State of our Seabirds 2021

Seabird ecology, research and conservation for the wider Hauraki Gulf / Tīkapa Moana / Te Moananui-ā-Toi region

Northern NZ Seabird Trust

G.I.F.T Gulf Innovation Fund Together
A Foundation North initiative

Hauraki Gulf Forum
Tīkapa Moana
Te Moananui-ā-Toi

Tītī wainui / fairy prions. Photo by Edin Whitehead.

Te Ora o ā Tātou Manu Moana 2021

Te mātai hauropi o te manu moana, te rangahau me te mahi whāomoomo ki te rohe whānui o Tīkapa Moana me Te Moananui-a-Toi.

Kei wareware hoki ki te tūmatangaingai
Te mana hoki o te Takareko, o te Mumuhau
Ko ngā manu kōrero, ngā manu arataki
I taru tere mai ngā mātua tūpuna

Lest we forget to ignite
The force of Takareko and Mumuhau
Supernatural birds that guided
The ancestors swiftly to these shores
– Waiata by Dr Korohere Ngapo, Pare Hauraki

Taranga / Hen Island with ōi / grey-faced petrel. Photo by Edin Whitehead.

Editorial notes

The contributions to this report were invited, with topics chosen to provide as comprehensive an overview of the current state of the region's seabirds as possible. Linking and introductory text to sections have been provided by the Northern New Zealand Seabird Trust to ensure continuity through the report.

All contributions have been peer-reviewed but, with few exceptions, the style and content are the choice of the authors.

The 'region' covered by the report is the wider Te Moananui-ā-Toi / Tīkapa Moana / Hauraki Gulf region, including the Hauraki Gulf Marine Park and east Northland offshore islands – all territorial waters from Cape Brett down to the south-eastern boundary of the Hauraki Gulf Marine Park (just south of the Aldermen Islands) and including the Firth of Thames and the Whangārei and Waitematā Harbours.

Species breeding in the region are listed in Table 1, and thereafter common names are used. Some authors have preferred using Māori names, and these have been retained but the English common name is included at first mention.

Māori names for islands (where they exist) are given first with English names following, e.g., Marotere / Chickens Islands. In general, the use of 'island' after Māori names that include 'Motu…' has been dropped – e.g., Motuora. Note, for some island groups (e.g., Poor Knights and Mercury Islands), there are Māori names for individual islands, not the whole group.

The views expressed in this publication do not necessarily reflect those of the Hauraki Gulf Forum and the Northern New Zealand Seabird Trust.

– Chris Gaskin October 2021

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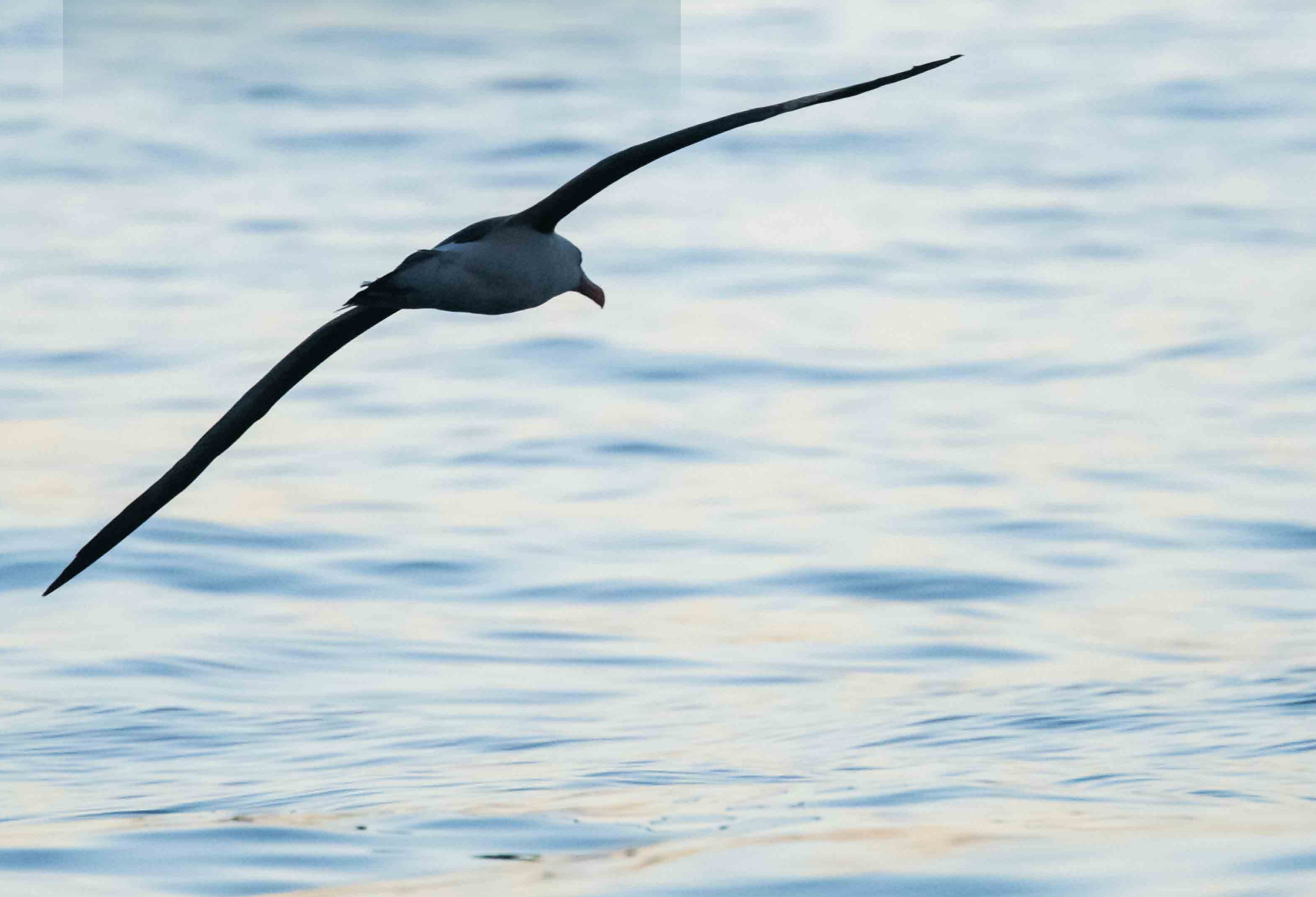
Cover: *Buller's shearwaters and fairy prions feeding in association with shoaling trevally. Photo by Edin Whitehead.*

Our ocean's Sentinels

Seabirds themselves reflect the health of our oceans and pass this knowledge on to those of us who watch over them. Their health and resilience relies on the health of the oceans, but they also play a pivotal role in nurturing and maintaining this. By simply existing, seabirds link the oceans to the land and in doing so enable the land to feed the oceans. Theirs is a vital role, and when we listen, they can tell us when these interconnected relationships are degrading or are broken. They are sentinels to changes in the environment, and can act as indicators of those changes, if we do our duty and pay attention.

Ngā hēteri o te moana

E whakaata ana te ora o ngā manu moana i te ora o ō tātou moana, ā, ka tukuna ēnei mātauranga ki te hunga e tiaki ana i ngā manu nei. Ka ora ngā wai, ka ora, ka māia hoki ngā manu moana, otirā, he wāhi nui anō tō ngā manu i te whakapūmautanga o te ora o ngā moana. Ko te manu moana te hononga o te moana ki te whenua, ā, nā te manu moana tonu, ka whāngaihia te moana e te whenua. He mahi tino nui tēnei, ā, ki te whakarongo tātou, kei ngā manu ngā kōrero mō te hekenga iho, mō te whatinga rānei o ēnei tūhononga. Ko ngā manu moana tonu ngā hēteri e kite ana i ngā huringa o te taiao. Mā ngā manu moana hoki ngā huringa e tautohu – me kaha tonu tātou ki te aro atu.



Albatross species are regular visitors offshore, although none breed in the wider Hauraki Gulf region. Toroa / Campbell albatross from Campbell Island in New Zealand's Subantarctic Islands.

FOREWORD

He au here Toroa whai mai ra ki au
"The current on the horizon links me to the albatross, and says follow me"

– Pātere o Ngātiwai[1]

The Hauraki Gulf, Tīkapa Moana, Te Moananui-ā-Toi is a place of striking seabird diversity. With its combination of multiple predator-free breeding sites on islands, and productive waters close to seabird colonies, the Hauraki Gulf region is a globally significant seabird biodiversity hotspot. This is remarkable given its proximity to the country's largest city.

However, as this important report demonstrates, far too many of our seabirds remain under threat or, in the case of tara-iti / New Zealand fairy tern, at dire risk of extinction.

It is not hard to see why. For some species, their threats come from the land: from predators like rats, stoats, wild cats, and pigs; through loss of habitat and encroaching urban development; and sadly, the behaviours of some who disrespect our indigenous wildlife. But it is at sea where conditions are perhaps changing fastest, with once productive feeding grounds under serious pressure from commercial and recreational fishing. While some gains have been made to reduce the threat of seabirds being caught as by-catch while foraging, the depletion of food in the nearby marine environment is having a significant impact. With all of this, and the increasing impacts of climate change, our seabirds are telling us that a perfect storm is brewing.

This State of Our Seabirds 2021 report lifts the lid on those pressures and offers us more insight and knowledge than ever before of the true state of our manu o te moana. Contributors to this report include experts working across a wide range of research and conservation projects, among them three Hauraki Gulf Forum Holdaway Award recipients and young researchers in the early stages of their careers.

Crucially, the report points to clear steps we need to urgently take to change the perilous trajectory and to help our seabird populations recover and then thrive. This can only happen through the holistic restoration of Hauraki Gulf food webs coupled with marine protection measures that recognise highly mobile marine species such as seabirds, along with marine mammals and pelagic fish.

One thing that is often underappreciated about our seabirds is their crucial importance to the overall health of our forests. Their nutrients power coastal vegetation and the near-shore marine environment, as we see around our least disturbed islands. Without them, that land/sea interface starts to break down. It is incumbent on all of us to do everything we can to ensure our seabirds have safe places to call home in the Marine Park and that they have plentiful feeding grounds.

Nicola MacDonald (Co-Chair)
Tangata Whenua

Pippa Coom (Co-Chair)
Auckland Council

[1] *This pātere denotes the freedom one finds within oneself through being with nature and illustrates the long-range flight and beauty of the albatross that follows the currents on the sea in search of new horizons. Interpretation by Nicola MacDonald, Ngātiwai, Ngāti Rehua.*

HE WHAKARĀPOPOTO

He taonga te pātaka kai o Tīkapa Moana i Te Moananui-a-Toi.

Ko te mauri te iho o te toiora o ngā mea katoa. Koia te orokohanga o te ao mataora, o ngā matū hoki. He mauri tō ngā mea katoa o te ao. Ka rongo tātou i te mauri, ā, ka rongo hoki te mauri i te pānga o tātou te tangata, otirā, ko te ao tukupū te whakatinanatanga o ērā āhuatanga katoa. He mauri tō ngā mea katoa. Ka whakahekea te mauri, heoi anō, ka taea hoki te whakarauora mai anō. Kei te rongo tātou katoa i te pānga o te mauri. He rite te mauri ki te hau– kāore e āta kitea ana, engari ka rangona ngā piki me ngā heke.

Ko ngā manu moana te mauri o Tīkapa Moana e tūhono ana i ngā wai me te whenua – e rere ana i runga i ngā hau.

Ka ora ana ngā manu moana, ka ora te Moana, ka ora anō ko tātou. Ka mārama ana tātou ki te noho o ngā manu ki runga i whenua me te moana, ka āhei tātou ki te arotake i ngā huringa o te taiao o Tīkapa Moana.

Ka kitekite noa tātou i ētahi o ngā manu moana o te rohe i ia rā, ko ētahi anō ka kitea i ngā mahi moana anake. Otirā, kei Tīkapa Moana ētahi manu moana kāore e tino kitea e te nuinga o tātou. Kāore hoki e āta mōhiotia ana. E rua tekau mā whitu ngā momo manu moana e whakawhānau pīpī ana ki te rohe whānui o Tīkapa Moana.

Ko ngā manu moana te whakatinanatanga o te mauri o te Moana – e tūhono ana i ngā wai ki te whenua – e rere ana i runga i te hau. Ka kite ana tātou i te ao mā ngā karu o te manu moana, ka puta mai he ara hou, he mahi rangatira hoki – kātahi ka āta kitea ngā hononga whakahirahira. Ahakoa kua whakahekea te mauri, ka taea te whakarauora anō. Nā ngā manu rangatira nei ngā iwi tuatahi i ārahi i Te Moananui-a-Kiwa ki tēnei whenua, ki Aotearoa, ā, mā ngā manu anō tātou e ārahi i roto i te whakarauoratanga nui mai o Tīkapa Moana, o tō tātou oranga anō – i ā tātou ake mahi tonu.

Pakahā / fluttering shearwaters with Te Hauturu-o-Toi / Little Barrier Island beyond. Photo by Edin Whitehead.

SUMMARY

Ko te pātaka kai o Tīkapa Moana Te Moananui-ā-Toi, he Taonga / The food cupboard of Tikapa is special.

Mauri is the life force in all things, the genesis of the living and non-living, all elements in the world have Mauri – Mauri impacts on us and we impact on it in the manifestation of the universe as it is observed. Everything has its own Mauri. Mauri can be diminished and it can be restored. We can all sense and see the effects of Mauri. Like the wind, we can't see the wind but we can see its impact as it rises and falls.

Seabirds embody the spirit of Mauri of our Hauraki Gulf, seamlessly linking its waters and the land, riding the winds. Their health and well-being reflect the Gulf's health and our interconnected wellbeing. Our understanding of their lives both on land and at sea allows us to evaluate changes in the Gulf's environment.

Some of the region's seabirds we see in our daily lives, others are familiar from time spent on the water. But there are seabirds that inhabit our Gulf many of us don't get to see, or even know they exist. Twenty-seven seabird species breed within the wider Hauraki Gulf region.

The report

This report complements the Hauraki Gulf Forum's three-yearly state of the environment reporting required under the Hauraki Gulf Marine Park Act (2000). The ***State of Our Gulf 2020*** State of the Environment Report painted a bleak picture, with headlines such as 'Crayfish in peril', 'Tarakihi just hanging in there' and 'Proliferation of kina barrens'. The ailing health of Auckland and Waikato's big blue backyard (the Hauraki Gulf Marine Park) was laid bare.

Contributions for this State of Our Seabirds 2021 report have been invited from multiple authors to cover topics chosen to provide as comprehensive an overview of the current state of the region's seabirds as possible, highlighting recent research and the efforts to protect them.

This is a report in four parts:

1. Seabirds and their world.
2. A living laboratory.
3. What the seabirds are telling us.
4. What are we doing? How well are we doing? Looking to the future.

New Zealand storm petrel on forest floor, Te Hauturu-o-Toi / Little Barrier Island. Photo by Edin Whitehead.

Seabirds and their world

Our region ranks highly compared to similar sites of international seabird importance in terms of species diversity and endemicity (e.g., New Zealand's subantarctic islands). The wider Hauraki Gulf region and many of its islands are recognised as globally important. Five species are endemic to the region meaning they breed nowhere else in the world – tākoketai / black petrel, tītī / Pycroft's petrel, rako / Buller's shearwater, New Zealand storm petrel and tara-iti / New Zealand fairy tern. This regional species endemism equals that of entire countries, those second to Aotearoa New Zealand [1]. The region also includes significant populations of other species – ōi / grey-faced petrel, tītī / Cook's petrel, pakahā / fluttering shearwater, tākapu / Australasian gannet, toanui / flesh-footed shearwater, northern little shearwater and takahikare-moana / white-faced storm petrel.

Ngā Poito o te Kupenga o Toi te Huatahi / the floats of the fishing net of Toi te Huatahi makes reference to the many islands of the region[2] that are seabird breeding grounds. Seabirds, when foraging, range widely across regional boundaries. Seabirds that breed on the Poor Knights, Taranga / Hen and the Marotere / Chickens Islands are commonly seen foraging within the wider Hauraki Gulf region. The region is also visited by seabirds from further afield. It is because seabirds forage across regional boundaries that seabird conservation and the research that underpins it needs inter-regional collaboration.

The Gulf's seabird diversity is mirrored by the numerous ways they utilise the region's dynamic marine environment, from estuaries and harbours to coastal waters, deeper shelf waters, to the edge of the continental shelf and deep pelagic waters far from land. Oceanic influences regulate east Northland and Gulf waters, a system of rich nutrient flows across the continental shelf and through its myriad of islands. This is where our seabirds find their food.

The islands where seabirds breed benefit from the marine nutrients they bring to land and are home to precious terrestrial fauna – land birds, reptiles and invertebrates. Seabirds are the start of a cyclical process whereby they gather food at sea, their presence feeds the land, and the land in turn feeds the nearshore marine environment, the sea.

A living laboratory

There is the need to provide a greater focus on how Te Moananui-ā-Toi / Tīkapa Moana / Hauraki Gulf is viewed through a Te Ao Māori lens. There is a mosaic of checks and balances that determine how the world is seen through Māori eyes and how that world is shaped in addressing these. There is a mingling of the spiritual and existential that calls for careful nurturing of all things animate and inanimate.

With checks and balances in mind, what makes the Gulf a hotspot for working with seabirds to study marine ecosystem changes? There is a diversity of seabird species with accessible predator-free breeding colonies so research can be directed onto seabirds' responses to changes in the marine environment. There's a concentration of research expertise, and tangata whenua, public and institutional support. There are also overlaps with a range of pressures, from both commercial and recreational fisheries and their impacts both direct and indirect; from sedimentation and an overload of nutrients; from pollution (plastics, artificial light at night); and climate change. All this adds up to a perfect system in which to utilise seabirds as indicators of change in the marine environment at different spatial and temporal scales.

In these kinds of reports, seldom do we get an insight into the people involved, but personal statements from two researchers who've dedicated years to long-term seabird studies highlight the value of taking the long view, and the challenges and rewards that come with this work. While some long-term studies in Aotearoa New Zealand have the benefit of institutional support, it comes back to the dedication of individuals' inquiring minds and tenacity around fieldwork to keep these vital studies running.

With seabird science we see a balancing of the innovative, cutting edge and traditional methods. And an acceptance of the privilege to be working in this very special environment.

What are the seabirds telling us?

The overall picture for Hauraki Gulf seabirds is concerning. Historically there have been huge losses of seabirds from the Gulf, although recent protection of breeding habitat on islands has arrested declines and promoted population increase for some, primarily pelagic migratory species, albeit at levels far below their former abundance. So there have been gains, and one is spectacular. The discovery of a species previously thought to be extinct, the New Zealand storm petrel, breeding on Te Hauturu-o-Toi / Little Barrier Island, a mere 50 kms from downtown Tāmaki Makaurau / Auckland is certainly that.

But many populations of resident seabirds remain in a poor state because of our devastation of the Gulf's food webs through overfishing and habitat damage. Tara-iti / New Zealand fairy terns are but a few wing beats from extinction with only 39 individual birds, maintained only through intensive management from a dedicated team. The Hauraki parekareka / spotted shags are not far behind, hanging on in three small colonies. Some inshore specialists (terns, gulls and shags) are seeing declines, and/or redistribution of nesting sites as species such as tākapu / Australasian gannet adapt to changes in prey distribution. Tākoketai / black petrel and toanui / flesh-footed shearwater are two species that are highly by-caught in fisheries, the latter by both recreational and commercial fisheries.

To get a measure on this roller coaster of highs and lows we turn to the birds to tell us what is going on in their lives, how they are adapting to changes in their environments. The people doing this work balance their time in the field, making observations, getting to know their subjects and the environment they inhabit, deploying tracking devices and downloading data, collecting samples, collating data and running analyses, drawing interpretations and conclusions.

What are we doing? How well are we doing? Looking to the future.

Threats to seabirds include, invasive species (mainly predators), fisheries (both direct and indirect effects), pollution, disease, climate change (including an increase in storm events and toxic algal blooms, and prey shifting), and direct human effects such as disturbance on land and in the water [1].

Above all else we must hold on to the gains we have made and enhance these where possible. The roll out of pest eradications across the outer Gulf has seen islands revitalised. Not only for seabirds, but also other fauna and flora – the land birds, reptiles, invertebrates and vegetation. These precious island refuges must be protected against reinvasion.

Across the region there are an increasing number of community groups factoring seabirds into their restoration plans, recognising the ecological gains that can be made. While restoring ecosystem resilience is a gradual process, the lessons we learn from islands with seabirds untouched by introduced predators, and those now recovering after predator removal, highlight the importance of this restoration approach.

In 2013 the Hauraki Gulf Forum commissioned and published ***Seabirds of the Hauraki Gulf***, a strategic plan. A check against the plan's recommendations ticks off research and conservation achievements in the eight years since. But reviewing that plan also highlights the need for a more cohesive, well-resourced strategic approach for the future.

Revitalising the Gulf – the Government's response to the Sea Change Plan makes headway in some areas of marine conservation, for example, protection of benthic habitats around reefs and islands, and some potential restrictions on bottom trawling. Seabirds are rarely incorporated in marine spatial planning, despite their visual and abundant presence across Gulf ecosystems, at times overwhelmingly dominant. That is, aside from recognising fisheries by-catch for select few species and recommending more research.

Conservation issues are exacerbated for seabirds and other large marine predators that have trans-boundary ranges, in particular migratory species that move between habitats. The lack of at-sea protection measures for seabirds in the Hauraki Gulf must be addressed, given that many populations are at risk due to high human-induced mortality. While ongoing monitoring of seabirds in the Gulf is necessary to identify critical foraging habitats in time and space, we have enough knowledge to manage commercial and recreational activities within some spaces appropriately.

This report – ***State of our Seabirds 2021*** – champions the potential of seabirds as sentinels for change in the marine environment. For example, an integrative approach to seabird biology can help realise the immense potential these species have as indicators of ocean change. It will increase the efficacy of conservation efforts in a rapidly changing world where conservation programmes are often fiscally constrained. To be effective, we need to be ahead of the game and get to a stage where we can forecast change and monitor an early warning system. Seabirds are attuned to the natural world on a global scale, a world that we are rapidly losing touch with.

We need to be able to measure progress in our understanding of the region's seabirds and Te Moananui-ā-Toi / Tīkapa Moana / Hauraki Gulf through their eyes. This report closes on a set of measures or indicators to be evaluated in five and ten years.

Seabirds embody the spirit of Mauri of our Gulf, seamlessly linking its waters and the land, riding the winds. By seeing our world through their eyes, we have the opportunity, and privilege, to bring these connections to the fore. As Mauri can be diminished, it can be restored. As our seabird taonga guided the first peoples across the Pacific to this land, Aotearoa, they can help guide us to a future where the Gulf's health and our interconnected wellbeing are greatly enhanced by our actions.

Contents

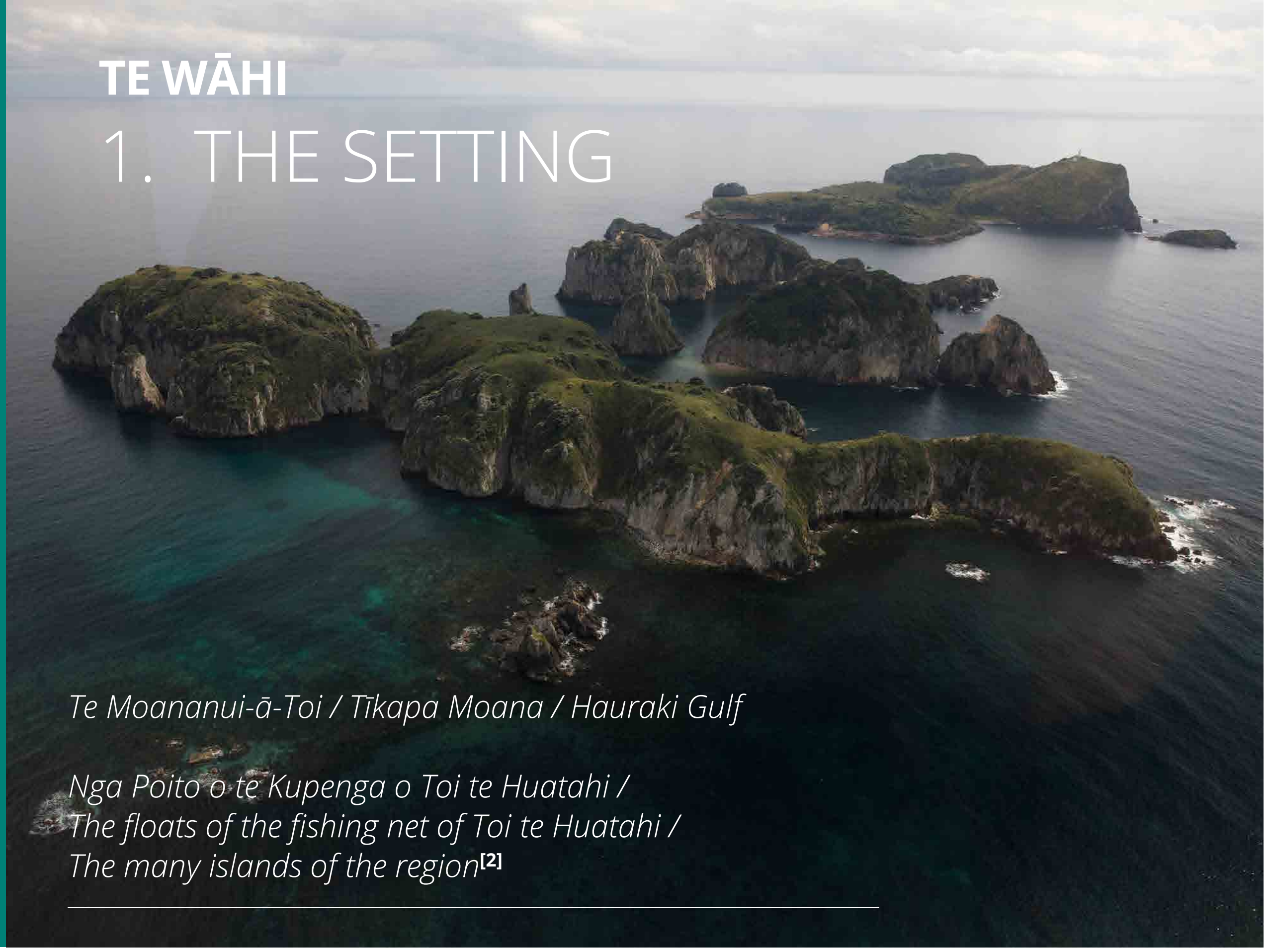
TE AO O TE MANU MOANA

SEABIRDS AND THEIR WORLD

Shearwaters at dawn. Photo by Edin Whitehead.

TE WĀHI

1. THE SETTING



Te Moananui-ā-Toi / Tikapa Moana / Hauraki Gulf

Nga Poito o te Kupenga o Toi te Huatahi / The floats of the fishing net of Toi te Huatahi / The many islands of the region[2]

Mokohinau Islands, outer Gulf. Photo by Richard Robinson, Depth NZ.

1.1 The region

The 'wider Hauraki Gulf region' covered by this report includes the Hauraki Gulf Marine Park and east Northland offshore islands and waters as far north as Cape Brett and south including the Mercury and Ruamāhua / Aldermen Islands . While definitions vary as to what geographically constitutes the 'Hauraki Gulf', seabirds know no political boundaries, whether they breed within the Marine Park or outside. Many of the seabirds breeding on islands adjacent to the Hauraki Gulf Marine Park are highly visible within it through much of the year, e.g., rako / Buller's shearwater, tītī- wainui / fairy prion, and pakahā / fluttering shearwater. Likewise, many of those that breed within the park, range widely, well outside local waters, e.g., tākoketai / black petrel, ōi / grey-faced petrel, tītī / Cook's petrel, tītī / Pycroft's petrel, and toanui / flesh-footed shearwater.

