FACT SHEET

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‘NextGen’ Projections for the Western Tropical Pacific:

Climate change projections to inform **black pearl production vulnerability in the Cook Islands**

Black pearls are an important product supporting the Cook Islands economy through direct export sales and tourism. The main pearl farming area in the Cook Islands is in Manihiki Lagoon, situated 1200 kilometres northwest from Rarotonga. The industry is a critical employer that sustains local livelihoods of atoll communities. Understanding the impacts of climate variability and projected climate change on black pearls is paramount to ensure the future sustainability and viability of pearl farming in the Cook Islands.

Sea surface temperature has already changed around Manihiki Lagoon, and these changes are projected to continue

Cook Islands lie within the Indo-Pacific Warm Pool (IPWP), with long-term (1982-2019) average sea surface temperatures (SST) being above 25°C. Manihiki is located in the warmest part of the Cook Islands region on average ~3-4°C warmer compared to islands in the southern Cook Islands.

Over the past decades, SST has warmed in the Manihiki lagoon region, with a stronger warming of temperatures during the cool season compared to the warm season. The ocean waters encompassing Manihiki Lagoon region also experienced an increase in the annual number of marine heatwave (MHW) events, with a higher incidence of “strong” events during the last 10 years (Figure 1).

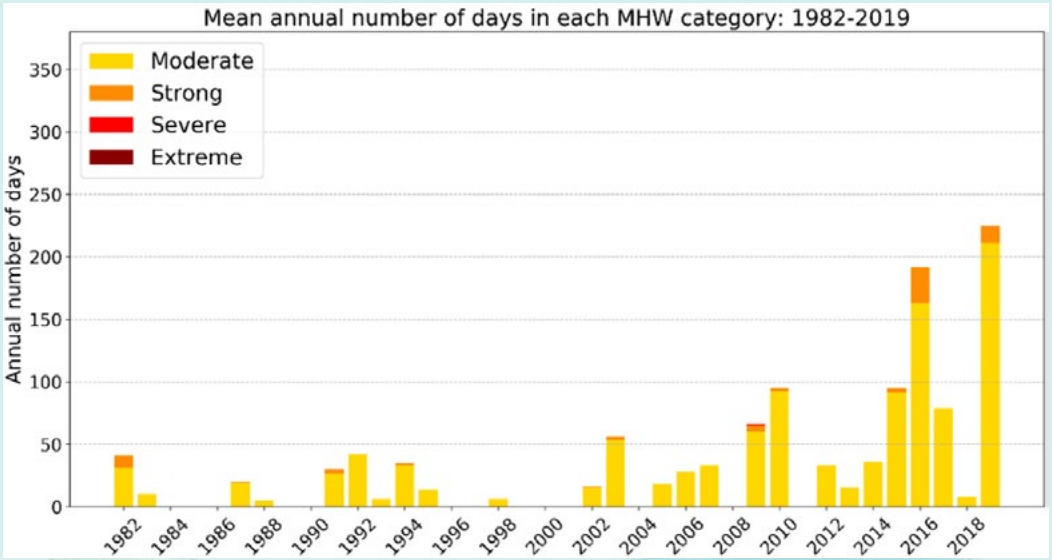


Figure 1 Historical average annual number of marine heatwave days in each of four categories (moderate, strong, severe, and extreme) using area-averaged OISSTv2-1 for a domain encompassing Manihiki Lagoon region.

Climate and ocean influences on oyster production

Pearl oyster viability involves inputs and complex interactions from multiple climate and ocean chemistry related factors (Figure 2):

- SSTs and MHWs directly affect oyster health. Indirect impacts also occur through effects of SST on oyster bacteria prevalence (e.g. *Vibrio harveyi*), and temperature-related changes to oxygen solubility which affects water quality.
- The characteristics and water quality of the lagoon seawater experienced by the pearl oysters is heavily influenced by lagoon circulation, which can be modified by sea level rise and changes to wind-driven waves, as well as extreme rainfall events and cyclones.
- Seawater chemistry, including aragonite saturation and pH levels (related to atmospheric carbon dioxide concentrations), can affect the oyster shell and pearl quality[1]. On Manihiki, farmers are noticing problems with oysters; shells are thinner and deformities in the pearls have become common in recent years[2].
- Coral reefs protecting the Manihiki Lagoon are also affected by ocean acidification resulting in slower growth and/or weaker skeletons in some coral species. Furthermore, as the ocean warms, the risk of coral bleaching increases, leading to mass coral mortality, with coral recovery dependent on many factors including the frequency with which corals are exposed to stressors like MHWs.
- Air temperature affects worker comfort and related farming practices for the pearl industry.

