and lessen the ability of a fish to withstand disease** (Materna 2001) (Emphasis added).

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
41	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 23. As can be seen from the GSI data, the global figures show an average normal mortality rate of 6- 6.5% per year. Mortality rates > 10% are seen to be, as we understand it, caused by an abnormal event, like disease or infestation or high water temperature or a combination of all three.
42	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 25. 2015 Mortality Event ... The following is taken from an interview reported on Stuff on 13 March 2015, with NZKS CEO Mr. Rosewarne: "*NZ King Salmon chief executive Grant Rosewarne said warm sea temperatures at the company's Waihinau Bay farm, in Pelorus Sound, had contributed to the deaths. Rosewarne would not say for commercial reasons how many salmon had died, or how many fish were at the farm, but said the mortality rate was a "multimillion-dollar problem to solve".* *Water temperatures at the Waihinau Bay farm had stayed above 18 degrees Celsius for three months, Rosewarne said. "I don't think we've ever had it quite as bad as this year." The increased salmon death rate in the Pelorus Sounds started in mid-February, Rosewarne said.*
43	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 26. From what MPI was prepared to confirm and in subsequent discussions it seems MPI has ruled out feed as a primary causative agent. MPI believed water temperature alone not to be the primary cause either. They preferred to point to a range of possible causative factors. MPI confirmed that they had collected past and present mortality data as well as temperature and other environmental data for analysis, but they did not share this data with us due to commercial sensitivity issues.
44	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 26. To date MDC records show that the Sound water temperatures in this El Niño year are even higher than in 2015. We will endeavour to find out what is happening at Waitata Bay. Given their close proximity we believe the Waihinau, Forsyth and Waitata farms could well share the same pathogens.
45	23 Feb 2021	Submission 110 - Kenepuru and Central Sounds Residents Association 27/04/2021	Schedule Two, p. 27. A likely consequence of high seawater temperatures during summer, combined with low to medium current flows, is to stress the salmon to the point of dying en masse from heat stress. It is possible that associated salmon pathogens are now endemic in the Pelorus.
46	23 Feb 2021	Submission 109 - Guardians of the Sounds 27/04/21	Page 3, (PDF p. 5). Salmon mortalities and disease: The variation section 32a report speaks of the benefits of high flow sites and cooler waters. At the BOI Waitata Reach site was promoted as the "best possible site in terms of flow and water temperature". In fact there have been mortality events of 40% at some farms. The water temperatures in Waitata Reach are too high resulting in mass deaths in July 2017 and again in 2019. If 40% of any farmed animals on land were dying because of disease and stress there would be a public outcry. Things have changed since the 2013 BOI. Water temperatures are increasing and the inner sounds is clearly not suitable for salmon farming. The continuation of salmon farming in the Sounds is inconsistent with the NZCP precautionary principle policy 8.

Appendix 2B: Aquaculture Variations – Variations 1 and 1A (Submissions received) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
47	N/A	Submission 108 - Marlborough Recreational Fishers Association 27/04/21	Page 1. 1. Commercial salmon rearing. The Association strongly opposed the establishment and expansion of salmon farms in the Sounds, when it was first proposed. We argued that first; the Sounds were environmentally inappropriate, being subject to high summer water temperatures, above the upper lethal limit for salmon in cramped conditions, and second, that the poor maintenance practices were likely to lead to accumulation of uneaten food material and faeces on the region underneath the farms. In addition the Association was concerned about the practice of using pilchards from Chile, a low quality product, to make fish food to fatten salmon to feed a high-end market. The Association suggested at the time that King Salmon were adopting a strategy akin to pig farming, at a time when the industry was pursuing more ecologically sound methods. Around the world, salmon farmers were moving first to deep water pens, and then to land-based systems. Sure enough, within a few years there were mass fish deaths, probably as a result of elevated temperatures or disease.
48	N/A	Submission 105 - Bridget and Tony Orman 27/04/21	Page 3. With reference to King Salmon's salmon farms, the water temperature is too warm, with high death rates and many tonnes of dead, at times diseased salmon, dumped at Havelock and Blenheim land fills.

