IN THE MATTER OF

POTENTIAL RELOCATION OF SALMON FARMS IN THE MARLBOROUGH SOUNDS PROPOSAL TO

AMEND THE MARLBOROUGH SOUNDS

RESOURCE MANAGEMENT PLAN TO ENABLE

THE RELOCATION OF UP TO SIX EXISTING

SALMON FARMS BY REGULATIONS

MADE UNDER SECTION 360A OF

THE RESOURCE MANAGEMENT ACT 1991

MPI DISCUSSION PAPER NO: 2017/04

STATEMENT OF EVIDENCE OF

ROB SCHUCKARD

For Friends of Nelson Haven and Tasman Bay Inc.

and

Kenepuru & Central Sounds Residents Association Inc.

March 2017

Summary:

i. This new application for expansion of salmon farming is applying for almost 24,600 tonnes of additional feed. In Waitata Reach, an increase of feed levels from consented 10,000 tonnes (maximum limit set by Board of Inquiry [BOI] for recently consented farms) with an additional 23.000 tonnes goes beyond the precaution identified by BOI in 2012 to mitigate uncertainty.

ii. If this proposal proceeds, total salmon production will contribute almost as much nitrogen to the Marlborough Sounds as all other sources.

iii. About 20% of all the waste from salmon farming is settling on the bottom of the marine environment underneath and in vicinity of the salmon farms. Deposition of this waste will be assessed through consent monitoring according to the Best Management Practice Guidelines (BMP). The other 80% of soluble waste is dispersed through the water column with unknown effects to the environment. The Minister has failed to take into consideration the cumulative effect of this expanding activity of salmon farming on the wider Marlborough Sounds environment. Concerns for potential and cumulative effects of the expansion of salmon farming within Pelorus Sound were expressed by the Board of Inquiry as a great concern.

iv. BMP is a monitoring tool for compliance. Occupancy of new fast flow areas will change the benthic environment from the natural Enrichment Stage (ES) 1.5-2.0 (pristine or semi pristine) into ES 3.0-5.0. This change of further eutrophication will result in less species diversity and is not an environmental benefit.

v. Of the 43.000 tonnes of salmon feed that was applied for in 2012, 14,000 tonnes were allowed by the BOI and in accordance with an adaptive management regime only. The Supreme Court ruled that this approach of adaptive management reflected in both the plan and the consent conditions, was consistent with a proper precautionary approach.

vi. Baseline environmental studies are effectively designed to establish the environmental conditions at a site prior to any site development. Once established, these "baseline" conditions then provide a benchmark against which to monitor and manage any potential future impacts resulting from industrial operations at the site.

vii. The baseline of 2012 was established to monitor 'effect' through adaptive management from the 10,000 tonnes of additional feed to be used in the new farms in the Waitata Reach. This precautionary approach through adaptive management was required to mitigate the uncertainty that was identified by the BOI with respect to water-column effects. Whereas the BOI farms in

the Pelorus Sound have only recently been established, no monitoring report about the effect has been produced as yet.

viii. In 2016 a new NIWA model was designed to measure the effect of 23,000 tonnes of feed from the proposed relocated farms in Waitata Reach. Instead of using the 2012 baseline, a new 2016 baseline was established integrating the 10,000 tonnes of feed from BOI farms. Where no monitoring reports have been presented to measure effect from the BOI farms, in my view the new model is thus pre-empting outcomes from monitoring that as yet has to be reported on which is both unwise and unacceptable. The careful and precautionary approach demanded by the BOI when granting consent for up to 10,000 tonnes of feed was required in order to achieve sustainable outcomes. An additional 23,000 tonnes without that carefully staged monitoring process is irreconcilable with the intent and objectives of the BOI decision.

ix. The new baseline has not developed a scenario where all farms have been integrated in the model. Calculations on feed loads to establish the 2016 baseline seem to be set excessively high. The hydrodynamic models are being stretched beyond their original scope and purpose, particularly in the Pelorus Sound.

x. Environmental concerns from the proposal from the impacts of benthic and water column changes, noise and additional light all have the significant potential to adversely affect the feeding habitat of King Shags in the Marlborough Sounds. The species is estimated at 839 birds and assessed to be "VULNERABLE", where this "*species is facing a high risk of extinction in the wild in the medium-term future*.

xi. Birds from the largest colony Duffers Reef are the most potentially affected by the proposal of relocating and expanding salmon farming activity in the Marlborough Sounds. The expansion is happening in the area where most birds from Duffers Reef forage.

xii. Increase of phytoplankton biomass through eutrophication is likely to impact on the light penetration to the deeper water layers and benthic communities, potentially decreasing the area suitable for King Shags to forage.

xiii. King Shag is dependent on deep benthic prey, including witch flounder, a species of flatfish most commonly known to occur in deeper waters. Shags in general require a high density of prey species. Small declines can have a severe impact on the viability of the species.

xiv. Harmful algae blooms (HAB) already occur in the Marlborough Sounds and management of these phenomena should reflect constraint in the release of nitrogen. The impact of some toxic and harmful algae on seabirds reveal an array of responses by birds ranging from reduced feeding activity, inability to lay eggs, loss of motor coordination and death.

xv. Further eutrophication of the Sounds through further increase of salmon farming should be avoided and a precautionary approach adopted through adaptive management of recently consented farms, as directed by the BOI decision.

Qualifications as an Expert and Scope of Evidence

1. My name is Rob Schuckard. I hold a Master of Science in Biology (University of Amsterdam – 1979 - ornithology). In New Zealand we live in the Marlborough Sounds where I operated between 1989 and 2000 two mussel farms in the Pelorus Sound. In 2005, our property received the Marlborough Rural Environment Award for Forestry and the Supreme Award for the work we have been carrying out on our property, where we integrated conservation and commercial aspirations as custodians of our land.
2. I have been involved in a number of ornithological projects with authored or co-authored publications in a range of journals. I also have been involved and still participate in a range of community and/or conservation projects. At the moment I am involved as:
    a. Environmental officer of French Pass Residents Incorporated – since 1997.
    b. Committee member for Friends of Nelson Haven and Tasman Bay – 1998-2002 and since 2011.
    c. Member of the Sounds Advisory Group – since 2010
3. I have considerable experience with projects to study marine and shorebird species including their population dynamics.
    a. Shorebird studies in the South Island of New Zealand.
    b. Benthic biodiversity of Farewell Spit.
    c. Biodiversity studies of seabird, marine mammals and pelagic fish of Tasman and Golden Bay.
    d. New Zealand King Shag projects.
    e. Australasian Gannet from Farewell Spit projects.

4. I presented evidence for Sustain our Sounds for a Board of Inquiry to consider The New Zealand King Salmon Co. private plan change request to the Marlborough Sounds Resource Management Plan through resource consent applications for nine new sites for salmon farming.
5. As a community-representative I have participated in a number of aquaculture working groups:
    a. Best Management Practice Guidelines for Salmon Farms in the Marlborough Sounds.
    b. Marlborough Salmon Working Group preparing the advice to Ministry for Primary Industries (MPI) on relocation of low flow farms.
6. During the 2012 Board of Inquiry process a number of concerns were raised regarding the effect of salmon farming on New Zealand King Shag. The Board directed the consent holder to establish a King Shag Management Plan (KSMP) for those newly to be established farms in the Waitata Reach, where overlap with the feeding areas of the New Zealand King Shag occurs. In 2015, I prepared for New Zealand King Salmon a King Shag Management Plan.
7. I have presented expert evidence for five Environment Court cases and a Board of Inquiry. I have read and agree to abide by the code of conduct for expert witnesses as set out in the Environment Court's Practice Note 2011.

Scope of Evidence

8. I have been asked by the committee of Friends of Nelson Haven and Tasman Bay to prepare an analysis of the environmental impact of the proposal to relocate and expand salmon farming in the Marlborough Sounds with particular regard to the impact on New Zealand King Shag (*Leucocarbo carunculatus*).

Preamble – Status of the Marlborough Coastal Marine Environment

9. The relocation for salmon farms is being considered by the Minister of MPI as a way to:

    '..ensure the environmental outcomes from salmon farming are improved through implementation of benthic best management practice (BMP). '

However, the Marlborough Salmon Working group identified a wider role for its advice to the Minister with a broader definition of 'environmental outcomes':

'*to ensure the enduring sustainability of salmon farming in Marlborough, including environmental outcomes and landscape, amenity, social and cultural values.*

10. The '*environmental outcomes from salmon farming*' as referred to by the Minister as an objective is not necessarily synonymous with the ensuring of '*enduring sustainability of salmon farming in Marlborough, including environmental outcomes and landscape, amenity, social and cultural values.*
11. The primary purpose of the Best Management Practice Guidelines (BMP[1]) is to provide consistent and clear requirements for the independently conducted, annual benthic monitoring and management of existing farms. Whereas about 20% of the waste is settling on the benthic environment, too much emphasis is placed on benthic BMP. The Minister has failed to take into consideration the cumulative effect of this expanding activity of salmon farming on the wider environment and whether sustainable management (as also is defined in the BMP[2]) has been achieved.
12. The Minister (surprisingly) continues that this proposal provides for industry growth through more efficient use of marine farming space, rather than from creating additional new space. Expanding the activity of aquaculture into the CMZ1 zone (prohibited for aquaculture) is a serious breach of the foundation and intention of the Plan's objective. To perceive such a proposition as 'more efficient use of marine farming space' is irreconcilable with the prohibited status of that activity in the Plan, while doubling the overall productivity of salmon farming.
13. A total feed use of the low flow sites in CMZ2 is about 5,700 tonnes and the maximum feed use for the newly proposed fast flow sites will be about 25,000 tonnes. This will effectively mean an almost fivefold increase in production compared to existing (to be relocated) low flow sites. To use the surface area as a parameter to measure expansion is incorrect. A farm is the portal for further environmental pressure through feed use leading to coastal eutrophication. Feed use of all farms owned by NZKS (including three BOI approved farms using adaptive feed levels) can

[1] Keeley, N. *et al.* 2014. Best Management Practice Guidelines for salmon farms in the Marlborough Sounds: Benthic Environmental Quality Standards and Monitoring Protocol. Final 2014.

[2] 'Sustainable management' as defined in Section 5 of the RMA (1991): "managing the use, development and protection of natural and physical resources in a way, or at a rate which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while: (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and (b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystem; and (c) Avoiding, remedying or mitigating any adverse effects of activities on the environment."

increase through adaptive management to 28.000 tonnes. The proposal of relocation as proposed by the Minister is almost doubling this total production level of the industry.

14. The Marlborough Sounds Resources Management Plan is the contract designed for the wellbeing of all the its people, stakeholders, departments, industry etc. Whether the intentions of the MSRMP are maintained through a Plan Change to effectively double the production of one resource user through expansion of salmon farming in the prohibited area for aquaculture is difficult to reconcile.
15. The Marlborough District Council, during the BOI process, explained that the areas identified as CMZ1 in the Plan have a fundamental role to play to offset areas where aquaculture is permissible[3]: '…..Mr. Jerram (Councilor MDC and chairperson of the Environment Committee) and Mr. Hawes (Planner MDC) made it clear in their evidence that the Council does not support any modification of the CMZ1 boundaries. Mr. Jerram confirmed that in his view: *'The whole idea of a prohibited zone is that it is prohibited in perpetuity I would have said.*' The Marlborough Sounds Resource Management Plan is the contract that provides the balance between competing views.
16. Coastal decline of biodiversity is a worldwide problem, most often caused by anthropogenic stressors. This same decline has also been identified in the Marlborough Sounds[4]:

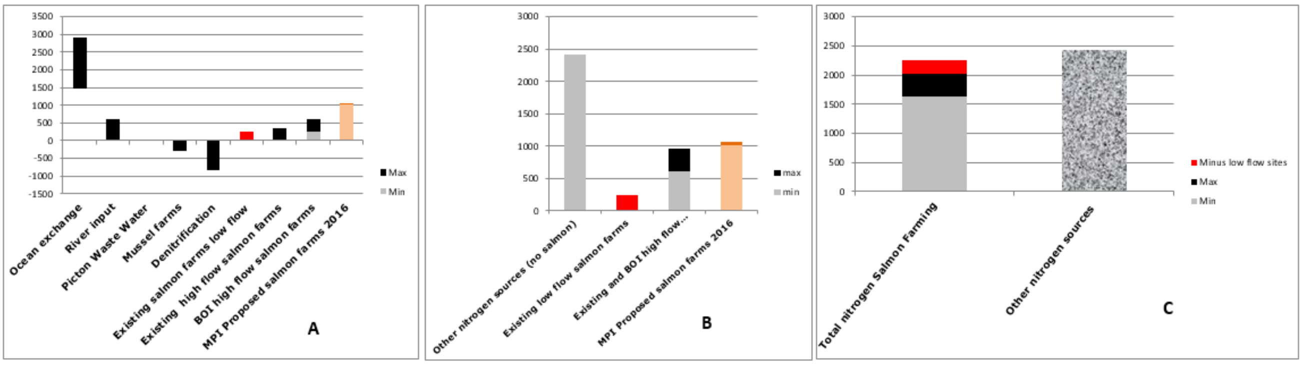
    '*Marlborough's marine biodiversity is not in good shape, particularly in the Sounds. The significant issues are: fewer fish, not as many species, serious loss of biogenic habitats, sedimentation in estuaries smothering thousands of hectares of seabed and biosecurity incursions.'*
17. The marine environment of the Marlborough Sounds is largely unprotected and subject to various anthropogenic activities affecting the quality and resilience of the ecosystem. To accommodate these uncertainties, the Marlborough Resource Management Plan has identified areas where e.g. aquaculture is prohibited.
18. The Board of Inquiry (BOI) identified the Waitata Reach as one of the least modified parts of the Sounds[5]. About marine farming, the BOI also identified that:

[3] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [167]
[4] State of the Environment Report 2015. Our Land, Our water and Our Place. Marlborough District Council, pp150.
[5] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [575], [576].

'Fortunately, few of these current operations extend beyond their more sheltered bay margins out into the Sounds' main channels.'

19. A number of nitrogen sources and sinks were identified by the Board of Inquiry in the Sounds environment.[6] Nitrogen and phosphorus loading into marine waters can initiate a biological process of eutrophication that, depending on the volume and duration of nutrient loading, and the assimilative capacity of the receiving waters, can culminate in a fundamental shift in the food web structure of an area and lead to ecological simplification, disrupting normal ecosystem functioning. It finally can result in a shift of phytoplankton species composition and create conditions that are favourable to nuisance and toxic algal blooms.

20. Also in the Marlborough Sounds, nitrogen is the limiting element for marine productivity[7]. The proposal by the Minister is doubling the nitrogen release from the activity of salmon farming to about 2000 tonnes. This is almost equalling all other nitrogen sources in the Sounds, including the main other source, the upwelling from Cook Strait.