1.2 Oceanographic perspective

The Hauraki Gulf and adjacent continental shelf waters of East Northland and the Bay of Plenty are some of the most productive waters of New Zealand, maintaining the country's largest inshore commercial/ recreational fin fisheries and mariculture industry. Sporadic non-toxic and toxic algal blooms also occur in these waters [3]. The East Auckland Current (EAUC) is a strong but variable south-eastward flow off the shelf edge on the north-east coast of the North Island, New Zealand (Fig. 1). The current is part of the western boundary of the Pacific Ocean subtropical rotating current system (gyre) in the South Pacific Ocean. The complete western boundary for the gyre comprises the East Australian Current and its offshore extension (the Tasman Front) along with the EAUC. The EAUC is that part of the flow which attaches to the New Zealand bathymetric platform, near North Cape. The flow down the north-east and east coast of the North Island is dominated by three semi-permanent eddies—the North Cape Eddy, the East Cape Eddy, and the Wairarapa Eddy [4].

The narrow shelf (<40 km wide) along the East Northland coast and off Aotea / Great Barrier Island and Coromandel Peninsula results in dynamic cross-shelf interactions between coastal and slope waters, mediated by frequent wind-driven upwelling in autumn, winter and spring and less frequent downwelling events in summer. Riverine nutrient inputs to the shelf are low and more than 50% of the nutrient supply to the coastal system of the inner Hauraki Gulf comes from offshore, deep ocean sources during upwelling periods, with additional supply from sediment remineralisation on the shelf and within the Gulf [6].

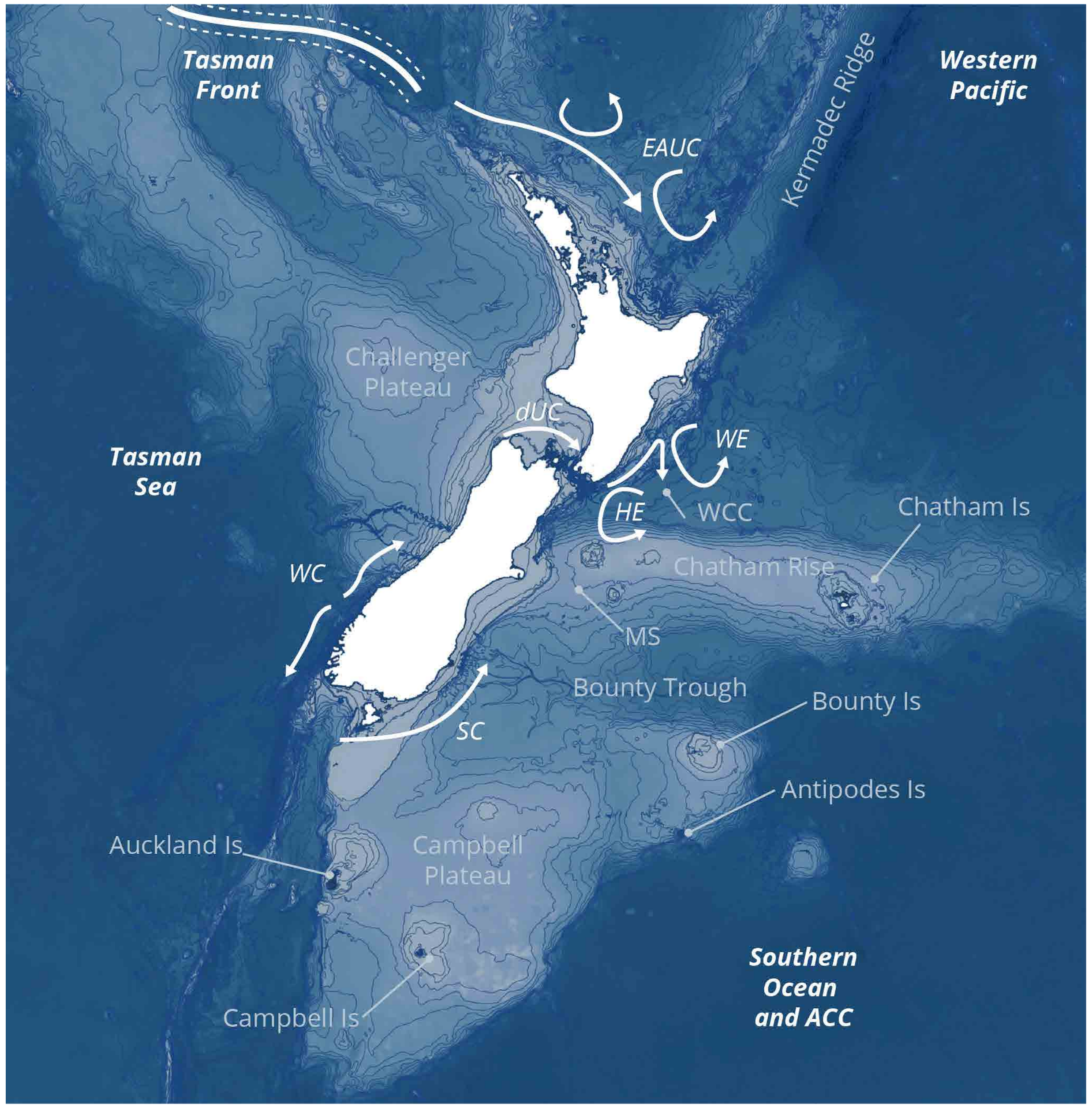


***Figure 1** New Zealand / Aotearoa at the shelf seas scale showing coastal currents, plateaus and features including the Tasman Front, East Auckland Current (EAUC), Wairarapa Coastal Current (WCC) and Eddy (WE), Westland (WC) and Southland Currents (SC), Hikurangi Eddy (HE), Mernoo Saddle (MS), d'Urville Current (dUC) and the Antarctic Circumpolar Current (ACC). Bathymetric contours are at 50m intervals to -250m, and 250m intervals below that. Adapted from* [5].

The shelf edge, bounded by the warm, high-salinity subtropical EAUC contrasts with the low-salinity, cooler shelf waters, which are often upwelling-affected. The mixing of shelf and oceanic waters varies inter-annually, seasonally and spatially and is undoubtedly an important factor in controlling primary productivity and biological activity [3].

The wider Hauraki Gulf region is a complex region of islands and relatively wide shelf, with several major islands and island groups: Tāranga / Hen Island), Marotere / Chickens Islands, Mokohinau, Te Hauturu-o-Toi / Little Barrier, Aotea / Great Barrier, Repanga / Cuvier, Mercury and Ruamāhua / Aldermen Islands. Its currents are strongly influenced by internal tide flows [7, 8]. Offshore temperatures range from typically c. 15°C in winter to c. 22°C in summer. Depending on location inshore surface temperatures are highly variable [9].

Within the Gulf itself, the presence of the Auckland urban areas, and the region's considerable recreational and commercial marine activities, has resulted in it being one of the better studied areas of New Zealand's shelf seas. Local factors (wind, rainfall, tides, water depth, and proximity to land) influence sea temperatures in the inner Gulf, whereas oceanic conditions prevail seawards of a line from Cape Rodney to Cape Colville [5].

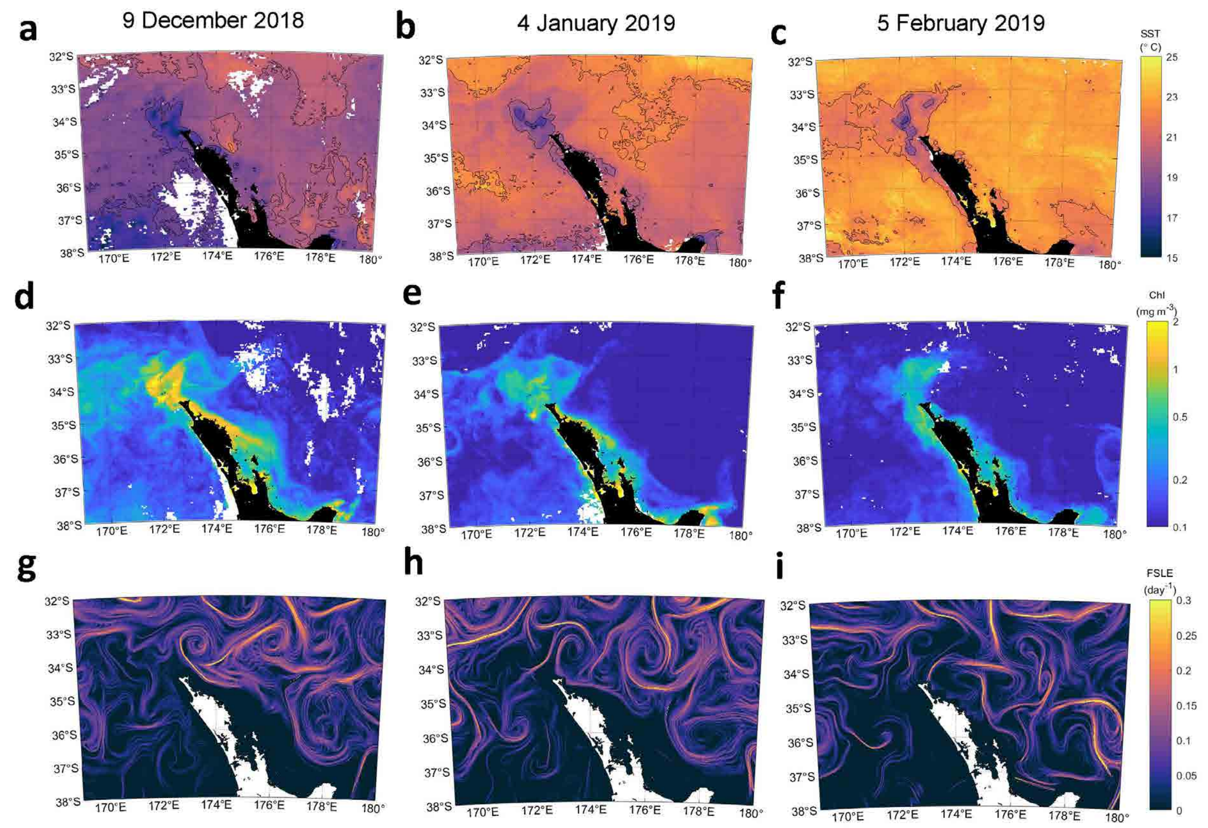


Figure 2. Variability of oceanographic features off the North Shelf as seen in satellite images. Three-days composites of sea surface temperature (SST, a-c; black lines indicate the 18°C and 22°C isotherms), near-surface Chlorophyll-a (Chl-a, d-f), and Finite Size Lyapunov Exponents (FSLE, calculated from altimetry-derived ocean currents, g-i). FSLE are an indicator of how quickly initially far away water parcels have converged to a given location and can be used as a frontal index. Dark coastal areas in (g-i) near the coast indicate coastal waters where water parcels that cannot be tracked using altimetry-derived ocean currents. White areas in (a-f) indicate cloud coverage.

Variability of oceanographic features off the North Shelf

Alice Della Penna[1]

[1]*University of Auckland / Waipapa Taumata Rau*

Oceanographic features in the continental shelf waters adjacent to the Hauraki Gulf are characterised by strong spatio-temporal variability that is readily visible in satellite images of sea surface temperature (SST, Fig. 2 a-c), near-surface chlorophyll (Chl-a, Fig. 2 d-f), and in a satellite-derived product indicating frontal activity (Fig. 2 g-i). The example showcased in Fig. 2 highlights the changes in these variables across three months, between the beginning of December 2018 and the beginning of February 2019. Temperature increases during this period and this increase corresponds, on average, to a decrease in near-surface Chl-a. These trends are not spatially uniform across the region: examples of this patchiness can be found near North Cape, but also in the offshore waters around 35 S, 177 E. This variability is connected to vertical water movements (upwelling/downwelling) and horizontal currents at scales between 1-100 km (mesoscale and submesoscale). Values of a frontal index (FSLE) (Fig. 2 g-i) highlight the locations of fronts induced by the stirring caused by mesoscale currents (higher values of FSLE).

Data source and acknowledgements. This study has been conducted using E.U. Copernicus Marine Service Information (CMEMS) for satellite altimetry, the MODIS-Aqua Ocean Color Data from NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group (http://dx.doi.org/10.5067/AQUA/MODIS_OC.2014.0), and Ocean Colour CCI Data Product (v. from the Ocean-Colour Climate Change Initiative, ESA, doi:10.5285/9c334fbe6d424a708cf3c4cf0c6a53f5). Details about the calculation can be found in [10-13]

ENDS

Figure 3. *NASA image created by Jesse Allen, using Landsat data provided by the United States Geological Survey 2002.*

1.3 El Niño La Niña

During normal conditions in the Pacific Ocean, trade winds blow west along the equator, taking warm water from South America towards Asia. To replace that warm water, cold water rises from the depths — a process called upwelling. El Niño and La Niña are two opposing climate patterns that break these normal conditions. Scientists call these phenomena the El Niño-Southern Oscillation (ENSO) cycle. El Niño and La Niña can both have global impacts on weather, wildfires, ecosystems, and economies and that episodes typically last nine to 12 months but can sometimes last for years. Events occur every two to seven years, on average, but they don't occur on a regular schedule. Generally, El Niño occurs more frequently than La Niña [14].

Although El Niño and La Niña have an important influence on New Zealand's climate, it accounts for less than 25% of the year-to year variance in seasonal rainfall and temperature at most locations. Nevertheless, its effects can be significant. During El Niño, New Zealand tends to experience stronger or more frequent winds from the west in summer, which can encourage dryness in eastern areas and more rain in the west. In winter, the winds tend to blow more from the south, causing colder temperatures across the country. In spring and autumn, south westerly winds are more common [15].

North easterly winds tend to become more common during La Niña events, bringing moist, rainy conditions to north-eastern areas of the North Island and reduced rainfall to the lower and western South Island. Warmer than average air and sea temperatures can occur around New Zealand during La Niña [15].

1.4 Climate change

Anthropogenically-induced climate change has been on the radar of threats to global ecosystems for many years [16]. While annual and decadal climate cycles fluctuate naturally and can severely impact the breeding success of seabirds [17], the rapidity and strength of change because of human activity presents new risks that species may struggle to adapt to. Changes in ocean temperature and productivity, current systems, and the greater extremity of natural cycles such as the ENSO are projected, which may have implications for the foraging distributions of seabird species [1].

How different seabirds will respond to climate and ecosystem changes is related to many factors including their range, foraging behaviour and diet composition, nesting habitat, and life history characteristics. Some characteristics may facilitate adaptation whereas others will limit it. In short, some seabird species may fare well in warming ocean conditions; others may become locally or globally extinct [1] (see Section 5.9).

Storm waves and pied shag, Mauimua / Lade Alice Island. Photo by Edin Whitehead.

1.5 From primary production to seabirds in the marine ecosystem of the Hauraki Gulf

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The Te Moananui-ā-Toi / Tīkapa Moana / Hauraki Gulf is a highly productive marine ecosystem, with much of the productivity channelled through small creatures swimming in the surface waters, krill and small fish, such as anchovies and mackerels.

Aggregations of krill and schools of small fish are important feeding locations for the phenomenal variety of seabirds living in the Hauraki Gulf.

Recent dramatic increases in the commercial harvesting of small surface-dwelling fish in the Hauraki Gulf has the potential to impact the feeding of seabirds.

Information is lacking for the effective management of harvesting of fish populations and the potential effects of harvests on seabird feeding success.

Other important threats to the successful feeding of seabirds in the Hauraki Gulf, include elevated levels of sediment from land runoff which reduces the clarity of seawater, making it more difficult for seabirds that hunt their prey visually.

The future security of seabird populations in the Hauraki Gulf will rely on better understanding and management of their feeding environment.

The Hauraki Gulf Marine Park encloses a unique coastal ecosystem that covers 1.2 million hectares of sea that is lined with a complex coastline, which includes hundreds of islands of a wide range of sizes. Consequently, the Te Moananui-ā-Toi / Tīkapa Moana / Hauraki Gulf / includes a very diverse range of coastal and marine habitats including sand dunes, mangroves, mudflats, seagrass beds, mussel reefs, kelp forest, sea sponge gardens, dog cockle beds, mud flats, marine worm mounds and deep reefs.

These diverse habitats are supported by the highly productive marine ecosystem, which is driven by natural upwelling of huge quantities of colder nutrient rich waters into the Gulf from the deeper surrounding ocean margins [18-25]. The dispersed flow of rich nutrients stimulates the growth of marine plant life that forms the natural basis of the food chains throughout the Hauraki Gulf. The abundance of the nutrient *"fertiliser"* promotes the rapid growth of phytoplankton, microscopic floating plants, which combine sunlight and the nutrients to grow in the shallow waters. Similarly, extensive seaweed forests that fringe many coastal areas, also use the nutrients for growing, while also shedding old seaweed tissue into the water column that is broken down into tiny particles. The resulting massive quantities of phytoplankton and seaweed particles are filtered and consumed by a variety of small swimming creatures, such as krill, which in turn provide food for larger marine animals. Hence, production from the phytoplankton and seaweed underpins a highly complex food web which ultimately provides the rich variety of food resources used by the remarkable range and abundance of marine life in the Hauraki Gulf including seabirds, as well as shorebirds (waders) that dwell along the coastal fringes of the Gulf. Seabirds are important ecologically, playing a significant role in moving nutrients into terrestrial habitats (See Section 2.5).

Large quantities of nutrients are also fed into coastal areas around the margins of the Hauraki Gulf by human activities, including wastewater discharges, use of fertilisers, effluent produced by livestock and land runoff [18, 19, 22]. These nutrients are mostly released in relatively high concentrations from rivers and streams into shallow coastal margins of the Gulf, and often mixed with large amounts of sediment, also washed off the land [26]. These excessive inputs to the Hauraki Gulf disrupt the natural ecological processes in these shallow coastal waters, contributing to sporadic algal blooms and decomposing bacteria that can reduce oxygen levels in the water to harmful levels.

The nitrogenous nutrients are generally considered to have the greatest effect on marine water quality, but phosphorus is also a nutrient of concern. By far, the largest source of nutrients produced through human activities that are fed into the Hauraki Gulf are the rivers draining the Hauraki Plains into the Firth of Thames. Estimates from 2016 indicate that Waihōu and Piako Rivers contribute around 97% of the nutrient load to the southern Firth of Thames, with agricultural sources (particularly dairy farming) estimated to account for 73% of the nitrogen and 41% of the phosphorus loads into this nearshore coastal ecosystem. Marked changes in the nearshore ecosystems in the Hauraki Gulf affected by excess nutrient and sediment discharges are likely to have impacted the diet and feeding ecology of seabirds living in these areas. Shorebirds feeding on the intertidal areas can also be affected.

Determining the impact of ecological changes in the Hauraki Gulf on seabirds is difficult because the diet and feeding ecology of many seabirds are poorly understood. However, the majority of seabirds, especially those feeding in open waters, typically rely on smaller marine animals, such as krill, squid and small pelagic fish, that tend to be more abundant in surface waters (less than 20 m depth) making these prey species easier for seabirds to find and to capture. Squid, small crustaceans, like krill, as well as small pelagic fish, such as saury *Scomberesox saurus*, kokowhāwhā / anchovies *Engraulis australis*, mohimohi / pilchards *Sardinops sagax*, and mackerel species, are a high-quality food source, rich in oil and protein, and more importantly only a short step along the food chain from phytoplankton. Most of these open water marine species also form swarms or

Fairy prions feeding on krill, some leaping clear of water as trevally school approaches. Photo by Edin Whitehead.

schools, and in so doing create patches of extremely high abundances of these prey species, which can further improve the feeding success of seabirds.

Besides seabirds, fish and marine mammals also gather to feed on these aggregations of prey. These are often seen at sea as large shoals of fish, often including arāra / trevally *Pseudocaranyx dentex* and kahawai *Arripis trutta*, that are actively feeding near the surface of the sea and creating the appearance of the sea boiling giving the rise to the common name *"boil up"* [27]. Frequently beneath these aggregations are larger predators, including haku / kingfish *Seriola lalandii*, skipjack tuna *Katsuwonus pelamis*, sharks, as well as dolphins and whales. Some seabird species also rely on these large predators to help to concentrate prey on the surface, increasing their availability to foraging seabirds [28].

An increased knowledge of these inter-specific feeding associations, as well as the complicated food web of the Hauraki Gulf would allow a greater understanding of how disruption in function at any level may impact the ecosystem [29]. Overseas studies show that human activities in the marine environment, such as fishing, pollution, and climate change, can alter the supply of marine food resources for seabirds, often resulting in marked declines in seabird numbers [1, 30, 31].

Most seabirds have some flexibility in their ability to search for and use a variety of prey (See Section 2.4). However, their energy demanding lifestyle requires a continuous supply of readily accessible energy-rich food [32]. Consequently, seabird populations are particularly vulnerable to depletion of their prey species, from either natural fluctuations in fish populations or from human influences, such as commercial fisheries. There have been declines in the populations of several seabird species within the Hauraki Gulf (see Section 5.1 for example). While it is not clear how much of the decline is due to changes in the capacity of the marine ecosystem to provision seabirds, it is highly likely given the large extent of human impacts on the marine ecosystem of the Hauraki Gulf. For example, the extensive removal of many marine mammals from the Hauraki Gulf through hunting would have reduced the competition for surface-dwelling prey for seabirds in the past two hundred years [33-35]. In contrast, the more recent dramatic expansion of commercial fisheries for small pelagic fish species would have greatly reduced the availability of these food resources for seabirds. The scale of the harvesting has continued to increase in recent years to the extent that currently nearly 60% of the total commercial fish landings in the Hauraki Gulf are pelagic species, such as blue mackerel, jack mackerel and pilchards [36]. For example, when the Hauraki Gulf Marine Park was established in 2000 the pilchard fishery landed 1 tonne a year, and this has grown to around 125 tonnes a year over the most recent period of 2016-2019.

Despite the potential negative impact of commercial fisheries on seabirds' food resources there is scant knowledge of the relationship for the Hauraki Gulf. Some preliminary studies indicate marked changes in the diets of seabirds and marine mammals in the

Sediment plumes in the inner Gulf. Photo by Shaun Lee.

Gulf over historical times (see Section 5.1), but the direct link to changes in food resources is difficult to establish. The possible impacts of the removal of food resources for seabirds and other marine mega-fauna are not given any consideration in setting commercial catch limits for these species currently. Even more concerning, is that for most of these fish species they are currently *"managed"* without any knowledge of the fundamental information typically used to sustainably manage fish populations, e.g., population size, growth rates, reproductive rates etc. This greatly elevates the risk of overfishing of these fish species.

The significance of seabirds in the Hauraki Gulf is widely recognised, both for their conservation significance and as key components of marine and terrestrial ecosystems. Numerous studies and reports have emphasised the need for greater protection and enhancement of seabird populations in the Gulf. However, these aspirations cannot be achieved without a more detailed understanding of the ecological connections of seabirds with their marine environment.

ENDS

Sedimentation & storm events

Sediment is ranked the third highest threat to Aotearoa New Zealand's marine habitats (after ocean acidification and global warming) [35]. It is a serious pollutant that degrades our coastal habitats and smothers marine life. Land activities, such as forestry, farming, mining, draining of wetlands and urban development, have greatly increased the amount of sediment that enters our waterways and harbours. However, research has shown that the main source of sediment accumulating in the Firth of Thames in recent times (2005–2015) is from catchment subsoil (around 50%), but a further 45% is from resuspended marine sediments that originated from deforestation and erosion that occurred over 100 years ago [36, 37].

The turbidity of coastal waters will also Increase as a result of increased storm frequency and intensity. In addition to the sedimentation, this may pose problems for visual foragers such as penguins, gannets, and shags.

Mass mortalities of little blue penguins happen regularly after poor conditions (storms, marine heatwaves), as the birds are unable to forage in such conditions. Although such events occur naturally, an increased frequency of them combined with increases in sedimentation levels may pose a risk for populations if the rate of mortality surpasses that of breeding success [1].

(From top to bottom) Malacostraca stomatopod *mantis shrimp larva,* Malacostraca brachyuran *crab* zoaea, Malacostraca euphausiid, Pteropo*d, Phyllosoma larva of rock lobster / crayfish. Photos by Charlie Johnson, School of Biological Sciences, University of Auckland / NNZST.*

The vital link – zooplankton

Lily Kozmian-Ledward[1]

[1]*Sea Lily Ltd.*

Plankton is comprised of often microscopic phytoplankton (plants) and zooplankton (animals) that inhabit the water column. Zooplankton are made up of an extraordinary diversity of species, many with forms so bizarre they would rival anything from the world of science fiction. Some species spend their entire lives in the plankton (e.g., jellyfish, krill, copepods), while others are only planktonic for part of their life cycle (e.g., many fish, crayfish, crabs, barnacles).

Zooplankton occupy a key position in the pelagic food web, transferring the organic energy produced by phytoplankton to higher trophic levels such as fish, seabirds, and baleen whales [38, 39]. Zooplankton abundance and diversity are determined predominantly by oceanographic (e.g., temperature, upwelling zones) and biological factors (e.g., predation) which result in a large amount of spatial and temporal variability [23].

Pelagic crustaceans such as krill, amphipods and copepods are often targeted as prey by seabirds particularly at those times when they occur at high densities near the sea surface. Seabirds may prey on these zooplankton directly, or indirectly by feeding on small pelagic planktivorous fish. In north-east North Island coastal waters, the krill Nyctiphanes australis appears to be an important prey for many seabirds including rako / Buller's and pakahā/ fluttering shearwater, tītī wainui / fairy prions, tara / white-fronted terns, and tarāpunga / red-billed gulls [40]. This krill species often forms dense aggregations at the surface during the daytime where they are preyed upon by both seabirds and fishes. Concentrated surface shoaling activity of trevally and kahawai can occur; the commotion, and potentially smell and sound of the fish feeding at the surface acting as cues for seabirds that there is abundant prey available [28, 41]. Krill aggregations have also been observed in areas away from fish shoals, where, in very calm conditions, even the riffles caused by small fish preying on the krill from below advertise the krill presence to birds foraging in the area [27].

Between 2017 and 2021, the Northern NZ Seabird Trust and University of Auckland, under contract to the Department of Conservation (DOC) Conservation Services Programme (CSP), conducted a programme of zooplankton net tows in association with foraging seabirds and fish shoal activity in the wider Hauraki Gulf region [27, 41]. While analysis of the zooplankton community composition has given us greater understanding of the associations between zooplankton, shoaling fish, and seabirds, much remains to be done.

ENDS

Larval fishes

Tom Trnski[1], *Severine Hannam*[1]

[1]*Tamāki Paenga Hira / Auckland Museum*

Most marine animals have a pelagic larval phase that develops in the coastal or open ocean. During two New Zealand storm petrel expeditions to the Far North (February and May 2021) surface plankton samples were collected out towards the shelf edge, off Cape Karikari and North Cape. Larval fish densities were very low, and the plankton diversity was typical of oligotrophic waters. In descending order of abundance, the February samples contained mostly salps, followed by chaetognaths (arrow worms), gastropods, jellyfishes, pteropods, Oikopleura (a filter-feeding sea squirt) and crustaceans. In May, dominant taxa were salps, followed by copepods, pteropods, jellyfishes, and a mix of crustaceans. Relative density of crustaceans was higher in May than February.

All the invertebrates collected complete their entire lifecycle in the planktonic environment, except for a small number of decapod crustaceans that will settle onto benthic habitats at the end of the larval stage. Even though fish larvae were numerically rare, the larval stage is the main dispersal stage prior to either settlement in benthic habitat or migration to a mesopelagic or pelagic habitat.