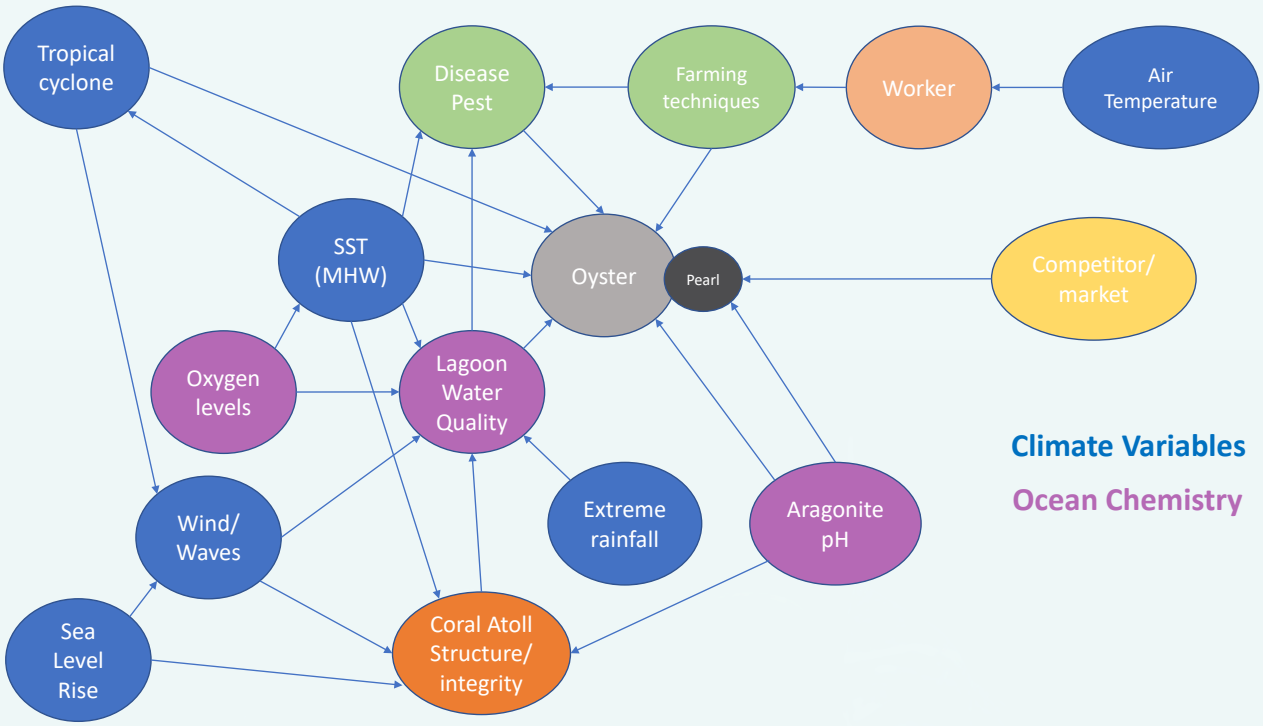


Figure 2 Interaction of climate, ocean chemistry, human, market and geographical factors on pearl production.

About NextGen case studies

As part of the Australia-Pacific Climate Partnership's *Next Generation Climate Projections for the Western Tropical Pacific* ('NextGen'), a selection of case studies has been developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Secretariat of the Pacific Regional Environment Programme (SPREP).

Incorporating local scientific and industry knowledge, the case studies demonstrate the application of climate change projections and serve as a starting point for national and subnational governments, meteorological services and sectoral stakeholders to identify adaptation needs and priorities, and to carry out more detailed assessments of climate change impacts.

Projected climate hazard-based impacts on pearl production: At a glance

Through consultation with Cook Islands' pearl farmers and researchers, various climate-related impacts were identified for pearl production (Table 1).