Nitrogen sources (tonnes) in Marlborough Sounds compared to existing and proposed salmon farms: **A - All sources itemized, B - All N-sources different from salmon farming amalgamated, C - Salmon farming nitrogen contribution compared to all other sources (red is nitrogen from to be relocated low flow farms).**

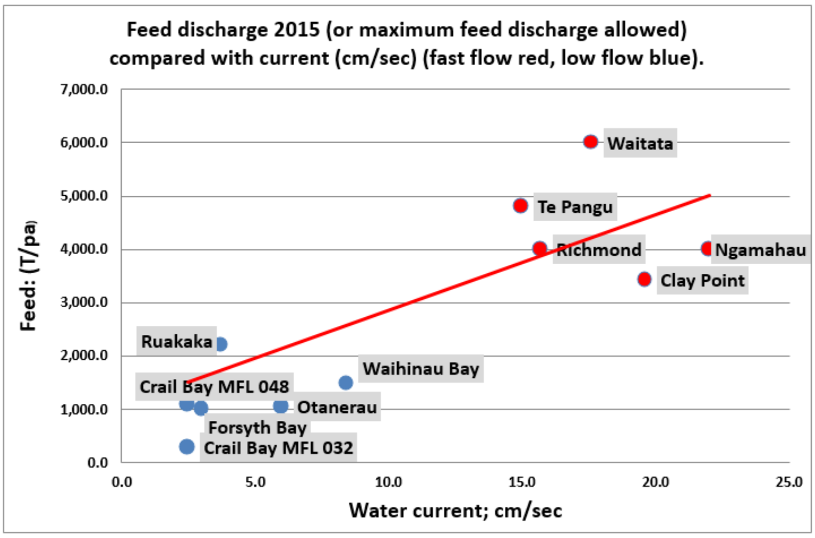
21. The percentage of total nitrogen and phosphorus input from feed that is lost to the aquatic environment is substantial. In general term, about 60%-80% of all the nitrogen and phosphorus in feed will be released into the environment. About 85% of the waste will be in dissolved forms (ammonium, urea, nitrate, together called dissolved inorganic nitrogen DIN), and the rest is in particulate form[8]. The assessment and control of the benthic footprint through a monitoring

[6] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [377]

[7] Broekhuizen, N., Hadfield, M., Plew, D. (2015) A biophysical model for the Marlborough Sounds part 2: Pelorus Sound. National Institute of Water & Atmospheric Research Ltd, NIWA Client Report (for Marlborough District Council) CHC2014-130 (project MDC13301): 163.

[8] Zeldis, J. 2008. Exploring the carrying capacity of the Firth of Thames for finfish farming: a nitrogen mass-balance approach. Prepared for Environment Waikato. NIWA Client Report: CHC2008-02. June 2008. NIWA Project: EVW08501.

protocol for salmon farms[9] is only dealing with up to 20% of all the waste that is created through this activity. Feed use of salmon farms can be directly correlated with the water currents around the farm, where higher currents disperse pollutants over a wider area. As a result, the industry has higher feed and production levels in high flow areas. At this stage, feed levels of all low flow farms are about 5700 tonnes and 22,000 tonnes for fast flow (when using the maximum feed levels for Board of Inquiry consented farms).

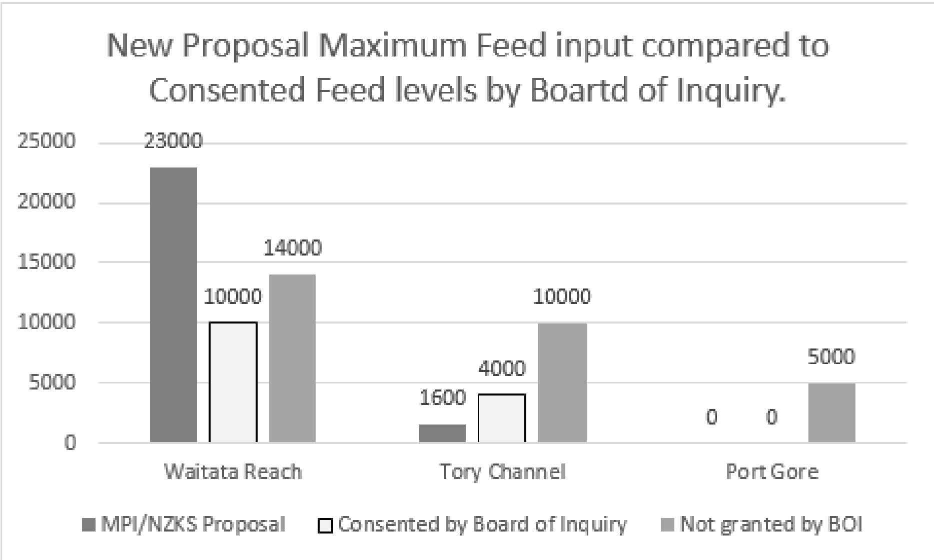


22. The Minister is intending to use executive powers under section 360A-C of the RMA. However, the Minister of Aquaculture can only make a recommendation if the Minister 360B (c) is satisfied that (ii) the matters to be addressed by the proposed regulations are of regional or national significance.
23. It is not clear how the 5700 tonnes of feed from low flow farms can be an issue of regional or national importance, unless the expansion to a total of 24.600 tonnes for the total relocation proposal is the true objective of what the Minister is trying to achieve. The Minister is completely bypassing the precautionary approach of salmon farm developments that was required by the Board of Inquiry to overcome uncertainties identified in the consenting process.

[9] Keeley, N. *et al.* 2014. Best Management Practice Guidelines for salmon farms in the Marlborough Sounds: Benthic Environmental Quality Standards and Monitoring Protocol. Final 2014

For the Waitata Reach, the BOI considered about 24,000 tonnes of salmon feed unsustainable and only granted consents authorizing a maximum discharge of 10,000 tonnes.

24. As stated, the two consented farms in the Waitata Reach were allowed to progress through adaptive management to a maximum feed discharge of 10,000 tonnes. To date, no publicly available monitoring reports are available to provide an initial understanding of the impact of the two BOI farms on the Waitata Reach. While the two BOI farms with up to 10,000 tonnes of feed are in adaptive management, the 'relocation proposal' expands the maximum production in the Waitata Reach with an additional 23,000 tonnes. This latter amount is similar to the total amount the was originally considered by BOI (24,000 tonnes), but is in addition to the 10,000 tonnes set as threshold for consent of salmon farming in Waitata Reach by the BOI in 2012.



25. The use of 23,000 tonnes of feed per annum in Waitata Reach (excluding the BOI farms) is an additional nitrogen source equivalent to about 180,000 people[10]. The waste will be released between 2 and 10km from Duffers Reef, the main feeding area of the biggest King Shag colony. I would regard the potential impact of eutrophication in this main feeding area as an unacceptable experiment, threatening the survival of a very significant portion of the total King Shag population. A shift of phytoplankton species composition can create conditions that are favourable to nuisance and toxic algal blooms. Impacts of toxic algae on seabirds reveal an array

[10] If we estimate a feed conversion rate of 1.8, and the production of 1 tonne of salmon to be comparable with the nitrogen release of 14 people: 23.000/1.8 ~13.000 tonne salmon. 13.000 tonnes salmon x 14 people ~ 180.000 people. (see EiC R. Schuckard for Sustain our Sounds for Board of Inquiry to consider The New Zealand King Salmon Co. Limited's private plan change requests

of responses ranging from reduced feeding activity, inability to lay eggs, and loss of motor coordination and death[11]. Bird deaths caused by HABs have been widely reported[12]. Some of the dinoflagellate produced foam destroys the waterproof layer of feathers that keeps seabirds dry, restricting flight and leading to hypothermia. One of these dinoflagellate *Akashiwo sanguinea* is regularly blooming in Opua Bay, Tory Channel[13].

26. The future challenges to already degrading coastal habitats will be exacerbated by predicted climate change and its impact on algal blooms[14]. 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 the consequences of this new reality. The impacts of eutrophication, independent of 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.
27. Planning towards these realities is not reflected in this proposal and the precautionary advice from the BOI decision has gone missing from the analysis of proposal No: 2017/04.
28. 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.

New Zealand King Shag *(Leucocarbo carunculatus)*

[11] Shumway, S.E., Allen, S.M., Boersma, P.D. 2003. Marine birds and harmful algal blooms: sporadic victims or under-reported events.? Harmful Algae 2, 1:1-17.

[12] Lewitus, A.J., Horner, R.A., Caron, D.A., Garcia-Mendoza, E., Hickey, B.M., Hunter, M., Huppart, D.D., Kudela, R.M., Langlois, G.W., Largier, J.L., Lessard, E.J., RaLonde, R., Rensel, J.E.J., Strutton, P.G., Trainer, V.L., Tweddle, J.F. 2012. Harmful algal blooms along the North American west coast region: History, trends, causes and impacts. Harmful Algae 19:133-159

[13] L. McKenzie presentation Aquaculture review meeting 3 October 2016 (NIWA, Wellington)

[14] Al-Ghelani, H.M., AlKindi, A.Y.A., Amer, S., and Al-Akhzami, Y.K. 2005. Harmful Algal Blooms: Physiology, Behavior, Population Dynamics and Global Impacts – A Review. SQU Journal For Science, 10: 1-30.

29. New Zealand (including Macquarie Island) is home to 7 of the 16 taxa of blue-eyed shags. These seven taxa have the lowest number of individuals among the *Leucocarbo* group. King Shag is considered a discrete species which does not share sub-species status with the other mainland taxon, Stewart Island Shag (*Leucocarbo chalconotus*)[15].
30. New Zealand King Shag (King Shag) is one of the rarest seabird species in the world, endemic to the Marlborough Sounds. The average total population of King Shags is estimated to be 839 birds, with 85% of all existing birds located at five distinctive colonies; Rahuinui Island, Duffers Reef, Trio Islands, Sentinel Rock and White Rocks. In 2015, 187 pairs/nests were recorded[16].
31. More recent studies indicate significant inter-annual variation in breeding success. Preliminary results for a 2016 survey showed a more than 37% decline in active breeding pairs compared to 2015 (Schuckard et al. *in prep.*). There is not enough information to put this difference of inter-annual breeding and recruitment in a further context apart from the significance of the observation and potential implications for the vulnerability of this threatened species.
32. In general, few cormorants and shags live more than 10-15 years but a lifespan of at least 20-30 years in the larger species has been recorded[17]. Based on the total annual chick production of between 48-60 chicks, a recent population modelling of long term census data of King Shag has suggested an annual adult mortality close to 10%[18].
33. Although the status of the King Shag was assessed to be stable in 2006[19], many fundamental data regarding population biology are lacking to expand the 'stable' population assessment beyond a simple number. To study the species is complex and there have been concerns that King Shags are sensitive to disturbance. This has resulted in very little research on this species to date; to the extent that future conservation management is potentially hindered by a lack of knowledge of its basic biology.
34. Historic data over a 40-year period, predating my own data set, are a very important source of information and could be helpful with today's management. However, this limited and anecdotal data set with unknown confidence intervals from different observers requires caution when applied today.

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[15] Kennedy, M., Spencer, H, G. 2014. Classification of the cormorants of the world. Molecular Phylogenetics and Evolution 79 (2014) 249–257

[16] Schuckard, R., Melville, D.S.M, Taylor, G.. 2015. Population and breeding census of New Zealand King Shag (*Leucocarbo carunculatus)* in 2015. Notornis Vol 62:209-218.

[17] Nelson, J.B. Pelicans, Cormorants and their relatives. 2005. Oxford University Press. ISBN 0 19 857727 3

[18] MacKenzie, D.I. 2014. King Shag Population Modelling and Monitoring. Proteus Wildlife Research Consultants. Report produced for King Shag Management Plan by New Zealand King Salmon.

[19] Schuckard, R. 2006. Population status of the New Zealand king shag (*Leucocarbo carunculatus*). Notornis 53(3): 297-307.

35. One of the major threats of King Shag conservation management is the relict distribution and low genetic diversity[20].
36. For these reasons, I fully endorse the finding of the Environment Court that a presumably stable condition of a threatened species is no reason for comfort[21]:

    However, when a taxon is reduced to less than 1,000 individuals on the planet, because of the risk of stochastic events, waiting for a reduction in population is no longer regarded as an appropriate trigger for protecting the taxon.

    A stochastic event took place recently at the White Rock colony when 58% of all the nests of King Shags were lost to an adverse weather event between 1st June 2015 and 16th June 2015[22]. We are unsure if these events are part of a 'new climate reality', or reflect the environment the species has always been dealing with. The position of the Environment Court is consistent with the 'unknown population trend' of King Shag identified by International Union for Conservation of Nature and Natural Resources (IUCN). Prevention of marine farming close to the colonies and to avoid further physical and benthic footprint overlap with feeding areas is part of proposed conservation actions.
37. Policy 11 of NZCPS requires the protection of indigenous biological diversity in the coastal environment and to:
    - *avoid adverse effects of activities on indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists;*
    - *taxa that are listed by the* IUCN *as threatened;*
    - *habitats of indigenous species where the species are at the limit of their natural range, or are naturally rare;*
    - *avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on habitats of indigenous species in the coastal environment that are important for recreational, commercial, traditional or cultural purposes;*
38. The criteria of the IUCN for threatened species has identified King Shag with 32 other New Zealand Birds as "VULNERABLE", where this "*species is facing a high risk of extinction in the*

[20] Rawlence, N. J., Till, C. E., Easton, L. J., Spencer, H.G., Schuckard, R., Melville, D.S., Scofield, P., Tennyson, A. J. D., Rayner, M., Waters, J.M., Kennedy, M.. Human-driven extinctions and range contraction in the endemic New Zealand King Shag complex. (*in prep.).*

[21] *R.J. Davidson Trust v Marlborough District Council* [2016] NZEnvC 81[285]

[22] Schuckard, R., Melville, D.S.M, Taylor, G.. 2015. Population and breeding census of New Zealand King Shag (*Leucocarbo carunculatus)* in 2015. Notornis Vol 62:209-218.

wild in the medium-term future". The status of this bird is based on the latest 2000 criteria of IUCN: Area of occupancy estimated to be less than 2000 km^2. King Shags are known to exist at no more than 9 localities within the Marlborough Sounds. The population is estimated to be less than 1000 mature individuals.

Red List IUCN	NZ threat classification	
Least Concern	Not Threatened	
Near Threatened	At Risk	• Naturally Uncommon • Relict • Recovering • Declining
Vulnerable Endangered Critically Endangered Extinct in the Wild	Threatened	• Nationally Vulnerable • Nationally Endangered • Nationally Critical
Extinct	Extinct	

New Zealand Threat Classification System compared with IUCN Red List. King Shag is highlighted red for both classifications.

39. Low numbers and a very small distribution area are of major concern for the survival of this species. In New Zealand, the conservation status of King Shag is Nationally Endangered based on its small population of between 250-1000 individuals[23]. Duffers Reef and Trio Islands have the highest numbers of King Shags of all colonies where Duffers Reef also has the highest recruitment of all colonies.

40. A first initial feeding distribution map for New Zealand King Shag was developed after one year of monthly field surveys of the Duffers Reef colony between 1991 and 1992[24]. The initial map with feeding distribution of birds attending the Duffers Reef colony was adopted by the Department of Conservation[25]. King Shag feeding areas were identified by DOC to be of national importance:

[23] Miskelly, C.M.; Dowding, J.E.; Elliott, G.P.; Hitchmough, R.A.; Powlesland, R.G.; Robertson, H.A.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A. (2008). Conservation status of New Zealand birds, 2008. Notornis 55: 117-135.

[24] Schuckard, R. 1994. New Zealand King Shag *(Leucocarbo carunculatus)* on Duffers Reef, Marlborough Sounds. Notornis 41:93-108.