Appendix 2C: Aquaculture Variations – Variations 1 and 1A (Further Submissions - received) Link			
	Date on document	**Name of document and Date uploaded**	**Excerpt from document**
1	31 January 2021	Further submission F127 - Friends of Onapua Bay Inc - Additional information - Variation 1B 08/09/2021	Pages 13–14, (PDF pp. 104–105). Instruments were deployed within the Tory Channel and Queens Charlotte Sound (and small bays within) to gain real time data from which to calibrate and validate the hydrodynamic and biophysical models. Furthermore, monthly salinity and temperature profiles, collected by the Marlborough District Council, were also used for model calibration and validation.
2	31 January 2021	Further submission F127 - Friends of Onapua Bay Inc - Additional information - Variation 1B 08/09/2021	Page 14, (PDF p. 105). From the results of the hydrodynamic model, Hadfield et al. (2014) were able to make the following conclusions: ... • The sub-tidal flow described above averaged over the final year of the simulation is 660 m3/s but there is a slow variation between less than 500 m3/s in winter to 1800 m3/s in early autumn. This variation does not appear to be related to wind but might be related to the seasonal variation in temperature and salinity.

Appendix 2D: Aquaculture Variations – Variations 1 and 1A (Section 42A reports) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
1	25 Aug 2021	Variation 1 Apex Marine Farm Submission and Further Submission - Appendix B 8/10/2021	Page 36, (PDF p. 43). It has been argued that carrying capacity concerns should be informed by considering current relative to historic bivalve and other filter feeder densities (Dumbauld et al., 2009; Bastien-Daigle et al., 2007). However, Newcombe and Broekhuizen (2018) suggested that rising sea temperatures may have played a role in declining phytoplankton levels in Pelorus Sound. This means that the carrying capacity for oysters and mussels (and other filter feeding organisms) may be less than it has been historically and that it may continue to decline as sea temperatures continue to increase.
2	25 Aug 2021	Variation 1 Apex Marine Farm Submission and Further Submission - Appendix B 8/10/2021	Page 41, (PDF p. 48). Changes to vertical mixing and the partial blocking of some water layers due to the presence of farm structures and crop can affect stratification, the layering of water caused by differences in temperature and salinity (Ministry for Primary Industries, 2013).