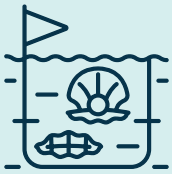
Table 1 Climate related conditions assessed in the NextGen case study and their implications on pearl production in Cook Islands.

Current climate impacts	Projected ocean conditions affecting pearl oyster production
Studies indicate pearl oyster viability can be affected by SST above 34°C.	The projected increase in SST would likely result in more episodes of lagoon water close to or above the 34°C threshold by 2030, potentially affecting productivity of Manihiki Lagoon pearl farming in future.
The typical number of MHW days is under 50 days per year, though becoming more frequent in the region over the past decade (see Figure 1), increasing pearl oyster vulnerability.	The projected increase in MHW days will be detrimental to pearl farming. By 2030, under a low emission pathway, about 150 MHW days per year are projected and about 200 days per year by 2050. This number is much higher under a high emissions pathway.
Climate-related changes in ocean chemistry, such as ocean acidification, can deleteriously affect oyster shell growth, pearl quality and protective coral reefs.	Ocean acidification is projected to increase. Under a low emissions pathway, the median aragonite saturation state never falls below 3.5 (generally considered 'marginal conditions' for coral growth) and increases slightly toward the end of the century. Under a high emissions pathway, the median aragonite saturation state may transition to marginal conditions for coral growth from 2040 and continues to strongly decline thereafter to values where coral reefs have not historically been found (< 3.0). This decline is of concern to oyster shell growth, pearl quality and coral reef structure of the Manihiki Lagoon.
Manihiki Lagoon is exposed to tropical cyclone activity, with Cyclone Martin (1997) for example, causing devastating destruction to pearl farms.	While the projected decrease in cyclone frequency would reduce vulnerability, the projected change in average cyclone intensity, combined with sea level rise and increased rainfall rates would increase cyclone impacts to pearl farming in future.

Recommendations for future work

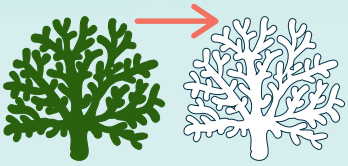
The climate influences on black pearls involve complex interactions. Building on this case study, the following recommendations are identified to reduce the impacts of climate change on black pearls:

Addressing the question of vulnerability of black pearl production requires scenario-based wave-flow hydrodynamic modelling to take into account the different factors that influence the Manihiki Lagoon. The NextGen climate change projections can be used within hydrodynamic modelling to assess climate influences under future conditions.



The **design of the entire infrastructure of pearl farms needs to be assessed** to increase durability during severe cyclones. Placing pearl oysters in deeper water to reduce the adverse effects of higher SST on nacre quality should also reduce damage by storms.

The **pearl industry is in a reasonable position** to adapt to some of the projected effects of climate change. Any effects of higher SSTs and ocean acidification on the collection of spat can probably be overcome by increasing the proportion of spat produced in hatcheries under controlled temperature and pH conditions, albeit at increased cost. It may also be possible to harvest the pearls during the cooler months of the year[1]. Relocation of pearl farming operations to atolls located further south in the Cook Islands region can also provide an adaptation option in the longer term.



Combating the likely effects of ocean acidification on pearl quality will be difficult because pearl oysters cannot be maintained economically under controlled conditions for the time it takes to produce pearls. However, there may be scope for identifying areas that remain buffered against lower aragonite saturation states, such as near well-flushed, carbonate-rich coral reefs, and close to areas with a good cover of seagrass and macrophytes[3]. Selective breeding is also likely to provide an important mitigation strategy to provide increased resistance to long-term changes in ocean chemistry[4].

[1] Pickering et al., 2011 [2] Rongo and Dyer, 2015 [3] Bell et al., 2013 [4] Fitzer et al., 2019

Where to find more information about this case study

The full case study report, including methods and data, as well as the references referred to in this factsheet, is available from: CSIRO and SPREP (2022). 'NextGen' Projections for the Western Tropical Pacific: Climate change projections to inform black pearl production vulnerability in the Cook Islands. https://doi.org/10.25919/sr2h-8282

Furthermore, a step-by-step guide for conducting climate hazard-based impact assessments for sectors is available from rccap.org

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