In February, 13 fishes were collected in five plankton tows and contained mostly oceanic taxa including *Myctophidae* (lanternfishes), *Exocoetidae* (flying fishes), saury, *Bythitidae* (brotulas) and a few pelagic coastal taxa including *Blenniidae* (blennies), Carangidae (trevallies) and mackerel.

In May, a total of 17 fish were collected in six of the seven plankton tows with a mix of mostly coastal taxa with a few offshore taxa including pilchard, lanternfishes, saury (*Scomberesox saurus*), snipefish (*Macrorhamphusus scolopax*), *Scorpis* (sweep/maomao), crested blenny (*Parablennius laticlavius*) and *Bothidae* (flounder). Night-lighting while adrift collected a mix of coastal and offshore taxa: *Exocoetidae* (flying fishes), saury, *Kyphosus* (drummer), yellow crested weedfish (*Cristiceps aurantiacus*) and blue mackerel.

During collecting the outer Hauraki Gulf in 2018-2019 by the Northern New Zealand Trust and University of Auckland, larval fishes were found in 24% of the samples collected, between October and May, comprising < 1% of the total counts [42].

ENDS

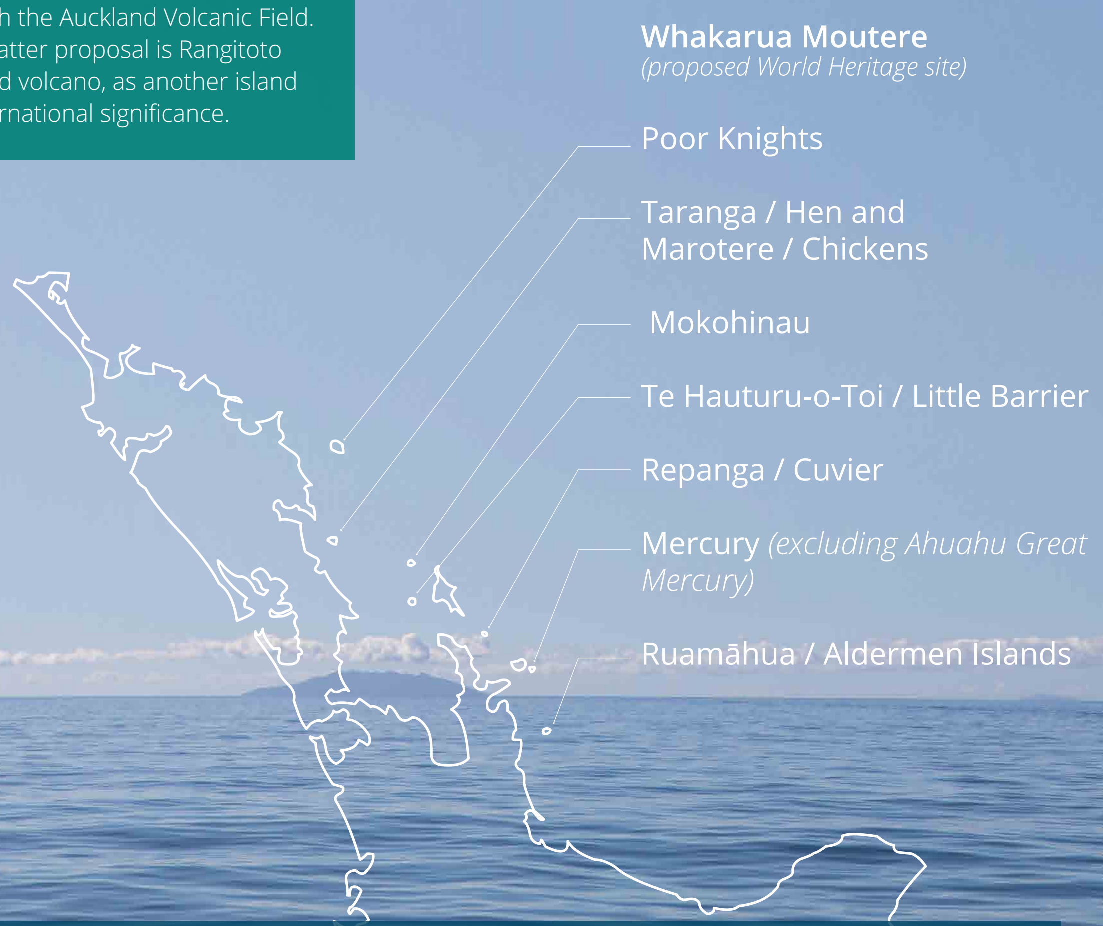
*(From top to bottom) Leatherjacket (*Meuschenia scaber*), Flatfish sp., Jack mackerel (*Trachurus novaezelandiae*), Trevally (*Pseudocaranx georgianus*). Photos by Charlie Johnson, School of Biological Sciences, University of Auckland/ NNZST.*

1.6 High biodiversity

The high biodiversity of islands in the wider Hauraki Gulf region means they are viewed as biodiversity hotspots with international significance, most can be regarded as 'seabird islands', where seabirds have a major influence on terrestrial ecosystems.

Proposed World Heritage Site – Moutere Whakarua

The Nature Reserve islands (listed below) have been included in a proposed World Heritage Site called Moutere Whakarua, and have been on the UNESCO Tentative List since 2007 – along with the Auckland Volcanic Field. Included in the latter proposal is Rangitoto as a recent shield volcano, as another island regarded of international significance.



Important Bird & Biodiversity Areas (IBA)

Important Bird & Biodiversity Areas (IBA) are sites that are recognised as internationally important for bird conservation and known to support key bird species and other biodiversity. The function of the IBA Programme is to identify and help focus and facilitate conservation action for a network of sites that are significant for the long-term viability of naturally occurring bird populations, for which a site-based approach is appropriate. The IBA Programme is global in scale using standard, internationally recognised criteria for selection. The programme's site-based approach presents a mosaic of locally identifiable sites that meet global criteria. Taken as a whole, the network provides a comprehensive overview of Aotearoa New Zealand's seabirds.

Taken individually, or in regional sets, government agencies with environmental responsibilities, tangata whenua, non-governmental organisations, business, community groups and individuals can work together to ensure conservation values are retained.

There are twelve IBAs identified for the wider Hauraki Gulf region, all islands or island groups, except for one on Aotea / Great Barrier Island centred on the summit of Hirakimata / Mount Hobson and the black petrel colony there. The marine IBA identified for the region encompasses the whole of the wider Hauraki Gulf.

For a detailed overview on the IBA programme for NZ seabirds, see www.forestandbird.org.nz/important-bird-areas

NGĀ MANU MOANA
2. SEABIRDS

Ōi / grey-faced petrel. Photo by Edin Whitehead.

2.1 Seabirds in our region

Twenty-seven seabird species breed within the Northern New Zealand region (Table 1). Five species are endemic to the region, they breed nowhere else in the world – tākoketai / black petrel, tītī / Pycroft's petrel, rako / Buller's shearwater, New Zealand storm petrel and tara-iti / New Zealand fairy tern. This regional species endemism equals that of entire countries, those second to Aotearoa New Zealand [1]. The region also includes significant populations of other species – ōi / grey-faced petrel, tītī / Cook's petrel, pakahā / fluttering shearwater, tākapu / Australasian gannet, toanui / flesh-footed shearwater, northern little shearwater and takahikare-moana / white-faced storm petrel. At the New Zealand scale, seabird diversity of the wider Hauraki Gulf region (Fig. 4), ranks highly compared to similar sites of international seabird importance in terms of species diversity and endemicity (e.g., Kermadec Islands, Chatham Islands, Snares Islands) [43]. Despite the proximity of these seabird colonies to New Zealand's largest city, many species in the region remain poorly studied. The New Zealand storm petrel was thought extinct until 2003. Its sole breeding site on Te Hauturu-o-Toi / Little Barrier Island was only discovered in 2013 [44]. For some species, such as fluttering and little shearwaters, we lack reliable population estimates despite their colonies being within easy access from the mainland. It is important we gain such estimates so that we can assess population vulnerability to current and future threats [1].

Many of the current island inhabitants can arrive by flying, and in case of plants, as wind-blown seeds of those in the guts or on feathers of birds. But there are other species that are flightless, including tuatara, lizards, numerous flightless insects such as wētā punga / giant wētā, and dozens if not hundreds of species of land snails (many of them minute) as well as peculiar little flightless parasitic wasps. There is little evidence that any of these species are capable of surviving for long in salt water; and so swimming between islands is not an option.

With the added abundance of many species of burrow, tree and surface-nesting seabirds, these islands are now extraordinary places. For some species, the islands have become the last refuge after waves of invasive predators swept across the mainland following human settlement and decimated populations of native species. Islands in the region include some of the last populations of tuatara, geckos and skinks. Furthermore, the diversity of species – even on small islands – can be staggering. For example, Green Island in the Mercury Islands has seven species of lizards on an island of only about 3 ha. This tiny area supports more species of lizards than in the whole of the United Kingdom. Despite the previous effects of fires, rabbits and kiore (since removed), Korapuki Island supports over 20 species of land snails and 70 species of spiders [63].

Many of the invasive species found on the mainland have made it to islands, but over the last 30 years, about 30 islands in the wider Hauraki Gulf region have been cleared of all invasive mammals. Some of these islands are large, such as Ahuahu / Great Mercury Island, Te Hauturu-o-Toi / Little Barrier Island and Rangitoto-Motutapu. Threatened endemic species such as the New Zealand storm petrel, tuatara, robust skinks (*Oligosoma alani*) and Whitaker's skinks (*O. whitakeri*) and the huge Duvaucel's geckos (*Hoplodactylus duvaucelii*) are now responding to these initiatives because of recovery (such as the New Zealand storm petrel and tuatara on Hauturu) or as active restoration on islands such as Tiritiri Matangi (see Section 6.3). Actions such as these also provide case studies of conservation success of great interest to the global community.

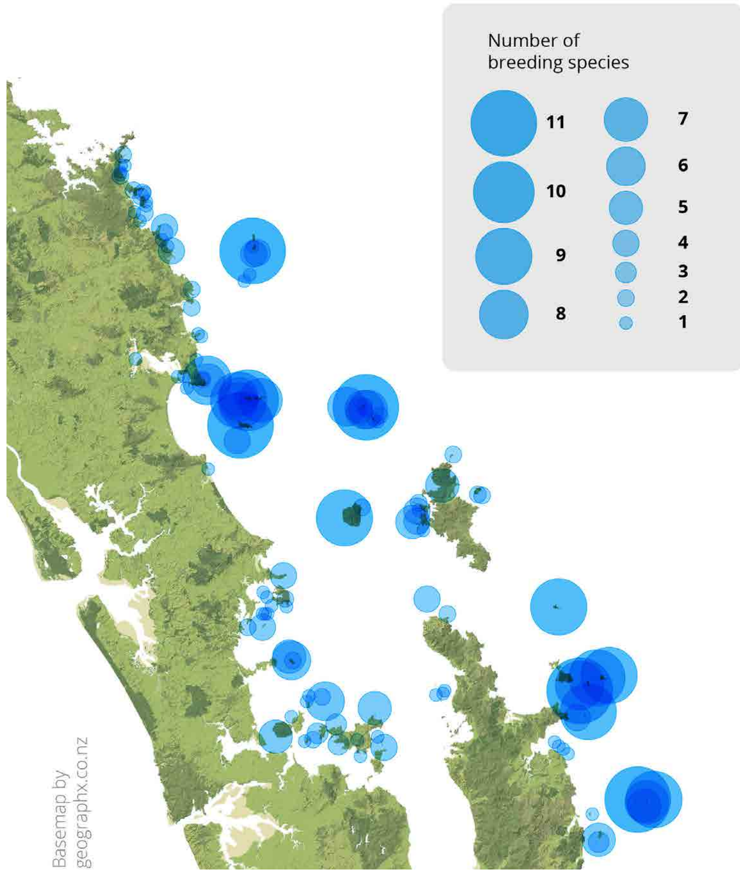


Figure 4. *Seabird species richness for islands across the wider Hauraki Gulf region. Source: Stephanie Borrelle, Chris Gaskin* [46].

2.2 Seabird biology

From Seabirds of the Hauraki Gulf: Natural History, Research, Conservation [43].

Seabirds have biological characteristics that differ dramatically to most land birds. These characteristics reflect the challenges of making a living from the changing marine environment and the evolution of many species in the absence of mammalian predators. The life-history characteristics of seabirds are often referred to as 'extreme', including long lifespans (20-60 years), delayed maturity (up to 15 years), small clutch sizes (often a single egg with no replacement), and long chick development periods [47]. By comparison many land birds, such as passerines, have shorter lives, lay larger clutches of eggs, and have chicks that mature more rapidly.

The feeding habits of seabirds vary. Some species regularly feed over land (gulls) or in freshwater (shags), others feed in tidal harbours and inshore waters (gulls, terns, cormorants, gannets), and the rest feed on the continental shelf and beyond in deep oceanic waters (albatrosses, petrels, shearwaters, and gannets). However, all seabirds spend some part of their life cycle on the open sea, an environment to which they are supremely adapted. Flight for many species (e.g., albatrosses, petrels, and shearwaters) is extremely efficient, with momentum gained via dynamic soaring, where birds take advantage of reduced wind speeds near the ocean's surface to gain speed to be used on the next ascent [48]. Other species such as penguins, shags, diving petrels and shearwaters fly underwater using their wings.

Seabirds forage over large distances. Excellent vision keeps them alert to the activities of other seabirds, fishes, and cetaceans (whales and dolphins) [49], and a strong sense of smell is enhanced by large olfactory bulbs [50]. Seabirds have water resistant feathering (from preen gland oils), webbed feet for swimming and bills with hooks, points, serrations and/or filters. These modified bills enable seabirds to exploit prey such as fish, crustaceans (e.g., krill) often in association with fish schools, cephalopods (squid), phytoplankton and zooplankton from the surface to depths of 60 metres or more [51] [52] [53] [54]. Unlike terrestrial species, the gut of albatrosses and petrels is modified to allow birds to store large meals that are converted to a low weight, rich oil, perfect for transporting large amounts of energy over long distances during breeding and migration.

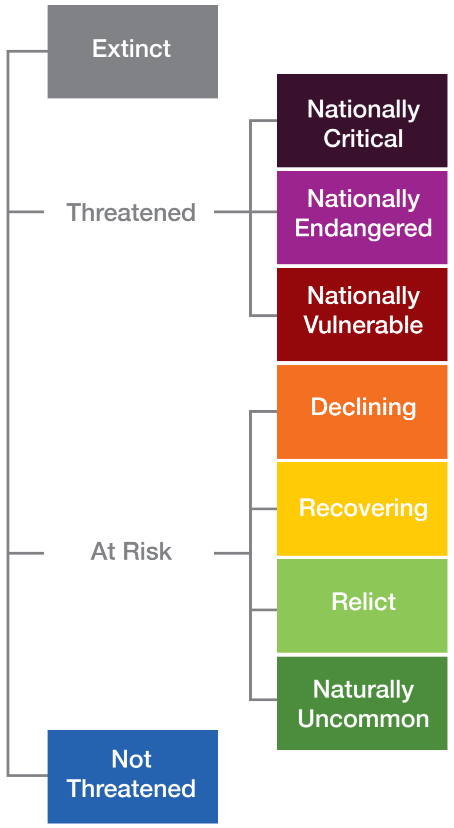
Many seabirds are colonial, with many species aggregating in loose or dense breeding colonies, where they find protection from predators by sheer numbers [47]. Species nest either on the surface (terns, gulls, gannets) or in trees (shags), in rock crevices (little penguins), or underground in excavated burrows (petrels, shearwaters) [47]. Birds return to their colony at the beginning of the breeding season to clean and defend the nesting site and re-establish pair bonds. Albatrosses, petrels, and shearwaters have particularly long incubation and chick-rearing phases. For most species, once the chick is large enough to thermoregulate independently it is left unattended whilst its parents forage at sea [47][51].

ENDS

Takoketai / black petrel.
Photo by Richard Robinson, Depth NZ.

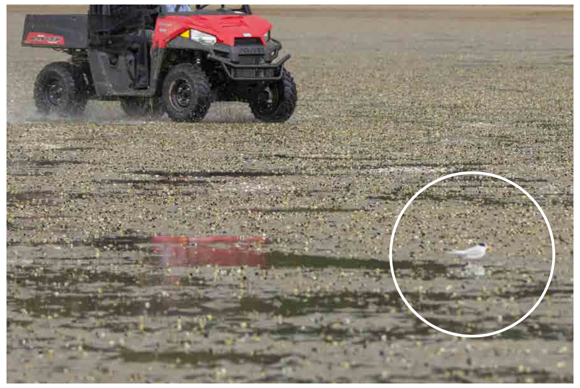
Species name (English/Māori)	Taxonomic name	Threat Status (DOC/IUCN Red List)	Endemism Status
Northern little (blue) penguin / **Kororā**	*Eudyptula minor iredalei*	**At Risk — Declining** Least Concern	NZ endemic subspecies
Black petrel / **tākoketai**	*Procellaria parkinsoni*	**Threatened — Nationally Vulnerable** Vulnerable	Region endemic
Cook's petrel / **Tītī**	*Pterodroma cookii*	**At Risk — Relict** Vulnerable	NZ endemic
Pycroft's petrel / **Tītī**	*Pterodroma pycrofti*	**At Risk — Recovering** Vulnerable	Region endemic
Black-winged petrel / **Tītī**	*Pterodroma nigripennis*	**Not Threatened** Least Concern	NZ native
Grey-faced petrel / **Ōi, tītī**	*Pterodroma gouldi*	**Not Threatened** Least Concern	NZ endemic
Buller's shearwater / **Rako**	*Ardenna (Puffinus) bulleri*	**At Risk — Naturally Uncommon** Vulnerable	Region endemic
Flesh-footed shearwater / **Toanui, tuanui**	*Ardenna (Puffinus) carneipes*	**Threatened — Nationally Vulnerable** Near Threatened	NZ native
Fluttering shearwater / **Pakahā**	*Puffinus gavia*	**At Risk — Relict** Least Concern	NZ endemic
Little shearwater	*Puffinus assimilis haurakiensis*	**At Risk — Recovering** Least Concern	NZ endemic subspecies
Sooty shearwater / **Tītī**	*Ardenna (Puffinus) grisea*	**At Risk — Declining** Near Threatened	NZ native
Fairy prion / **Tītī wainui**	*Pachyptila turtur*	**At Risk — Relict** Least Concern	NZ native
Northern common diving petrel / **Kuaka**	*Pelecanoides urinatrix urinatrix*	**At Risk — Relict** Least Concern	NZ native
White-faced storm petrel / **Takahikare-moana, takahikare**	*Pelagodroma marina maoriana*	**At Risk — Relict** Least Concern	NZ endemic subspecies
New Zealand storm petrel	*Fregetta maoriana*	**Threatened — Nationally Vulnerable** Critically Endangered	Region endemic
Australasian gannet / **Tākapu, tākupu**	*Morus serrator*	**Not Threatened** Least Concern	NZ native
Pied shag / **Kāruhiruhi, kawau**	*Phalacrocorax varius varius*	**At Risk — Recovering** Least Concern	NZ endemic subspecies
Little shag / **kawau paka**	*Phalacrocorax melanoleucos brevirostris*	**Not Threatened** Least Concern	NZ endemic subspecies
Black shag / **Kawau, tuawhenua**	*Phalacrocorax carbo novaehollandiae*	**At Risk — Naturally Uncommon** Least Concern	NZ native
Little black shag / **Kawau tuī**	*Phalacrocorax sulcirostris*	**At Risk — Naturally Uncommon** Least Concern	NZ native
Spotted shag / **Parekareka, kawau tikitiki, pāteketeke**	*Stictocarbo punctatus punctatus*	**Not Threatened** Least Concern	NZ endemic
Southern black-backed gull / **Karoro**	*Larus dominicanus dominicanus*	**Not Threatened** Least Concern	NZ native
Red-billed gull / **Tarāpunga**	*Chroicocephalus (Larus) scopulinus*	**At Risk — Declining** Least Concern	NZ endemic
Black-billed gull / **Tarāpunga**	*Chroicocephalus (Larus) bulleri*	**Threatened — Nationally Critical** Endangered	NZ endemic
White-fronted tern / **Tara**	*Sterna striata*	**At Risk — Declining** Near Threatened	NZ native
Caspian tern / **Taranui**	*Hydroprogne caspia*	**Threatened — Nationally Vulnerable** Least Concern	NZ native
New Zealand fairy tern / **Tara-iti**	*Sterna nereis davisae*	**Threatened — Nationally Critical** Vulnerable	NZ and region endemic sub-species

Table 1. *Seabird species richness on the islands in the wider Hauraki Gulf region. Updated from [46].*



See Section 7.1 How are seabirds faring?

The threat rankings in the table of seabird species breeding in the wider Hauraki Gulf region are from the New Zealand Threat Classification System (NZTCS) 2016 (bold) and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species.



Tara-iti / NZ fairy tern, Aotearoa / New Zealand's rarest endemic bird. Photo by Shaun Lee.

2.3 Life Cycle Stages

In general, all seabirds follow a similar life cycle pattern. However, there can be considerable variation in life cycle stages between species and the different seabird groups, in terms of behaviour, duration and season, and the threats they face.

Pre-egg stages

Cleaning out burrows (Little Penguin, petrels, shearwaters), building surface nests (most penguins, albatrosses, gannets/boobies, shags, gulls, terns, noddies).

Pre-lay exodus – during this period, the female will head out to sea to feed and grow the egg; males can also spend time away from colonies but may stay to defend nest sites.

Laying and incubation

Eggs laid.

Incubation (changeover times varies). Petrels and albatrosses have long incubation periods, with both partners sharing time on the nest. Changeover times will depend on food availability and where it is located, i.e., distances flown and time away from the nest.

Non/pre-breeder activity

In the colony the non-breeders include pre-breeders (i.e., birds too young and inexperienced to nest successfully) and birds that have bred before and are not currently doing so or are failed breeders.

At sea non-breeders (or unemployed birds) do not have the demands of raising chicks and can range more extensively or are conspicuous as birds gather in the vicinity of colonies.

Departure (generally earlier than breeding birds).

Chick raising

Eggs hatch.

Chicks reared. In most seabirds the brood time is quite short. Both parents do the feeding. Intervals between feeds depend on food availability and distances from nest sites.

Parents depart. Some seabirds will feed their chicks right up to fledging. Others will stop earlier during which time the chick uses up stored fat prior to departing the nest.

Fledging

Chicks depart.

Moult

Feathers do not last forever and need to be replaced. Moulting patterns reflect factors such as their habitat, food, clutch size, migration distance and body size. Timing of moult is different for seabird species.

Post-breeding

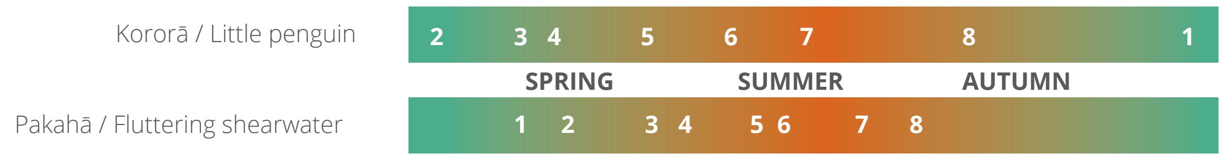
None or few birds on breeding grounds.

Seabirds remain resident at breeding grounds.

Migration

Half the region's species migrate post-breeding –see next pages.

These long-distance voyagers moult progressively during migration.



Adapted from Forest & Bird (2014). New Zealand Seabirds: Important Bird Areas and Conservation. The Royal Forest & Bird Protection Society of New Zealand, Wellington, New Zealand. 72 pp.

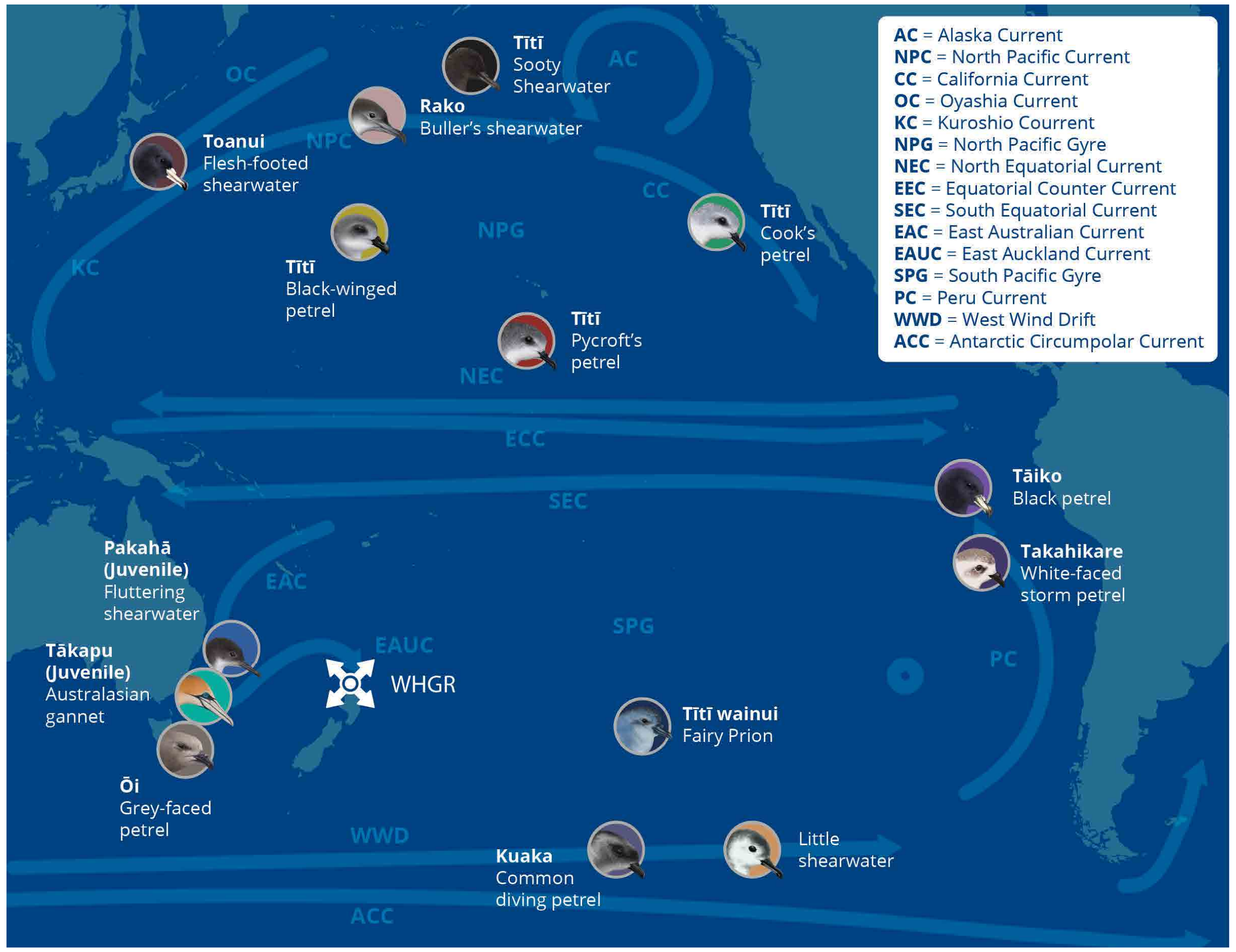


Figure 5. *General migration destinations for 14 species that breed in the wider Hauraki Gulf region (WHGR). Blue lines and arrows denote major oceanic surface currents and gyres.*

Extending our blue backyard

Chris Gaskin [1]

[1]*Northern New Zealand Seabird Trust*

Animal migration is generally the long-distance movement of individuals post-breeding on an annual or seasonal basis, triggered by local climate, and seasonal flushes in food availability. For some seabirds this means heading thousands of kilometres to the Northern Hemisphere; others will stay within the Southern Hemisphere.