[25] Davidson, R.J., Courtney, S.P., Millar, I.R., Brown, D.A., Deans, N.A., Clerke, P.R., Dix, J.C., Lawless, P.F., Mavor, S.J. and McRae, S.M. 1995. Ecologically important marine, freshwater, island and mainland areas from Cape Soucis to Ure River, Marlborough, New Zealand: recommendations for protection. Department of Conservation, Nelson/Marlborough Conservancy. Occasional Publication No. 16.

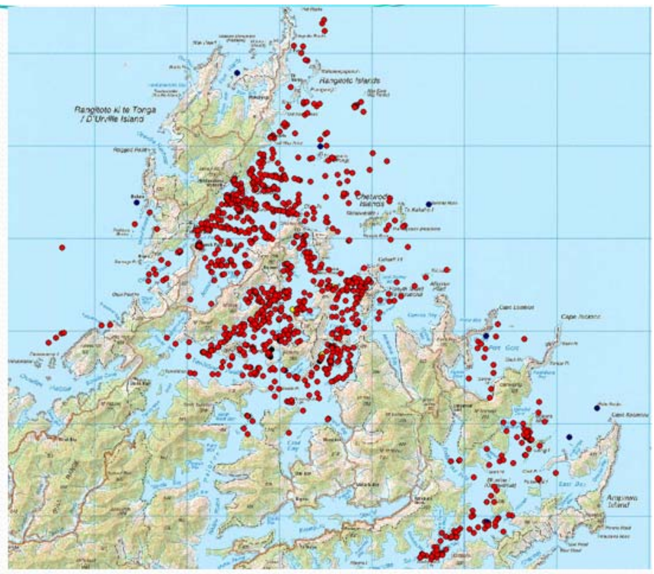
'Preliminary observations on King Shag feeding areas suggest that these birds target specific feeding areas/habitats only in the Marlborough Sounds. These areas are, therefore, vital for the continued survival of this endemic New Zealand shag.'

41. Whereas in 1995, feeding areas were identified to be 'vital' for the survival of the species, the '2011- Ecological Report' (referred later in paragraph 65 and 68) only identified breeding sites to be of ecological significance. The same report does not provide an assessment in support of a change of the 'vital' status of King Shag feeding areas. Combining foraging range data for spatial distribution with other information on the foraging ecology of species are fundamental for the management protocols of seabirds. Habitat preferences, oceanographic preferences, diet, and the depths, at which diving birds obtain their prey, allow for a more refined approach to delineate foraging areas that require protection. Many of these data have been collated over the years and are readily available for King Shag management in the Marlborough Sounds.
42. Area-based conservation for species is an integral part of the activities of the IUCN Species Survival Commission. This activity can be initiated in relation to the specific demands of the particular species, since protection of threatened populations requires protection of the habitat in which they occur. The threat criteria for species Red-Listing include '*extent of occurrence*' and '*area of occupancy*', both explicitly reflecting spatial requirements important for continued survival of species populations. The Red List term '*Area of Occupancy*' is defined as:

…. the area within its 'extent of occurrence' which is occupied by a taxon. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. In some cases, (e.g., irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data.

Extent of Occurrence (A)

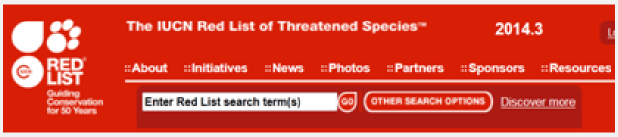
.........is the spatial distribution of known, inferred or projected sites of occurrence.

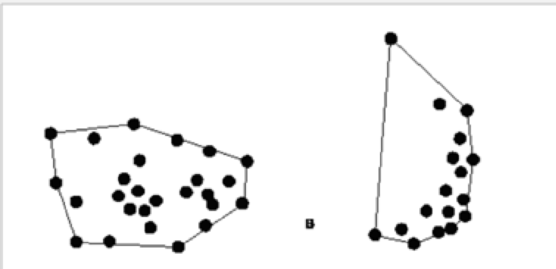


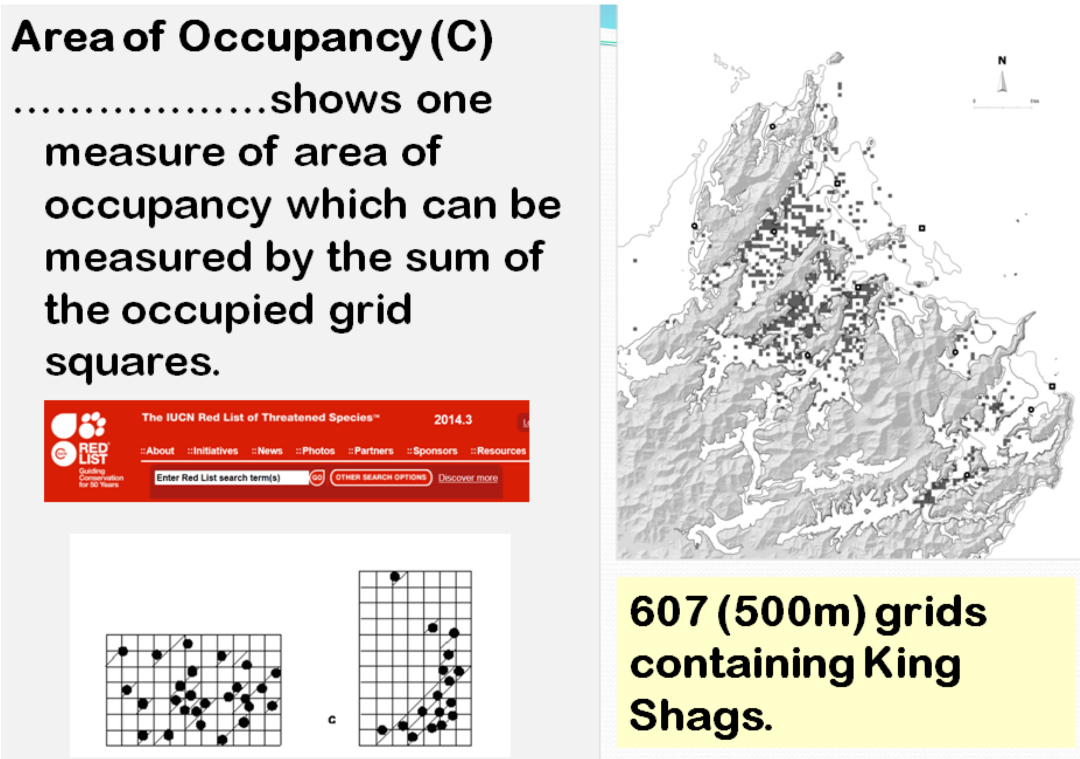
Distribution of >1000 waypoints of feeding King Shags in the Marlborough Sounds.

Area of Occupancy (B)

……… shows one possible boundary to the extent of occurrence, which is the measured area within this boundary.







43. Seaward extensions of breeding seabird colonies have been strongly promoted in the nationwide assessment for Important Bird Areas[26]:

> ……*include those parts of the marine environment which are used by the colony for feeding, maintenance behaviours and social interactions'.*

King Shag is one of the species for which this seaward extension is recommended.

44. The most comprehensive prey analyses used samples collected in 1991/92, from a roost at the east of Maud Island[27], Te Kaiangapipi. Witch (*Arnoglossus scapha*), was the most dominant prey in items and in wet mass. A further four pellets from the Trio Islands in March 1992[28] yielded > 20 prey items, of which only 4 were witch. This initial work from one of the breeding colonies showed a greater diversity in prey compared to the Te Kaiangapipi roost containing witch, leatherjacket (*Parika scaber*), blue cod (*Parapercis colias*) and sea perch (*Helicolenus percoides*).

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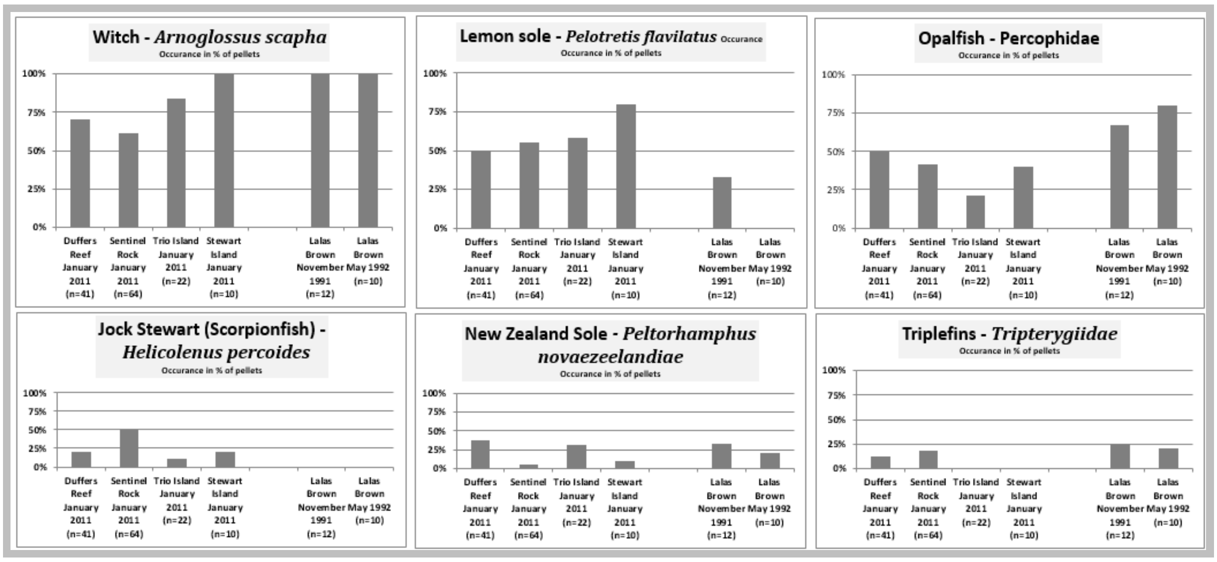
[26] Gaskin, Ch. 2014. Important Areas for New Zealand Birds. Report prepared for Forest and Bird.
[27] Lalas C.; Brown, D. 1998. The diet of New Zealand King Shags (Leucocarbo carunculatus) in Pelorus Sound. Notornis 45: 129-139.
[28] Lalas unpubl. 2001, in Butler, D.J. 2003. Possible impacts of marine farming of mussels (*Perna cannaliculus*) on King Shags (*Leucocarbo carunculatus*). DOC Science Internal Science Series 111.

45. Prey species for King Shag reported up to 2003[29] are: witch (*Arnoglossus scapha*), opalfish (*Hemerocoetes* sp), lemon sole (*Pelotretis flavilatus*), other sole species (P*eltorhamphus* sp.), flounder, (*Rhombosolea* sp.), leatherjacket (*Parika scaber*), blue cod (*Parapercis colias*), sea perch (*Helicolenus percoides*), red cod (*Pseudophycis bachus*), red scorpionfish (*Scorpaena papillosus*), pilchard (*Sardinops neopilchardus*)[30], New Zealand sole (*Peltoramphus novaeseelandiae*), sandfish (*Gonorhynchus gonorhynchus*), triplefins (Tripteriigydea) and spotty (*Notolabrus celidotus*).
46. In 2011 five King Shag colonies in the Marlborough Sounds were visited to collect further prey information[31]. A total of seventeen species of fish were identified in the 132 pellets (regurgitations where toughest parts of prey species e.g. otoliths allow identification) from five King Shag colonies. While the list of prey species for King Shag expanded compared to what was known before, the six most common prey items were recorded in the King Shag diet previously. The prey diversity from the 2011 study is higher and represents the first sampling regime from the main colonies. These 2011 results are difficult to compare with the 1991/92 study, the latter study being of a site on the fringe of the foraging distribution of King Shag in the Waitata Reach.

[29] Butler, D.J. 2003. Possible impacts of marine farming of mussels (*Perna cannaliculus*) on King Shags (*Leucocarbo carunculatus*). DOC Science Internal Science Series 111.

[30] Falla, R.A. 1933. The King Shag of Queen Charlotte Sound. The Emu:Vol. XXXXIII: 44-49.
Prey of King Shag is of benthic origin, predominantly bottom dwelling fish with the exception of this paper. Falla visited the White Rocks at 25th August 1933 and it is possible that pilchards are not pelagic at that time of the year. However, the author refers to pilchard prey as 'regular':
'*…………there is a regular seasonal occurrence of the 'Picton herring (Sardinia neopilchardus).* The reference to substantiate this note is unknown.

[31] Schuckard *et al.* in prep.



The six most important King Shag prey items from four colonies (*Schuckard and Melville in prep.*) compared with Lalas and Brown (1998)

47. The predominant prey from 2011 was: witch (*Arnoglossus scapha*), lemon sole (*Pelotretis flavilatus*) and opalfish (*Hemerocoetes sp.*). While witch was an important prey item, the dominance of this species was less profound on Duffers Reef and Sentinel Rock compared to the 1991/92 study. Colonies in Admiralty Bay (Trio Island and Stewart island) had witch in more than 2/3 of the pellets. Dwarf octopus (*Octopus sp.*) was recorded as new prey species in 2011.

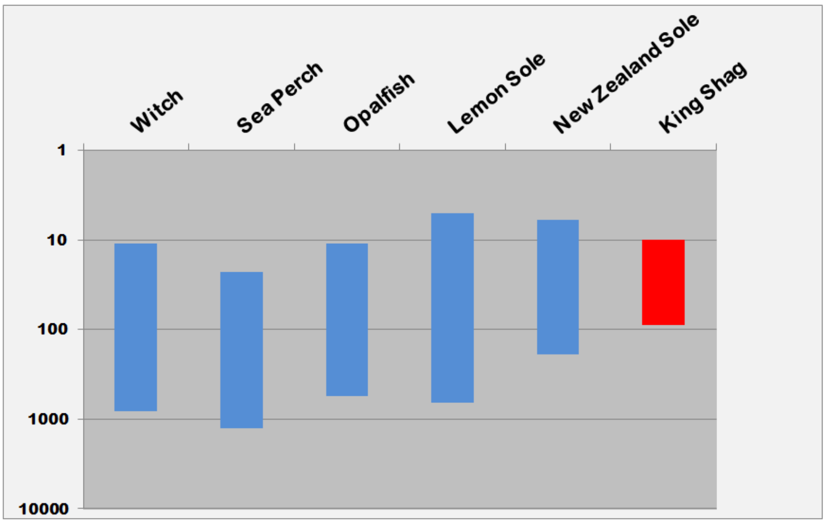
Common name	Latin name
Witch	***Arnoglossus scapha***
Lemon Sole	***Pelotretis flavilatus***
Opalfish	***Percophidae***
Silver Conger	***Gnathophis habenatus***
Ling	***Genypterus blacodes***
Roughy	***Trachichthyidae***
Spotty	***Notolabrus celidotus.***
sea perch/jock stewart	***Helicolenus percoides***
True Sole	***Peltorhamphus novaezelandiae***
Triplefin	***Tripterygiidae***
Butterfly Perch	***Caesioperca lepidoptera***
Stargazer	***Uranscopidae***
Stargazer	***Leptoscopidae***
Gurnard	***Chelidonichthys kumu***
Sandfish	***Gonorhynchus gonhorhynchus***
Red Cod	***Pseudophycis bachus***
Javelinfish	***Lepidorhynchus denticulatus***

King shag prey species recorded from pellet samples during the summer of 2011[32].

