Factsheet 5: Projected Climate-related Impacts on Food Safety Systems in the Seafood and Aquaculture Sector

The risk matrix represents a sector specific overview of the climate change impacts to food safety and systems, their risk now, in the future under a high emission scenario, and following suggested adaptation options. The risks are defined as low = green, medium = yellow, high = orange, high = red. Information used to develop the risk matrices was sourced from scientific publications and industry feedback from Workshop 1 and based on the high emission scenario. The purpose of the risk matrix is to provide a summary of potential impacts for discussion with representatives from the NZ food sectors, research providers and government agencies.

Issues have been categorised as follows:

Category 1: Existing hazards affected by climate change

- Those arising from infectious agents
- Those arising from naturally occurring chemicals and biotoxins

Category 2: From risk management to address climate change issues

- Chemical interventions (pesticides, antibiotics etc.)
- Other changes in production processes

We have based our indications of climate change expected over the next 100 years on the highest representative concentration pathway (RCP) 8.5, because this enables us to more clearly assess future change.

Additional commentary is provided below the table.

CLIMATE CHANGE AND FUTURE IMPACTS

The following oceanic changes are projected for the whole New Zealand Exclusive Economic Zone (EEZ) region.

Sea surface temperature (SST) and iron concentration are projected to increase (by around 2.5°C and 0.031 nM, respectively); while chlorophyll, nitrate, phosphate, and silicate are projected to decrease by, respectively, -0.043 mg Chl m-3, -0.49 µmol m-3, -0.039 µmol m-3, and -0.18 µmol m-3. These changes are for the end of the century (compared with the period 1986-2005) and are based on RCP8.5 and the average from several global climate models (Law et al., 2016).

The rising atmospheric concentration of CO_2 is also causing 'ocean acidification', a collective term used to describe the changes in different components of the ocean carbonate system (Orr et al., 2005). This change is most apparent as a decrease in pH. All projections indicate that the annual pH range falls below the current pH range by 2025, with only RCP2.6 projecting a return to this range by the end of the century (Cummings, 2016).

Global mean sea level rose by 0.19 ± 0.02 m from 1901 to 2010 (IPCC, 2013). Sea level rise around New Zealand is comparable to the global average, being approximately 0.17 ± 0.1 m for the 20th century (IPCC, 2014). Sea level is projected to rise by between 0.5m and 0.8m by the 2090s (2090 to 2099) relative to the 1980-1999. For longer-term considerations an allowance for further sea-level rise of 10 mm/year beyond 2100 is recommended (Ministry for the Environment, 2008).

Additional oceanic changes are also possible (for example, to the location and strength of ocean currents and sedimentation rates to river mouths and estuaries), however these have not been assessed in detail at present.

FOOD SAFETY SYSTEM ISSUES

Impact on fisheries:

Phytoplankton from the base of marine food webs and support ecosystems and fisheries. Primary phytoplankton production in surface waters is projected to decline by an average 6% from the present day under RCP8.5, with Subtropical waters, which have low primary production, experiencing the largest decline (Law et al., 2016).

A proportion of the organic matter produced by phytoplankton in the surface of the ocean sinks down through the water column. This particle flux from surface to sea-bed is an important factor that determines energy flow through marine ecosystems, and also the amount of carbon sequestered in the deep ocean. Consequently determining the impact of climate change on particle flux into the ocean interior is important for predicting future carbon uptake by the ocean, and the impacts of climate change on marine ecosystems and fish stocks. Particle flux from the surface to the seabed is projected to decrease by 9-12% by 2100, which indicates that carbon sequestration will decline in the open ocean around New Zealand. Changes in particle flux will alter the food available for fish.

Impact on aquaculture:

The 'Australasia' chapter of IPCC (2014) concludes that climate change could lead to substantial changes in production and profit of aquaculture species such as salmon, mussels and oysters. Ecosystem models also project changes to habitat and fisheries production.

Climate change may adversely affect pāua (*Haliotis iris*). Experimental work on the impacts of acidification in New Zealand waters on juvenile pāua showed that while survival was not affected, growth was significantly reduced, and dissolution of the shell surface was evident (Cunningham 2013). Similar effects were found for growth and shell surfaces of flat oysters (*Tiostrea chilensis*) (Cummings et al., 2013, 2015). Rock lobster (*Jasus edwardsii*) may also be adversely affected by the effects of climate change, including ocean acidification (Cornwall and Eddy, 2015).