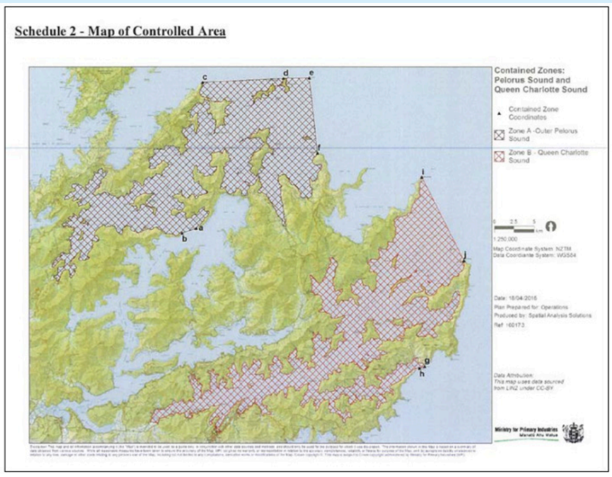
Appendix 2D: Aquaculture Variations – Variations 1 and 1A (Section 42A reports) Link			
Number	**Date on document**	**Name of document and Date uploaded**	**Excerpt from document**
3	25 Aug 2021	Variation 1 Apex Marine Farm Submission and Further Submission - Appendix B 8/10/2021	Page 18, (PDF p. 142). In their review of MDC’s water quality State of the Environment monitoring data collected from 2011 to 2018, Broekhuizen and Plew (2018) present temperature, salinity, dissolved oxygen, turbidity8, and chlorophyll a profile data from a site in Onapua Bay at approximately 16 m water depth. Data are collected monthly using a CTD (conductivity-temperature-depth) instrument. Temperature ranges from approximately 10 to 18°C. The water column is generally well mixed in winter, but temperature stratification is apparent in summer with bottom water temperatures not warming as much as surface waters. Sporadically reduced salinities in surface water likely reflect freshwater inflows from strong rainfall events. It appears what salinity varies between years with particularly low values in 2016 and 2017 but this may be an artefact. The water column of Onapua Bay is generally well oxygenated with oxygen saturation typically above 90%.
4	25 Aug 2021	Variation 1 Apex Marine Farm Submission and Further Submission - Appendix B 8/10/2021	Figure 6, p. 19, (PDF p. 143). Temperature, salinity, dissolved oxygen, and chlorophyll a data collected from Onapua Bay between 2011 and 2018 as part of MDC’s water quality SOE monitoring programme. Source: Broekhuizen and Plew (2018). 
5	25 Aug 2021	Variation 1 Apex Marine Farm Submission and Further Submission - Appendix B 8/10/2021	Page 30, (PDF p. 154). Newcombe and Broekhuizen (2020) analysed chlorophyll a concentration data from Pelorus Sound since the early 1980s. Their analysis indicated that phytoplankton concentrations (as measured by chlorophyll) in the Sound have declined at some sites since the 1980s (consistent with declines around much of New Zealand’s coastline over the past 20–30 years) but emphasised that they found no evidence of a correlation between chlorophyll anomalies and expansion of the marine farming industry. In contrast, they attributed this trend partially to inter-annual fluctuations in river flow and raised the possibility that rising sea temperatures may also play a role.
6	8 Oct 2021	Volume 4 Coastal Management Units and Aquaculture Management Areas s 42A Report 8/10/2021	Paragraph 736, pp. 120–121, (PDF pp. 124–125). Kenepuru and Central Sounds Residents’ Association253 oppose FAMA 6 in CMU 28: Maud Island and FAMA 7 in CMU 44: Waitata Reach on the basis that it is in breach of the NZCPS and Part II of the RMA. Further, they say that the sea water temperatures make the locations unsuitable for finfish. They provided background material with their submission to support this view. Finally, the Association noted the proximity to the King Shag feeding and colony areas.

Appendix 3: MPI reports

Appendix 3A: MPI Aquaculture report			
Number	**Date of document**	**Name of document**	**Excerpt from text**
1	Sep 2019	The New Zealand Government Aquaculture Strategy Link	Page 15. Selective breeding can drive significant gains: – Resilience gains to a changing environment: temperature, pH, diseases and pests

Appendix 3B: MPI reports on salmon deaths			
Number	**Date of document**	**Name of document**	**Excerpt from text**
1	Dec 2019	Legal controls to manage the spread of an unwanted organism in Marlborough farmed salmon Link	Page 1. Over the past few summers there have been higher than usual numbers of fish deaths on some Marlborough salmon farms. It is likely the increased death rates are due to a range of factors. These may include environmental factors (like water temperature), management practices at affected farms and exposure of salmon to bacterial infection.
2	May 2017	Intelligence Report Link	Page 2, (PDF p. 6). During 2012 MPI tested tissue samples from dead fish but could not find a definitive cause of mortality. The Ministry concluded that there were likely to be multiple factors at play including the farm site, water temperature and flow, and feed.
3	May 2017	Intelligence Report Link	Page 6, (PDF p. 10). NZKS moves smolt from hatcheries to the seafarms during spring and autumn. In spring, smolt from Tentburn are transferred to Ngamahau, Te Pangu, and Clay Point. Between March and May fish from these farms are transferred to Otanerau, a farm which is only stocked in the cooler winter months due to high water temperatures in summer. In autumn, smolt from Tentburn are transferred to Waitata, Ruakaka, and Te Pangu. In order to meet harvest demands, some fish are counted and size graded about 6 months after seawater entry.
4	May 2017	Intelligence Report Link	Page 8, (PDF p. 12). On post-mortem examination, affected fish were found to have inflammation of the heart, liver, and muscle tissues, which was not consistent with other common infectious salmon diseases. There were also no obvious acute changes in environmental conditions (e.g. dissolved oxygen content, water temperatures, or weather events), management practices (e.g. feeding changes, grading events, or harvesting events), or predation that could explain the increase in mortality.
5	May 2017	Intelligence Report Link	Page 12, (PDF p. 16). T. maritimum is a bacterium that grows optimally in water temperatures ranging from 15°C to 35°C. Mortality rates in susceptible fish species increase with higher water temperatures and lower water salinities, which favour pathogen replication. T. maritimum is only found in the marine environment, not in freshwater. Previous outbreaks in farmed salmonids have also been linked to extended periods of cloud-free days with water temperatures elevated above 20°C.
6	May 2017	Intelligence Report Link	Page 12, (PDF p. 16). The severity of outbreaks may be related to differences in environmental and management conditions. The optimal temperature for pathogen replication in laboratory culture is between 15°C and 18°C, whereas survival outside the fish is significantly increased at water temperatures below 10°C. Periods of rapidly fluctuating temperature have also been associated with outbreaks of P. salmonis.