[32] Schuckard and Melville *in prep*.

48. Witch is also the most common species of flatfish in all New Zealand marine waters, occurring from shallow waters to depths of over 800m. All left-eyed flounders are carnivorous, usually ambushing prey of small fishes and crustaceans[33]. It is not known whether King Shags target so many witch because of their apparent high density, or whether they specifically hunt for witch above other species. Both King Shag and witch are predators of organisms within the benthic and epibenthic environment in their own right, and are dependent on clear water with deep light penetration for successful foraging.

49. All the preferred prey items that have been identified to date are predominantly benthic and epibenthic species (possibly with the exception of pilchard recorded in 1932[34]), highlighting the deep diving capabilities and dependency on the benthic and epibenthic environment in the Marlborough Sounds. The most common prey species of king shag are caught at the upper level of their recorded depth distribution[35].



Most common prey species of King Shag caught in the upper limit of their depth distribution.
(Note depth log scale in metres on Y-axis.)

50. Lemon sole is the second most important prey item for King Shags from Duffers Reef, Trio Island, Stewart Island and Sentinel Rock and was also identified in the summer prey items from the King Shag roost near Maud Island. The distribution of five flatfish species has been studied

[33] Randall, J.E. 2005. Reef and Shore Fishes of the South Pacific. New Caledonia to Tahiti and the Pitcairn Islands. University of Hawai'i Press. Honolulu.
[34] Falla, R.A. 1933. The King Shag of Queen Charlotte Sound. The Emu:Vol. XXXXIII: 44-49.
[35] Anderson et al. 1998. Atlas of NZ fish and squid distributions from research bottom trawls. NIWA Tech Rep 42.

in Wellington Harbour[36] of which three are known prey species for King Shag in the Marlborough Sounds. Lemon Sole and True Sole fed on benthic in-fauna and epifauna while Witch fed on benthic epifauna and pelagic organisms. Witch dominated in clear deeper water with a greater influx of oceanic water from the Cook Strait on coarser grained sediment, while Lemon Sole and New Zealand Sole were more common in shallow areas underlain by fine sediments:

> '*The non-random distribution of flatfish species in the harbour may be related to sediment types and water depth or associated with distribution of prey in different sediment types*'[29]

51. The Wellington harbour study recorded a number of families of polychaete worms of which species like *Maldanidae* were consumed by all 5 flatfish species. Seven of the polychaetas have also been recorded as in-faunal species in the Marlborough Sounds[37]. These polychaetes occur as infaunal species in the soft bottom habitats with silt and clay. They are a food source for a number of flatfish species targeted as prey by King Shag and they are the main diet for Lemon Sole and New Zealand Sole.
52. Polychaetes dominate marine and estuarine soft bottom benthic communities in terms of numbers of species and individuals; they are critical in marine food chains, as important prey for many crustaceans, molluscs, fish, birds and other organisms, and as predators in their own right.

53. Bio-turbators like polycheates play a major role in the breakdown, subduction and incorporation of organic matter into sediments as well as the aeration of the benthic environment. Bio-turbators recycle organic material through nitrification[38] and denitrification processes. Tube building polychaeates (e.g. *Maldanidae*), have been recorded to rapidly subduct freshly deposited algal carbon and inorganic materials to a depth of 10cm or more in the sediment column. They play a fundamental role in the recycling of organic material[39].

[36] Livingstone M.E. 1987. Food resource use among five flatfish species (*Pleuronectiformis*) in Wellington Harbour, New Zealand. N.Z.J.Mar.Freshw.Res.21:281-293.
[37] McKnight, D.G. and Grange, K.R. 1991. Macrobenthos-Sediment-Depth Relationships in Marlborough Sounds. D.O.C.Investigation No.P692.
[38] Nitrification is the aerobic process where bacteria change ammonia to nitrite and nitrite to nitrate. Denitrification is the anaerobic process where other bacterial species can take nitrate and change it back to nitrogen gas.
[39] Levin, L., Blair, N., DeMaster, D., Plaia, G., Fornes, W., Martin, C., and Thomas, C.. 1997. Rapid subduction of organic matter by maldanid polychaetes on the North Carolina slope. Journal of Marine Research 55:595-611.

54. Shallower redox depth[40] and higher organic matter content with a decrease (see first table underneath) in the abundances of some taxa that appear to be relatively intolerant of conditions below the farms (but increases in abundance of other species) has been recorded[41]. One of the taxa that became absent underneath a mussel farm compared to the control site were *Maldanidae* (see second table underneath), a very important polychaete bioturbator and prey species for a variety of flatfish.

NIWA Taihoro Nukurangi

Table 1: **Sample position and sediment characteristics at grab sample stations for U990821. Positions are reported according to WGS84. 'nd' – not determined. Sample positions are shown in Figure 11.**

Grab ID	Inside/ Outside farm lines	Latitude	Longitude	Water Depth (m)	Redox depth (cm)	Organic Matter %	Grain size composition (%)		
							<63 µm	63-200 µm	>200 µm
1	In	40 57.676	173 57.288	21	1	6.9	77.8	7.0	15.2
2	In	40 57.674	173 57.372	21	3	7.0	91.4	7.0	1.6
3	In	40 57.722	173 57.419	24	nd	6.2	79.9	8.6	11.5
4	Out	40 57.769	173 57.341	27	8	5.7	87.3	12.4	0.3
5	Out	40 57.811	173 57.392	33	6	5.3	79.3	20.2	0.50
6	Out	40 57.820	173 57.430	40	8	5.5	76.8	18.2	5.01

Table 3 **Numbers of animals per grab (ca 0.13 m^2). See Table 1 and Figure 11 for location of samples.**

Grab No	1	2	3	4	5	6
Inside/Outside mussel lines	In	In	In	Out	Out	Out
TAXON						
Priapulida						
Priapulopsis australis		1		1	2	
Sipuncula						
Sipunculus sp.		1				
Polychaeta						
Capitellidae	1		1		1	
Cirratulidae		1				
Dorvilleidae	6	1	1	7		
Eunicidae			2			
Flabelligeridae		1		1	1	
Glyceridae	1		1	3	1	
Lumbrineridae	5	4	1	2	2	1
Maldanidae				9	6	1

[40] Organic enrichment of sediments usually leads to reduced conditions which equate to "bad" sediment quality, wherein natural benthic communities undergo substantial changes. The oxidation-reduction (redox) conditions in surface sediments depend on the degree of organic enrichment.

[41] Brown, S., Stenton-Dozey, J., Hadfield, M., Cairney, D.. 2009. Fisheries resource impact assessment for a marine farming permit application in Horse Bay, Pelorus Sound, Site U990821. NIWA Client Report:2009-039, Sanford Havelock.

55. Occasional *Maldanidae* tubeworms communities are common and widespread if conditions are right. They are part of (and in some cases dominant aspect of) the polychaete assemblage of Blowhole North, Blowhole South, Waitata North and South, Richmond Bay and Horseshoe Bay[42] playing an essential role in denitrification and nitrification processes that are part of the Sounds dynamics and health. A spatial concept for these communities is lacking as well as differences in abundance. A study from 1983 showed taxonomic groups that would provide for the King Shag prey species to be widespread. However, the study is not regarded as quantitative. Data from sample stations were reduced to presence/absence[43] and are of limited support to describe habitats of King Shag prey and Sing Shag feeding habitat as 'widespread'.

56. Also in overseas studies, a strong correlation was established between the occurrence of flatfish species like Plaice (*Pleuronectus platessa*) and the abundance of benthic fauna[44]. In particular, infaunal tube dwelling polychaetes, a valuable food source for Plaice, dominated some of their preferred habitats.

57. A recent Environment Court decision further analyzed the effect of mussel farms on King Shag feeding habitat based on expert input. The court had[45] adequate information to find/predict that:

    (1) King Shag habitat will be changed by shell drop and sedimentation;
    (2) the effects of the farm accumulate and are likely *(66-100% probability)* to be adverse; and
    (3) it is as likely as not there will be adverse effects on the populations of New Zealand King Shags and their prey;
    (4) there is a low probability (it is very unlikely *(0-10% probability)* but possible) that the King Shag will become extinct as a result of the application, being considered in that case.

58. Mussel farms are not used by foraging King Shags but mussel boys are used as a resting place:

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[42] Brown S., Anderson T.J., Watts A., Carter M., Olsen L. and Bradley, A.. 2016 Benthic Ecological Assessments for Proposed Salmon Farm Sites. Part 1: Benthic Ecological Characterizations. NIWA Client Report No: NEL 2016-003.

[43] McKnight, D.G. and Grange, K.R. 1991. Macro benthos-Sediment-Depth Relationships in Marlborough Sounds. D.O.C.Investigation No.P692.

[44] Rabaut, M., Moortel, L.van de., Vincx, M. and Degraer. 2010. Biogenic reefs as structuring factor in *Pleuronectes platessa (*Plaice) nursery. Journal of Sea Research 64: 102-106.

[45] *R.J.Davidson Trust* v *Marlborough District Council* [2016] NZEnvC 81[206]

'*……, the importance of musselfarms as foraging sites for King Shags or alternative roosting sites to land reported by Brown (2001) was not substantiated by this study.*[46]'

59. Based on presented evidence, the Environment Court found that King Shag forage within mussel farms only very infrequently and that a likely contributor to infrequent foraging is the reduced presence of flatfish on or in the changed seafloor underneath the farms. King Shags use of mussel farms is likely to be largely confined to resting on the buoys[47].

60. It is in the interests of resident and long-lived benthic foragers to learn to apply efficient foraging tactics throughout their lifetime and thus increase their individual foraging efficiency. Foraging efficiency of the shags through memorisation of the bottom's topography and the habits of its fauna could considerably reduce search time among marine predators by enhancing the predictability of prey location for a given individual. It is expected that this strategy is used among all benthic top predators especially by individuals of resident species [48]. Foraging area fidelity is suggested for Crozet Shag (*Phalacrocorax melanogensis*) and it is acceptable to extrapolate these results to King Shag in the Marlborough Sounds as the best available information for its management in the meantime. Precaution in fully understanding the vital feeding characteristics and areas is of fundamental importance in avoiding adverse effects on threatened species like King Shag.

61. Research on Kerguelen Shag (*L. verrucosus*) provide a combined set of data of diving depth, GPS, air speed and under water speed[49], a suitable proxy for King Shag feeding behaviour. The average distance from the colony was 8.1 km with a maximum of 26km with an average diving depth of 23.4 m, an average maximum of 45.6 m and absolute maximum of 94.2m. These birds regularly rested at sea during both outbound and inbound flights without any diving, which were interpreted by the authors as necessary recuperation for the high flight energy costs. The implication of deep diving at the cost of flight performance was an important outcome of this

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[46] Fisher, P.F. and Boren, L.J.. 2012. New Zealand King Shag (*Leucocarbo carunculatus*) foraging distribution and use of mussel farms in Admiralty Bay, Marlborough Sounds. Notornis Vol. 59: 105-115.

[47] *R.J.Davidson Trust* v *Marlborough District Council* [2016] NZEnvC 81[134]

[48] Cook, T.R., Lescroel, A., Tremblay, Y., Bost, C-A. 2008. To breathe or not to breathe? Optimal breathing, aerobic dive limit and oxygen stores in deep-diving blue-eyed shags. Animal Behaviour, 2008, 76: 565-576.

[49] Watanabe, Y, Y., Takahashi, A., Sato, K., Viviant, M., Bost, C-A.. 2011. Poor flight performance in deep diving cormorants. The Journal of Experimental Biology 214: 412-421.

study. The average distance from the colony and the diving depth of Kerguelen Shag has similarities with choices of exploration of the feeding area by King Shag.

62. Seabirds live in a changing environment, where worldwide many are already affected by a warming climate and exposure to new anthropogenic pollutants[50]. These changing circumstances may potentially affect their immune-competence, overall resilience, and as such their long term survival.

63. Parameters of survival and reproduction of a relative of King Shag, Brandt's Cormorant *(Phalacrocorax penicillatus*) deteriorated under poor environmental conditions (fish abundance, El Nino). Changes in wider environmental parameters explained their population fluctuations[51]. All these important conditions like population structure, environmental resilience, immune-competence etc. are missing from the conservation assessment of King Shags. In a changing marine environment, a relatively small number of King Shag is not necessarily synonymous with a secure future for the species.

64. The four main King Shag breeding colonies have protected status of 'Wildlife Sanctuary' under the Reserves Act. The significance of the feeding habitats of King Shag is recognized in the ecological maps of the current Marlborough Sounds Resource Management Plan, Appendix B: Schedule of Areas of Ecological Value. King Shag feeding habitat is assessed to be of national importance[52].

65. A reassessment of the ecological significant sites in the Marlborough Sounds[53] (2011- Ecological Report) was published by Marlborough District Council and the Department of Conservation in 2011 but the status of this document remains obscure, as does its purpose. The document states that 'Greater detail about the ecology, distribution, breeding, feeding, threats and status of important species is on the Marlborough District Council's website', however the only information on King Shag appears to be Appendix B Schedule of Areas of Ecological Value (of the current Plan) which notes a number of sites, as being 'King Shag feeding habitat'.

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[50] Sagerup, K., Hendriksen, E.O., Skorping, A., Skaares, J.U., Gabrielsen, G.W.. 2000. Intensity of parasitic nematodes increases with organochlorine levels in the glaucus gull. J.Appl.Ecol.37:532-539.

[51] Nur,N., Sydeman, W.J.. 1999. Survival, breeding probability and reproductive success in relation to population dynamics of Brandt's Cormorant (*Phalacrocorax penicillatus*). Bird Study 46: 92-103.

[52] Marlborough Sounds Resource Management Plan Volume Two – Rules. Appendix B2-3.

[53] Davidson, R., Duffy, C., Gaze, P. Baxter, A., DuFresne, S. Courtney, S. and Hamill, P. 2011. Ecologically Significant Marine Sites in Marlborough, New Zealand. Coordinated by Davidson Environmental Limited for Marlborough District Council and Department of Conservation.

66. Earlier evidence presented for a marine farm application (U991170) by Sandford South Island Ltd. in Orchard Bay, northeast from Duffers Reef Dr Lalas from Otago University carried out a statistical analysis of my early data on dispersion of King Shag dive sites with respect to distance from the Duffers Reef colony and to the areas of the Pelorus Sound with bottom depths between 20-40m. The halo dispersion of the shags correlates with a Poisson probability distribution. The relationship indicated that the numbers foraging increase to a peak at 6-10 kilometres flight distance from Duffers Reef and then taper off only slowly to 18 kilometres. The probability of the distribution was 'statistically highly significant ($p<0.001$) and accounts for 90% of the recorded variation'. Dr Lalas continues: 'These results are indisputable'.

67. According to Dr Lalas' analysis, data for dispersion of foraging King Shags show that most feeding takes place between 2-12km from the colony. This is the area where the relocations of the farms in the Pelorus Sound will take place.