However, post-breeding behaviour is not always clear cut. For example, some adult Australasian gannets migrate to Australia yet most stay in New Zealand year around. Fledglings soon after leaving their breeding colonies by contrast fly from New Zealand to Australia directly and typically do not return to their home colonies until their third year. Similarly, about 95% of grey-faced petrels migrate to eastern Australia each summer but a few stay near New Zealand for unknown reasons. Many fluttering shearwaters remain locally, although birds from the Hauraki Gulf have been found to disperse to Subantarctic waters, and Australian waters. Pre-breeders, or birds that haven't started breeding, can also spend time in Australian waters.

Species that migrate outside New Zealand's Exclusive Economic Zone (EEZ)

To the northern Hemisphere (flesh-footed, Buller's and sooty shearwaters; Cook's, Pycroft's and black-winged petrels) (Fig. 5).

Within the southern Hemisphere (black petrels and white-faced storm petrels to the eastern Pacific Ocean and Humboldt Current off South America; fairy prions to the sub-tropical Convergence, mid ocean; common diving petrels and little shearwaters to the South Polar Front) (Fig. 5).

Australian waters (grey-faced petrels, and some fluttering shearwaters and Australasian gannets) (Fig. 5).

Resident species (those that remain in wider Hauraki Gulf region).

Little penguins can spend time further out to sea and further along the coast from the breeding areas post-breeding.

Shag, gull, and tern species. For example, red-billed gulls in the Hauraki Gulf congregate at winter feeding grounds such as the Mokohinau Islands, and birds from multiple colonies merging including from outside the region.

Species that visit

Seabirds breeding in other parts of Aotearoa New Zealand's EEZ and in other countries also visit the Hauraki Gulf and Northland waters, e.g., korure / mottled petrel (*Pterodroma inexpectata*) and tītī/ sooty shearwaters from the islands around Rakiura / Stewart Island, cape petrel (*Daption capense*), toroa / white-capped albatross (*Thalassarche steadi*), toroa / Campbell albatross (*Thalassarche impavida*), grey petrel (*Procellaria cinerea*), white-headed petrel (*Pterodroma mollis*) from New Zealand's subantarctic islands, short-tailed shearwaters (*Ardenna (Puffinus) tenuirostris*) from Australia, Indian yellow-nosed albatross (*Thalassarche carteri*) from the Indian Ocean, and Wilson's storm petrel (*Oceanites oceanicus*) from Antarctica.

Timing is everything

Understanding the timing of species' life stages is critical to developing effective measures to mitigate against pressures that threaten their survival. For example, for petrels and shearwaters fledging is when they are most susceptible to fallout from light pollution, and so knowing when this occurs allows targeting of efforts to reduce light spill and searches for grounded fledglings as at Kaikōura [59] and Punakaiki [60] in the South Island, and on Kauai in Hawaii [61]. Or periods when species are largely absent from islands after they finish breeding allows for intensive pest and weed control operations (if required) to occur, without the danger of causing damage to burrowing seabird habitats, or disturbance during a critical stage of the breeding season. When species are on migration to either the North or Eastern Pacific Ocean, they will be largely absent from local waters, and that could be factored in when considering fisheries closures. Flesh-footed shearwaters and black petrels, two species most at risk from longline fisheries by-catch, are largely absent from north-eastern North Island waters from late-May to mid-September. Note, by-catch mitigation measures are best practised all year round, so that fishers get used to implementing them automatically without having to check the date to see if seabird species are present or not.

Takahikare-moana / white-faced storm petrel. Photo by Edin Whitehead.

Remarkable journeys

The sight of a small 45g storm petrel kicking along mid ocean, about halfway between Pitcairn Island and Tauranga New Zealand, was a real eye-opener. A bird totally at home in a vast ocean. White-faced storm petrels use their long legs and webbed feet to bounce across the surface of the sea. Outstretched wings allows them to glide between bounds. Mid ocean and with a following wind, this meant long glides with seemingly minimal effort. The sighting was in September 2016 and this bird would have been heading back to Aotearoa New Zealand for the start of its next breeding season – maybe in the Hauraki Gulf, maybe the Rēkohu / Wharekauri / Chatham Islands, or an island near Rakiura / Stewart Island. In the Hauraki Gulf they breed from September through to March/early April, after which they migrate out of our waters all the way to the eastern tropical Pacific, and along the South American seaboard, south from Ecuador. Theirs is quite a remarkable journey, when you think of their preferred flight behaviour, 'pogo hopping', gliding, and flapping, when necessary, all the way there, all the way back. While no white-faced storm petrels have been tracked from Aotearoa New Zealand, their presence in eastern tropical Pacific Ocean is known from a unique New Zealand band recovery [56] and sightings during research cruises undertaken by National Oceanographic and Atmospheric Administration (NOAA) [57].

Common diving petrels are chunky little seabirds that can easily fit in the palm of one's hand. With their high wing loading they are extremely energetic fliers, with continual whirring, close to the ocean's surface and frequent water contact. There is little or no ability for dynamic soaring, a feature of many *Procellariiformes* (petrels, shearwaters, prions and storm petrels). Tracking conducted in 2011-2012 with birds from Pokohinu / Burgess Island in the Mokohinau Islands and Kauwahaia Island, near Te Henga / Bethells Beach on the West Coast, revealed that once these birds finish breeding in late November, they fly south and east to an area on the Southern Polar Front, about halfway to Chile and the southern tip of South America. Not only were they covering 3000-5000km for the outward journeys, but one bird made its 3000km journey in 3 days. Once at the Polar Front, while feeding in these highly productive waters their pelagic lifestyle sees them spending an unprecedented amount of time (95%) on and under the surface of cold Antarctic polar front waters (~ 4°C) [58].

Kuaka / common diving petrel. Photo by Edin Whitehead.

Pakahā / fluttering shearwater and tītī wainui / fairy prions with shoaling trevally. Photo by Edin Whitehead.

2.4 Associations – shoaling fish, foraging seabirds, workups

Chris Gaskin [1]

[1]*Northern New Zealand Seabird Trust*

North-eastern North Island waters, from the Three Kings Islands to East Cape, are notable for large numbers of seabirds gathering and feeding in association with concentrations of zooplankton and fish, variously known as a 'fish shoals', 'fish schools', 'work-ups' or 'boil-ups'. Fish species include kahawai, trevally, skipjack tuna, jack mackerel (*Trachurus novaezelandiae*), blue mackerel, saury, pilchard, and anchovy [28].

The general hypothesis is that fish shoals drive krill and other prey species to the surface making them more readily available to surface feeding seabirds. The alternative hypothesis is that krill aggregate at or near the surface in areas of upwelling or current flows which fish shoals target, providing visual and potentially olfactory cues to seabirds [27]. In both cases, when fish shoals come across the krill patches (in high enough concentrations) they go into 'feeding mode', massing even more tightly together and potentially further concentrating the krill. In turn their feeding activity advertises krill presence to predators. The commotion, and potentially smell and sound of the fish feeding at the surface act as cues for seabirds that there is abundant prey available. Reefs, pinnacles, groups of islands and river mouths can be highly productive areas attracting many fish species. Plankton biomass may be increased in these areas possibly because of local enhancement of productivity caused by nutrient input, tidal flows and upwelling. However, krill also aggregate in areas away from fish shoals and are targeted by seabirds cued by other visual signs besides surface shoaling activity and potentially also olfactory signs [27].

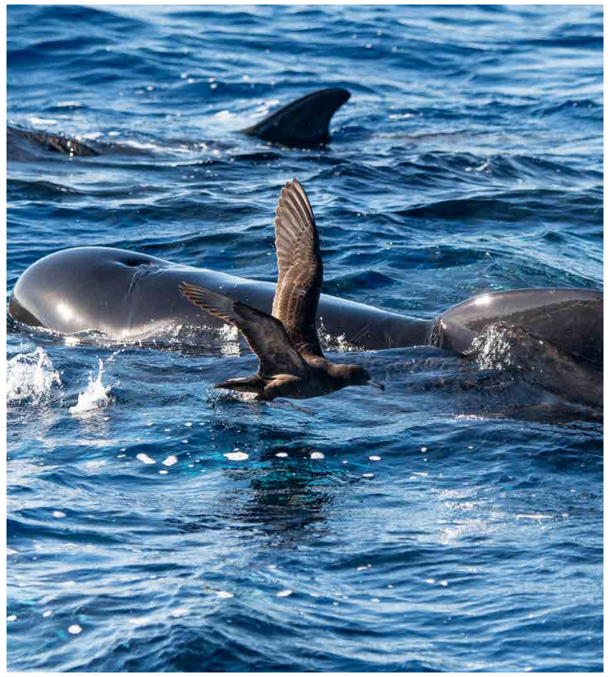
Skipjack tuna school, outer Hauraki Gulf. Screenshot from videography by NNZST.

Event type	Fish species	Seabird species	Activity
Mixed fish shoal	Trevally (often the dominant fish species), kahawai, blue maomao, kingfish. Can be just trevally schools.	BUSH, FLSH, FAPR, RBGU, WFTE (plus sometimes SOSH, FFSH, STSH, WFSP, COPE, GRNO)	Tightly packed, very active dense schools, sometimes with several schools merging to form very large schools. Birds either forage in the wake of the schools, or sometimes feed ahead of and around the schools. Fish will erupt explosively if disturbed either from below (e.g. predatory fish) or from above (e.g. birds flying low over school). Shearwaters and prions have been filmed diving in the wake of school activity.
Kahawai school	Kahawai	FLSH, WFTE, RBGU, FAPR	Fast-moving schools, birds moving in 'leap-frogging' formations, shearwaters plunging and diving. Also, tightly packed schools separate from trevally schools in the same vicinity
Saury school	Saury	AUGA, FFSH (BLPE, SOSH)	Shearwaters and gannets diving on saury. Can occur in association with common dolphins.
Jack mackerel school	Jack mackerel	AUGA	Schools most commonly identified by gannets coming to the surface with prey. Fish occasionally seen breaking the surface.
Blue mackerel school	Blue mackerel	AUGA, FLSH, BUSH, FAPR	Very eruptive mobile schools, one minute here, the disappearing to appear somewhere else.
Forage fish shoal	Pilchard, anchovy, koheru	AUGA, FLSH, BUSH (FFSH, WFSP, COPE)	Often tightly packed schools, sometimes forming spinning 'bait balls' close to the surface. Birds plunging/diving and pursuing prey underwater. Can occur in association with common dolphins.
Tuna school	Skipjack tuna	BUSH, FLSH, AUGA, RBGU, occasional WFTE	Fast-moving fish sometimes jumping clear of water. Shearwaters following at speed, leapfrogging from one emergent feeding area to the next.

Table 2. *Some examples of seabird feeding events in the wider Hauraki Gulf involving fish shoals and schools. Seabird species acronyms and full names as follows: AUGA: Australasian gannet, BLPE: black petrel, BUSH: Buller's shearwater, CODP: common diving petrel, COPE: Cook's petrel, FAPR: fairy prion, FFSH: flesh-footed shearwater, FLSH: fluttering shearwater, GRNO: grey noddy, RBGU: red-billed gull, SOSH: sooty shearwater, STSH: short-tailed shearwater, WFSP: white-faced storm petrel, WFTE: white-fronted tern* [28, 42].

Event type	Seabird species	Activity
Krill patches	BUSH, FLSH, FAPR, CODP, WFSP, SOSH	Mainly krill and salps with birds actively feeding from the surface, often well-spread, occasionally across several sq. kms.
Current lines	FAPR, FLSH, WFSP	Current lines containing planktonic crustaceans, salps and juvenile fish. Birds actively feeding without prey being visible at the surface.

Table 3. *Other types of seabird feeding events in the wider Hauraki Gulf where seabirds are observed feeding in the absence of fish shoal activity.* [28, 42]



Toanui / flesh-footed shearwater and ūpokohue / long-finned pilot whales. Photo by Edin Whitehead.

Messy feeders – marine mammals and seabirds

Marine mammals can be messy feeders, with their feeding generating discards, the uneaten parts of prey scattered on the surface that the birds then feed on. This behaviour has been observed with mixed pods of false killer whales (*Pseudorca crassidens*), terehu / bottlenose dolphins (*Tursiops truncatus*) and long-finned pilot whales (*Globicephala meias*). Black petrels dominate this feeding association with large groups of sometimes 100+ birds following pods (especially mixed pods of false killer whales and bottlenose dolphins). The birds will feed aggressively on scraps brought to or close to the surface by the whales' feeding. Birds will peer underwater to watch the whales' feeding below and will race to where they surface. Multiple species (e.g., black petrels, Buller's and fluttering shearwaters, Cook's petrels, white-faced and New Zealand storm-petrels) have been seen feeding around large mixed pods of false-killer whales and bottlenose dolphins. The storm-petrels mostly feeding over oily slicks the whales left at the surface [28].

Fishing vessel, Hauraki Gulf. Inset, toanui / flesh-footed shearwaters. Photos by Chris Gaskin and Edin Whitehead.

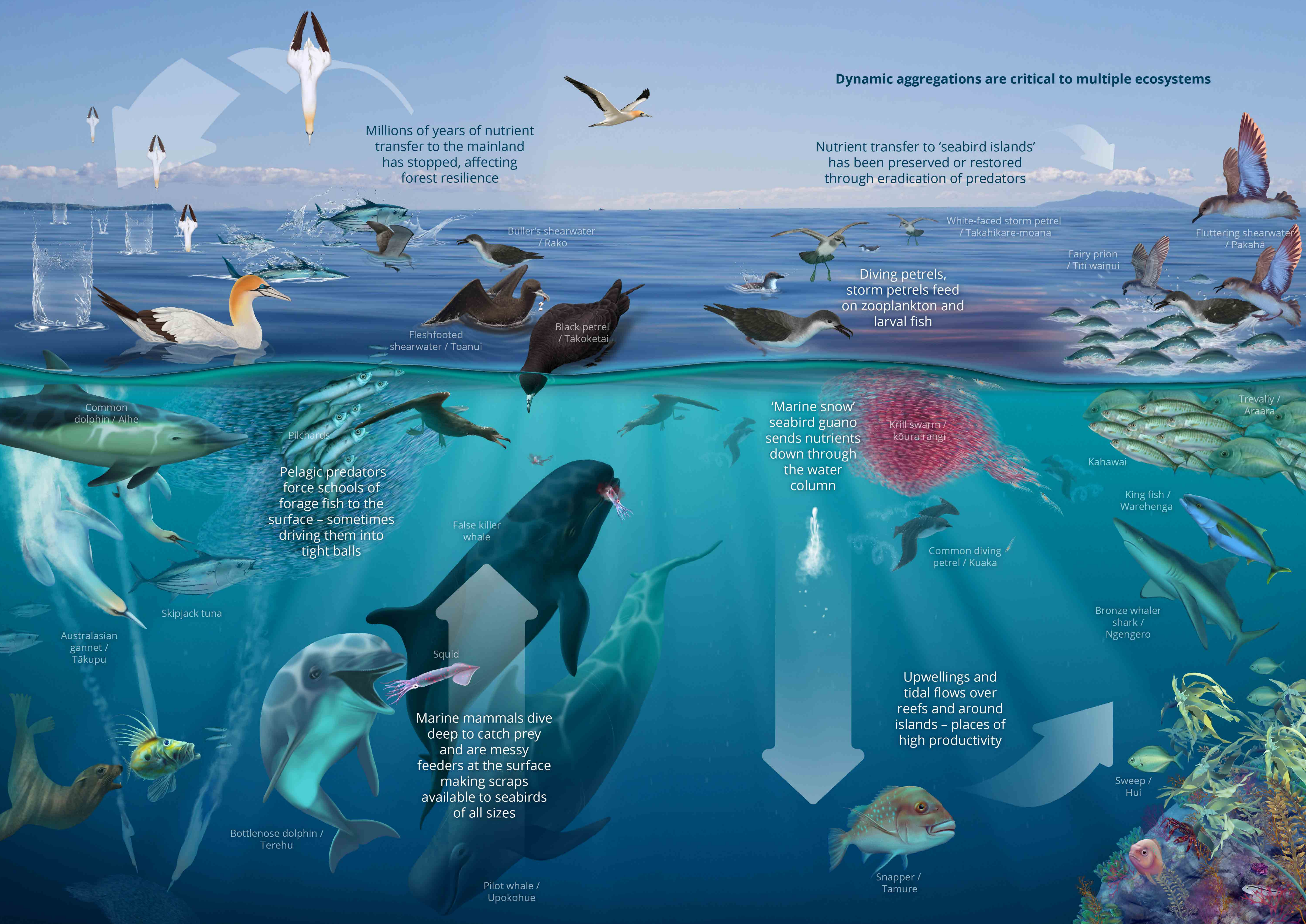
Big steel messy feeders

Seabirds are great opportunists for finding food at sea and will investigate all potential source either by sight or smell. Feeding on marine mammal feeding discards is a natural feeding behaviour. However, that natural feeding behaviour gets them into problems around fishing vessels. From a seabirds' perspective these vessels are essentially big steel messy feeders and their inadvertent or deliberate release of fish discards, scraps, oily residues from fish, and smell, attract albatrosses, petrels, and shearwaters as well as gulls. See Section 6.2 for efforts to mitigate against seabirds being injured and killed because of interactions with fishing vessels (bottom and surface long line, trawl and set net fisheries).

Rako / Buller's shearwaters feeding on a krill swarm. Surface riffles caused by small fish attacking the krill from below. Photo by Chris Gaskin.

Marine mammal species	Activity	Birds
Aihe / Common dolphin *Delphinus delphis*	Generally, very active pursuit by dolphins, sometimes herding or rounding baitfish into tightly packed spinning schools; spectacular with gannets diving, sometimes in very large numbers, also smaller seabirds active amid the action; shearwaters diving in pursuit of prey.	AUGA, FFSH, FLSH, REBGU, WFTE
Aihe / Common dolphin *Delphinus delphis*	In contrast to the above, more sedate feeding activity by the dolphins (although with occasional surges); attendant birds on the surface peering below, sometimes diving in pursuit of prey, or flying to where new action takes place.	FFSH, AUGA, FLSH, BUSH
False killer whale *Pseudorca crassidens*, pelagic terehu / bottlenose dolphins *Tursiops truncatus*	The cetaceans feed at or below the surface; petrels and shearwaters dive underwater to pick up discards; birds often scrapping over food. Storm-petrels have been observed feeding on small scraps and the oily slicks generated by the feeding activity.	BLPE, FFSH, COPE, BUSH, FLSH, WFSP, NZSP
Ūpokohue / long-finned pilot whales *Globicephala meias* and pelagic bottlenose dolphins	Mostly seabirds following the pods which for the most part don't appear to be feeding; however, the birds pay close attention to the cetaceans underwater which occasionally bring squid which the birds pick up and fight over.	BLPE, BUSH, WCAL, CAAL
Kekeno / New Zealand fur seal *Arctocephalus forsteri*	One occasion, NZ fur seal feeding on a John dory at the surface, seabirds in attendance and picking up scraps	BUSH, FAPR, WFSP

Table 4. *Other feeding associations recorded during surveys. Additional seabird species acronyms and full names as follows (see also Table 2): WCAL: white-capped albatross, CAAL: Campbell albatross* [28, 42].


Dynamic aggregations are critical to multiple ecosystems
Millions of years of nutrient transfer to the mainland has stopped, affecting forest resilience
Nutrient transfer to 'seabird islands' has been preserved or restored through eradication of predators
Buller's shearwater / Rako
White-faced storm petrel / Takahikare-moana
Fluttering shearwater / Pakahā
Fairy prion / Tītī wainui
Diving petrels, storm petrels feed on zooplankton and larval fish
Fleshfooted shearwater / Toanui
Black petrel / Tākoketai
Common dolphin / Aihe
Pilchards
'Marine snow' seabird guano sends nutrients down through the water column
Krill swarm / kōura rangi
Trevally / Araara
Kahawai
Pelagic predators force schools of forage fish to the surface – sometimes driving them into tight balls
False killer whale
King fish / Warehenga
Common diving petrel / Kuaka
Skipjack tuna
Australasian gannet / Tākupu
Bronze whaler shark / Ngengero
Squid
Marine mammals dive deep to catch prey and are messy feeders at the surface making scraps available to seabirds of all sizes
Upwellings and tidal flows over reefs and around islands – places of high productivity
Sweep / Hui
Bottlenose dolphin / Terehu
Snapper / Tamure
Pilot whale / Upokohue

Tautara eating. Photo by Shaun Lee.

2.5 The nature of seabird islands

Dave Towns [1] with Holly Jones [2], Lyndsay Rankin [1,2], and Stephanie Borrelle [3]

[1] *Auckland University of Technology (AUT)*
[2] *Northern Illinois University*
[3] *BirdLife International, Pacific Secretariat*

Isolated communities

Most of the islands in the wider Hauraki Gulf region once had a past life as high points on a wide coastal plain on the edge of the mainland. During the peak of the last ice age, about 20,000 years ago, so much water was bound up in ice so sea levels were 130 m lower than today. The coastline was beyond the Poor Knights, Mokohinau, Hauturu / Little Barrier, Aotea / Great Barrier and Repanga / Cuvier Islands. The Mercury Islands were well inland. Many of the inhabitants of today's islands are the offspring of species that became marooned as the climate warmed, ice thawed, and sea levels rose to isolate the islands we now know. The communities of plants and animals on these young islands are representatives of communities once continuous with those found on the adjacent mainland [62]. This is what makes these islands so special.

Many of the current island inhabitants can arrive by flying, and in case of plants, as wind-blown seeds of those in the guts or on feathers of birds. But there are other species that are flightless, including tuatara, lizards, numerous flightless insects such as wētā punga / giant wētā, and dozens if not hundreds of species of land snails (many of them minute) as well as peculiar little flightless parasitic wasps. There is little evidence that any of these species are capable of surviving for long in salt water; and so swimming between islands is not an option.

With the added abundance of many species of burrow, tree and surface-nesting seabirds, these islands are now extraordinary places. For some species, the islands have become the last refuge after waves of invasive predators swept across the mainland following human settlement and decimated populations of native species. Islands in the region include some of the last populations of tuatara, geckos and skinks. Furthermore, the diversity of species – even on small islands – can be staggering. For example, Green Island in the Mercury Islands has seven species of lizards on an island of only about 3 ha. This tiny area supports more species of lizards than in the whole of the United Kingdom. Despite the previous effects of fires, rabbits and kiore (since removed), Korapuki Island supports over 20 species of land snails and 70 species of spiders [63].

Rako / Bullers shearwater on Tawhiti Rahi, Poor Knights Islands. Photo by Edin Whitehead.

Many of the invasive species found on the mainland have made it to islands, but over the last 30 years, about 30 islands in the wider Hauraki Gulf region have been cleared of all invasive mammals. Some of these islands are large, such as Ahuahu / Great Mercury Island, Te Hauturu-o-Toi / Little Barrier Island and Rangitoto-Motutapu. Threatened endemic species such as the New Zealand storm petrel, tuatara, robust skinks (*Oligosoma alani*) and Whitaker's skinks (*O. whitakeri*) and the huge Duvaucel's geckos (*Hoplodactylus duvaucelii*) are now responding to these initiatives because of recovery (such as the New Zealand storm petrel and tuatara on Hauturu) or as active restoration on islands such as Tiritiri Matangi (see Section 6.3). Actions such as these also provide case studies of conservation success of great interest to the global community.

Tara / White-fronted tern. Photo by Edin Whitehead.

Seabird-driven ecosystems

The word guano, derived from the Inca of South America, means a gift of the gods. The gift is dried seabird droppings, which, when mined from Nauru, was for decades the fertiliser of choice for New Zealand agricultural lands. Guano is produced naturally in huge quantities on seabird islands in the wider Hauraki Gulf region. Perhaps the most visible examples are seen as pungent deposits around gannet colonies and beneath shag roosts. But the far more widespread examples are hidden within colonies of burrowing seabirds such as petrels and shearwaters. Here the guano is incorporated directly into the soils as the birds return at night, clean their burrows and throw freshly minted compost complete with fertiliser across the forest floor. Because most seabirds – whether burrowing or not – live in colonies, the localised production of guano can be staggering. Seabird colonies have been estimated to spread up to 100 times more nitrogen and 400 times more phosphorus than is normally applied to agricultural land. On forested islands, the burrowing activities and guano production by seabirds have such profound effects, the birds are often referred to as ecosystem engineers or ecosystem drivers. In a further twist, none of this material is derived from terrestrial sources, as seabirds only feed at sea. The guano is produced from resources gained in oceans and deposited on land, bridging two vastly different ecosystems [64].

Most likely, islands of less than 200 ha within the region were once dominated by enormous numbers of burrowing seabirds. Where and how the islands' permanent biological residents lived is reflected in the engineering effects of the nesting birds. The few islands untouched by introduced predators, and those now recovering after predator removal, provide indications of the interactions within these extraordinary ecosystems. Multidisciplinary studies conducted on many of the islands in the Hauraki

Gulf demonstrated that the presence of seabirds drives almost every level of ecosystem functioning, including litter decomposition rates and invertebrate abundance and community composition (Fig. 6). The nutrient-rich and heavily burrowed soils also promote communities comprised of plants able to withstand disturbance, acidic soils, high nutrient loads and dry conditions. The plants need to be long-lived, able to sprout from the base to overcome the effects of toppling in the loose soils, and able to produce prolific seeds to take advantage of light gaps [65]. Plants living in this environment also need to compensate for very high seedling mortality as the seabirds rip up anything they can find to line their burrow nests.

As a result of seabird activity, invertebrates may also face a shortage of leaf litter in which to shelter, except at the foot of slopes. Here litter and rich friable soil accumulates from seabird *"gardening"* and enormous numbers of invertebrates take advantage of the favourable conditions. Comparisons between islands with and without seabirds have demonstrated the advantages to invertebrates if they can find the right conditions. For example, up to 10 invertebrate groups were more abundant on islands occupied by burrow-nesting seabirds than on islands without seabirds [66]. In places, bright green crusts of algae and moss on hard surfaces such as tree-trunks and boulders provide evidence of the effects of seabird droppings. At night, these surfaces are grazed by large flightless darkling beetles, which in turn are one of the favourite foods of tuatara. In addition to tuatara, the seabird burrows provide shelter for an array of large, nocturnal skinks. This unique combination of the high diversity of nesting seabirds and reptiles, including tuatara, provides another reason for the international significance of the islands in the region.

Large flightless darkling beetle. Photo by Shaun Lee.

Seabird garden. Photo by Edin Whitehead.

Why burrows — the strange habits of tuatara and nocturnal skinks

The abundance of tuatara and nocturnal skinks on seabird islands has presented a physiological puzzle. These islands can be dry for long periods and the smaller ones have no streams or standing fresh water. Yet studies of tuatara and nocturnal skinks indicate that they are very poor at resisting desiccation; their skin is not the effective moisture barrier found in most other reptiles.

*Marbled skink (*Oligosoma oliveri*). Photo by Shaun Lee.*

How have these species managed to survive on relatively arid islands?

One solution is to be active at night, because this is when there is often plenty of dew. The other is to avoid the heat of the day and use burrows – which conveniently have been made available in large numbers by seabirds. Furthermore, burrows provide a moisture-saturated environment ideal for species unable to tolerate dry conditions. A further bonus is that burrows occupied by seabird chicks can provide central heating for the tuatara or lizards if the birds are willing to share, which for some species is not likely. For example, toanui / flesh-footed shearwaters are notoriously bad-tempered. However, even if heating is not a bonus, spilled regurgitations by the chicks, or the flies and beetles attracted when chicks die in burrows, are easy pickings for lizards. Some of them, such as the Whitaker's skinks in the Mercury Islands, seem to remain in the burrows for most of the year.