Appendix 3B: MPI reports on salmon deaths			
Number	**Date of document**	**Name of document**	**Excerpt from text**
7	May 2017	Intelligence Report Link	Page 18, (PDF p. 22). This mortality event may have been unusually severe due to higher water temperatures (a greater number of days where the water temperatures exceeded 18°C) and an abrupt decline in feed intake approximately 4 to 6 weeks prior to the mortality peak that was not associated with any known dietary or management changes. These factors may have created an optimal environment for pathogen replication and/or predisposed fish to developing clinical disease through the immunosuppressive effects of thermal and nutritional stress. Apart from water temperature, Secchi depth, and the presence of T. maritimum, there were no other significant differences in environmental conditions or management practices between the six production sites that could explain the variation in mortality rates.
8	May 2017	Intelligence Report Link	Page 18, (PDF p. 22). Assuming that both T. maritimum and NZ-RLOs are ubiquitous in the Marlborough Sounds region and may have been present for some time, the multivariate analysis findings suggest that high water temperatures coupled with an acute drop in feed intake may predispose fish to experiencing unusually high mortality rates.
9	May 2017	Intelligence Report Link	Page 25, (PDF p. 30). Kakariki Proteins Ltd advised that no berley is produced by or sold from their facility. All salmon waste received by them is rendered at a high temperature over a long period of time sufficient to inactivate any pathogens. The fish meal produced is used in pet food.
10	Oct 2015	Unusual mortality rates in Marlborough farmed salmon Link	Page 1. At the time of the 2012 event, MPI tested tissue samples from dead fish but could not find a definite cause. The Ministry concluded that there were likely to be multiple factors at play including the farm site, water temperature and flow and feed.
11	Oct 2015	Unusual mortality rates in Marlborough farmed salmon Link	Page 1. MPI is planning to sample fish from marine farms in other regions of the country to see if the bacteria are present there. This sampling will take place later in the summer when water temperatures increase and a mortality event is more likely to occur.
12	Nov 2014	Best Management Practice guidelines for salmon farms in the Marlborough Sounds: Benthic environmental quality standards and monitoring protocol Link	Page 32. In the case of NZ King Salmon farming in the Marlborough Sounds, many of the farms contain multiple year-classes and so there is often no single sampling period. Fish stocking and harvesting strategies also vary considerably between farms, but historically the summer months have been associated with the highest feed use. Mid to late summer also generally coincides with highest water temperatures and hence highest benthic mineralisation rates and oxygen consumption, and therefore benthic impacts.
13	Jul 2013	Salmon Mortality Investigation Link	Page 6. Dissolved oxygen and water temperatures are routinely monitored by the farm, but no obvious changes were observed by the farm operator that would account for the increased mortality (e.g., higher than usual water temperature, decreased dissolved oxygen, algal blooms). No recent husbandry activities such as grading or changes to feed were evident.