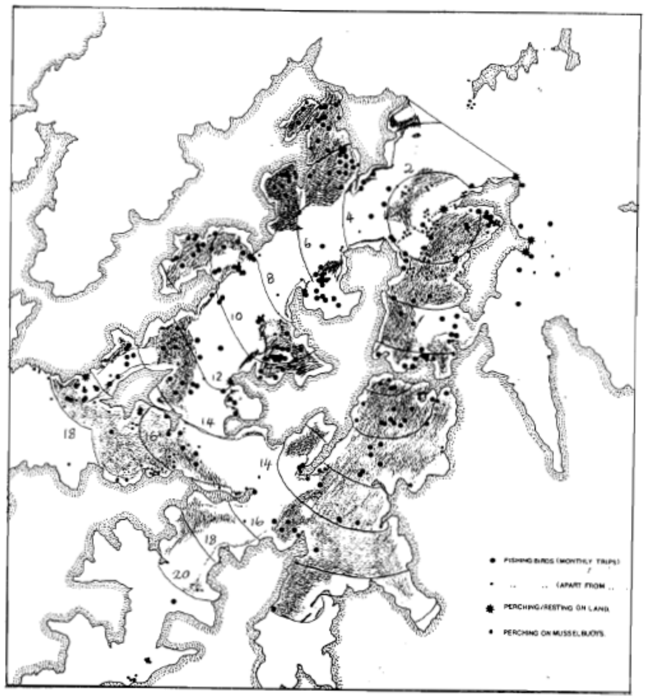

Figure 1: Dispersion of random dive sites recorded for King Shags in Pelorus Sound

Sources of map and data

The original of this map was presented by Mr Rob Schuckard in his evidence presented at the Kuku Mara Port Ligar marine farm Council hearing in April 2000. This is the data for dispersion of dive sites from which Mr Schuckard derived his Figure 8 "Main feeding area of king shags from Duffers Reef" in Schuckard (1994).

Schuckard (1994) found that 74% of dives were in depths of 20-40 m, and so I defined as zones in Pelorus Sound in this depth range as "target habitat". I superimposed shaded areas on this map to show areas of target habitat, as derived from Navy Chart NZ 6152.

Analyses of data

Schuckard presented positions for 219 random dive sites for King Shags. The data set I used here was 211 dives. I excluded the seven dives in Guards Bay because my May 2000 surveys indicated that these were unrepresentative. (Qualitatively, I found that Guards Bay held the highest density of foraging King Shags within or adjacent Pelorus Sound). I also omitted the only dive site that was beyond 18 km flight distance from Duffers Reef,

I collated data into 2 km intervals for the shortest flying distance over water from the colony at Duffers Reef. The only exception was for birds heading south that could have flown over Piripaua Neck between Forsyth Bay and Beatrix Bay.

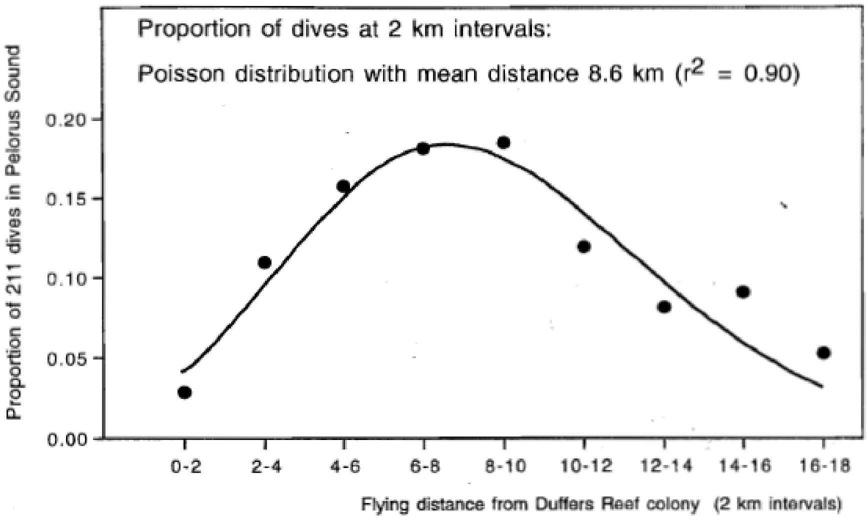

Figure 3: Graph of Poisson probability distribution curve fitted to distances flown from Duffers Reef by King Shags feeding in Pelorus Sound

Determined from data depicted in Figure 1.

The Poisson distribution is defined as $p(x) = \mu^x e^{-\mu} / x!$

where $p(x)$ = probability of a shag feeding at y km from Duffers Reef
μ = average (mean) flying distance from Duffers Reef
e = 2.718

The curve was calculated from transformed x values, where 0-2 km = 1; 2-4 km = 2, etc.

68. The IUCN protocol for the management of threatened species does not recognize the 'relative importance' of areas occupied by threatened species. All feeding areas are important for the survival of the species. It is important to realize that this protocol (adopted by the NZCPS 2010) is fundamentally different from the protocol used to identify 'Ecologically Significant Marine Sites in Marlborough, New Zealand.' [54] For birds and supposedly marine mammals the assessing team should restrain from using 'relative importance' of distribution area and instead use the IUCN protocol to identify 'extent of occurrence' and 'area of occupancy'. Both explicitly reflect

[54] Davidson, R., Duffy, C., Gaze, P. Baxter, A., DuFresne, S. Courtney, S. and Hamill, P. 2011. Ecologically Significant Marine Sites in Marlborough, New Zealand. Coordinated by Davidson Environmental Limited for Marlborough District Council and Department of Conservation.

spatial requirements important for continued survival of species populations. This protocol is what I have used for the purpose of the distribution maps of King Shag.

69. Cormorants belong to the “flapping species” where a high wing loading is likely related to lower energy efficiency of “flapping flight”[55]. A lack of sufficient muscle power to fly at speed nearer to the most energy efficient air speed per distance flown has been suggested. Wing morphology and flight behaviour of Cormorants make them belong to those birds that have little leeway to speed up or slow down because they must flap at a rate near their maximum capability (i.e. they probably fly as fast as they can under any conditions)[56],[57]. The energy use by Cormorants to reach the feeding areas is among the highest of all seabirds and may well be an evolutionary bottleneck for the species.

70. Eight surveys between 2002 and 2015 were conducted by Duffers Reef to identify the direction of departing King Shags. These surveys started prior to the first early morning departures of the shags and lasted till at least 50% of the birds had left. Importance of survey sector was to establish the direction where most shags were feeding. Sectors with most departures were W, SW (Waitata Reach), S and SE (Forsyth and Beatrix Bay). About 74% -96% of the Duffers Reef birds forage in two distinctive directions, Forsyth and Beatrix Bay (southeast and south) and Waitata Reach (southwest and west). A slightly higher numbers of King Shags forage in the Waitata Reach (29%-71%) and its bays compared to the Forsyth Bay and Beatrix Bay directions (22%-48%).

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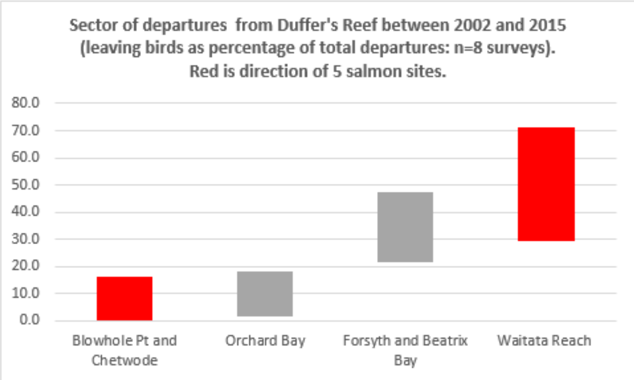
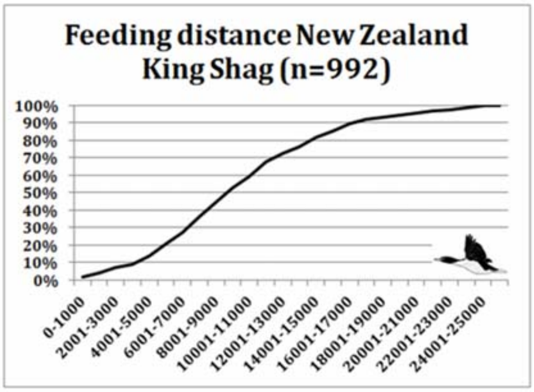
[55] Spear, L.B.; Ainley, D.G. 1997. Flight behaviour of seabirds in relation to wind direction and wing morphology. Ibis 139: 221-233.
Spear, L.B.; Ainley, D.G. 1997. Flight speed of seabirds in relation to wind speed and direction. Ibis 139: 234-251.

[56] Pennycuick, C.J. 1987b. Flight of aucks (Alcidae) and other northern sea birds compared with southern Procellariformes: J. Exp. Biol. 128:335-347.

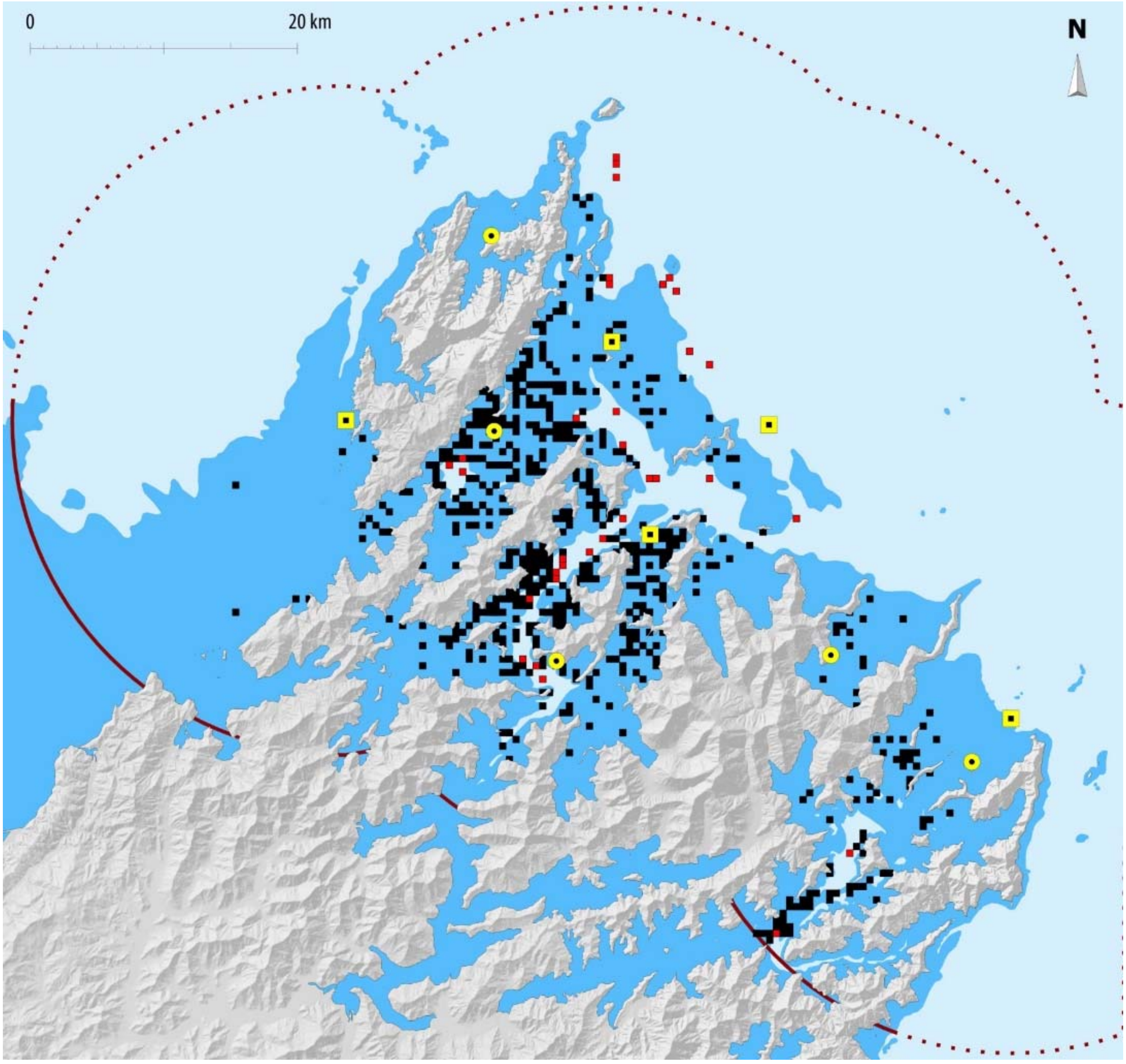
[57] Alerstam, T. & Gudmundsson, G. A. & Larsson, B. 1993. Flight tracks and speeds of Antarctic and Atlantic seabirds: Radar and optical instruments. Phil. Trans. R. Soc. Lond. B.:55-67





Feeding Direction and cumulative feeding King shags per kilometer from the colonies in the Marlborough Sounds.

71. Shags do not randomly use feeding areas, but target specific locations of the marine environment Successive data collated since the early 1990's have provided consistency in proposed parameters of King Shags feeding in the waters of the outer Marlborough Sounds. Important feeding areas of King Shags are determined by water depth (<50m), direction from colony (predominantly between the southern and western sectors from the main colonies) and distance from the colony (maximum 25km). To date, King Shags have been recorded feeding in 607 grids (500m) with 34 grids (5%) of birds foraging in waters deeper than 50m. These parameters can be extrapolated to an area of about 1,300 km² of the Marlborough Sounds marine waters where King Shags can feed.



607 grid squares (500m) where foraging King Shags have been observed: ■<50m, ■>50m (5% of all grids). Red circle: 25km radius from the main colonies (>50 birds). Dark blue ≤50m: 130.000ha.

72. Distribution and diving behaviour of Great Cormorant (*Phalacrocorax carbo*) has been studied at the Chausey Islands in France[58]. Here birds forage within an area of approximately 1,131 km² representing only 25% of the maximal potentially available area that birds may utilize considering their maximum foraging range of 35km. Individual birds remained within restricted individual foraging areas, on average 10-18% of the total utilized area. The preferences of each

[58] Grémillet, D.; Wilson, R.P. 1999. A life in the fast lane: energetics and foraging strategies of the great cormorant. Behavioral ecology 10: 516-524.

cormorant not only encompass the horizontal dimensions of its feeding environment, but also the maximum depth, as individuals tend to prefer a particular depth zone.

73. Whereas spatial distribution of foraging King Shags in the Marlborough Sounds is reasonably well known, individual site fidelity to return to specific areas within their feeding range is not known. Studies on other shags however provide some useful insights into general concepts of foraging fidelity.

74. During the breeding season, the Imperial Shag (*Phalacrocorax atriceps*) in southern Argentina, had a specific foraging area distinct from other individuals. Females are more consistent than males in the maximum distance they moved from the colony and the shore, the sexes segregated in their foraging areas and individual females segregated from one another. Individuals from this colony exhibited consistency over time which is also linked to stability of the environment at the location where the colony occurs[59].

75. Individual fidelity to a particular foraging area is also suggested for the Crozet Shag (*Phalacrocorax melanogensis*). This could help increase foraging efficiency through memorisation of the bottom's topography and the habits of its fauna. Such a strategy could considerably reduce search time among marine benthic top predators (especially by individuals of resident species) by enhancing the predictability of prey location for a given individual[60].