Changes to carbon markets may threaten some supply chains. For example a life cycle analysis of Australian rock lobsters identified that airfreight to markets had 50% of global warming potential, a measure of the environmental footprint (van Putten et al 2015) that could threaten the supply chain.

Projected increases in heavy rainfall (with likely related increases in river flooding events) could result in changes in sediment characteristics that reduce suitability of habitats for aquaculture species in intertidal areas of estuaries. This typically results in muddier habitats and reductions in the abundance of sea grass meadows and intertidal shellfish beds (Cummings, 2016).

Warming ocean temperatures (Polar shift) could facilitate/assist arrival and spread of invasive organisms into cooler regions and how this could impact aquaculture and wild stocks i.e. habitat change through invasive seaweed outcompeting our native species and how this could impact ecosystem function and energy transfer.

The effects of higher temperatures on salmon farming may affect future production and sustainability of the industry, as temperatures over 16 degrees can negative impacts on Chinook Salmon i.e. current farming sites may not be viable under future climate predictions, this will be very important for future planning of new aquaculture sites and species selection.

SUPPLEMENTARY INFORMATION FOR RISK MATRIX:

Infectious agents:

Increased ocean temperature:

- Most important hazard is *Vibrio* spp., research is in progress at Plant and Food Research. Seawater temperatures above 19 degrees have been suggested as trigger for increased risk and monitoring (Cruz et al., 2015). As well as a food safety issue, *Vibrio* can cause wound infections.
- Post-harvest processing options for such hazards include low temperature pasteurisation, freezing, high hydrostatic pressure and irradiation.
- Refrigeration will be an increasingly important component of the food chain, for both maintaining quality and preventing pathogen growth.

Increased runoff from rainfall:

- Increase in rainfall predicted for western regions of New Zealand, and in south of South Island. Decrease in rainfall and extremes in north and east of North Island.
- This is likely to affect marine environments for aquaculture and feral populations of shellfish. Effects could include increased viral contamination of filter feeders, and increased sediment runoff affecting growth.
- May affect mussel farms in southern region (Stewart Island). For farms in Marlborough Sounds and Golden Bay, Ministry for the Environment predicts more extreme rainy days by 2090.[1]
- Adaptation through aquaculture farm location may be possible.

Chemicals and biotoxins

Cadmium

- Ocean acidification has been shown to increase cadmium accumulation by bivalve molluscs (blue mussels, blood and hard clams) (Shi et al., 2016). Cadmium affects kidney toxicity, cancer. If this effect also occurs in species harvested in New Zealand, increased absorption may need to be monitored.

[1] http://www.mfe.govt.nz/climate-change/how-climate-change-affects-nz/how-might-climate-change-affect-my-region/marlborough accessed 7 Dec 2017

- In New Zealand cadmium dietary intake estimates are within WHO guidelines[2], and oysters (along with bread and potatoes) are major contributors (2009 Total Diet Survey).
- Benthic shellfish more likely to be affected than those raised higher in the water column

Algal blooms

- A study of harmful marine algal bloom growth rate and duration over the last 40 years concluded that increasing ocean temperature is an important factor facilitating the intensification of these from 40°N to 60°N in the North Atlantic, although the link was less strong in more northern regions (Gobler et al., 2017). The risk for New Zealand is uncertain, but any such increases may affect feral and farmed shellfish. Risk to human health from consumption will affect harvesting through closures, and any restrictions on mussel spat movement may affect production (MacKenzie et al., 2014).

Chemical interventions

- Temperature changes may also increase animal stress, requiring greater disease management.

Other production processes

- There is no conclusive evidence of climate change impact on fish abundance in New Zealand waters (Reisinger, 2014).
- In a comparison of 147 countries, New Zealand marine fisheries assessed as amongst the least vulnerable to climate change. Vulnerability to climate change was defined as the product of three variables, namely: (1) exposure to climate change impacts; (2) sensitivity of an economy/community/country to changes in productive capacity associated with climate change impacts; and (3) adaptive capacity, or the ability to modify or adjust fisheries and livelihoods in order to cope with the negative impacts of climate change and pursue any emerging opportunities (Blasiak et al., 2017).

REFERENCES

Blasiak R, Spijkers J, Tokunaga K, Pittman J, Yagi N,OÈsterblom H (2017) Climate change and marine fisheries: Least developed countries top global index of

[2] https://www.mpi.govt.nz/protection-and-response/environment-and-natural-resources/land-and-soil/cadmium/ accessed 21 November 2017

vulnerability. PLoS ONE 12(6): e0179632. https://doi.org/10.1371/journal.pone.0179632

Cornwall, C.E.; Eddy, T.D., 2015. Effects of near-future ocean acidification, fishing, and marine protection on a temperate coastal ecosystem. Conservation Biology 29: p207-215.