Appendix 3C: MPI reports on The 2017 salmon investigation report – search for 'contained zones'			
Number	**Date of Document**	**Name of Document**	**Excerpt from text**
1	May 2017	Intelligence Report Link	Page 21, (PDF p. 25). Given the potential significance of a RLO detection in New Zealand, on 19th October 2015 NZKS were served with a Notice of Direction under section 122 of the Biosecurity Act 1993 requiring them to apply all 'status red' biosecurity measures detailed in their Biosecurity Management Plan (dated 10th July 2015). This included the cleaning and disinfection of equipment and personal protective equipment (PPE), disposal of dead fish and restricting the movement of equipment and stock between farming operations. Dead salmon could only be taken out of the contained zones for human consumption or rendering.
2	May 2017	Intelligence Report Link	Pages 21–22, (PDF pp. 25–26). On 20th April 2016 a Controlled Area Notice (CAN) was implemented under section 131 of the Biosecurity Act 1993 to limit the spread of New Zealand Rickettsiaceae species as unwanted organisms, protect other marine salmon farming areas from an incursion of these species, and to monitor associated risk pathways for the movement of Rickettsiaceae species to other parts of New Zealand. Ministry for Primary Industries The CAN specified two Contained Zones (A & B) (Appendix 1) and detailed movement restrictions on risk items such as salmon, salmon products and waste products, farm-related vessels, farming equipment, and Personal Protective Equipment.
3	May 2017	Intelligence Report Link	Page 22, (PDF p. 26). 7.1.4 Notice of Direction July 2016 On 18th July 2016 NZKS were served with a Notice of Direction under section 122 of the Biosecurity Act 1993 to cease the distribution of bait and berley products derived from farmed salmon taken within the Marlborough Sounds Contained Zones as specified in the CAN.
4	May 2017	Intelligence Report Link	Page 23, (PDF p. 27). 8.2 Section 131 Audit June 2016 The second audit took place on 22nd and 23rd June 2016 with NZKS being audited against the s131 Controlled Area Notice which required them to apply for permits before moving specified items out of the two contained zones. The following locations were visited during the audit: • NZKS Waitata farm • NZKS Waihinau Bay farm • NZKS Ruakaka farm • NZKS Te Pangu Bay farm • NZKS offices, Picton • O'Donnell Park Barging Ltd offices, Picton
5	May 2017	Intelligence Report Link	Page 36, (PDF p. 40). Appendix 1: Controlled Area Notice Contained Zones Map of Contained Zones A & B imposed pursuant to s131 of the Biosecurity Act 1993.  Map of Contained Zones A & B imposed pursuant to s131 of the Biosecurity Act 1993.

Appendix 4: Not related to NZKS but related to Marlborough Sounds

<table>
<tr><th colspan="4">Appendix 4A: NIWA Reports</th></tr>
<tr><th>Number</th><th>Date of document</th><th>Name of document</th><th>Excerpt from text</th></tr>
<tr><td>1</td><td>2016</td><td>The Climate and Weather of Marlborough Link</td><td>Page 22.
Monthly mean sea surface temperatures off the coast of Marlborough are compared with mean air temperature for Blenheim Research EWS in Figure 13. Between March and September, mean air temperatures are lower than mean sea surface temperatures. However in the warmer months, mean air temperatures are higher than mean sea surface temperatures. Figure 14 shows the mean sea surface temperatures for the New Zealand region for February and August, which are the warmest and coolest months with respect to sea surface temperatures.

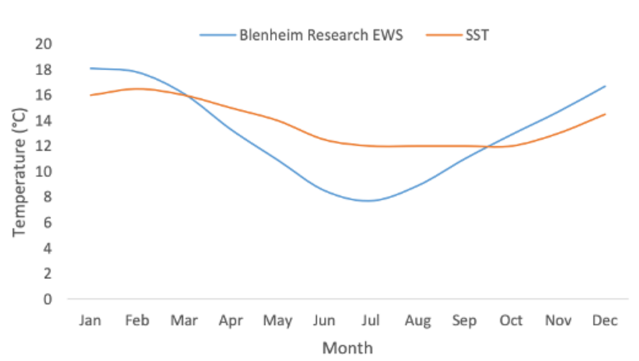


Figure 13. Mean monthly land (Blenheim Research EWS) and sea surface temperatures (off the coast of Blenheim).