76. Male Pelagic Cormorants (*Phalacrocorax pelagicus*) in Alaska are also faithful to one particular foraging area. Distinct, specialized foraging behavior is thought to be advantageous in reducing intra- and interspecific competition but may also render the species vulnerable to changing environmental conditions[61].

77. 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

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[59] Harris, S., Rey, A.R., Zavalaga, C., Quintana, F. 2014. Strong temporal consistency in the individual foraging behaviour of Imperial Shags (*Phalacrocorax atriceps*). Ibis 156:523-533.

[60] Cook, T.R., Cherel, Y., Tremblay, Y. 2006. Foraging tactics of chick-rearing Crozet shags: individuals display repetitive activity and diving patterns over time.

[61] Kotzerka, J., Hatch, S.A., Garthe, S.. 2011. Evidence for foraging site fidelity and individual foraging behaviour of Pelagic Cormaorant rearing chicks in the Gulf of Alaska. The Condor 113: 80-88.

requirements[62]. 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. Models of the effects of environmental conditions and energy requirements on the feeding performance and distribution of European Shag (*Phalacrocorax aristotelis*) predicted that bird numbers would decline where predicted daily feeding times were high[63]. The abundance of available prey is an important parameter for the feeding habitat of all shags.

78. Within this foraging area, 64% of the world population of 839 birds (Stewart Island [26], North Trio [173], Duffers Reef [297] and Tawhitinui [43]) feed in a relatively small subsection of their overall distribution formed by Admiralty Bay and the Pelorus Sound. It is in particular these two areas where most of the up to 3,000 ha of marine farming has occurred and where further expansion of salmon farming is now planned in the main feeding area of the King Shags from Duffers Reef. Benthic effects from mussel farms are described in general[64]:

> *Faecal pellet and pseudofaecal production by mussels and/or oysters increases sedimentation rates under culture sites. This results in changes in sediment texture and local organic enrichment with an associated increase in oxygen consumption, increased nitrogen release rates, sulphate reduction and lowered redox potential. Increased organic loading usually results in a mildly enriched infauna. The enrichment level is generally much lower than for finfish farms, i.e. ES 2–4. Enrichment from mussels is usually limited to within 50m of farm structures.*

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[62] Grémillet, D.; Wilson, R.P. 1999. A life in the fast lane: energetics and foraging strategies of the great cormorant. Behavioral ecology 10: 516-524.

[63] Wanless, S.; Bacon, P.J.; Harris, M.P.; Webb, A.D.; Greenstreet, S.P.R.; Webb, A. 1997. Modeling environmental and energetic effects on feeding performance and distribution of shags (Phalacrocorax aristotelis): integrating telemetry, geographical information systems, and modeling techniques. ICES journal of marine science 54: 524-544.

[64] Keeley, N. 2013. Literature Review of Ecological Effects of Aquaculture. Benthic Effects. Ministry of Primary Industry.

General description and main environmental characteristics of Enrichment Stages (ES) 1 to 7 differentiated for low flow (LF) and high flow (HF) sites

ES	General description		Environmental indicators
2	Minor enrichment. Low-level enrichment. Can occur naturally or from other diffuse anthropogenic sources. "Enhanced zone".	LF	Richness usually greater than for reference conditions. Zone of "enhancement" – minor increases in abundance possible. Mainly compositional change. Sediment chemistry unaffected or with only very minor effects.
		HF	Changes as for LF.
3	Moderate enrichment. Clearly enriched and impacted. Significant community change evident.	LF	Notable abundance increase, richness and diversity usually lower than reference site. Opportunistic species (i.e. capitellid worms) begin to dominate.
		HF	As for LF.
4	High enrichment. Transitional stage between moderate effects and peak macrofauna abundance. Major community change.	LF	Diversity further reduced, abundances usually quite high, but clearly sub-peak. Opportunistic species dominate, but other taxa may still persist. Major sediment chemistry changes (approaching hypoxia).
		HF	As above, but abundance can be very high while richness and diversity are not necessarily reduced.

79. The Environment Court accepted that King Shag habitat will be changed by shell drop and sedimentation[65]. Whereas musselfarms elevate the enrichment level to between ES 2-4, salmon farms when consented through monitoring regime of Best Practice Guidelines will be compliant with an enrichment level between 2.9 - 5. A significant part of the 3,000-ha marine farming in the sounds has been established in the bays along the Waitata Reach, the additional 112 ha footprint area of the salmon proposal is proposed in the most important feeding area of the King Shags from Duffers Reef. The implication of slow creep from marine farming developments, including salmon farming, on the quality of King Shag feeding areas has only been indirectly and marginally studied. All prey of King Shags are benthic species and these may well be affected by small but significant cumulative changes in marine farming areas. To accommodate these uncertainties, the Board of Inquiry allowed two more salmon farms in the Waitata Reach to be established through adaptive management.

80. Ribbon development of marine farms in the Marlborough Sounds have covered a very specific habitat along the coast subtidal slopes. I have never seen King Shags feeding in a mussel farm. I have seen them feeding between farms, near the deepest water corners of the farms. There is

[65] *R.J.Davidson Trust* v *Marlborough District Council* [2016] NZEnvC 81[206]

evidence in support of the argument that marine farms effectively exclude King Shag from feeding. This evidence consists of:

- no shags observed feeding within marine farms
- fish species from marine farms do not occur in regurgitations from King Shag; hence these fish species are either unsuitable prey or impossible to catch.

81. King Shag biology is very poorly known. The Environment Court ruled in a recent decision on this particular matter of uncertainty:

> *However, the prediction remains: potentially the King Shag could be driven to extinction by the accumulated and accumulative effects of mussel farms which are part of the environment in Beatrix Bay. That is a low probability event, but extinction is indubitably a significantly adverse effect which would be exacerbated, to a small extent, by the Davidson proposal*[66]

Board of Inquiry and King Shags

82. The Board of Inquiry (BOI) identified the implications of increased phytoplankton and consequential reduction in water clarity as potentially significant for the feeding habitat of King Shag[67]. This was recognized as a matter of national importance under Part II of the Act[68] (S6c) relating to the protection of significant habitat and the presence of threatened species such as King Shag.

83. While the BOI did not expect a major shift in the trophic state of the Marlborough Sounds as a result of the proposed salmon farms, they did not rule out the possibility of shifts in the trophic state in affected embayments at different times of the year or in some years. The possibility of more subtle ecosystem changes in response to the increased nutrients from the farms was also acknowledged. The implications of increased phytoplankton and consequential reduction in water clarity was identified as potentially significant in the feeding habitat of King Shag[69]. The BOI suggested that water clarity should be measured, but were reluctant to set a water clarity

[66] *R.J.Davidson Trust* v *Marlborough District Council* [2016] NZEnvC 81[280]
[67] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [431].
[68] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [282].
[69] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [431], [458].

standard. Instead, an additional objective relating to King Shag was imposed and required monitoring of the population, in particular the colony at Duffers Reef.

84. The BOI had the greatest concern for the potential for cumulative effects within Pelorus Sound – given the number of proposed farms combined with the trends in riverine inputs, and the King Shag colony at Duffers Reef[70]. The BOI identified a lack of quantification of the overall risk of the farms on King Shag but they were satisfied with the potential for adverse impacts on the feeding habitat and foraging activity of the species[71].

85. The BOI identified three areas of concern that applied specifically to the Waitata Reach[72], one of them being the ecological integrity, particularly with respect to the habitat for the King Shag:

> ‘*…the consequences of any adverse impact on such a small population could be serious and the experts agree that King Shag may well be particularly sensitive to any habitat changes*.’

86. The BOI recommended a King Shag Management Plan as part of the conditions of consent for any farms within Pelorus Sound[73]. The objective of this plan is to ensure that there is no significant decrease in the overall population and the colony at Duffers Reef.

87. A precautionary approach was required given the threatened status and limited geographic range of this species[74].The BOI decided that the siting of four proposed farms in this Reach would not be appropriate[75] where the assimilative capacity of the receiving waters and the potential cumulative effects on the foraging areas of the King Shag are uncertain.

88. The BOI appropriately applied the precautionary principle[76]and acknowledged the uncertainty regarding the King Shag in the Waitata Reach. In other instances, matters of uncertainty were mitigated by the strong proposed adaptive management conditions of consent.

[70] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [465].
[71] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [532].
[72] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [1244].
[73] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [533].
[74] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [1246].
[75] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [1252].
[76] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [1278].

89. A King Shag Management Plan[77] was prepared. A baseline survey[78] was conducted in 2015. In the event that a statistically significant decline[79] of King Shag numbers ($p<0.05$) is detected since the previous survey, the consent holder shall investigate whether the operation of the marine farm is causing or contributing to the decline.

90. After the initial baseline census in February 2015, the management requires a follow up count. This is planned in February 2018.

King Shag Expert Evidence of Applicant of Relocation Proposal.

91. The applicant for the Plan Change of Relocation of Six Salmon Farms in the Marlborough Sounds provided a number of reports and reviews of relevance to King Shag. They are:

- **Taylor, P. 2016. Effects of salmon farming in the Marlborough Sounds on the prey of King Shag, *Leucocarbo carunculatus*. Statfishtics.**

92. Mr. Taylor is of the opinion that the nett effect of relocations would not be significant to King Shag for the following reasons:

- The dominant prey species, representing some 90% of the King Shag diet, is a visual feeder; its own diet includes a range of epifaunal species as well as small pelagic finfish, which is an alternative to benthic foraging and is largely beyond the influence of the salmon farm.
- Similar epifauna and infauna to that of the relocation sites is widespread within the Sounds; the total area represented by the relocation is small compared to the total area of the Sounds.

93. Mr. Taylor is over-estimating witch flounder being a dominant part of the diet of King Shags but to imply that salmon farms only have a 'benthic effect' is incorrect. An increase in phytoplankton and consequential reduction in water clarity was identified by the BOI as potentially significant for the feeding habitat of King Shag[80]. Turbid conditions reduce the efficiency of prey capture

[77] Schuckard, R. 2015. King Shag Management Plan. The New Zealand King Salmon Company Ltd. Richmond and Waitata Marine Farms.
[78] Schuckard, R., Melville, D.S.M, Taylor, G.. 2015. Population and breeding census of New Zealand King Shag (*Leucocarbo carunculatus)* in 2015.
[79] MacKenzie, D.I.. 2014. King Shag Population Modeling and Monitoring. Proteus Wildlife Research Consultants. September 2014.
[80]FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [458].

and prey selection by visual feeding flatfish[81]. The dominance of witch diet were crustaceans (*Periclimenes yaldwyni*) and anchovy (*Engraulis australis*), two prey species from the pelagic environment. Mr. Taylor has suggested a prey switch of King Shag diet from a diverse diet (20-50 years ago) to a predominant witch flounder diet recorded in a 1991/1992 study[82]. He proposes such an apparent switch of prey species to be the result of fishing pressure.

94. Earlier prey species records, predating the 1991/1992 study, are not a reflection of systematic sampling regimes. Some of these earlier records could be linked to particular colonies (e.g. Falla 1933) other reports do not mention the origin of the prey species identified at all (e.g. Nelson 1971). The interpretation of feed samples away from the main roost sites while on the edge of the main feeding distribution can provide a skewed interpretation of the diet of King Shag[83].

95. Whether the 1991/1992 study provides a sample of King Shag prey that is representative for the wider Pelorus Sound or for King Shag in general, is questioned. Our own 2011 samples from Duffers Reef and three other colonies identified a higher variety of prey on colonies compared to the 1991/92 study, more resembling the diversity of prey species from the earlier records. Feeding areas of King Shags in the Pelorus Sound need to be recognized until we have a better understanding how King Shag is utilizing its environment. The maintenance of the CMZ1 (aquaculture prohibited) is fundamental until knowledge based decisions on the management of this threatened species are possible.

96. Mr. Taylor is correct that the taxonomic groups of infaunal and epifaunal species of importance to King Shag prey are widespread throughout the sounds. However, the 1983[84] survey was a quantitative analysis of presence and absence of certain taxa. E.g. *Maldanidae*, an important polychaete for all prey species of King Shag, occurred in high numbers at all proposed sites in the Pelorus Sound. Whether that means that these sites are reflecting a widespread high density of the relevant taxa in the Outer Sounds or represents a specific selection of habitat of the selected sites with high numbers of certain polychaetes is unknown. The IUCN and the IBA programme have adopted the distribution map of foraging areas for King Shags beyond what is

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[81] Livingstone M.E. 1987. Food resource use among five flatfish species (*Pleuronectiformis*) in Wellington Harbour, New Zealand. N.Z.J.Mar.Freshw.Res.21:281-293.

[82] Lalas C.; Brown, D. 1998. The diet of New Zealand King Shags (Leucocarbo carunculatus) in Pelorus Sound. Notornis 45: 129-139.

[83] Butler, D.J. 2003. Possible impacts of marine farming of mussels (*Perna cannaliculus*) on King Shags (*Leucocarbo carunculatus*). DOC Science Internal Science Series 111.

[84] McKnight, D.G. and Grange, K.R. 1991. Macrobenthos-Sediment-Depth Relationships in Marlborough Sounds. D.O.C.Investigation No.P692.

recognized as 'marine significant sites', the breeding colonies. This map finds its origin in all known feeding King Shags and is determined by water depth (<50m), direction from colony (predominantly between the southern and western sectors from the main colonies) and distance from the colony (maximum 25km) (see par.71). These maps do not distinguish areas of high and low use for feedings shags. Because we can't interpret the relevance and significance of 'high and low' feeding frequency of shags, all feeding areas should be recognized to be significant.

97. Whether lost habitat for epifauna and infaunal species from high flow sites would be 'offset' through the vacated sites in low flow sites, is highly speculative and unsubstantiated. Embayments communities are likely different from the Waitata Reach due to their difference in environmental dynamics. A presumed similarity of communities from undisturbed embayments and the Waitata Reach could have been tested in support of this argument. That hasn't been done and any comfort from this proposition is speculative. The recovery of compromised sites also takes longer as suggested by Mr Taylor but can be complete after five years. Subsequent on-going benthic instability was however observed beyond five years during recovery projects[85].

- **Thompson, D. 2016. Seabirds – Potential Salmon Farm Relocations in the Marlborough Sounds – Update of Existing Report, NIWA Client Report No. 2016164WN.**

98. Dr. Thompson assessed the potential effects of relocating up to six farms. He is proposing (page 7 – 3.3) that if the number of farms stay the same compared to the current low flow farms and if '***<u>all other factors being similar'</u>*** the population is likely to be stable in the new farm environment. Whether a fivefold increase of salmon feed into the waters of the Marlborough Sounds, known to be significant feeding habitat for King Shags from Duffers Reef, is part of this consideration is unclear and missing from his analysis.

99. Unfortunately, Dr. Thompson has considered effects of salmon farms on feeding King Shags in Tory Channel (3.3.1 and 3.3.3), an area where to date no records of feeding shags are available apart from a roosting juvenile from Ngamahau Bay. The strong currents in the channel may possibly prevent a bottom feeder from successfully exploring this environment. I will not further comment on his findings on this particular analysis.

[85] Keeley, N. B., Macleod, C. K., Hopkins, G.A., Forrest, B.M. 2014. Spatial and temporal dynamics in macro benthos during recovery from salmon farm induced organic enrichment: When is recovery complete?. Marine Pollution Bulletin 80: 240-262.