Cruz CD, Hedderley D, Fletcher GC. 2015. Long-term study of Vibrio parahaemolyticus prevalence and distribution in New Zealand shellfish. Appl Environ Microbiol 81:2320 –2327. doi:10.1128/AEM.04020-14.

Cummings, V., Hewitt, J., Allen, S., Marriott, P., Barr, N., Heath, P., 2013. Ocean acidification: impacts on key NZ molluscs, with a focus on flat oysters (*Ostrea chiliensis*). Final Research Report for the NZ Ministry of Primary Industries on project ZBD200913. 18 p.

Cummings, V. Smith, A, Peebles, B., Marriott, P., 2015. Shell mineralogy of flat oysters under ocean acidification conditions: preliminary report. Progress report to Ministry of Primary Industries Project ZBD201306. 9 p.

Cunningham, S. C. 2013. The effects of ocean acidification on juvenile *Haliotis iris*. Master of Science Thesis, University of Otago.

Gobler CJ, Doherty OM, Hattenrath-Lehman TK, Griffith AW, Kang Y, Litaker RW. Ocean warming since 1982 has expanded the niche of toxic algal blooms in the North Atlantic and North Pacific oceans doi: 10.1073/pnas.1619575114 PNAS May 9, 2017 vol. 114 no. 19 4975-4980

IPCC 2014. Summary for policymakers. In: Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastrandrea, M. D., Bilir, T. E., Chatterjee, M., Ebi, E. L., Estrada, Y. O., Genova R.C., Girma, B., Kissel, E. S., Levy, A. N., Maccracken, S., Mastrandrea, P. R. & White, L. L. (eds.) Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC 2013. Climate Change 2013: The Physical Science Basis. In: Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V. & Midgley, P. M. (eds.) Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Chapters 12 and 13. United Kingdom and New York, NY, USA: Cambridge University Press, Cambridge.

Law, C.S., Rickard, G.J., Mikaloff-Fletcher, S.E., Pinkerton, M.H., Gorman, R., Behrens, E., Chiswell, S.M., Bostock, H.C., Anderson, O. and Currie, K., 2016. The New Zealand EEZ and South West Pacific. Synthesis Report RA2, Marine Case Study. Climate

Changes, Impacts and Implications (CCII) for New Zealand to 2100. MBIE contract C01X1225. 40p.

Mackenzie, A. L. 2014. The risk to New Zealand shellfish aquaculture from paralytic shellfish poisoning (PSP) toxins. New Zealand Journal of Marine and Freshwater Research, 48, 430-465.

MFE, 2008. Climate Change Effects and Impacts Assessment: A Guidance Manual for Local Government in New Zealand (2nd edition). In: Mullan, B., Wratt, D., Dean, S., Hollis, M., Allan, S., Williams, T., Kenny, G. & MfE (eds.). Wellington, New Zealand.

Orr, J. C., Fabry, V. J., Aumont, O., Bopp, L., Doney, S. C., Feely, R. A., Gnanadesikan, A., Gruber, N., Ishida, A., Joos, F., Key, R. M., Lindsay, K., Maier-Reimer, E., Matear, R., Monfray, P., Mouchet, A., Najjar, R. G., Plattner, G.-K., Rodgers, K. B., Sabine, C. L., Sarmiento, J. L., Schlitzer, R., Slater, R. D., Totterdell, I. J., Weirig, M.-F., Yamanaka, Y. & Yool, A. 2005. Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. 437, 681.

Reisinger, A, Kitching, RL, Chiew, F, Hughes, L, Newton, PCD, Schuster, SS, Whetton, P (2014). Australasia. In Barros, VR, Field, CB, Dokken, DJ, Mastrandrea, MD, Mach, KJ, Bilir, TE, White, LL (Eds), Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp 1371–1438). Cambridge and New York: Cambridge University Press.

Shi, W. et al. Ocean acidification increases cadmium accumulation in marine bivalves: a potential threat to seafood safety. Sci. Rep. 6, 20197; doi: 10.1038/srep20197 (2016).

Van Putten, IE, Farmery, AK, Green, BS, Hobday, AJ, Lim-Camacho, L, Norman-Lopez, A, Parker, RW. 2015. The Environmental Impact of Two Australian Rock Lobster Fishery Supply Chains under a Changing Climate, Journal of Industrial Ecology. 20(6): 1384-1398