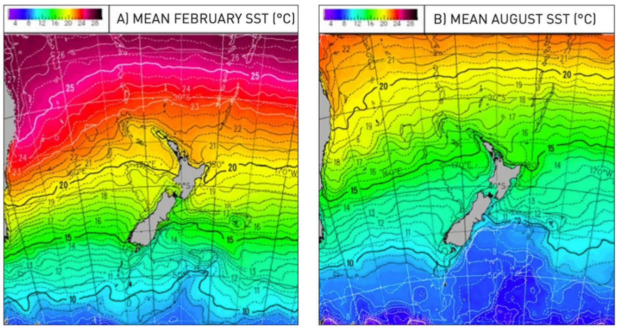
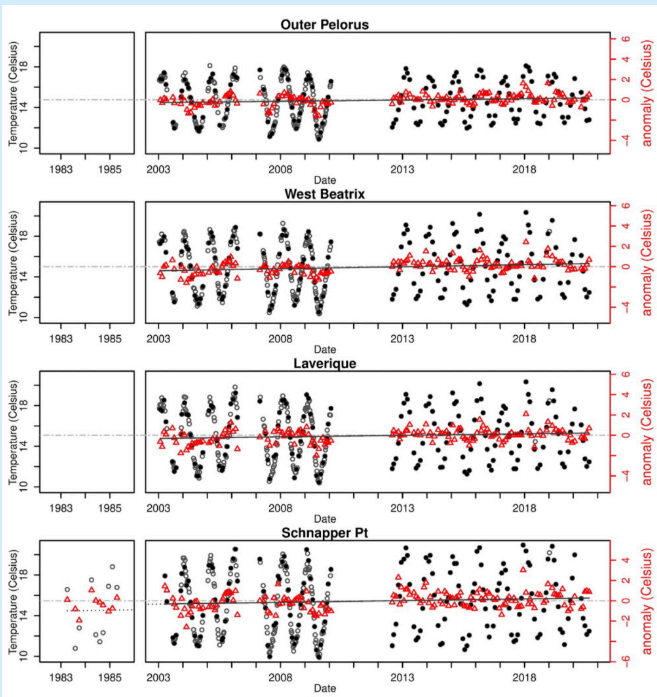


Figure 14. Monthly mean sea surface temperatures (°C) for: a) February; b) August. Source: NIWA SST Archive, Uddstrom and Oien (1999).</td></tr>
<tr><td>2</td><td>Sep 2011</td><td>Estimation of feed loss from two salmon cage sites in Queen Charlotte Sound Link</td><td>Pages 11, 15.
Water temperature, water clarity (secchi depth), dissolved oxygen, the total amount of feed distributed and the duration of each feed were recorded.

Table 3-1: Number of feed pellets and environmental data recorded at the Ruakaka and Clay Point farms. Eight sampling traps were deployed at each time of sampling at each farm (see text for details). 'nr' not recorded. * on this occasion the feed monitoring equipment failed and did not stop feed distribution when the fish stopped feeding. ** this sample consisted of two small pieces of pellet..
<table>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th></th><th colspan="8">Trap number</th><th></th><th></th></tr>
<tr><th>Location</th><th>Date</th><th>Time</th><th>Water temp (°C)</th><th>DO (ppm)</th><th>Secchi depth (m)</th><th>Duration of feed (min)</th><th>Direction of tidal flow</th><th>Tide time Picton</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>Mean</th><th>SE</th></tr>
<tr><td>Ruakaka</td><td>22/9/11*</td><td>07:30</td><td>12.2</td><td>8.8</td><td>9</td><td>26</td><td>north</td><td>08:15 (0.4)
14:29 (1.0)</td><td>234</td><td>128</td><td>51</td><td>3</td><td>1</td><td>656</td><td>54</td><td>1</td><td>141.00</td><td>78.83</td></tr>
<tr><td></td><td>26/9/11</td><td>16:30</td><td>11.6</td><td>7.6</td><td>7</td><td>nr</td><td>south</td><td>08:12 (1.3m)
13:22 (0.2m)</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0.25</td><td>0.164</td></tr>
<tr><td></td><td>27/9/11</td><td>07:30</td><td>12.9</td><td>8.5</td><td>7</td><td>nr</td><td>north</td><td>0858 (1.4)
14:09 (0.1)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0.13</td><td>0.125</td></tr>
<tr><td>Clay Point</td><td>22/9/11</td><td>14:25</td><td>12.6</td><td>nr</td><td>nr</td><td>6</td><td>east</td><td>08:15 (0.4)
14:29 (1.0)</td><td>0</td><td>0</td><td>0</td><td>2</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0.25</td><td>0.250</td></tr>
<tr><td></td><td>23/9/11</td><td>10:00</td><td>12.6</td><td>nr</td><td>nr</td><td>23</td><td>east</td><td>09:48 (0.5m)
17:06 (1.0)</td><td>1**</td><td>0</td><td>2</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0.50</td><td>0.267</td></tr>
</table>
</td></tr>
</table>