100. Dr. Thompson makes some observation (3.3.1) that the current Forsyth Bay farm has a similar distance to Duffers Reef compared to Blowhole North and South sites and for that reason these two proposed farms are '*highly unlikely to cause any disturbance'.* The Forsyth farm has used about 11,000 tonnes of feed between 2001 and 2015 during six productive years. The two farms by Blowhole Point are proposed for almost this same amount each year, with maximum feed level of 9,500 tonnes per annum, more than 10 times the amount of feed used for the Forsyth farm. Whether this will still fit in the analysis '***all other factors being similar'*** is unclear. Both Blowhole farms are mentioned to be '*...sufficiently far from the colony to pose negligible disturbance'.* It is again unclear what threshold is being used to identify 'sufficiently far'. All areas between 2 and 12 km of certain depth are important King Shag feeding areas, including the Blowhole Point farms.

101. Three farms (Blowhole North, Blowhole South and Waitata Central) at a distance between 3-5 km from Duffers Reef are proposed to use a maximum of 16.500 tonnes of feed. As a comparison, the total feed use of all NZKS farms in the Sounds between 2013 - 2015 was about 14.000 tonnes per annum.

102. The impact of noise (3.3.2) in particular the sound of feed dispensers on King Shags is unclear. The study for the proposal[86] did not address the impact of noise underwater and how that can not only affect marine mammals but also fish and foraging birds. As aquatic and terrestrial habitats differ in their sound propagation properties, i.e. sound in water travels faster and greater distances, and attenuates less than sound in air, noise pollution in aquatic ecosystems may be more far-reaching than in terrestrial ecosystems by covering larger areas. The interplay with other environmental stressors may intensify the problems for species inhabiting noise-polluted aquatic habitats. The effects of noise underwater is poorly understood and the analysis presented on this matter by is not designed to be specific for wildlife[87]:

> Underwater noise has been used to prevent waterfowl from foraging, in order to reduce commercial losses of farmed molluscs[88]. Very little is known about the importance of

[86] Halstead, M. 2016. Salmon Farm Relocation Noise Effects Assessment. Marshall Day Acoustics.

[87] McCluskie, A.E., Langston R.H.W. & Wilkinson N.I. Birds and wave & tidal stream energy: an ecological review. Birds and wave & tidal stream energy: an ecological review.

[88] Ross, B. P., Lien, J. & Furness, R. W. (2001) Use of underwater playback to reduce the impact of elders on mussel farms Ices Journal of Marine Science, 58, 517-524.

hearing underwater to birds and whether noise can disorientate them or adversely affect their foraging success. Marine noise and more especially vibration will potentially have a greater impact on fish, and could thus alter the distribution of fish prey around device arrays. Studies have found that noise, such as from shipping activity, can cause an avoidance or attraction in fish[89]. The sensitivity of fish to noise is unknown for most species, particularly those of importance to seabirds, such as sand eel (*Ammodytes marinus*), and for those with a swim bladder, such as clupeids. Studies have found that noise, such as from shipping activity, can cause an avoidance or attraction in fish.

103. Dr Thompson has assessed that there is no information about areas of importance to King Shags as foraging locations and how these locations may change. IBA's (see par 43) and the IUCN distribution map have adopted three parameters (depth, distance and direction to colony) to explain the majority of the distribution of foraging shags recorded so far:

1) marine waters, at 25km from the main colonies.

2) at a depth of <50m

3) in southwestern direction from colonies.

This area is about 1,300 km². In a joint Statement for the Environment Court[90] between the two avian experts, Dr Thompson and Dr Fisher, the existence of this IBA was acknowledged and as such 'the area of importance to King Shags as foraging:

> *'The Marlborough Sounds IBA is defined by the seaward extensions to seabird colonies and includes coastal congregations of non-breeding seabirds. The qualifying species include: King Shag (foraging range (25km) from colony and extent of foraging depth (50m);…'*

It is unfortunate this information was not communicated in Dr. Thompson's evidence.

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[89] Thomsen, F., Lüdemann, K., Kafemann, R. & Piper, W. (2006) Effects of offshore wind farm noise on marine mammals and fish Biola, Hamburg

[90] Joint Statement Paul Richard Fisher & David Richard Thompson. In Environment Court ENV-2006-WLG-000057, 60, 66, 73, 81, 88, 92, 94, 97.. Appeals under s.120 of the Act between Friends of Nelson Haven and Tasman Bay Inc. (Appellant) and Marlborough District Council (Respondent). 25th May 2016.

104. Dr Thompson acknowledges that enhanced levels of productivity may occur but predicting on how these changes may affect King Shags remains extremely difficult. I concur with his conclusion. Where a range of important issues have been identified, information for a further analysis on these issues was lacking (e.g. impact enhanced productivity, uncertainty about feeding distribution, lack of information on how wildlife respond to noise etc.). Where the increase of the production is significant (doubling total production of New Zealand King Salmon Inc.) it is surprising Dr Thompson comes to the following conclusion (3.4): '*it to be unlikely that the proposed new farm locations would affect King Shags in anything other than a negligible way.'*

105. The King Shag Management Plan was part of the requirement by the Board of Inquiry to overcome uncertainty while allowing two farms to proceed with adaptive management to a total maximum feed level of 10,000 tonnes in the Waitata Reach. That amount is now proposed to increase by 23,000 tonnes to a total of 33,000 tonnes. It seems difficult to reconcile on how King Shag information and in particular the lack of it, allows Dr Thompson to make this assessment of effect to be 'negligible'.

- **Taylor, G. 2016. Comments on the NIWA seabird reports assessing issues with relocation of salmon farms in Marlborough. Department of Conservation.**

106. It is unfortunate that Mr. Taylor is not alluding to the scarce knowledge of this threatened species, a reason why the Environment Court and the BOI decided to adopt a precautionary approach for future management of this species. Whether this precaution is reflected in a more than doubling of the feed levels in the Waitata Reach is missing from Mr. Taylor's analysis. The IUCN has adopted prevention of marine farming close to colonies and avoiding further physical and benthic footprint overlap with feeding areas. The proposal clearly contradicts this precautionary approach.

Benthic Expert Evidence of Applicant of Relocation Proposal.

- **Brown, S. 2016. Benthic Ecological Assessments for Proposed Salmon Sites. Part 1 Benthic Ecological Characterizations. NIWA Client Report No: NEL2016 -003**
- **NIWA – Benthic Ecological Assessments for Proposed Salmon Farm Sites – Part 2: Assessment of Potential Effects Dec 2016.**

107. The assessment to test the significance of benthic environments of the proposed sites is based on results of previous studies and publications[91],[92],[93]. Personal observations and consideration of the representativeness, rarity, distribution and functional importance of the features played a further role in the assessments. To use trigger levels for significant habitats that were developed more than 20 years ago (Davidson 1995), can be problematic when decline in abundance and diversity has been recorded.

108. With the mapping of various habitat and taxa identified at the proposed sites, notable ecological features within the wider depositional footprint may still be negatively affected by even lower levels of bio deposition according to the benthic report. With no spatial information, available about a qualitative mapping of habitats that are specific for fast flow environments, transformation of areas with scallops, brachiopods, small biogenic clumps, kelp communities, tube worm beds, hydroids, sponges etc. quantification of the perceived losses in Sounds wide environment are missing.

109. Policy 7 of the NZCPS 2010, strategic planning, requires to identify areas of the coastal environment where particular activities and forms of subdivision, use and development are inappropriate or may be inappropriate without the consideration of effects. Where monitoring of the effect of two farms in adaptive management (Waitata and Richmond) has not gone beyond the establishment of a baseline, a further decline of fast flow habitats without an understanding on how 'widespread' these ecological features are, seems not to reflect the strategic planning that is required prior to a plan change. Effects beyond the predicted primary footprint is acknowledged in the evidence and perceived as a potential risk from the relocation proposal.

110. Objective One of NZCPS-2010 requires safeguarding the integrity, form, functioning and resilience of the coastal environment and sustaining its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by:

- **protecting representative or significant natural ecosystems** and sites of biological importance and maintaining the diversity of New Zealand's indigenous coastal flora and fauna;

[91] Davidson, R.J. 1995. Guideline for ecological investigations of proposed marine farm areas. Department of Conservation. Occasional Publication No.25.
[92] McKnight, D.G. and Grange, K.R. 1991. Macrobenthos-Sediment-Depth Relationships in Marlborough Sounds. D.O.C.Investigation No.P692.
[93] Davidson, R., Duffy, C., Gaze, P., Baxter, A., DuFresne, S., Courtney, S., Hamill, P. 2011. Ecologically Significant Marine Sites in Marlborough, New Zealand. Marlborough District Council and Department of Conservation.

111. The concept of representativeness first appeared in court decisions as per the Reserves Act 1977 with the following goal:[94]

> *Ensuring, as far as possible, the survival of all indigenous species or flora and fauna, both rare and commonplace, in their natural communities and habitats and the preservation of representative samples of all classes of natural ecosystems and landscape which in the aggregate originally gave New Zealand its own recognizable character.*

In CIV-2010-409-002466, the purpose of the representative criterion[2] was:

> *...to provide for the maintenance and persistence of biological diversity in the West Coast.*

112. Without any formal protection of marine habitats in the Pelorus Sounds, the proposal is pushing ecosystem functionality to levels that is not reflecting the precaution that is required with declining biodiversity in the sounds and lack of knowledge and spatial distribution of fast flow communities.

113. The outer effect of the deposition model for the proposed farms is an enrichment stage ES3. The Best Practise Guidelines prescribe an outer effect of ES<3.0, where maintenance of the natural conditions is the industrial operational goal:

> *ES 3.0 corresponds to discernible 'moderate enrichment' and is a state that is unlikely to be found naturally. 'Natural' (i.e. non-farm impacted) seabed in the Marlborough Sounds from ES~1.5 to ES~2.5 (but no greater than ES 2.9). Careful reference station selection is therefore critical. The total footprint presented in the benthic reports need to be seen as a minimum but likely will be larger around the edges*[95].

114. With an Outer Limit Effect of ES 3.0 the model could not exclude '*some effect from both farms on the reef community of Blowhole Point.'* The effect from both Blowhole North and Blowhole South will be exacerbated if compliance with Benthic Guidelines (ES<3.0) needs to be achieved.

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[94] In West Coast Regional Council versus Friends of Shearer Swamp(CIV-2010-409-002466): Reserves Act 1977, s 3(l)(b).

[95] Keeley,, N. *et al.* 2014. Best Management Practice Guidelines for salmon farms in the Marlborough Sounds: Benthic Environmental Quality Standards and Monitoring Protocol. Final 2014.

115. Also, the Richmond South deposition model may well have a wider deposition that can affect nearby Reef/Cobble/Kelp and Reef habitat with Shell Biogenic and Brachiopods at Horseshoe Bay.

Water quality Expert Evidence of Applicant of Relocation Proposal.

- **FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY (BOI)– 22 February 2013**
- **NIWA – Modelled water column effects on potential salmon farm relocation sites in Pelorus Sound – HAM Report 12, 18 Oct 2016.**
- **Cawthron Institute – Peer review of the Marlborough Sounds biophysical model predictions Sept 2016.**

116. The BOI made a decision in 2013 about plan changes and applications for resource consents by The New Zealand King Salmon Company Limited. The greatest concern was expressed for the potential for cumulative effects of the expansion of salmon farming [465] within Pelorus Sound:

> *'……given the number of proposed farms, the trends in riverine inputs and the King Shag colony at Duffers Reef.'*

117. The baseline information was regarded to be insufficient at the time of the BOI hearing [461]. To mitigate this lack of information, their proposed consent conditions required a historical baseline of water quality conditions and further water column monitoring relevant to the enrichment status of Pelorus Sound in particular. Water column monitoring should incorporate [448]:

- nutrients (NH4-N, NO3-N, NO2-N, DRP, Si, TN and TP), not cause elevation of nutrient concentrations outside the confines of established natural variation for the location and time of year, beyond 250m.
- Chlorophyll-a concentrations (water clarity)
- phytoplankton composition and biomass (i.e. diatoms vs. dinoflagellates, with no increased frequency of harmful algal blooms (HAB's) and no noxious build-up of macroalgal)
- salinity,

- temperature,
- turbidity
- dissolved oxygen (not to reduce to levels that are potentially harmful to marine biota)

118. The “natural” depositional flux was identified to be **<u>the existing baseline situation</u>** [324] with respect to both marine and terrestrial derived sediment, including the contribution from agriculture and logging operations within the catchments, rather than a pristine environment.

119. The BOI [181] considered that, before endorsing an adaptive management approach, it would have to be satisfied that:

(a) there will be good baseline information about the receiving environment;

(b) the conditions provide for effective monitoring of adverse effects using appropriate indicators;

(c) thresholds are set to trigger remedial action before the effects become overly damaging; and

(d) effects that might arise can be remedied before they become irreversible.

120. Baseline environmental studies are effectively designed to establish the environmental conditions at a site prior to any site development. Once established, these “baseline” conditions then provide a benchmark against which to monitor and manage any potential future impacts resulting from industrial operations at the site.

121. Due to the established uncertainties about water column issues, every three years the results of the wider water quality and ecosystem monitoring were to be reviewed [440] to assess trends and implications for the ecosystem, including any potential for a shift in trophic status. The Board decided that these conditions and the associated monitoring and management plans to provide: *‘a sufficiently structured, but flexible, adaptive management approach’* (Marine Environmental Monitoring and Adaptive Management Plan – MEM-AMP). The farms were obliged to operate at all times in such a way as to comply with Water Quality Standards and associated responses, for the near farm and wider-scale water column environment of Pelorus Sound.

122. The purpose of the first biophysical modelling was to predict the effects of existing and proposed mussel and finfish farms on water quality[96]. ***<u>Present day/existing farms scenario</u>*** with

[96] Broekhuizen, N., Hadfield, M., Plew, D. (2015) A biophysical model for the Marlborough Sounds part 2: Pelorus Sound. National Institute of Water & Atmospheric Research Ltd, NIWA Client Report (for Marlborough District Council) CHC2014-130 (project MDC13301): 163.

mussel farms in operation in 2010 (counted by aerial-surveys), and New Zealand King Salmon Ltd. salmon farms that operated during 2012/2013 (Waihinau Bay, Forsythe Bay, and two farms in Crail Bay) were the basis to set the original baseline as required by consent conditions by BOI.

123. The '***Approved farms as for the present day'*** scenario, included additional mussel and fin fish farms that have been approved or existed but were not occupied during the 2010 aerial survey. The additional salmon farms were Richmond, Waitata and Port Ligar[97] (and a small farm in Beatrix Bay).

124. To give effect to precaution to the development of the salmon farms consented by BOI, the conditions require the results of the wider water quality and ecosystem monitoring to be reviewed every three years. This is to assess trends and implications for the ecosystem, including any potential for a shift in trophic status, and to make recommendations as to management actions and/or suitable indicators for assessing the water column ecosystem. These conditions and the associated monitoring and management plans were perceived to provide[98]*: 'a sufficiently structured, but flexible, adaptive management approach'*.

125. The 3 consented new farms have recently all been stocked and are operational under monitoring terms of MEM-AMP: Ngamahau (U140296) – November 2015, Waitata (U140294) – January 2016 and Kopaua (Richmond) (U140295). At this stage, one annual monitoring plan has been produced for the Ngamahau farm and no reports are available from the Pelorus Sound.