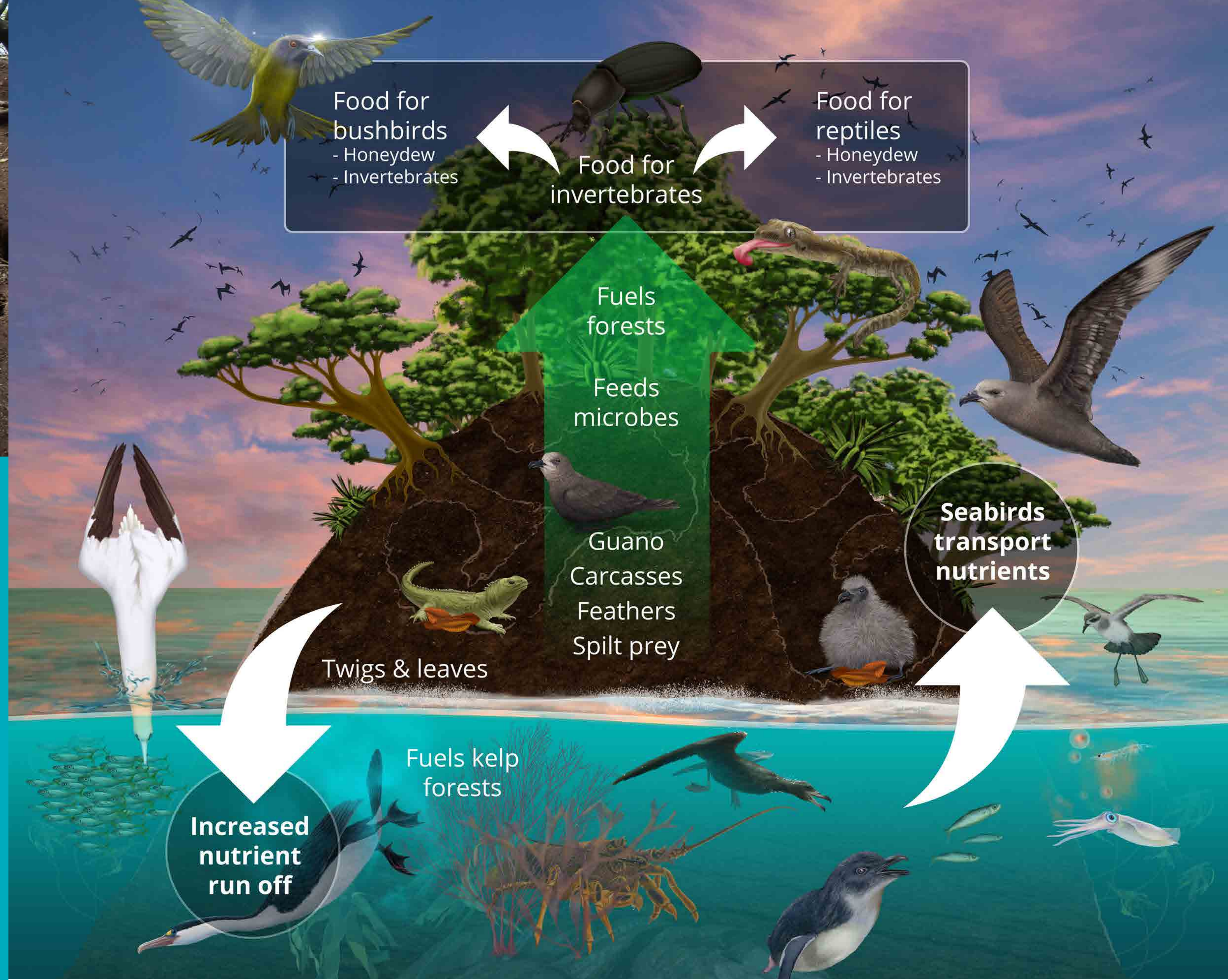


Figure 6. *The circular seabird economy*

Unique relationships between seabirds and reptiles

One unusual feature of the reptiles on our northern seabird islands is that over 80% of the fauna on any island is likely to be nocturnal. Night-activity makes sense for tuatara and those lizard species using burrows when their seabird tenants return during the nesting season. It is also when many of the invertebrates are most active, and these dominate the diet of tuatara and most of the ground-living species of lizards. However, for geckos, most of which are arboreal, there is another source of food indirectly attributable to the actions of seabirds.

Because of the conditions resulting from seabird activity, two species of forest plants can be widespread on seabird islands: ngaio (*Myoporum laetum*) in areas with strong light around the coast and karo (*Pittosporum crassifolium*), which grows near the coast and under forest cover. Both species are hosts to parasitic scale insects that live under the bark and produce long anal threads through which they excrete waste in the form of honeydew. This rich source of energy is attractive to geckos, with large numbers congregating at night on the trunks of trees infested with scale insects. During the day, the same resources are the food of choice for tui and korimako / bellbirds (*Anthornis melanura*) [67]. A chorus of song from bellbirds often indicates that they are defending their chosen honeydew trees from neighbouring birds.

This leads to another characteristic of seabird islands: they are loud. There can be constant bird song from land birds during the day, but it is at night when the noise levels really wind up. Thousands of seabirds arrive within a short space of time at dusk or soon thereafter. They then feel compelled to announce their safe landing – often after crashing through the foliage in a shower of leaves and twigs. For some, such as kuaka / common diving petrels, the call is a pleasant soft coo. But if pakahā / fluttering shearwater colonies are nearby, the night is filled with an unnerving maniacal cackle. This cacophony of calling can last until shortly before dawn, which is when the birds often depart again to forage at sea. It is also when the dawn chorus of bellbirds begins. Sleep is a luxury.

Seabirds and the nearshore ecosystem — bi-directional nutrient flow?

The circular seabird economy – whereby seabirds feed in the ocean, transport marine-derived nutrients onshore to their breeding colonies, and then seabird-derived nutrients runoff into the ocean, enriching nearshore ecosystems – is a critical driver of biodiversity and functioning on islands and in nearshore marine ecosystems (Fig. 6).

Recent research used SCUBA surveys of marine algal composition and then stable isotope analyses of nearshore marine algae to track the influence of seabirds. Macroalgal diversity was highest at islands never invaded by introduced mammals in the Mercury Island's, and lowest at the island that had invasive predators removed just two years prior. Seabird-derived nitrogen was highest in the rainy season, at shallow depths, and with low wave exposure. Red algae were the most sensitive to seabird-derived nutrient runoff compared with brown algae. A similar analysis at 17 islands in the Hauraki Gulf revealed that factors influencing seabird-derived nitrogen in the nearshore varied greatly by algal species with time since eradication important in only two of the five study species. Algal communities in the nearshore marine environment were most like never invaded islands after 30 years. A further study combined nearshore marine data with data taken from terrestrial points on the Mercury Islands and found strong links between terrestrial variables such as seabird burrow density and macroalgal community composition. However, only one of the six most common macroalgal species – the red algae – showed a link between terrestrial seabird nutrients and its own nutrient enrichment and that was only true on never invaded islands.

Taken together, this suggests that on never invaded islands, we can detect a circular seabird economy, but that this linkage is still not fully recovered even after 30 years of eradication.

Poor Knights nearshore habitat. Photo by Edin Whitehead.

11

Never had mammalian predators

38

Had mammalian predators eradicated

25

Have mammalian predators – seabirds are functionally extinct

Figure 7. *Islands with, restoring or without seabird-driven ecosystems.*

Nutrient flow from land back to sea

Traces of the marine-derived nutrients deposited by seabirds can be found at every trophic level on these islands, from invertebrates through to plants. The nutrients can be tracked using a peculiarity of nitrogen, which naturally forms stable isotopes (variants). One isotope can be used to track the marine origins of this nutrient. It is now clear that the vegetation cover of islands is not able to use all this material and, therefore, much of it runs off into the coastal environment. Also, some of it is deposited close to the coast by species such as penguins and shags. Much more is bonded into the soil, some of which washes off during heavy rain. How this enriching material might influence the abundance of intertidal organisms is not yet known for New Zealand islands. But it can have profound effects on islands where it has been studied overseas. We do know from recent studies in the wider Hauraki Gulf region, that the nutrients continue to act on subtidal communities [68] (see also 'Seabirds and the nearshore ecosystem' left).

The cliffs and forests of Tawhiti Rahi, Poor Knights Islands. Photo by Edin Whitehead.

Islands as an example of the efficient filtering of nutrients

On seabird islands, the bulk of the nutrient input is bound up in soil and plants, so the only detectable influxes into the surrounding sea are during heavy rain events. On islands there is this complex interplay between nutrient input and its use; with many filters in existence through vegetation and soils [64]. On the mainland the adoption of riparian strips along waterways achieves a similar filtering effect. Where these filters are absent, the grass sward cannot deal with inputs and the whole lot ends up in waterways, or ground water. Soil horizons have been developed as means of producing more grass, and not allowed to develop their ability to process nutrients [69, 70].

ENDS

HE MOANA ORA

OUR LIVING LABORATORY

Multi-species work up at Northwest Reef, Te Hauturu-o-Toi / Little Barrier Island in background. Photo by Edin Whitehead.

TE MĀTAURANGA MĀORI
3. MĀTAURANGA MĀORI

Moturehu / Double Island, Mercury Islands. Photo by Edin Whitehead.

3.1 Ngā Tohu Māori – Core Māori values

This Core Māori Values section first featured in the 2020 State of Our Gulf report produced for the Hauraki Gulf Forum. It is included here with the permission of the authors of that ground-breaking report, Rauru Kirikiri and Dr Shane Kelly [36].

There is the need to provide a greater focus on how the Marine Park is viewed through a Te Ao Māori lens. Essentially Te Ao Māori is defined as a value system that is pervasive throughout Māori communities, wherever they might be. It is a mosaic of checks and balances that determine how the world is seen through Māori eyes and how that world is shaped in addressing those checks and balances. There is a mingling of the spiritual and existential that calls for careful nurturing of all things animate and inanimate. Te Ao Māori does not necessarily make the distinction between the living and the non-living in the way that western science does, but it does not make the Māori world view any less relevant.

Significant Māori values (uara) that apply to environmental management are described here.

Kaitiakitanga – Guardianship

A key overarching value in this report is kaitiakitanga (guardianship) — a means to care for and protect the environment. Tangata whenua are kaitiaki (guardians) of both the land and waterways in their rohe, and it is this responsibility that traditionally ensured the continued good health and abundance of resources. Such was the intimate relationship between people and their environment that it was said that the health of a community was reflected in its environment, and vice versa. For example, if the marine space was under stress something was obviously amiss with the people of a coastal rohe.

What is more in question these days is the ability or freedom of tangata whenua to exercise kaitiakitanga. Modern day legal and other bureaucratic constraints often get in the way of the ability of kaitiaki to practice kaitiakitanga to ensure the on-going prosperity of a taonga.

Manākitanga – Caring for / showing respect

The mana (prestige / authority) of iwi, hapū, or whānau is extremely important in Māori society, and can be measured in different ways. It can, for example, be assessed by the ability to manaaki (care for/host) manuhiri (visitors), especially on important occasions such as tangihanga (funerals) or other traditional hui. Being able to cater for manuhiri, particularly with delicacies known to be rohe specialties, is expected, in some instances obligatory. For coast dwellers like those across the Marine Park's expanse it is usually generous helpings of kai moana (seafood) that manuhiri will remember. Kai moana like kōura (rock lobster), ika (fish), kina (urchin), kuku (mussels), parengo (seaweed), tītī (mutton birds) and pipi. To not cater accordingly, for whatever reason, brings great shame (whakamā) on the iwi.

Caring for the environment from which such riches are gathered is a function of kaitiaki. Without a healthy and thriving environment in which food resources are plentiful, the ability to properly host manuhiri is diminished, perhaps even nullified.

Tangata whenua are expected to be exemplary custodians of breeding grounds on the one hand, and hosts par excellence on the other. Whilst some might argue the two do not always go hand-in-hand, it is nevertheless important that there are checks and balances to ensure that they do. This is a challenge that iwi in the Marine Park rohe deal with constantly.

"Kai ana mai koe he atua, noho ana au he tangata" — You eat like a God while I sit here as a mere mortal.

Mahinga kai – Food gathering places

Mahinga kai in marine environments include traditional fishing grounds, diving spots, and shellfish gathering places. Some will be well known and frequented; others not so — they may be well-guarded secrets, or in out of the way, less visited, locations.

The health of mahinga kai is a perennial concern for iwi, often reflecting a yearning to recapture a time when the mahinga kai were an indisputably resplendent pātaka kai (food cupboard) full of the bounties of the sea god Tangaroa. Whilst there are various factors that contribute to a poorly performing mahinga kai, one that iwi are all too familiar with is their own inability to control how they are managed and monitored in the face of overwhelming overuse.

Rangatiratanga – Right to exercise authority / sovereignty

The right of an iwi / hapū / whānau to participate in meaningful decision-making about the marine and terrestrial environment in which they hold mana whenua is fundamental in Te Ao Māori. As a Māori scholar once said: rangatiratanga is *"high-order leadership, the ability to keep the people together in order to maintain and enhance the mana of the people."*

Rangatiratanga is about being in control, having the right to determine one's own destiny, often in ways that have, until now, been absent or withheld in some way.

That right is normally inherited.

ENDS

Mixed school of kahawai, trevally and blue maomao, Mokohinau Islands. Screenshot from videography by NNZST.

4. A LIVING LABORATORY

HE MOANA ORA
4. A LIVING LABORATORY

Nocturnal fieldwork. Photo by Chis Gaskin.

Seabirds are highly visible at sea. Large numbers gather annually to breed at colonies where it is possible to study their biology in detail every year. They are high-profile components of marine ecosystems, feeding at a wide range of trophic levels and across all marine habitats – from coastal inshore to open ocean. Their position at or near the top of most marine food chains makes many seabirds powerful sentinel organisms for monitoring changes within marine ecosystems. A further advantage with seabirds breeding in the wider Hauraki Gulf region is that many do so on islands that are free of invasive predators and disturbance from humans, arguably the greatest threats to seabirds' survival worldwide. With the threat on land largely absent, we can focus on what seabirds are telling us about the marine environment.

What makes the Gulf the perfect place for working with seabirds to study marine ecosystem changes?

- Diversity of seabird species across a range of seabird groups.
- Accessibility to predator free breeding colonies, hence the focus for research can be on seabirds' response to changes in the marine environment.
- Concentration of research expertise.
- Concentration of tangata whenua, public and institutional support.
- Overlaps with both commercial and recreational fisheries, and their impacts both direct and indirect.
- Overlaps with a range of pressures from sedimentation and high levels of nutrients, pollution (plastics, light attraction), and climate change.
- Offers the perfect system in which to utilise seabirds as indicators of change in the marine environment at different spatial and temporal scales.
- To make the most of this wonderful resource, future research across the wider Hauraki Gulf region needs to be planned strategically and for the long term.

4.1 The value of long-term studies

Lance Richdale was described as the father of albatross research and a legend in seabird science internationally. His studies in the 1930s and 1940s of the hoiho / yellow-eyed penguin and toroa / northern royal albatross on the Otago Peninsula were based on meticulous manual analysis of the massive amounts of data he collected. He came to the field of seabird research with a natural ability to observe and analyse [71]. His legacy, that of long-term studies of single species in Aotearoa New Zealand, has continued through the work of Jim Mills (red-billed gulls at Kaikoura); Paul Sagar and colleagues at NIWA (Buller's albatross on the Snares and Solanders Islands); and Kath Walker and Graeme Elliott (Gibson's and Antipodean albatrosses on Adams and Antipodes Islands). The Chatham Island taiko has seen several people take the lead in its research since its rediscovery in 1978. The value of these studies has been many-fold, where years of research allow detection of changes in seabird populations, their diet, foraging distributions and physiology in response to changes in the marine environment, climate change, and pollutants.

In our region, two researchers, Graeme Taylor with and Elizabeth (Biz) Bell have dedicated many years to their studies ōi / grey-faced petrel and tākoketai / black petrel respectively. Here are their stories.

Biz Bell with black petrel, Aotea / Great Barrier Island. Photo by Paul Garner-Richards.

Graeme Taylor at Te Henga / Bethells Beach. Photo by Tony Whitehead.

Graeme Taylor

No one starts out planning to do a long-term study of seabirds. The aims of the study tend to evolve over time as more unanswered questions arise as the research and monitoring progresses. For me the catalyst was the publishing of the Handbook of Australian, New Zealand and Antarctic Birds in 1990. Thumbing through the species accounts it became obvious that there was very little or no information about the basic life history of many seabird species. Key demographic data on things like age of first return, age of first breeding, timing of the breeding cycle, incubation behaviour and survival rates of juveniles and adults were either poorly known or had never been studied. The patterns of at-sea movements of most species before, during and after breeding were largely unknown for most seabirds in the 1990s. For someone curious and wishing to discover new knowledge about our native species this was a fertile area for research. By 2020 we have succeeded in gathering a lot of new knowledge about our native and endemic seabirds, but there is still so much more to discover, including that for many of our common breeding species that occur close to Auckland.

Starting out in what may grow into a long-term study, the important things are locating a good study site that is logistically suitable for regular repeat visits and where the impact of research on the birds you are studying (not damaging burrows for example) is minimal. Having access to a field hut will ensure that the study can outlast the period you are prepared to sleep on the ground in a tent in all weathers. Beginnings are about finding out what species are present in the area you plan to keep visiting, how many breeding pairs you have got in your chosen study area and marking and mapping out these nests. Establishing study access holes to reach nest chambers is important with burrowing species if you want to follow breeding birds and capture their chicks.

For long-term research you need to have a marked population of banded or PIT-tagged birds to follow over time. The early cohorts of adults and chicks you mark are the foundation birds in the study, and it is good to get a large sample of marked birds early in the study

Graeme Taylor at Te Henga / Bethells Beach. Photo by Tony Whitehead.

so that you can start to recognise the recruitment of younger birds and the visits of transients from other colonies. The birds present at the start of a long-term study will be a mixture of age classes but over time if you have banded chicks you will begin to see recruitment of known-aged birds occurring. It is quite exciting seeing your first marked chicks come back. I can still remember the first banded ōi / grey-faced petrel chicks I found back at the colony three years later, two years earlier than reported in the literature at that time. Eventually you will see that some of the established breeding birds will start to disappear from the colony and be replaced by these younger birds. Information around natal site fidelity, pair bond retention and movements between breeding burrows shows up early in the study. The first banded birds from other colonies are also a special occasion and show that your species is part of a wider metapopulation. At Te Henga / Bethells Beach, there have been birds that were banded at Taranaki, Mauimua / Lady Alice Island, east Northland, and Mauao / Mount Maunganui and Moutohora / Whale Island in the Bay of Plenty, show up at the colony.

Every year there is something new to discover, to test with new gadgets and surprising new facts about your study species will be revealed. This sustains your interest in the project. At some stage you realise that the study has become a huge investment of your time and energy, and you are unlikely to start another project like this again so you may as well continue! A ten-year study is very useful to tackle a lot of the basic questions about a seabird species, but it takes 20 or even 30+ years to really start to see what is happening with seabird populations. Worldwide there are very few projects that have endured this long and hardly any without institutional support of some kind. A recent global comparison of long-term seabird studies has shown how important they are at beginning to grapple with the serious consequences of climate change and long-term shifts in breeding success rates [72]. The seabirds breeding at Bethells Beach provide a valuable understanding of how populations that move across the globe are faring with changes in the marine environment. The study site provides information about population trends in grey-faced petrels, tītī / sooty shearwaters and toanui / flesh-footed shearwaters and has shown how hard it is for a small species like common diving petrels to cope with pest incursions.

These seabirds are very long-lived. A grey-faced petrel banded in the first month of the project in 1989 is still breeding and so are chicks hatched that year. The first flesh-footed shearwater adult captured on the colony in 1989 was still there in 2020. All the time the world is changing. Issues you had not considered at the start of the project become important such as climate change, fisheries by-catch, plastic and light pollution and the increasing frequency of predator irruptions. Taking good notes is critical. Record a wide range of notes across subject areas including the habitat the birds live in. It is amazing how much things change over time if you keep visiting the same location. You don't want to be asking yourself all the time – why did I not make records of that event or those activities ten years ago?

The major handicap for long-term studies is finding the time and the resources to do them. Some are going to be much more expensive if they involve boat travel to remote sites. The lower the costs of getting to the study sites the more likely you are to keep finding funds to support the work. If the species is one where others want the information, then funding will be available for much of the study, and this will help with the data management. If the study is operating outside of institutional support and more driven by personal interest and curiosity, then you need to have very low overheads for the project and be prepared to spend a lot of your spare time managing the data.

Very few people get a commitment from an institution to keep studying a seabird species for decades. You need to be creative around tackling issues that are currently of concern to other people or needed to support other projects such as those on threatened species. And you have to just tough out the years when it seems no one out there is interested in what you think is important. It is for these reasons that long-term demographic research is still carried out on only a handful of species and why most species that breed in New Zealand do not have anyone studying them beyond a few years. We need more people of the obsessive variety and high levels of curiosity about the natural world who are willing to take on research on species that may live longer than the researcher.

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Elizabeth Bell winning the Holdaway Award at the Hauraki Gulf Conference 2017. Photo by Shaun Lee.

Elizabeth (Biz) Bell

When I began monitoring tākoketai / black petrels in 1996, little did I realise that 26 years later I would still be captivated by these birds and their habits. Now, if anyone asks, I always say that I hope to be still coming up Hirakimata / Mount Hobson to monitor the tākoketai into my 90s even if I need a zimmer-frame to make it up the mountain. Early questions of this research focused on the life history and behaviour of tākoketai at the Hirakimata colony on Aotea / Great Barrier Island and how land-based and at-sea threats might impact the population. However, we found that we learn something new almost every year and often these discoveries pointed us in different directions for new research and understanding of this species breeding ecology, population parameters and behaviour.

Understanding key life-history factors such as adult and juvenile survival, recruitment, and age of first breeding are key to determining population structures and trends of seabirds. Many of these demographic factors take years to determine and understand especially as they can be affected by external factors such as pollution, predators, climate change and habitat alteration. A key piece of information required to inform conservation management of threatened seabirds is an accurate estimate of population size and understanding the population trend, and for many seabird species across the Hauraki Gulf, and New Zealand, these are poorly understood or entirely unknown. Both an accurate population estimate, and key demographic parameters are needed to inform risk assessment models – all data that should be collected over the lifespan of the species, but also through inter-generational studies as chicks return to natal colonies and recruit into the breeding population.

We are just beginning to collect this level of information on tākoketai on Aotea at the Hirakimata colony where we have nearly 500 study burrows across a 35ha study area. Long-term research projects like this require a marked population to understand age structures of the population and recruitment into the colony; there are over 5000 banded adults and 4000 known-age birds banded as chicks. Recognising birds returning to the colony as first-time breeders after years at sea and learning that tākoketai can return to Aotea as young as 2 years old rather than 6 years old has been incredible as is the return of a 32-year-old female that continues to breed successfully with her partner of the past 16 years.

Using newly developed technology to understand tākoketai at-sea distribution and behaviour has been rewarding – determining migration routes to South American waters for both adults and juveniles on their first flights from the colony. Using dive depth devices to learn that tākoketai can dive to 34 m, but that 95% of adults forage shallower than 10 m has allowed for clear mitigation strategies to be developed in collaboration with the commercial fishing industry. We are lucky enough to have easy access to the study colony and can be based at a research hut onsite, with fantastic support from the local DOC office and Ngāti Rehua.

Research of this length requires a commitment not only of personnel, but also funding. Often this type of seabird research is done on a shoestring budget to ensure it continues without any breaks in the overall data collection period when conservation agencies or funding bodies do not support the project each year. Ongoing support for and commitment to long-term studies of seabirds is vital for our understanding of species within the Hauraki Gulf and elsewhere in New Zealand and how they fare against the myriad threats including climate change, predation, regional and international recreational and commercial fishing, and pollution within the New Zealand Exclusive Economic Zone and across the global marine environment. Like I said earlier, I plan to be monitoring the tākoketai if I can still climb up those steps on Aotea; an iconic New Zealand seabird living on an amazing island that we have plenty to still learn about and need to protect.

ENDS

4.2 Using integrative biology to map seabird stress levels

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Stress causes changes in behaviour and metabolism of seabirds, which may impact breeding success.

The level of these changes differs among species thus longitudinal studies are key.

Measuring multiple parameters of behaviour (foraging effort, flight speed, diving rate) and metabolism (hormones, biochemical pathways, cellular changes) identifies the extent, duration, and impact of the stress a species is experiencing.

What is integrative biology?

Change in the earth's biosphere is continuing with frightening speed. In this respect, seabirds will be uniquely impacted as they are vulnerable to ecosystem changes both on land and at sea that can affect population viability. Understanding how shifts in oceanic conditions affect the stress of seabirds and what impacts this has on their breeding success is paramount if the ecosystem functions that seabirds provide are to be maintained.

A key aim of our work has been to integrate responses of birds across all levels of biological organisation, i.e., from the atom up to the individual, so we can then map how change in broadscale ecological and environmental processes impact upon the stress of adults and chicks – a fantastic challenge. Luckily for us, there has been intense research effort conducted on commercial poultry species which we can now utilise within field situations. Avian stress and health biomarkers (blood profiles, stress hormones, etc.) that signal the effects of key stressors are well described and the necessary analytical tools are readily available. Furthermore, only minute quantities of sample are required i.e., feathers or blood (Fig. 10) to assess stress and health from the study animal and make more informed management decisions.

However, unpicking the causative agents on seabird stress levels is daunting due to their lifestyle – foraging at sea, but breeding on land. The key here is an integrated approach utilising multiple lines of inquiry, incorporating stress physiology matched with energetics, movement ecology, foraging behaviour and dietary analyses, as this allows a fuller interpretation of stress responses and how much biological *"headroom"* a colony has before chick health starts to suffer. Here we outline case studies to illustrate the benefit of an integrative approach to understanding seabird stress within the Hauraki Gulf and provide recommendations for future research effort.

Seabirds can be sensitive indicators of change over small spatial scales, as illustrated by the following studies. This interpretation needs to be referenced against a broader assessment of colony health across the distribution of the species through space and time to truly understand the drivers of change in seabird populations. Long-term studies incorporating physiological methods will give us tools to understand the adaptability of seabirds to change and identify where conservation action needs to be targeted to ensure their survival.

Case studies

Question 1: *Does seabird stress physiology change among breeding seasons?*

Despite the wealth of work performed on poultry, comparatively little research has been performed on the stress physiology of seabird species in the field. Thus, our first question was are there any differences in basic blood stress parameters across multiple years in breeding seabirds?