Appendix 4B: Other supporting documents			
Number	**Date of document**	**Name of document**	**Excerpt from text**
1	21 Jan 2021	Sea temperature rise over the period 2002-2020 in Pelorus Sound, New Zealand – with possible implications for the aquaculture industry Link	The residual flow through Cook Strait is usually NW to SE (Tasman Sea to eastern Pacific) (Stevens 2014; Chiswell et al. 2016) and there is ample evidence indicating that north-westerly winds can trigger upwelling events in western Cook Strait that subsequently influence water properties within Pelorus Sound (Zeldis et al. 2008; Chiswell et al. 2016). North-westerly winds tend to be more frequent during El Niño conditions. The symptoms of upwelling events (lower water temperatures, higher nutrient concentrations etc.) tend to be more evident during the summer months. In most years, peak summertime water temperatures in inner and central Pelorus Sound exceed 18°C (e.g. Figure 2). During two recent ocean heatwave years (BOM & NIWA 2018) they remained above 20°C for several weeks. Figure 2. 15 m depth-averaged temperatures (black circles, left axis), temperature anomalies (i.e. differences from the long-term median of the RCTS data for the calendar month; red triangles, right axis) and the estimated Sen-slope trend-line (black line). The trend-line is solid if the data indicate that the trend is positive with probability >0.95. Otherwise, it is drawn with long dashes. The anomalies are drawn centred upon the mean of the relevant components of the RCTS (pale grey dashed line). Solid circles and triangles indicate the records that were retained for use after sub-sampling to monthly resolution. Open grey circles and open triangles indicate the records that were excluded by the sub-sampling. The image for Schnapper Point also shows temperature data from studies undertaken in the early 1980s (Gibbs et al. 1991; Hickman et al. 1991; Gibbs et al. 1992) and the extrapolated trend-line (short-dashed line). The data from the 1980s were not a part of the set used to estimate the Sen-slope trend (because the absence of any data during the latter 1980s and 1990s introduces an undesirably long gap into the composite time-series). Plots were generated using the gap.plot() function from the Plotrix package (Lemon et al. 2020). 
2	17 Oct 2019	Sea-surface temperature Link	What is measured This indicator measures the temperature of the first few metres of surface water in coastal and ocean regions around New Zealand using satellite data.