126. So far, the only information available on the environmental effects of the three BOI consented farms is the biophysical model. The model's predicted effect for scenario of 'approved farms as for the present day'[99] are:

- effects induced by additional fish farming will extend through the entire Pelorus system.
- relative to the present-day scenario, the modelling suggests that the approved additional fish and mussel farms will induce:

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[97] This farm was appealed for the Environment Court and no consent was granted: KPF INVESTMENTS LIMITED and (ENV-2012-CHC-80) PELORUS WILDLIFE SANCTUARIES LIMITED, J & R BUCHANAN & H T ELKINGTON (ENV -20 12-CHC-68) Appellants MARLBOROUGH DISTRICT COUNCIL

[98] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [440]

[99] Broekhuizen, N., Hadfield, M., Plew, D. (2015) A biophysical model for the Marlborough Sounds part 2: Pelorus Sound. National Institute of Water & Atmospheric Research Ltd, NIWA Client Report (for Marlborough District Council) CHC2014-130 (project MDC13301): 163.

i. winter-time phytoplankton biomass changes of <5% and increase slightly in the main channel of central and inner Pelorus but decline within Crail/Clova/Beatrix Bays.

ii. summer-time phytoplankton biomass changes of <15% at most and will increase throughout Pelorus. The greatest (but still relatively small) changes will be in the vicinities of the new fish farms (i.e., in Beatrix/Crail/Clova Bays, and around Richmond/Waitata/Port Ligar).

127. The model predicted that nutrient inputs associated with the additional fish farms are to increase summertime near-surface phytoplankton standing stocks by 5–10% relative to the existing conditions (present day/existing farms scenario). The simulated phytoplankton concentrations are higher than is the norm for New Zealand coastal waters, but they would not be higher than values that are intermittently (but fairly frequently) recorded in our coastal waters.

128. The modelers allude to some uncertainties, where field data indicate that the ‘existing conditions’ simulation may be over-estimating summertime near-surface phytoplankton abundance and the ‘additional fish farms’ scenario will also contain this embedded tendency to over-estimate.

129. The 2012 baseline was required to monitor the real-world effect of the farms that were consented, in particular the Pelorus Sound where the greatest concerns were raised for the potential cumulative effects[100]. The proposed adaptive management in combination with a baseline survey was assessed to be sufficient to overcome the uncertainties. Of the 24,000 tonnes of salmon feed proposed in 2012 by New Zealand King Salmon for the Waitata Reach, the Board consented a maximum feed level of 10,000 to go ahead with stringent monitoring. To date no monitoring reports have been available the compare real-world effects with the model.

130. The proposal for relocating low flow farms to the Waitata Reach is asking for consent for maximum of 23,000 tonnes of feed in addition to the 10,000 tonnes consented by BOI. This approach is irreconcilable with the intentions and precaution for salmon farms consented by the BOI in 2013, a careful approach also supported by the Supreme Court decision.

131. For the biophysical model of the 2016 proposal for relocation, a new baseline was created. All currently (2016) approved mussel farms and finfish farms (Crail Bay 1, Crail Bay 2,

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[100] FINAL REPORT AND DECISION OF THE BOARD OF INQUIRY – 22 February 2013 - [465]

Beatrix Bay, Waitata, Richmond, Waihinau & Forsyth) have now been part of a 'new baseline', the $baseline_{2016}$. The $baseline_{2016}$ is fundamentally different from the $baseline_{2012}$, undermining the principles of what a baseline is about. A baseline is to provide a benchmark against which to monitor and manage any potential future impacts resulting from industrial operations at the site. Whether such a shift in baseline scenario was anticipated by the BOI (and the Supreme Court) to overcome uncertainty in environmental information to underpin sustainability of the management of the Marlborough Sounds is very doubtful.

132. Scenario 13 in the model is the closest to the total relocation proposal for Pelorus Sound. Inconsistencies in the presentation of the model occur. Where Horseshoe Bay and Waitata Mid Channel SE are according to Fig. 2-1 (page 24) not part of the scenario, Table 1-1 page 19 (farm inputs for each scenario) seem to have integrated Horseshoe Bay in the modelling as per scenario 13. As such there is confusion about the scale of scenario 13. The modelers were originally presented an '*erroneous'* farm production schedule (6,672 tonnes over 18 months) for the Waitata Reach farm (existing). This figure was corrected to 8,432 tonnes. It is noted that Richmond is also provided with two production schedules. Whether this is also a correction similar to Waitata is uncertain.

133. Where the majority of the feed production schedules in Table 1-1 were integrated in the model between 1st May 2017 - 31st October 2018 (18 months) the correction for Waitata (and possibly Richmond) ran between 24th May 2012 - 6th October 2013 (16.5 months). The number of corrections and omissions (e.g. discrepancies between Fig 2-1 and Table 1-1) that took place are providing problems with interpretation of outcomes of model

134. For the new baseline and model, a number of feed inputs have been used. **<u>If</u>** Richmond Bay (5,865.6 tonnes of feed) ran for 18 months, the 12-month feed schedule will be 3,910 tonnes, only 90 tonnes less compared to the maximum consented. If Waitata Bay (8,432.4 tonnes of feed) ran for 18 months, the 12-month feed schedule will be 5,621.6 tonnes, only 380 tonnes less compared to the maximum consented. Whether these high feed levels reflect the concern from the Board of Inquiry's process with e.g. water column issues for the Waitata Reach as a result of eutrophication from salmon farming is doubtful. To integrate these high feed levels in the new baseline for the Pelorus Sound is pre-empting the outcome of adaptive management required for both Waitata and Richmond farms.

135. Also, the levels set for a number of low flow farms for scenario 1 (the new baseline) seem to be set at levels that are too high or have been proven to be unsustainable:

- Crail Bay 1 and 2 – 18 months ~1600 tonnes, 12 months ~1100 tonnes: One of these farms has only been productive in 2010 and 2011. Conditions for these low flow farms are already mimicking what the Best Practise Guidelines want to achieve, to stay between ES 3.0 - 5.0. No information has been provided to extrapolate these conditions to a production and feed level. The feed levels for $baseline_{2016}$ are likely not reflecting the sustainable feed protocol for these farms.
- Forsyth Bay – 18 months ~4400 tonnes, 12 months ~ 2900 tonnes. Only in 2010 and 2011 were these feed levels used in two consecutive years. The benthic environment never recovered from these levels and the farm site has been very problematic ever since. To present these feed levels in the baseline scenario seems unrealistic.
- Waihinau Bay – 18 months ~4000 tonnes, 12 months ~2700 tonnes. Since 2014, this farm is using between 1500 and 2500 tonnes. The amount used for the baseline is reflecting the upper level of feed applications and problems with management of this farm are a concern.

136. For scenario 13 (the maximum number of farms but not all of them) also reveals that uncertainties in farm feed inputs for the model occur:

- Waitata Reach – A feed input for Waitata Reach NE is provided for 18 months of ~15,758 tonnes, where Waitata Reach SW is zero. This amount seems to contradict Fig 2-1 where scenario 13 has only Waitata NE activated. If we assume that the model was using the mid Waitata Reach maximum feed levels of 7,000 tonnes, the numbers are even more problematic and confusing. The 12-month equivalent of 15,758 tonnes for 12 months is 10,505 tonnes, more than 3,000 tonnes above of what is applied for.
- Richmond Bay South – For 18 months, ~8,500 tonnes of feed is proposed, ~5,700 tonnes for 12 months. That amount of feed is unrealistic compared with the maximum of 5,000 tonnes applied for.

- Horseshoe Bay – For 18 months, ~3,900 tonnes of feed is proposed, ~2,600 tonnes for 12 months. That amount of feed is unrealistic compared with 1,500 tonnes applied for.
- Blowhole South – For 18 months, ~8,019 tonnes of feed is proposed, ~5,300 tonnes for 12 months. This farm is applying for a maximum feed level of 5,000 tonnes.
- Blowhole North – For 18 months ~7,500 tonnes is proposed, about 5,000 tonnes in 12 months. This farm has applied for 4,500 tonnes.

137. Overall, the biophysical model presents a number of uncertainties:

- The modelers have not provided a clear rationale why the baseline_{2012} changed to a baseline_{2016}. This question is fundamental to maintain trust in hydrodynamic models. The protocol to accommodate uncertainties (that were identified by the BOI to allow 10,000 tonnes of feed to proceed with adaptive management) have been put aside to accommodate an additional 23,000 tonnes of feed for this proposal No: 2017/04.
- Scenario 1, the baseline_{2016} – feed levels for existing farms are set unrealistically high in comparison with today's production levels reflecting older but existing consents.
- Discrepancies occur between Figure 2-1 (maps of farms) and Table 1-1
- Scenario 13, the maximum number of farms that are modelled – This scenario is surprisingly not modelling all the farms proposed. If not all proposed farms are incorporated, the model is missing those low flow farms that will stay active. If e.g. both Crail Bay farms will be vacated (2x 0.47 ha or ~1ha of surface structure area), the surface area is similar to e.g. Richmond South (surface structure area 0.933ha). Such a proposition would not have any environmental gains as promoted in the application, to the contrary:
    - Conditions of Crail Bay are already reflecting the Best Management Guidelines (ES 3.0-5.0)
    - These farms have not been active for at least 5 years
    - The environmental change will be from zero feed levels to maximum 5,000 tonnes.
- All new farms applied for, that are part of the scenario 13 model, have higher or extreme higher feed inputs compared to what is applied for.

138. It is beyond the scope of my evidence to provide a judgement on the validity of the biophysical model to measure the impact of the farm or farms that are proposed for in particular the Waitata Reach. However, major concerns have been raised and need to be addressed prior to any progress on allocating sites in fast flow areas.

139. Uncertainties about the approved farms and their impact on the overall environment of the Waitata Reach is potentially identified by the modelers (page 69):

> *Certainly, chlorophyll concentrations in the baseline*$_{2016}$ *scenario are often greater than 3.5 mg chlorophyll m−3 (and even 5 mg chl m−3). To a small degree, this may be a result of the two newly approved farms (Waitata and Richmond) but previous modelling suggests that the model tends to over-predict chlorophyll even in the absence of these farms.*

140. Chlorophyll is an important measure to model the impact of salmon farming released nutrients on the wider environment. Water clarity and turbidity are parameters that will very much affect the quality of the fast flow habitats of the Waitata Reach and as such the feeding habitat of King Shag. Significant problems for the modellers have occurred to interpret thresholds for chlorophyll:

> *' ..whilst most offer chlorophyll thresholds, many are vague in important details (e.g., degree of spatial-temporal averaging to apply to field data before comparing measurements with thresholds, size-fraction of the phytoplankton community to consider etc.*'

141. The 5mg m^{-3} threshold for chlorophyll was suggested by the Board of Inquiry to be a good indicator of a shift towards eutrophic conditions and soundly based on monitoring results to date. Five mg of chlorophyll was pointed out as a level that would affect clarity, and a level that gets exceeded periodically in some bays due to natural processes. This exceedance has not been well captured with the MDC state of the environment monitoring to date. The interim water quality standards for the BOI granted farms (Waitata, Richmond and Ngamahau) were informed by analysis by NIWA of TN and Chlorophyll-*a* levels from recent monthly monitoring results and baseline data collected for NZKS by NIWA. The interim water quality standards are <3.5mg m^{-3} for Chl-*a*; <300 mg/kg for TN; and $\geq$90% DO concentration 250m beyond the edge of salmon net pens.

142. To date, exceedance of Chl-a above 2.0 mg m^{-3} for Chl-*a* are exceptional in those stations situated in the Waitata Reach, (PLS 6 and PLS 7).

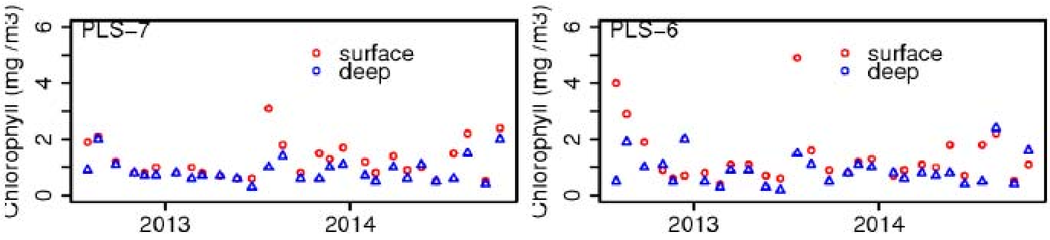

Figure 5-3: Time-series of chlorophyll-a concentrations (mg Chl-a/m³) measured at the seven MDC stations in P

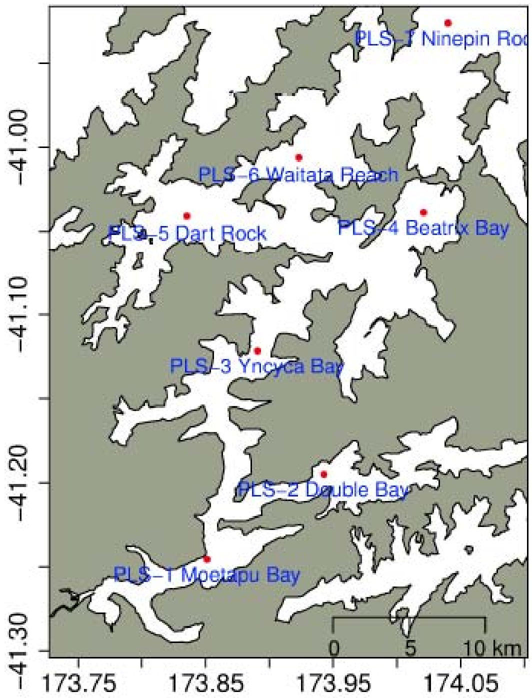

Figure 1-2: Map of Pelorus Sound showing the locations of the seven Marlborough District Council water-quality monitoring sites.

143. Concerns about the shifting baseline2016 compared to baseline2012 was shared by Mr. Knight, the peer reviewer of the modelled water column effects of potential salmon farm relocation sites in Pelorus Sound. At the 3rd October 2016, Mr Knight presented a review of water quality modelling scenarios and had some initial thoughts:' ***Concern that baseline was not 'existing' scenario from 2012/2013.***'

144. Mr. Knight's peer review[101] is concerned that the responses of the model to substantial feed increases is going far beyond the levels for which they are validated: *'….there would need to be a higher standard of proof on the accuracy of the models if they are the sole method of estimating effects.'*

145. Whether Mr. Knight has incorporated all of the farms in Pelorus Sound is questioned. When (Table 2-page 6) comparing existing and proposed consented annual feed inputs for Pelorus Sound, the two BOI farms are missing from this table (4,000 and 6,000 tonnes). Whether this potential omission is further raising concerns he already was alluding to is not clear. The BOI farm Ngamahau is integrated in the feed inputs for Queen Charlotte (Table 1-page 5).

146. I agree with Mr. Knights final conclusion (page 16):

> *The sensitivity of phytoplankton to additional nutrients is at the core of the model results. In my opinion, the models are being stretched beyond their original scope and purpose, particularly in the Pelorus Sound. If the models are to be used as the sole source of assessment, they will require a high level of confidence.*

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[101] Knight, B. 2016. Peer Review of the Marlborough Sounds Biophysical Model Predications. Cawthron Institute – Report 2913.