Shown in Fig. 8 is a simple plot of bird weight and red blood cell volume for kuaka / common diving petrels. Higher volume red blood cells indicate greater turnover of red blood cells (a biomarker of stress) and production of larger immature cells in birds [73]. Over this period, we see a significant downward trend in bird weight during the years of 2015-2016 when intense El Niño Southern Oscillation (ENSO) conditions were recorded, before rebounding in 2017 when ENSO switches. Corresponding with this

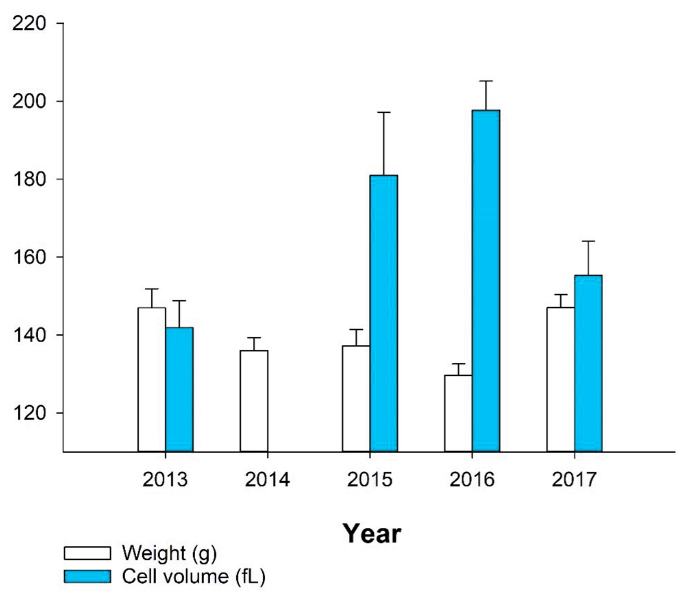

Figure 8. *Weight and red blood cell volumes of kuaka / common diving petrels sampled at Mokohinau Islands, Hauraki Gulf during September 2013-2017. Weights and cell volumes in 2015 and 2016 were significantly different i.e. REML(4, 80) = p< 0.0007 for Weight; and REML(3, 80) p< 0.00001 for Cell volume, potentially due to shifts in prey composition.*

is an increase in the volume (size) of red blood cells (and internal haemoglobin contents) of these birds, showing that during 2015/16 breeding seasons birds were lighter and stress biomarkers were consequently higher. Such an increase in blood cell volume and mean cell haemoglobin when weights are low is also evident in other Hauraki Gulf seabirds e.g., tītī / sooty shearwater, ōi / grey-faced petrel.

Thus, from very simple measurements we can get an insight into stresses birds are experiencing among seasons and in response to broad scale oceanographic cycles. What is needed now is to identify what specifically caused the stress, as local Sea Surface Temperature (SST)/Chlorophyll-a (Chl-a) data showed no real change over this time, hence it may relate to natural fluctuations in their zooplankton (krill, copepods) prey that are potentially responding to water flow dynamics.

Question 2: *Are there spatial differences in ecophysiological profiles among differing colonies of seabirds?*

Within the Hauraki Gulf exist gradients of productivity and prey types. For example, the abundance of copepods and krill (the preferred prey of kuaka / common diving petrels) is much higher in the outer Gulf waters i.e. Hauturu / Little Barrier Island

Foraging effort in Kuaka / Common diving petrel is relative to prey abundance

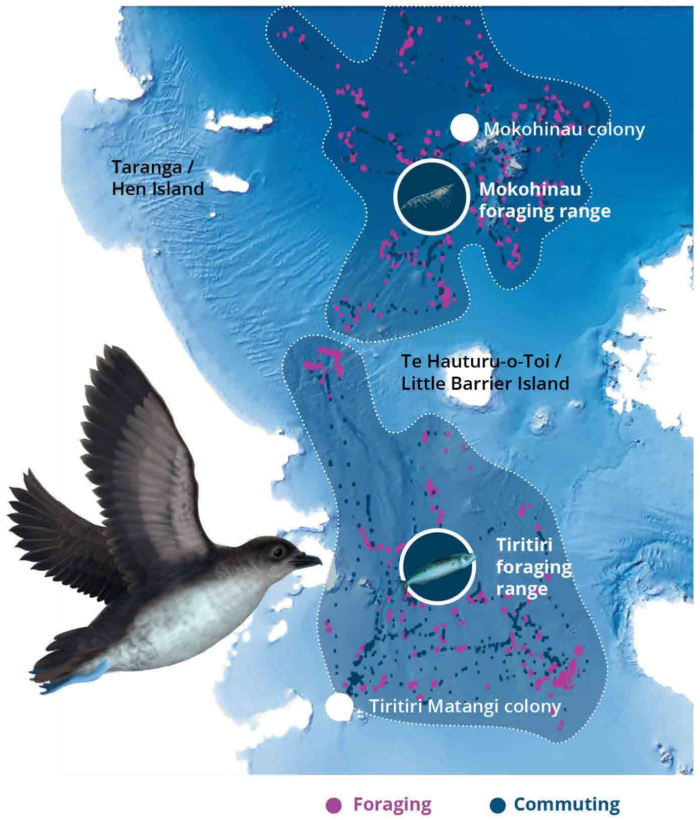

Figure 9. *Foraging distributions and hypothesised prey of kuaka / common diving petrels resident at two colonies (Mokohinau and Tiritiri Matangi) within the Hauraki Gulf.*

northwards; whereas the inner gulf waters around Tiritiri Matangi tend to be dominated by crab and bivalve larvae [23] which common diving petrels do not feed on (Fig. 9). So, does this have any effect on colonies separated by tens of kilometres?

To check this, we fitted diving petrels from both Mokohinau (outer gulf colony) and Tiritiri Matangi (inner gulf colony) with Global Positioning System (GPS) tags and allowed them to forage freely. Upon recovery of tags, we then analysed the GPS fixes to identify areas where the birds are foraging, and how far/fast they are travelling from their colony to find food. Finally, blood samples were taken to compare stress hormones (corticosterone) and trophic level of prey targeted e.g. zooplankton, fish, and squid among colonies [74]. We wanted to know whether inner gulf colonies are more stressed if they are potentially travelling further to find food?

What we found from this integrative approach is that despite differences in prey, stress hormone levels of birds were not different. However, despite colonies being separated by only 70 km, Tiritiri Matangi birds were flying 1.5x further and faster chasing a more nutrient dense prey (fish/squid) within the inner Hauraki Gulf [75]. We hypothesise that this diet shift has kept stress levels lower. Had we only looked at stress profiles we would never have picked this up. Thus, we now know that this colony is highly vulnerable to any decreases in fish numbers. If we stand on Hauturu and observe the broad expanse of the Hauraki Gulf it looks somewhat similar to human eyes. However, as an environment for seabirds to live in it is quite variable and the birds in colonies separated by short distances are behaving quite differently. But what of the chicks themselves?

Question 3: *Do seabird chick stress profiles differ within the Hauraki Gulf Auckland region?*

In our final study, the stress physiology of ōi / grey-faced petrel chicks and adults were compared between east, Te Hāwere a Maki / Goat Island, and west coast, Te Henga / Bethells Beach, colonies (Fig. 11). These nearshore island colonies are relatively small compared to the larger ōi colonies off the east coast, however it is known that chicks from Te Hawere take longer to grow (at least two weeks, up to a month) and fledge from the colony than those at Te Henga [76, 77]. East coast chicks are also typically much lighter than the west coast chicks, is that because they are more stressed? To investigate this, we analysed endocrine stress hormones laid down in chick feathers between these colonies. Feather hormones in chicks record developmental stress, as the hormone is deposited in the feather while it has a blood supply during its growth. East coast chicks both weighed less and exhibited higher feather stress profiles, indicating that growing up on the east coast is tougher for these vulnerable life stages. Stress during development can have life-long impacts and may reduce the likelihood of these birds returning to breed as adults. Parent birds did not differ in any stress profiles implying that any costs of breeding on the east coast are passed on to the chick i.e., parent feeds itself first and preserves its own body condition. This is a common strategy in long-lived birds like petrels and shearwaters, as they have more potential attempts to breed over their lifespan and can afford to abandon a breeding attempt in a poor year. Recurring poor years, however, will mean that these populations fail to generate new recruits – a decline that will be masked by the longevity of these species.

How widespread this trend now needs to be uncovered, does this occur every year and at every site across the wider Hauraki Gulf region and beyond[2]? As the climate changes, will these differences in chick health deepen further?

[2] *Almost all the global population of ōi / grey-faced petrels occur along the eastern coast of the northern North Island and its offshore islands – from Manawatāwhi / Three Kings Islands to East Cape (Whangaokeno / East Island).*

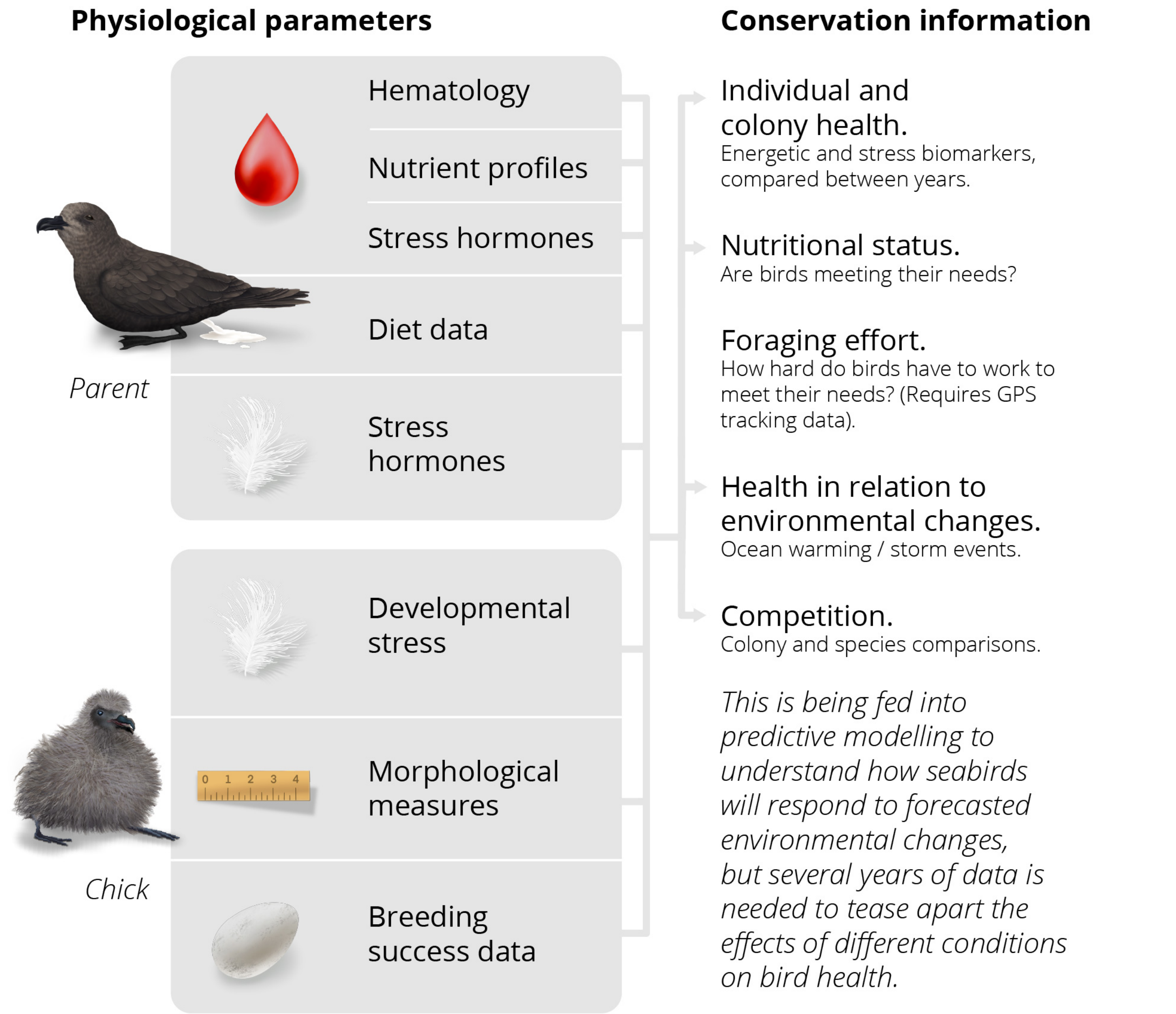

Figure 10. *Sample types and information we can currently obtain from a single sample of blood (0.4 mL) or feathers with relevant conservation implications for Hauraki Gulf seabirds (an abridged list).*

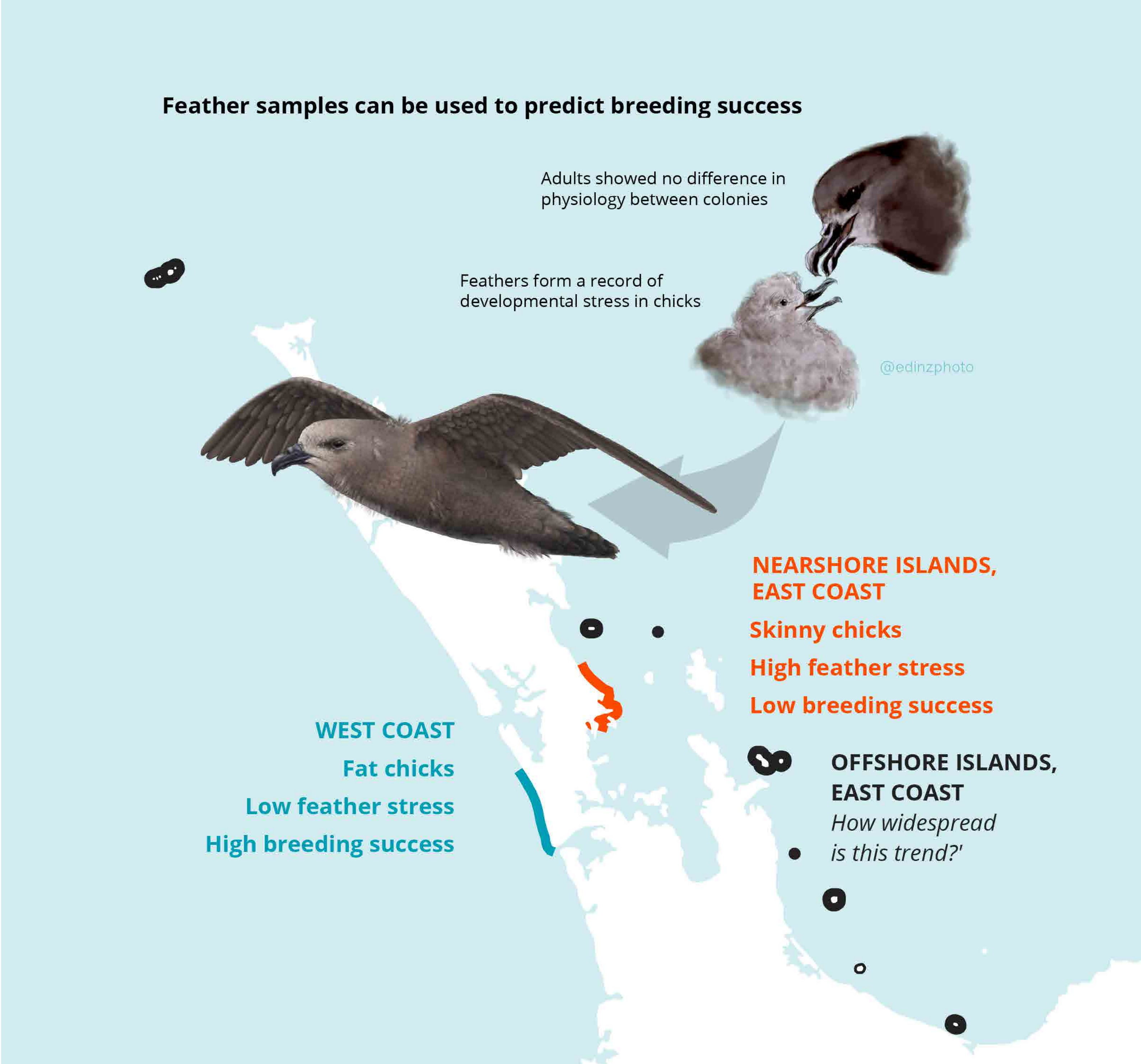

Figure 11. *Breeding success and chick feather stress markers of ōi / grey-faced petrels from east and west coast populations within the Auckland region.*

Conservation benefit of an integrative approach

So, what does this all mean?

By monitoring stress profiles of seabirds across space and time we can identify species or sub-populations more at risk should ocean conditions continue to worsen. This can help guide management actions and detail any in-direct causes on chick mortality e.g., heat waves, prey shifts etc.

However, what is needed is a region-wide monitoring programme of chick performance at various colonies to match our stress estimates to. This will allow us to unpick what suite of environmental conditions result in declines in chick performance. Maintaining chick growth and survival is the only way for these precious taonga to maintain their tenuous foothold within the seabird capital of the world.

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Survey team, Motukino / Fanal Island, Mokohinau Islands. Photo by Hamish Allen.

4.3 Regional monitoring and research for seabirds in the Auckland Region

Gaia Dell'Ariccia[1], Todd J. Landers[1]

[1]*Research and Evaluation Unit (RIMU), Auckland Council*

Auckland Council is implementing a regional programme to monitor and research seabirds to inform restoration.

Monitoring has been established for most species and sites for which we identified a major knowledge gap.

Research projects on key threats to seabirds (e.g., contaminants) are being developed to inform priority management actions.

Auckland Council's Indigenous Biodiversity Strategy [78] has among its objectives to achieve long-term recovery of the greatest number of threatened species whose range includes the Auckland Region, and hence is committed to improving the status of our most threatened birds, the seabirds. This need was also recognised in Sea Change – Tai Timu Tai Pari Hauraki Gulf Marine Spatial Plan [79], which identified the need to halt further decline in biodiversity and to restore species diversity so that there are healthy and functioning populations within the Hauraki Gulf Marine Park. In response to the need to improve seabirds, Auckland Council has been developing a regional seabird programme. This is in addition to other Council programme's designed to improve and protect biodiversity in the region, such as the Treasure Islands programme which continues to invest in supporting and maintaining the pest free status of islands in the Hauraki Gulf.

The Natural Environment Targeted Rate (NETR) was approved in June 2018 and included a budget for the development and implementation of a long-term seabird monitoring and research programme to help improve seabirds in Auckland. Specific goals of the programme include increasing the knowledge on the presence, health, and trends of seabird populations in the Auckland region, exploring the factors affecting population distributions and trends to advise management for protection, and identifying the most effective actions to restore ecosystems and seabird biodiversity. The programme started with a gap analysis; a comprehensive literature review of all published/unpublished material and discussions with experts was conducted to understand the current state of knowledge for all Auckland-breeding seabirds. The gap analysis outputs were then used to perform a standardised prioritisation process to determine which species most needed attention. Monitoring priorities were then given to species and sites for which we identified an information gap and/or restoration research need [80]. As we collect new information and insights, we will establish a feedback loop system to re-evaluate the knowledge status, so to develop more sound and specific monitoring and research projects.

Monitoring started in late 2018, using a variety of techniques and strategies. For some species, population studies were established using the capture-mark-recapture method [81]. Recurrent standardised capture sessions in which all captured birds are marked (i.e., banded) allows an estimate of population size calculated from the proportion of recaptured versus new birds in every session. This method is particularly useful when ground surveys are not advisable, like for white-faced storm petrels on fragile Ruapuke / Maria Island, The Noises, a species for which information on population size and trends are missing. We captured over a hundred birds just in the first night of work in October 2020. Repeating several more capture sessions will allow us to gain enough data to estimate population size and survival rates. We are using the same technique also on Pokohinu / Burgess Island, Mokohinau Islands where there is another colony of white-faced storm petrel, allowing for comparisons between the two colonies.

Deploying acoustic recorder. Photo by Maira Fessardi.

We started to use the mark-recapture method also on black petrels captured at sea, a collaboration project with Wildlife Management International Ltd [82], which we plan to continue. These captures will allow an alternative population estimate to ground surveys and inclusion of the whole population from the two existing colonies on Aotea / Great Barrier Island and Te Hauturu-o-Toi / Little Barrier Island (see Section 5.6). Black petrels are endemic to the Hauraki Gulf. On Aotea, the population have been regularly monitored for the past 26 years [83](see also Section 5.6). On Hauturu, monitoring started in late 1970s/early 80s to assess the impact of rats and cats before eradication [84] but has subsequently become only occasional, opening a big knowledge gap for this species [85] requiring urgent attention.

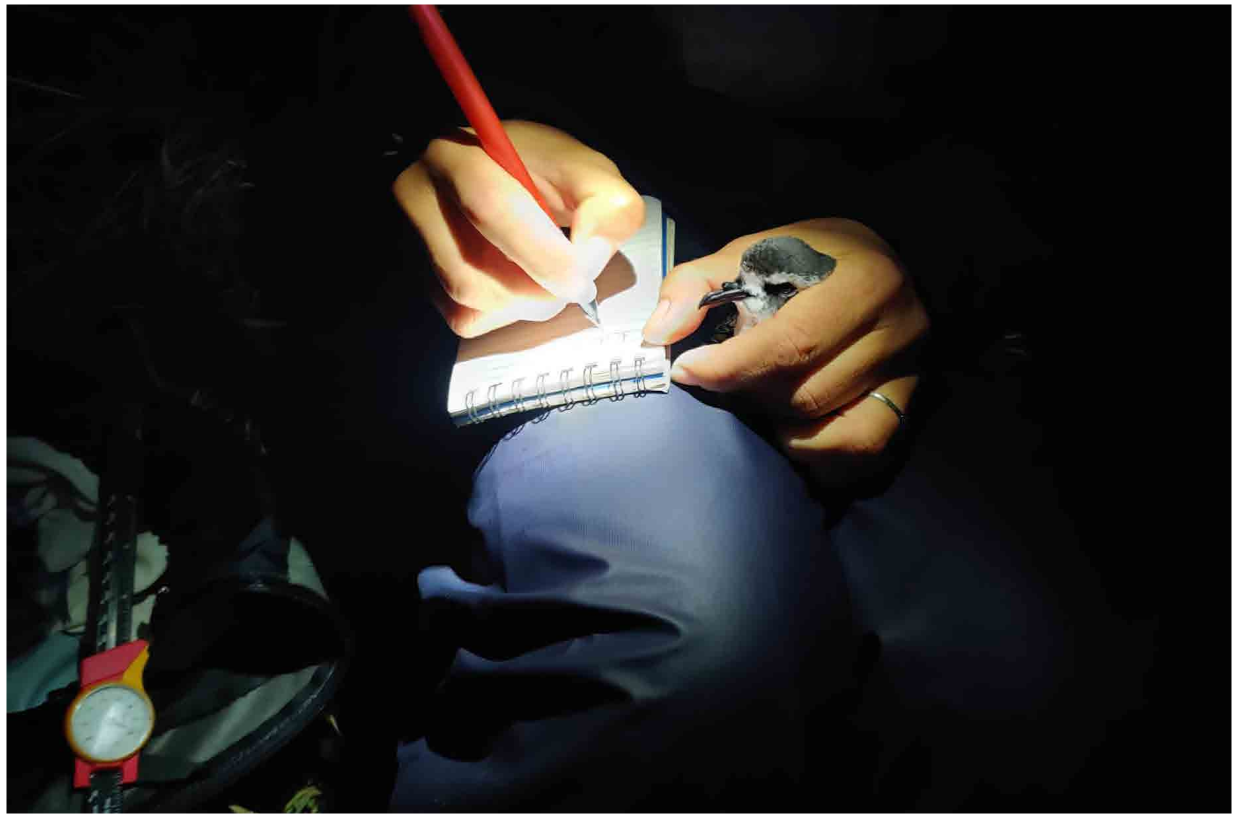
The 2020/21 breeding season was our first-year monitoring tākoketai / black petrels on Hauturu. We found that nest occupancy was only 21%, with a relative breeding success just above 70%. These numbers are much lower than any previous monitoring, with the most recent one in 2015-16 recording a burrow occupancy of 56% with 85.2% of chicks successfully fledging [85]. We don't know why occupancy and breeding success were so low. It could have been just a 'bad year' or related to other factors. These numbers and resulting questions underline the importance of regular monitoring.

Tītī / Cook's petrel, another of our prioritised species, also has its main colony on Hauturu. They breed in very high numbers – last estimate was ~286,000 pairs in 2007 [86], and the population is thought to be increasing. However, there have been no population surveys since then, despite the removal of several hundred chicks between 2012 and 2016 for establishing new colonies at Cape Sanctuary and Boundary Stream (C. Mitchell pers. comm.). In the 2020/21 breeding season, we found that over 73% of nests were occupied and 68% of those successfully fledged a chick. Again, such numbers will require several more years of monitoring to gain any insight from them.

In November 2020, one pair of Cook's petrel was recorded breeding on pest-free Ōtata Island (The Noises) for the first time ever, with the chick successfully fledging. At this stage we cannot know if this is an indication of an expanding population, or if it was just a vagrant pair that decided to breed there just once. What this interesting finding underlines, though, is the importance of predator-free islands as this gives the possibility for seabirds to safely nest and potentially expand their breeding range. This is important as we know that Cook's petrel attempt to breed every year also on Aotea, but unfortunately it is very rare that chicks manage to fledge as they are almost always predated by rats in the early stages of their life (E. Bell pers. comm.). Predation by invasive species is one of the main threats to seabirds [87], making the predator-free status a determining factor for allowing our seabirds to survive and grow.

Some of the Gulf islands are very difficult to access which means extremely little is known about what seabirds are breeding there (as well as other biodiversity). This is very much the case with Motukino / Fanal Island, Mokohinau Islands. This island has a ~100m cliff all around it, making landing extremely difficult, and has very few tracks to move around through the thick vegetation. This restricted accessibility has so far limited regular and comprehensive studies and thus we have little knowledge of what species are present and virtually no information on their population health [88, 89]. To help fill this knowledge gap, we have been conducting seabird surveys on Motukino including deploying automatic acoustic recorders in January 2020. After long COVID-19 related island access delays, these data are being analysed and will provide useful insight on what seabirds are visiting the island, and thus which are potentially breeding there. We will use this information to identify areas to conduct ground surveys to locate major breeding colonies, with the aim to eventually have estimates of breeding population sizes and health for all resident species. A preliminary ground survey using distance sampling [90] suggested that the number of burrows on the island (excluding the cliffs) may range between 3600 and 6000 burrows, with the next step to identify how many of these burrows are currently being used and by which species.

Another species requiring attention is the kārohiruhi / pied shag. This species breeds on trees overhanging the water on the coastline and in lakes. It is considered at risk [91] with known threats being human disturbance



Measuring and banding takahikare-moana / white-faced storm petrel on The Noises Islands. Photo by Maira Fessardi.

at their colonies and occasionally falling victim to by-catch in fishing lines and set nets [92]. Despite numerous colonies being present regionally, only a few of them are monitored. To fill this gap and gather information on the population status and trends of this species, we established region-wide monitoring. Every year we monitor a sector of the region so that the whole region will be monitored in 3 yearly cycles, collecting data on population size, trends and breeding. As pied shags often breed in mixed-species colonies, this approach will allow us to monitor at the same time three other species of shags that are in the region, kawau paka / little, kawau / black and kawau tūī / little black shags. We also are monitoring and researching (GPS tracking) one of our most endangered shags in Auckland, the Hauraki parekareka / spotted shag, in collaboration with Auckland Museum, with hope that we can identify and reduce the threats to the disappearing Auckland population (see Section 5.2).

Several mainland sites are also the focus of regular seabird surveys, monitoring and research, as we attempt to restore seabirds to areas where they would have once flourished. Auckland's mainland includes a variety of additional challenges that come from sharing space in highly populated human areas, such as from habitat loss, disturbance and predation by introduced mammals [1], all issues which we are working on through a variety of collaborative research projects and initiatives. Most of our mainland work occurs in the Waitākere Ranges / Te Wao nui o Tiriwa, where we have been conducting regular seabird-detection dog surveys of little penguin and grey-faced petrel [93]. Several inner Hauraki Gulf mainland areas have also been surveyed, such as Leigh and Ti Point (working with the local community group), where little penguins were found to be breeding.