Appendix 4B: Other supporting documents			
Number	**Date of document**	**Name of document**	**Excerpt from text**
3	17 Oct 2019	Sea-surface temperature Link	**Why it is important** Measuring oceanic sea-surface temperature tells us how fast the topmost layer of the ocean is warming. This surface layer (called the surface mixed layer) is where the majority of oceanic primary production usually occurs. Increased temperatures can affect primary production rates. As primary production is the process that forms the basis of food webs in the marine environment, temperature changes in this layer can have broad impacts on marine ecosystems. Measuring changes in coastal sea-surface temperature helps us estimate temperature changes throughout the water column where greater mixing occurs.
4	2 Feb 2018	Hotter-than-normal water kills off salmon in the Sounds Link	Salmon in the marlborough sounds are dying in their farms as an “extraordinarily hot” summer continues to take its toll on marine life.
5	2 Feb 2018	Hotter-than-normal water kills off salmon in the Sounds Link	King salmon prefer temperatures between 12 and 17 degrees Celsius, but the farms have been warmer than usual since early December, and one farm has been consistently over 19C at a depth of 5 metres for the last three weeks.
6	2 Feb 2018	Hotter-than-normal water kills off salmon in the Sounds Link	Salmon could not self-regulate through perspiration like humans, and some had ultimately died, [NZKS chief executive Grant] Rosewarne said.
7	2 Feb 2018	Hotter-than-normal water kills off salmon in the Sounds Link	Rosewarne would not say how many had died from the heat so far this summer. They were being dumped at a landfill, Rosewarne said.

Abbreviations

ADCP	Acoustic Doppler Current Profile
BRAN	Boulder Research and Administrative Network
CAN	Controlled Area Notice
CTD	Conductivity, Temperature, and Depth (a primary tool for determining physical properties of sea water)
DIN	Dissolved inorganic nitrogen
DO	Dissolved oxygen
DRP	Dissolved reactove phosporous
ENSO	El Niño/Southern Oscillation
EPA	Environmental Protection Authority
EQS	Environmental Quality Standards
ES	Ecosystem service
EWS	Early Warning Systems
FCR	Feed Conversion Ratio
HAB	Harmful algal blooms
MDC	Marlbough District Council
MEA	Millennium Ecosystem Assessment
MODIS	Moderate Resolution Imaging Spectroradiometer
MPI	Ministry for Primary Industries
MSRMP	Marlborough Sounds Resource Management Plan
NH4-N	Ammoniacal-Nitrogen
NO2-N	Nitrate Nitrogen
NO3-N	Nitrate Nitrogen
NZCPS	New Zealand Coastal Policy Statement
NZKS	New Zealand King Salmon
NZ-RLO	New Zealand rickettsia-like organism
NZSFC	New Zealand Sports Fishing Council
OSTIA	Operational Sea Surface Temperature and Sea Ice Analysis
PE	Polyethylene
PIM	Pressure Injection Moulded
RLO	Rickettsia-like organism
SCHISM	Semi-implicit Cross-scale Hydroscience Integrated System Model
SI	South Island
SST	Sea surface temperature
TAN	Total ammoniacal nitrogen
TN	Total nitrogen
TP	Total phosperous
WFR	Water Flow Rate
WQS	Water Quality Standards

Glossary

Many reports found use very specific scientific terms, this glossary contains definitions for these such words. Where possible we have used in text glossaries to define terms as they were intended by the author.

Abiotic	relates to a non-living part of an ecosystem that shapes its environment
Benthic	relates to or occuring at the bottom of the ocean[1].
Biota	the flora and fauna of a particular region, in this case King Salmon would be part of the biota of the Sounds[2].
Chlorophyll-a	a green pigment that is found in plants or algae and enables them to perform photosynthesis. Often measured to determine the total amount of algae in water[3].
Ectothermic	they rely on external factors to regulate their body temperature (see Appendix 1x, [name of doc])
Pelagic	something that relates to or lives in an open sea[4].
Phytoplankton	also known as plant plankton, perform photosynthesis and provide oxygen[5].
Stratification	the layering of water as a result of different temperatures or salinity[6]

Endnotes

1 https://www.merriam-webster.com/dictionary/benthic

2 https://www.merriam-webster.com/dictionary/biota

3 https://www.lawa.org.nz/learn/glossary/c/chlorophyll-a/

4 https://www.merriam-webster.com/dictionary/pelagic

5 https://teara.govt.nz/en/plankton/page-1

6 https://www.mpi.govt.nz/dmsdocument/4300-Overview-of-ecological-effects-of-Aquaculture

MCGUINNESS INSTITUTE
TE HONONGA WAKA