Thus far we have established monitoring for most of the species and sites for which we identified knowledge gaps, with plans to keep expanding this work on further species and sites to achieve a comprehensive, regionwide understanding of the regional conservation status of Auckland-breeding seabirds. However, merely recording the population trend of a species does little to suggest management options. Population size is a retrospective tool, telling only after the fact if a population has increased or decreased. To implement effective restoration measures, we also need to identify possible causes of change and solutions to remove the threats/issues. Valuable cues to understand changes can be found by integrating population estimates with other data on sex ratio, age distributions, survival rates, weights, contamination rates, and population movements. For this reason, we aim to develop a holistic view that integrates monitoring with research, tackling different issues at the same time. On one side there is population monitoring and dynamics, while on the other we plan to develop research on threats (e.g., contaminants and pollutants) to understand how they impact different species. This holistic approach will provide deep insights and sound advice to inform management actions for seabird conservation and restoration.

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4.4 The importance of Waikato and Northland Regions' seabird islands

Chris Gaskin [1], Megan Friesen [2], Kerry Lukies[1], Jingjing Zhang [3], Claudia Mischler [4]

[1] Northern New Zealand Seabird Trust, [2] St. Martin's University, [3] Auckland University of Technology, [4] Department of Conservation.

The roll call of seabird islands that fall within the Northland and Waikato Regions is impressive. The former islands lie outside the Hauraki Gulf Marine Park, the latter within and either side of the Coromandel Peninsula. From a seabirds' perspective these islands (i.e., Poor Knights Islands, Bream Islands, Marotere / Chickens Islands, Taranga / Hen Island, Motukawao Group, Repanga / Cuvier Island, the Mercury Group, and Ruamāhua / Aldermen Islands) and the waters that surround them, are as vital as those that lie between, i.e., those that form the part of the Gulf that stretches north of Tamaki Makārau / Auckland Isthmus (Fig. 12).

Seabird research conducted in both the Northland and Waikato regions has been patchy with some notable work in last three decades of the twentieth century [94-101]. However, some significant seabird islands and island groups have received, at best, only rapid surveys [102], and some nothing at all [43].

Since 2011, there has been something of an upsurge in research activity into:

- Seabird recolonisation following eradication of predators and pets from several important island and island groups, e.g., Marotere / Chickens, Repanga / Cuvier, and several of the Mercury Islands [103-107].
- Fisheries impacts of flesh-footed shearwater populations through MPI/ DOC contracts [108, 109] (see Section 5.6).
- A new population estimate of Buller's shearwaters [110].
- Ongoing tracking and physiological studies of little penguin [111], Buller's and little shearwaters, and fairy prion.
- Restoration efforts and monitoring of seabird recolonisation on Ahuahu / Great Mercury Island [112].
- Seabird surveys of four Mercury Islands targeting elusive flesh-footed shearwater populations and assessing Pycroft's petrel numbers [113-115].

Yet, there is much to be done. In a priority list of future island surveys prepared for DOC Conservation Services Programme in 2017 [28], 14 of Northland and Waikato Regions' islands and island groups within the wider Hauraki Gulf were included, most with high and medium-high rankings. The most notable, and greatest challenge, is a much needed comprehensive ecological survey of Taranga / Hen Island, 10 years after the eradication of rats from the island [116].

Tackling knowledge gaps

Knowledge of the distribution of seabird breeding colonies, their size and population trends are essential for sound conservation management of seabirds. There is a paucity of accurate, up-to-date population and trend data for seabirds in these regions, including those breeding at several globally important sites. While species presence and diversity are generally known for many islands, the coverage has been extremely patchy [28, 43].

For example, fluttering shearwaters breed on many islands across the region and are often seen at sea in very large congregations. Although they have been recorded off the eastern coast of Australia post-breeding, the bulk of the northern population remains in northern North Island waters throughout the year [117]. However, one of the mysteries, given the numbers seen at sea and relatively few at known breeding sites, has been the location of large colonies of this species. Surveys conducted in 2018-2020 confirmed that Taranga, Marotere / Chickens Islands and some of the Mercury Islands are strongholds for this species, however an accurate population estimate of this species remains to be done [118].

Raft of fluttering shearwaters (with red-billed gulls), outer Hauraki Gulf. Photo by Edin Whitehead.

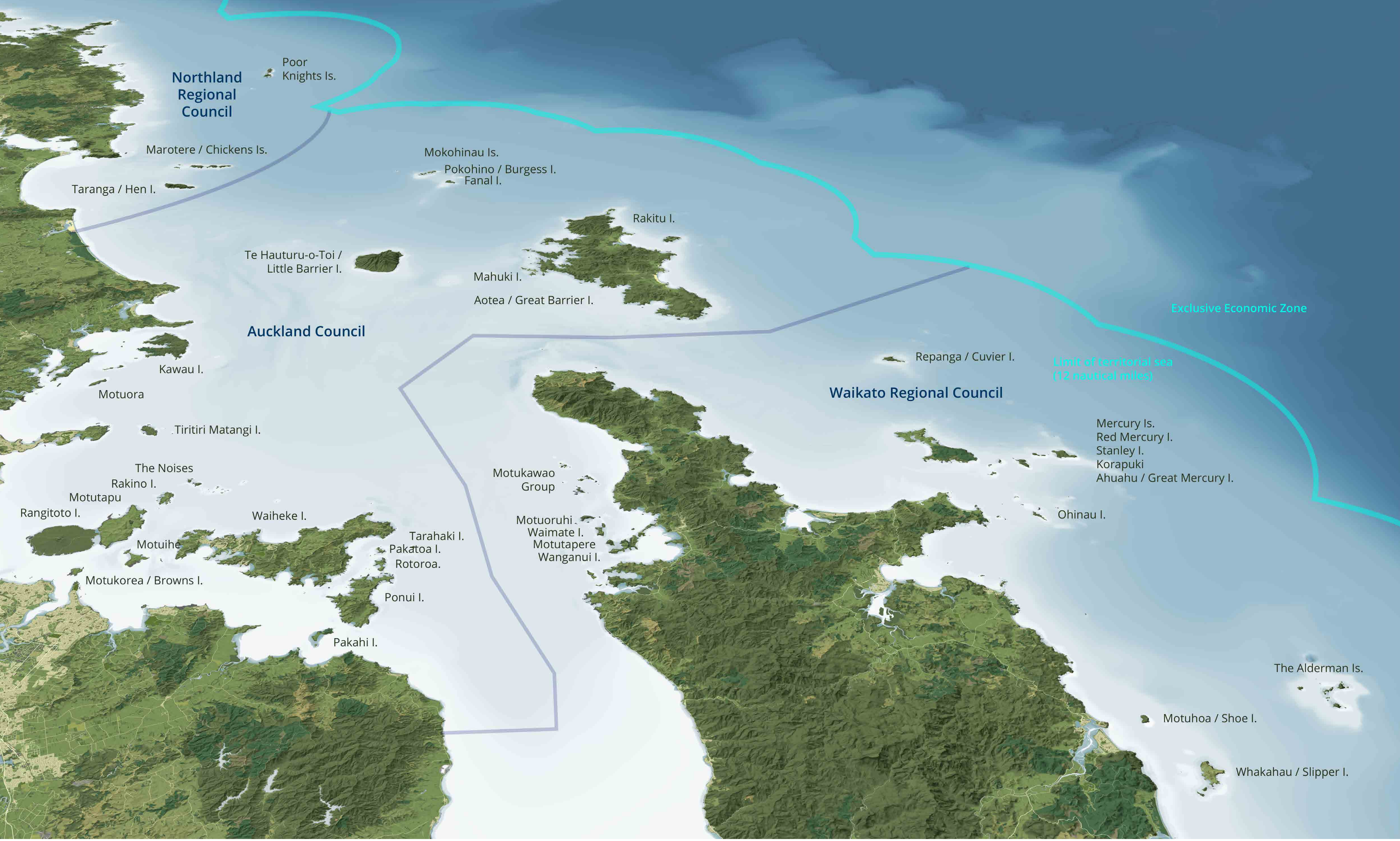


Figure 12. *The wider Hauraki Gulf region. Base data by Geographix*

Burrow checks in a survey plot, Tawhiti Rahi, Poor Knights Islands. Photo by Chris Gaskin.

New population estimate for an abundant marine indicator species, Rako / Buller's shearwater

Rako / Buller's shearwater is endemic to the wider Hauraki Gulf region with the Poor Knights Islands their only known breeding site.

Infrequent population estimates over the last four decades have fluctuated between 100,000 and 200,000 breeding pairs.

The most recent population survey, undertaken between 2016/2017 and 2017/2018, has calculated the estimated breeding population of Buller's shearwater to be around 78,645 (67,176-89,178).

Rako / Buller's shearwater is endemic to the region with the Poor Knights Islands their only known breeding site. It is a species that forages in the greater Pacific Ocean during their non-breeding season. Buller's shearwaters are also an important sentinel of ocean health as they have been relatively protected from terrestrial threats. They are commonly seen in the Hauraki Gulf during the breeding season (September to May) and population speculations in the 1980's estimated the species population to be around 2.5 million, including 200,000 breeding pairs [95, 119]. Despite this, no quantitative population assessment was completed until recently. In 2011, rapid surveys on Aorangi Island suggested that there were perhaps just c. 100,000 pairs, and so indicated that the 1981 population estimate was far too high [120].

The first quantified population estimate for Buller's shearwater was based on burrow counts and state of occupancy during surveys conducted at the Poor Knights in the 2016-2017 and 2017-2018 seasons. Information on habitat availability and preference were incorporated in the population models. The estimate of 78,645 (67,176 – 89,178) active burrows, broadly representing breeding pairs, is lower than some previously published assessments. This is a repeatable quantitative study of the Buller's shearwater breeding population, including breeding activity, and provides critical baseline data to determine population trends for this species. A baseline for breeding success was also established [110].

This survey on Tawhiti Rahi and Aorangi, and subsequent surveys conducted on Tawhiti Rahi, showed that while the population estimate established was lower than expected, the species is not currently at carrying capacity on the islands due to the large number of survey plots on the islands where there were inactive burrows or no burrows at all. Observations since, also suggest a sizeable non-breeding population, potentially a mix of non-breeders (possibly some breeders skipping a year) and pre-breeders [118].

Surveying burrows on Tawhiti Rahi, Poor Knights Islands. Photo by Glenn McKinlay.

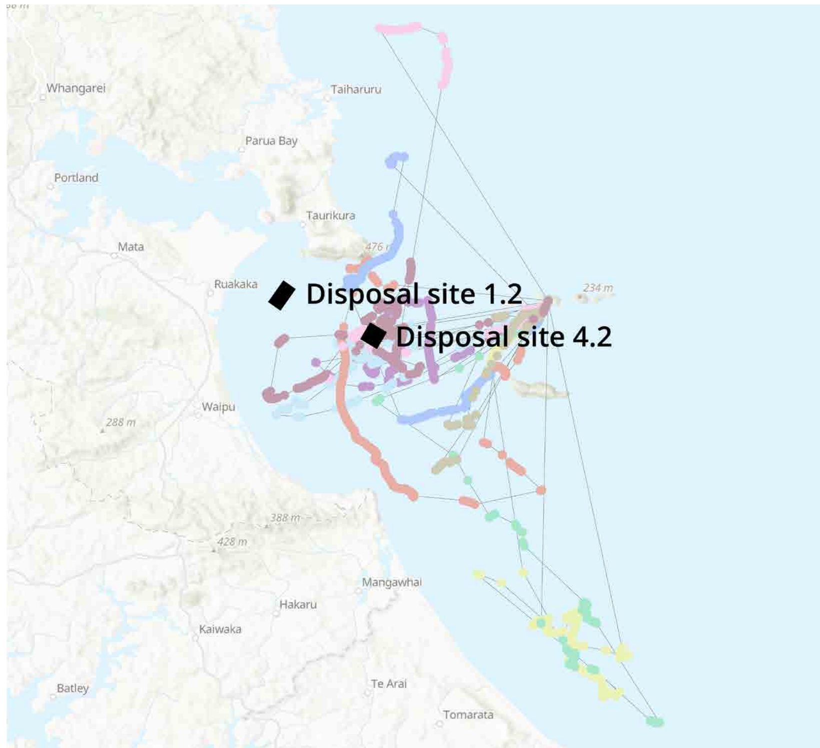


Figure 13. *Proposed sediment disposal sites and the foraging trajectories of kororā / little penguins from Mauimua / Lady Alice Island in 2020.*

If the dredging of Whangārei Harbour goes ahead as proposed by Refining NZ [127], the suggested sites for sediment disposal overlap with the foraging areas of little penguins from Mauimua. As visual foragers, sediment can impact the visual acuity of little penguins and make it difficult for them to detect prey [128]. To minimise the impact of the harbour dredging on little penguin foraging, sediment disposal could be moved further offshore (i.e., beyond 50m depth) and/or could be undertaken outside of the little penguin breeding season (July-December) when little penguin foraging is less spatially restricted.

It is important to note that little penguins also nest on other islands in the area, Taranga / Hen Island, all the Marotere / Chickens Islands, Bream Islands, as well as at Bream Head on the mainland [129].

Kororā / Little penguin GPS tracking – Mauimua (Lady Alice Island)

Kororā from Mauimua / Lady Alice Island travelled in a westerly direction toward the mainland and primarily foraged in Bream Bay where the water is <50 m deep.

Kororā from Lady Alice Island travelled further to forage than kororā from Pokohinu / Burgess Island (Mokohinau Group), which travelled < 15 km in an easterly direction from the island. The distance travelled by birds from each colony may reflect differences in the availability of prey.

Kororā / little penguins were tracked from Mauimua / Lady Alice Island in the Marotere / Chickens Islands during the 2018 (eight penguins tracked) and 2020 (ten penguins tracked) breeding seasons. Penguins were captured on the beach at night and had a small (~25g) GPS device attached to the lower back. The birds were recaptured on subsequent nights to remove the devices and obtain the tracking data. Penguins were foraging to the west of Mauimua toward the mainland, concentrating around the Whangārei Harbour entrance and Bream Bay in both years. This direction appeared to correlate to a seafloor depth of less than 50m, which has been determined as the maximum foraging depth of little penguins given their small body size and associated anaerobic capacity [121].

This is the first time little penguins have been tracked from Mauimua and the second time kororā have been tracked in the wider Hauraki Gulf region, the first being that of Zhang [122]. This study enhances our knowledge of the foraging ecology of the New Zealand sub-species of little penguin and contributes to filling the knowledge gap of little penguin foraging ecology in the wider Hauraki Gulf region [123]. The penguins from on Pokohinu / Burgess Island foraged at locations close to the Mokohinau Islands approximately less than 15 kms from their colony. All foraging trips took place on the eastern side of the colony, probably due to the location of the beach penguins used for departure. As a contrast, the penguins from Mauimua chose to forage at the western side of their colony, with obvious commuting phases at the beginning and end of their foraging trips. Most penguins travelled from their colony to the potential foraging grounds near-shore areas, especially Bream Bay. Such commuting seems to have contributed to longer traveling distances of these birds, compared to those living on Burgess Island.

Like other seabirds, little penguins are central-place foragers during the breeding season [124] with foraging while guarding young chicks and individuals usually restricted to one-day trips within 25-30km of their nest [125, 126]. This suggests that little penguins from Mauimua may rely heavily on the Whangārei Harbour entrance and Bream Bay to find prey during the breeding season.

Moturehu / Double Island and Whakau / Red Mercury from Kawhitu / Stanley Island. Photo by Jake Osborne.

Mercury Islands surveys 2021

Invasive mammals were eradicated from the Mercury Islands 20 years ago.

Surveys undertaken in 2021 set out to investigate how some seabird species have recovered following the eradication of pests.

Populations of flesh-footed, little, fluttering, and sooty shearwaters were identified, as well as Pycroft's, grey-faced and black-winged petrels, and little penguins.

Almost 20 years on from the eradication of mammalian pests on the Mercury Islands, a survey was conducted in January 2021 on four islands – Korapuki, Moturehu / Double, Kawhitu / Stanley, and Whakau / Red Mercury Islands – to investigate the recovery of species previously impacted by these pests. The primary objectives of the surveys were to:

- Establish whether flesh-footed shearwaters breed on the islands surveyed.
- Estimate seabird burrow density to enable an analysis of population trends for tītī / Pycroft's petrel.
- Identify what other species of seabird breed on the islands.

Flesh-footed shearwater surveys included dusk and dawn listening from vantage points spread out across each island over several nights. Day-time searches for suitable habitat and large burrows were also done. Historically, flesh-footed shearwaters were reported for the four islands in the survey. Approximately 50-100 pairs were found on the northwest corner of Kawhitu in January [114], but none was found on any of the other three islands [113, 115]. It is likely that pairs have overflowed from Atiu / Middle Island onto Kawhitu because Atiu holds the largest flesh-footed shearwater colony in New Zealand with approximately 5,800 pairs estimated in 2017 [130], and the two islands are only about 2 km apart.

Strip transects and/or plots were conducted on all islands to determine burrow density of Pycroft's petrels. They were found to have increased on all islands surveyed, with largest population on Whakau. Despite limitations to the survey timing and methods, the results provide a useful summary of mean burrow densities on four islands [113]. Other seabird species found breeding on the islands were little penguin, grey-faced petrel, and little, fluttering, and sooty shearwaters. Black-winged petrels were heard calling on Moturehu [115].

Toanui / flesh-footed shearwater. Photo by Jake Osborne.

Tītī / Pycroft's petrel. Photo by Edin Whitehead.

Korapuki Island. Photo by Edin Whitehead.

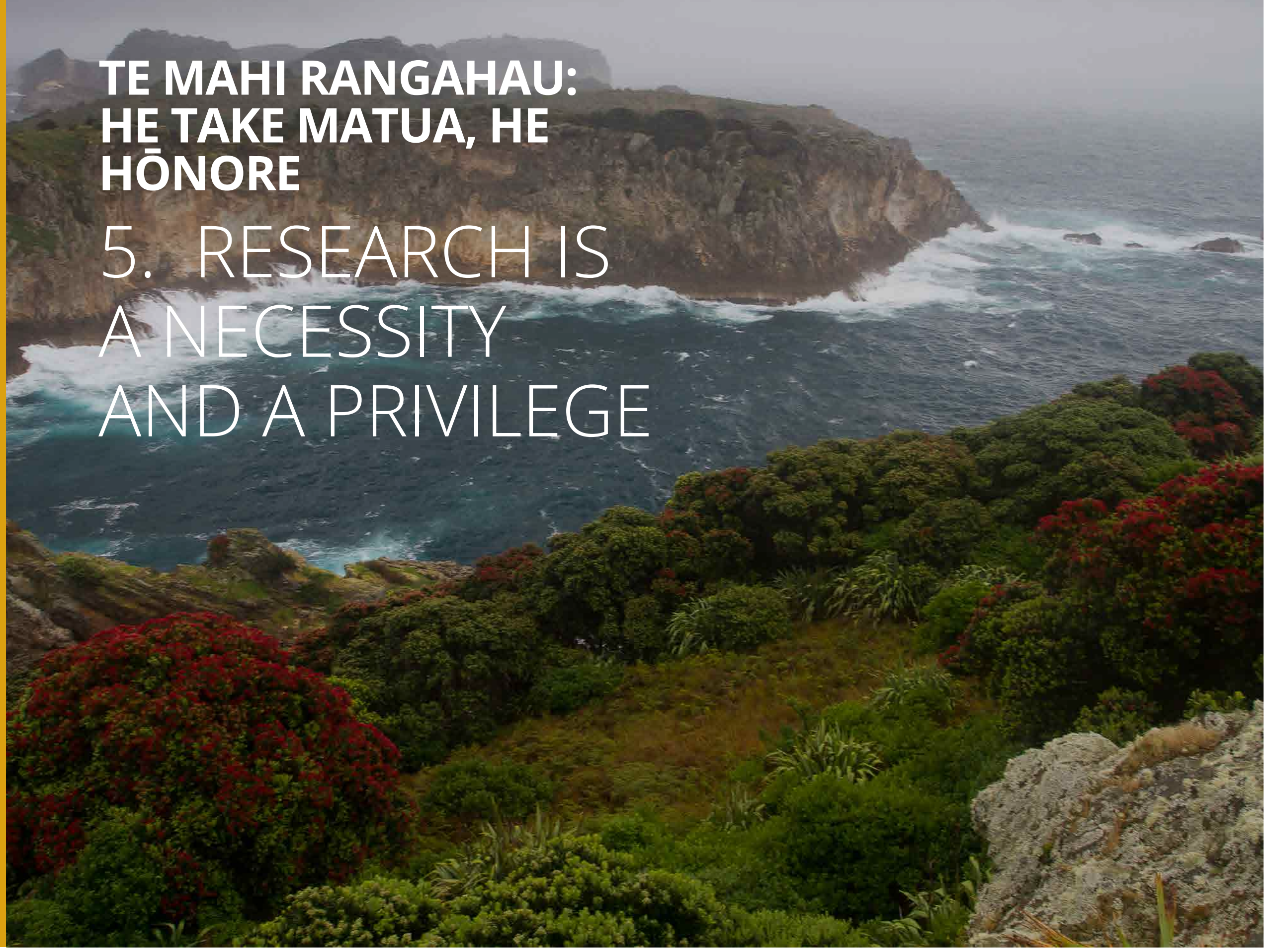
NGĀ KŌRERO A NGĀ MANU MOANA

WHAT ARE OUR SEABIRDS TELLING US?

Kuaka / common diving petrel, Pokohinu / Burgess Island, Mokohinau Islands. Photo by Edin Whitehead.

TE MAHI RANGAHAU: HE TAKE MATUA, HE HŌNORE

5. RESEARCH IS A NECESSITY AND A PRIVILEGE



'Petrel weather', Pokohinu / Burgess Island, Mokohinau Islands. Photo by Abe Borker.

The contributions in this section relate to recent and ongoing research within the wider Hauraki Gulf region. Conservation actions are impossible without research contributions to underpin them. If we don't understand the lives and status of these birds, we can't help them, and so fulfil our duty as good stewards of the natural world. Research is never 'complete'. As the world changes, we need to monitor these changes and gather data that enable us to predict future issues before they arise. As seabird researchers we have the privilege of working in some amazing places, the treasured islands especially, and working with our truly remarkable seabird taonga.

5.1 Long-term ecological responses to food web change in the Hauraki Gulf

Matt Rayner [1]

[1] *Tāmaki Paenga Hira / Auckland Museum*

The Hauraki Gulf's seabird community is globally significant but remains vastly reduced from historic abundance.

Removal of mammal pests from islands has resulted in population increases for predominantly offshore feeding and migrating species such a petrels, shearwaters, diving petrels, and storm petrels through recolonisation of breeding habitats, predominantly in the outer gulf.

Within the inner gulf year-round resident seabird populations remain in a poor state or declining and have responded to food web changes by shifting foraging habitats away from the coast.

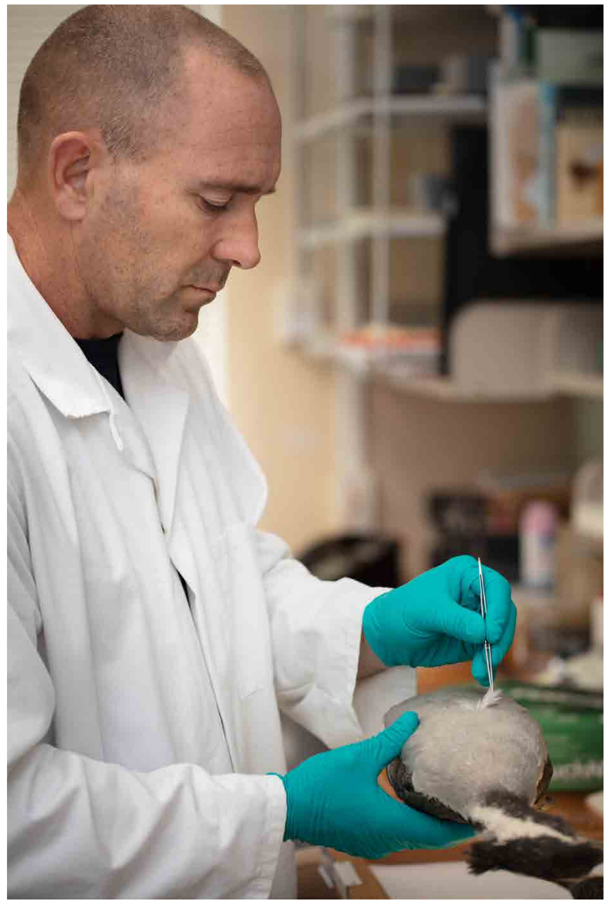
Whole ecosystem protection is essential within the gulf to improve the health of food webs that these species depend upon.

The numbers and diversity of seabirds of seabirds in the Hauraki Gulf are spectacular and it is no doubt that this community of 27 breeding species is a national and global treasure [55, 131]. However, this perceived abundance belies the sad reality that the seabird flocks of Hauraki Gulf / Te Moananui-o-Toi / Tikapa Moana are just a fraction of their former glory. Research suggests that between settlement of the region by the first New Zealanders (around 1350) and today, seabird numbers in the Gulf ecosystem have declined by an astonishing 69% [29].

These declines were primarily driven by the catastrophic impacts of a range of introduced predators (rats, mustelids, cats, dogs) and human exploitation of seabirds as a food source. However, by the mid-20th century we have increasingly protected seabird nesting sites by establishing pest free reserves on Gulf islands and, though introduced predators and fisheries by-catch remain major threats for certain species (e.g., New Zealand fairy tern, black petrel, flesh-footed shearwater), certain seabird groups are re-establishing populations and trending upwards for the first time in centuries, albeit at numbers just a fraction of their historical abundance. These *"good news"* species are dominated by pelagic and migratory seabirds such as petrels, shearwaters, diving petrels and storm petrels which are connected to oceanic food webs beyond the Gulf during breeding and migrations that take them far from New Zealand for up to half the year. As a result of this open ocean lifestyle, these seabirds are buffered from ecosystem impacts at local levels. However, population data suggest at best a lack of recovery and at worst ongoing declines for other seabird species such as terns, gulls, penguins, shags (i.e., all predominantly inshore feeders) that call the region home year-round and are closely dependant on the Gulf's food web for survival.

The reasons behind the ongoing decline of many Gulf seabird populations are complex but are ultimately driven by human-induced changes to marine ecosystems and prey in the modern era. Our impact on the Gulf has been particularly profound since 1950 with the industrialisation of commercial fishing and the adoption of a *"maximum yield"* approach over the last few decades that seeks to maintain targeted fish stocks at a biomass that permits maximum take, without ecosystem consideration [29]. Indirectly there have been major habitat impacts from fishing practices including the destruction of undersea reef and mussel bed habitat through trawling and dredging. On the coast sediment and nutrients derived from farming, deforestation, and increasing urban sprawl have swamped vast areas of coastal habitat in a sea of silt and mud. Disease has also played its part with the accidental introduction of pilchard herpesvirus to the Gulf in the 1995, either in ship ballast water or from imported bait from Australia, that had a devastating impact on pilchard populations [132].

Tara / white-fronted tern with anchovy. Photo by Edin Whitehead.



Collecting feather samples for stable isotope analysis from a spotted shag specimen. Photo by Jennifer Carol, Auckland Museum.

Parekareka / spotted shag. Photo by Edin Whitehead.

Kāruhiruhi / pied shags and tarāpunga / red-billed gulls roosting. Photo by Edin Whitehead.

The result of these *"modern"* impacts has been a catastrophic decline in Gulf marine life including prey that form the basis of the seabird food web [36, 133, 134]. Fish in general within the Gulf have been reduced by 60% of their historic biomass [35]. For middle trophic level groups such as small fishes, which are energy and nutrient-rich seabird kai, declines are estimated at around 45%, lower trophic level prey such as squid, macro zooplankton and gelatinous zooplankton have also declined by around 10% [29].

This loss of food has impacted the breeding success of resident seabird populations [135], but what of changes to diet and foraging distribution over time? Recent research has used nitrogen and carbon stable isotopes found in seabird feathers collected from museum specimens, some collected 140 years ago, from living birds in the field, and the tissues of their prey to answer such questions [136]. Results demonstrate how species *"carve up"* available prey sources with species such as pied and spotted shag and terns targeting primarily fish, little penguins exploiting a mixed diet of fish, squid and marine zooplankton and red-billed gulls foraging primarily on lower trophic level prey such as marine invertebrates. Surprisingly, there was little evidence for long-term declines in the trophic levels exploited by the seabirds studied over the 140-year study period as indicated by feather nitrogen isotopes. This lack of change in diet, despite massive loss in prey abundance, is likely related to seabird population declines that have reduced competition for food, allowing each species to continue to exploit their foraging niches despite less of their preferred prey. However, feather carbon isotope data indicated shifts in the foraging habitats of Hauraki Gulf seabirds in the period between 1878 and 2019. Large pursuit divers, including pied shag, spotted shag, and little penguin, showed major declines in carbon isotope values indicating a shift away from inshore habitats to more offshore environments. The shift is likely explained by declines in inshore prey brought on by overfishing and the destruction of inshore reefs and benthic structure through dredging and sedimentation. Boat traffic has also been implicated in the disturbance of seabirds that pursue prey underwater, and growth in the commercial and recreational boat fleet utilising the inner Gulf could potentially play a role in forcing birds away from areas of high boat traffic and disturbance. The spotted shag is, however, an anomaly here showing declines in both nitrogen and carbon isotopes that reflect a complex and concerning conservation situation for this endangered Gulf seabird (see Section 5.2, Fig. 15).

The overall picture for Hauraki Gulf seabirds is concerning. Historically there have been huge losses of seabirds from the Gulf with recent protection of breeding habitat on islands arresting declines and promoting expansion of populations of some, primarily pelagic migratory species, albeit at levels far below their prehistoric abundance. However, many populations of resident seabirds remain in a poor state because of our devastation of the Gulf's food webs through overfishing and habitat damage. Despite the challenges, these species have shown resilience; adapting to new prey sources or foraging habitats to make a living. Recovery of the Gulf's seabird flocks to anywhere near their former glory will require the restoration of a beautiful and complex food web damaged by our activities. To do this an ambitious holistic ecosystem protection plan must be rolled out across land and sea. Such a plan would provide safe habitats for seabird breeding and high-quality foraging habitat for a broad range of seabird taxa. As marine creatures high up in the food chain, seabirds reflect the condition of our whenua and moana, and so restoring abundant seabird populations can only be to our benefit.

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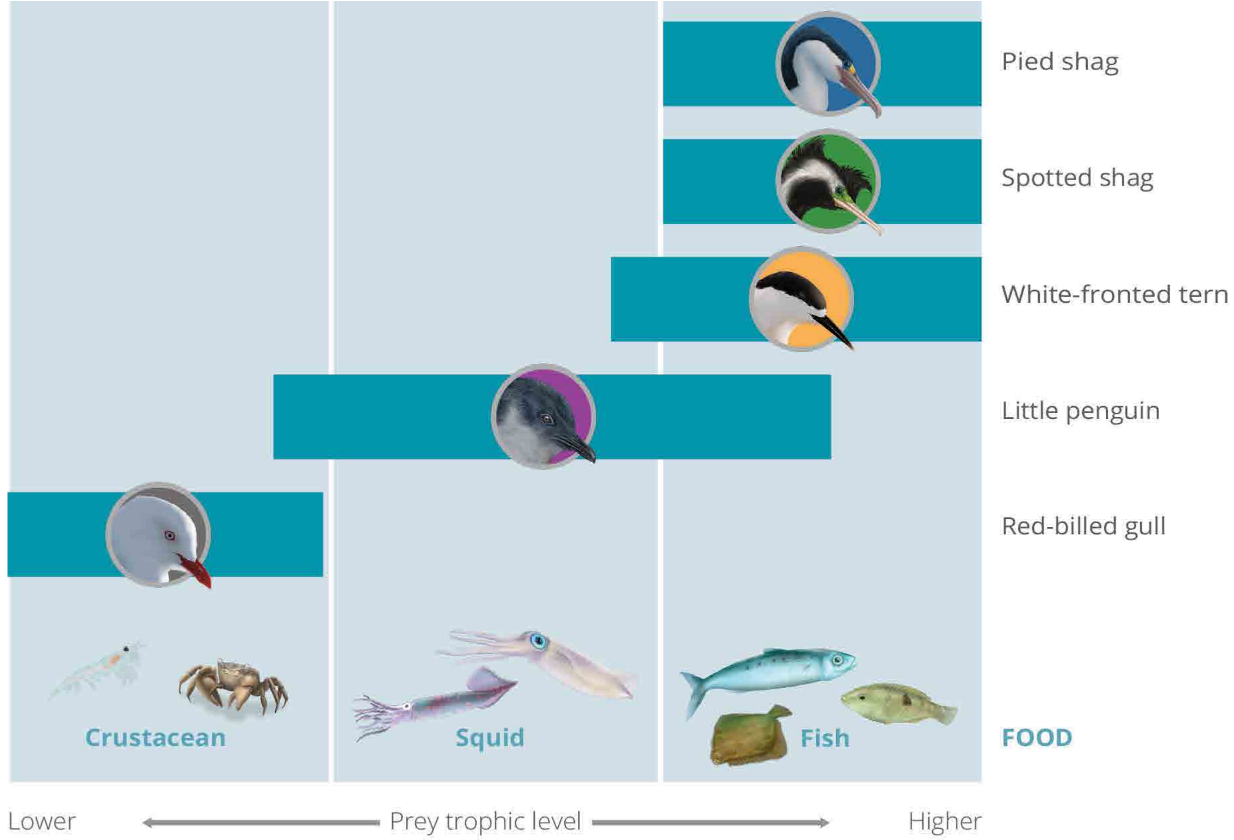
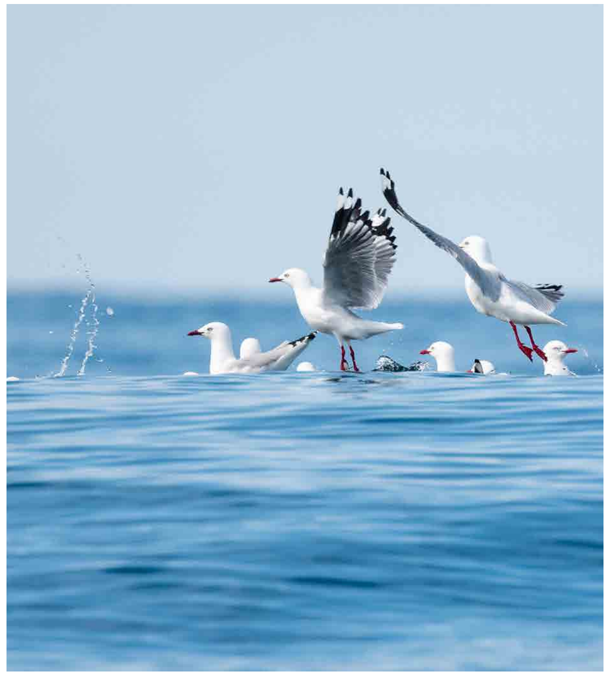


Figure 14. *Nitrogen isotope and direct dietary analyses show how inner gulf seabird exploit differing foraging resources between species. Adapted from [136].*

The Noises, Inner Gulf. Photo by Shaun Lee.



Tarāpunga / red-billed gulls. Photo by Edin Whitehead.

5.2 The plight of parekareka / spotted shag

Matt Rayner [1]

[1]*Tāmaki Paenga Hira / Auckland Museum*

Hauraki Gulf parekareka are genetically distinct and isolated from populations in southern New Zealand and their numbers, abundant in the early 19th century, have crashed to only 300 breeding pairs today.

The decline of parekareka populations parallels our destruction of inner Gulf marine habitats and food webs on which these birds are dependant.

Behaviourally parekareka have been forced to feed down the food web and shift their foraging habitats over time.

Of particular importance today as a foraging habitat is mussel farms that likely support abundant prey formerly found in the vast areas of inner gulf benthic mussel beds that have been destroyed.

Whole ecosystem protection is essential within the Gulf to improve the health of food webs that this species depends upon.

Parekareka / spotted shag is one of New Zealand's most beautiful endemic seabirds. Its current New Zealand population is 10,000-50,000 pairs, mostly found in the South Island [129]. Nationally, spotted shags are classified as not threatened, but the species is regionally threatened in the Hauraki Gulf where it reaches its northern limit and where recent research has shown its dwindling populations to be genetically distinct and reproductively isolated from populations further south [137].

Parekareka historically bred widely in the Gulf with midden deposits suggesting the species was an important food source for Māori. However, since the early 20th century the Gulf population has experienced a complex history of declines and increases with an overall steep negative trend compared with populations in southern New Zealand. While widespread in the Gulf before 1910, by the early 1930s the decline of parekareka colonies prompted legislation to halt their extermination by shooting, which was carried out in the mistaken belief it protected fisheries stocks [138, 139]. Birds subsequently increased after 1940 and by the 1960s surveys counted over 2000 pairs breeding in the Firth of Thames [138, 140, 141]. However, by the 1990s parekareka were again declining and today the population comprises a total of 300 breeding (Fig. 16) [142, 143].

On-land threats to the remaining parekareka colonies are limited, with the bulk of the population breeding on the safe cliffs of predator free Tarahiki Island. However, of more importance are threats at sea with recent research indicating that the fate of parekareka reflects the decline in the health of the Gulf ecosystem. Parekareka are underwater pursuit hunters that love nutrient-rich fish prey. However, in the Gulf stable isotope results indicate that since the late 1800s the trophic level of parekareka has declined, shifting from a diet dominated by fish to less nutritious lower trophic-level prey such as squid (Fig. 15). Likewise feather carbon isotopes have declined significantly indicating that today birds are foraging further offshore than they were more than a century ago[144]. Together these results suggest a significant shift in the diet and behaviour of spotted shags linked to changes to the marine ecosystem.

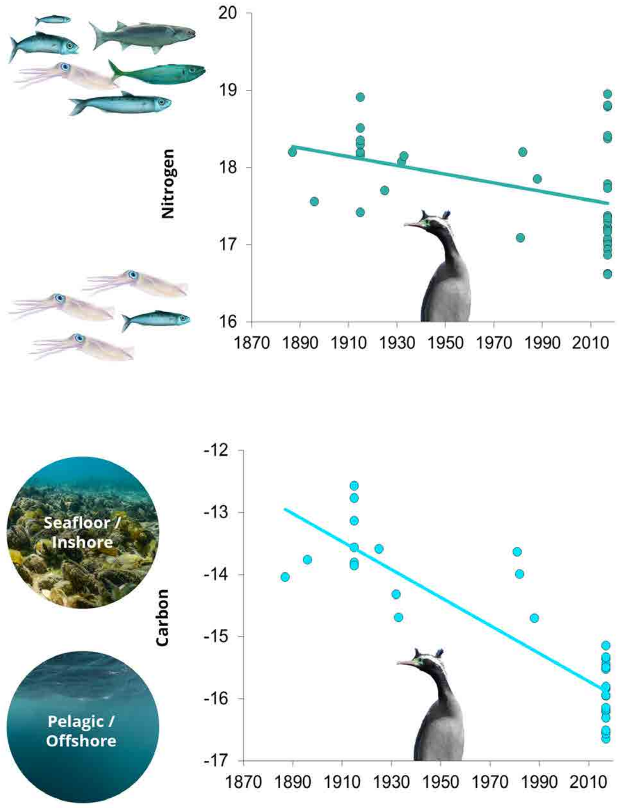


Figure 15. *Stable isotope values for nitrogen and carbon from feathers of Hauraki Gulf spotted shags collected between 1887 and 2020 indicate declining trophic levels of prey and changes in foraging habitat by birds.*

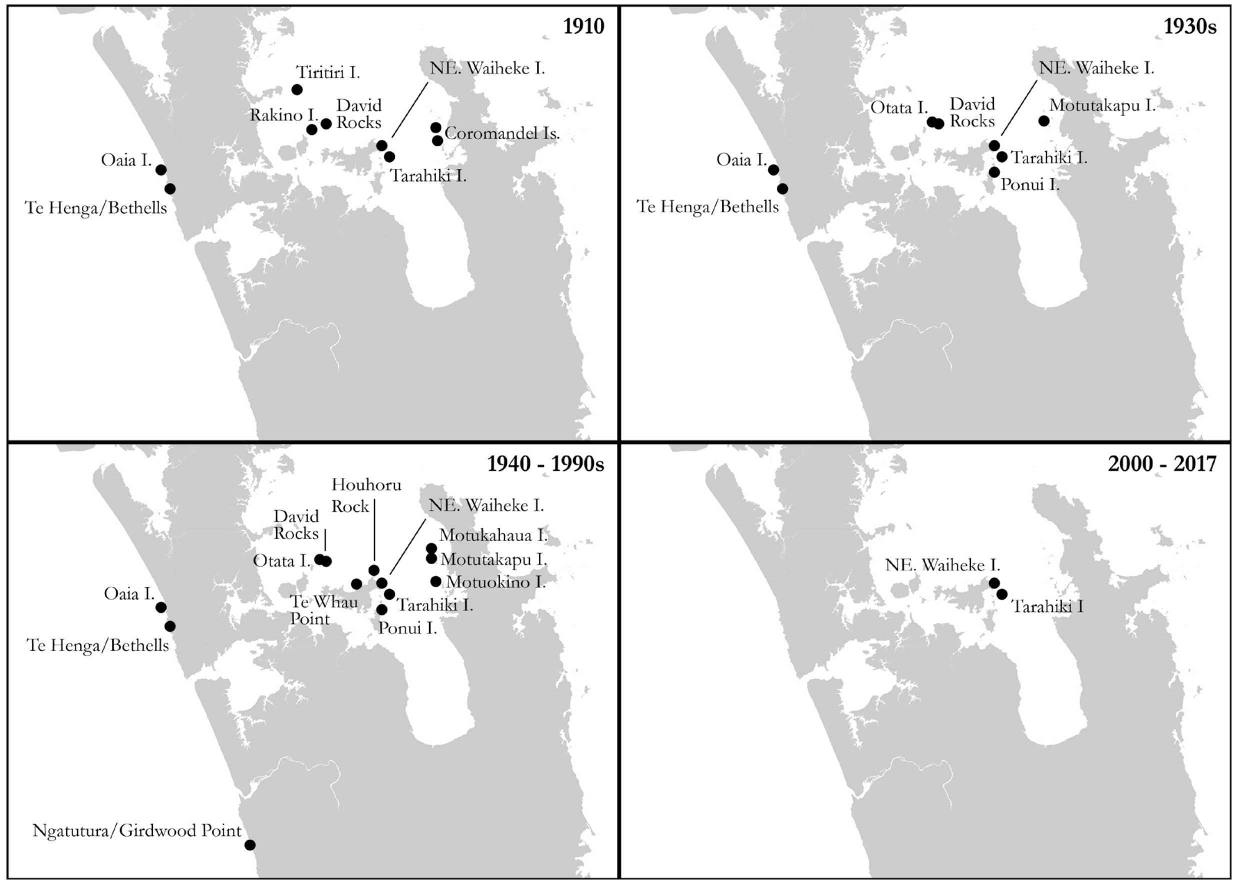


Figure 16. *Complex population history, populations recovered following protection from hunting in the 1930s but have since crashed from the 1990s and are in dire straights today. From Rawlence et al 2019.*

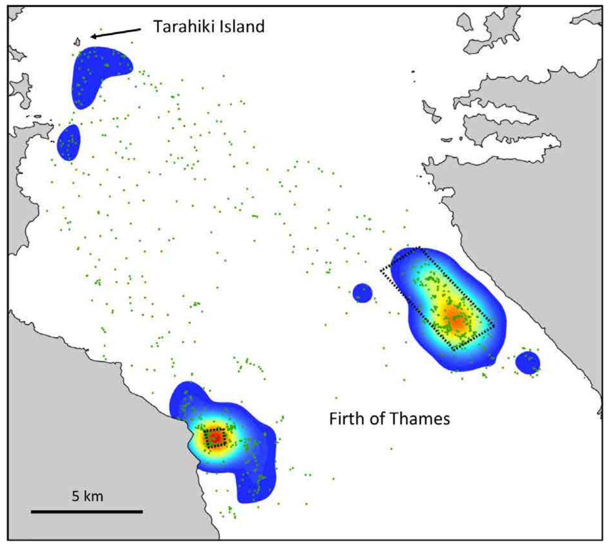


Figure 17. *Foraging areas for parekareka / spotted shags from Tarakihi Island. Mussel farm zones are delineated by rectangles.*

Spotted shags on mussel farm buoys. Photo by Tim Lovegrove.

Recent tracking of parekareka (Fig. 17) has shown that birds often forage within, or close to, offshore mussel farms in the Firth of Thames [144]. The vertical mussel clad lines of these farms support a rich underwater community of marine life that foraging shags can target. Such communities were historically found in the form of vast mussel beds that formed a biologically diverse habitat structure across much of the Firth of Thames and indeed wider Gulf area. The removal of these benthic mussel beds through dredging or destruction by indiscriminate fishing methods and sedimentation appears to have had a major impact on the food chain with parekareka representing a sleek maritime canary in the coal mine for our inner Gulf waters.

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Tara-iti / NZ fairy tern. Photo by Edin Whitehead.

5.3 Status and current recovery work for tara-iti

Tony Beauchamp [1 2], *Catherine Beard* [1 2]

[1]*Tara-iti Recovery Group*, [2]*Department of Conservation*

Tara-iti is the most critically endangered breeding seabird that uses the northern Hauraki Gulf. The population is c. 40 adults, and its survival is dependent on active conservation management.

Currently there are only four frequently used breeding sites: Papakanui Sandspit (Kaipara Harbour), Mangawhai Sandspit, Waipu Sandspit and Pakiri River mouth (all Hauraki Gulf).

Tara-iti nest apart and defend breeding patches and fishing areas from each other. Chicks are fed live fish and foraging areas need to be within 4 km of the nest site to enable sufficient food delivery. Both estuarine and pelagic fish are taken.

The Department of Conservation and many partner organisations have increased the scale and extent of management of controllable threats, but there are others, like increased storminess due to climate change, that cannot be controlled.

The Department of Conservation-led recovery group has used a Structured Decision-Making process with the community and iwi to examine how to move forward and build the population. The results of this analysis and recommended changes to the programme will be used to inform future recovery planning.

Tara-iti / New Zealand fairy tern is New Zealand's rarest endemic breeding bird and is classified as Nationally Critical [45, 91]. It has an adult population that has fluctuated between 32 and 42 birds since the entire breeding population was first colour banded in 2010.

There are four breeding sites at Papakanui Sandspit, Mangawhai Sandspit, Waipu Sandspit and Pakiri River mouth that have been used most seasons during the past 18 years [148]. Te Arai canal mouth has also been used four times since 2012, and the Poutawa Stream mouth has been used once.

Fairy terns are generally restricted to the outer Hauraki Gulf area, north of Mahurangi Harbour. Since 2004, four immatures and three adult breeding terns have been seen in the Firth of Thames, and as far south as Maketu on the east coast of the North Island. Six first year birds were seen as far south as Foxton Estuary on the west coast. All but one of these birds returned to the breeding range i.e., between Pakiri River mouth, Waipu Estuary, and the mid-Kaipara Harbour. Early in the breeding season these birds frequent the breeding sites. During the summer small flocks of non-breeding birds have been seen at high tide roosts on the Kaipara Harbour and on the eastern beaches between Warkworth and Whangarei.

Banding a tara-iti / NZ fairy tern chick. Photo by Steffi Ismar.

The population has been intensively managed since 1991 [146-148] and this has led to a gradual increase in the number of birds to 42 in 2017. Since 2010, the breeding population has fluctuated between seven and 11 egg laying pairs. The current population comprises 20 birds that have bred, and 19 pre-breeding birds. Birds can breed from 2-3 years old, and the breeding population is currently constrained by a lack of mature females.

Paired and some single male fairy terns defend estuarine foraging sites against other fairy terns from pre-breeding up until chicks fledge in late summer. These sites are used to condition females pre-laying and provide food for the adults and chicks during the breeding season. Newly fledged chicks are taken to these sites to be taught how to forage.

Fairy terns feed on live fish c. 15-70 mm long. These include estuarine bottom dwelling gobies and patiki-totara / flounders (*Rhombosolea spp*) and pelagic elvers (*Anguilla sp*.), aua / yellow-eyed mullet (*Aldrichetta forsteri*), parore (*Girella tricuspidata*), ihe / piper (*Hyporhamphus ihi*) inanga / young galaxiids and other fish species [146, 149]. Fish are taken within the estuaries, and from the open ocean out to at least 500 m offshore. Fish are obtained by hovering and surface plunge diving, catching fish in the bill [149], so fish must be within 20 cm of the surface to be captured. Only one fish can be delivered to young at a time. At Mangawhai, during chick rearing, fish are delivered throughout the tidal cycle at an average of 2.1 (SD = 2.2, n = 450) fish per hour. However, nearby marine fish resources at Mangawhai have been harvested at 10-22 fish per hour during both low and high tides. Where wind exceeds 30 knots, adults are frequently unable to hover or catch food, and if these conditions last more than 48 hours eggs are deserted, and young are lost. The Department of Conservation has reduced losses to predators and has created nest sites that have lower risk of tidal inundation, but high winds remain a threat. Multiple depressions that formed in the Tasman Sea, likely associated with increased ocean water temperature [150], caused problematic wind events during the 2018 and 2020 seasons.

Checking tara-iti / NZ fairy tern nest. Photo by DOC.

Young fledge the natal nesting site at c. 23-26 days and are supplementary fed by the parents while they learn to fish for themselves for at least the first month after fledging, usually on sandflats or the coastal margin, but sometimes on the open water surface. Young are then taken from the natal area to other sites because fish resources like estuarine gobies naturally collapse annually within the east coast estuaries during late summer.

Towards the close of the breeding season non-breeding birds and young and breeding birds from Mangawhai, Waipu and Pakiri River mouth often flock at Te Arai Stream mouth [151]. During that time birds are seen foraging at Slipper and Spectacle Lakes at Tomarata [152]. The flocking birds then move west to the central-south Kaipara Harbour for much of the winter. Also, birds infrequently visit the east coast throughout the non-breeding period and during the breeding season some breeding terns have been recorded feeding in the Kaipara Harbour after nest losses and before relaying on the east coast [153].

Tara-iti feeding chicks. Photo by Brian Chudleigh.

In Australia, fairy terns are colonial and feed within a few hundred meters of nesting sites, thus allowing frequent foraging returns for feeding young [154]. Other subspecies of fairy terns in New Caledonia have been seen to be colonial, and to have isolated pairs. Since 2018, pairs at Mangawhai have bred more colonially at one of the sites. However, there is no indication that while doing so that they have the food resources to change from a territorial estuarine foraging system to a near nest site one. The types of fish that would drive such changes have potentially declined in the past 150 years as the swamps that were habitat for migratory galaxiid populations have virtually disappeared, and the mullet populations and marine fish populations with small fish related young have diminished.

There are many people and organisations that have recently devoted time to saving fairy terns or understanding how the population works. These include staff at Auckland Zoo, community representatives (Birds New Zealand, Royal Forest and Bird Protection Society, About Tern, The New Zealand Fairy Tern Charitable Trust), iwi (Patuharakeke, Te Uri o Hau, Ngāti Whātua o Kaipara, Ngāti Manuhiri, Ngāti Wai), resource providers (The Shorebirds Trust) and universities (genetics – Canterbury University; future management – Institute of Zoology, Zoological Society of London). The future management of fairy tern has been investigated using a *"Structured Decision Making"* process which takes into consideration the aims and values of all the groups to define solutions based on shared values [155]. A range of management strategy options were developed and evaluated as part of the process. Strategy options included continuing with the existing management programme, enhancing the existing field programme to cover more of the year and more sites, increasing predator control at roost sites, adding a captive-rearing component, and managing pairings and genetics. An assessment of the various options has very recently been completed and will be used to guide current and future work to recover the fairy tern population. Advice on fairy tern recovery and management is provided by the Tara-iti Recovery Group, a Department of Conservation-led group of specialists comprising DOC Science & Technical and Operations staff, iwi, and an independent fairy tern specialist.

***Acknowledgements:** The authors here thank Gwenda Pulham, the independent fairy tern specialist on the Tara-iti Recovery Group for her input into the article.*

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New Zealand storm petrel with bands. Photo by Edin Whitehead.

5.4 The curious case of the New Zealand storm petrel

Or, accidentally saving a seabird we did not know existed and proved hard to study when we did.

Matt Rayner [1]

[1]*Tāmaki Paenga Hira / Auckland War Memorial Museum*

> The New Zealand storm petrel was rediscovered from presumed extinction in 2003 and research has focussed on key questions guiding the species conservation status.

> The species breeding population was discovered in 2013 by tracking birds radio-tagged at sea back to Te Hauturu-o-Toi / Little Barrier Island.

> A mark recapture study indicates this population consists of around 1,600 individuals, recovering from around 300 individuals around the time of kiore eradication from Hauturu in 2004.

> Current research is seeking to use DNA analyses to identify the signature of other New Zealand storm petrel populations from blood samples collected from birds caught at sea off the coast of northeast New Zealand.

Seabirds can be tricky research subjects; living life far out at sea and breeding on remote, windswept island outposts, often coming ashore only at night to nest in hidden underground burrows. However, even among sea fowl not all species are equal, the New Zealand storm petrel for example. To recap the history of this enigmatic seabird, New Zealand storm petrels were considered extinct and known only from three museum specimens until resighted off the east coast of North Island in 2003. Following this rediscovery, net guns allowed at-sea captures of these tiny (35 g) birds and analysis of DNA extracted from blood samples, plus the patterns of moult of the birds' feathers confirmed they were *Fregetta maoriana*, the long-lost New Zealand storm petrel, and most likely breeding somewhere in the Hauraki Gulf [44, 156].

Of course, the *"where"* question was not an easy one to answer. Storm petrels are tiny seabirds, and notoriously susceptible to predation by mice, rats, and stoats so the breeding location was likely predator free. However, there were many candidate islands that had either always been pest free, or recently cleared of introduced mammals and with recovering seabird populations. Again, new technology came into play, and in 2013, the New Zealand storm petrel research team (a group of seabird experts, advocates, and enthusiasts from all over the country) were able to track birds caught at sea and fitted with radio tags back to a breeding site on Te Hauturu-o-Toi / Little Barrier Island [44]. Then the research challenges really began.

The conservation threat ranking of a species is critical to the amount of conservation funding, that a species receives. At the time of its discovery on Hauturu, New Zealand storm petrel was ranked under the New Zealand Threats Classification Scheme (NZTCS) as Nationally Vulnerable and under the International Union for the Conservation of Nature (IUCN) as Critically Endangered. Critical to these rankings is knowledge of their population size and trend, and how many populations there are – all data lacking for the species in 2013.

Understanding the size and trend of the Hauturu population presented a challenge. Our studies of radio-

Researchers study egg at natural burrow 4, Parihakoakoa Valley, Te Hauturu-o-Toi / Little Barrier Island. Photo by Steffi Ismar.

Telemetry tracking for radio-tagged New Zealand storm petrels, Te Hauturu-o-Toi / Little Barrier Island. Photo by Arno Gasteiger, NZ Geographic.

tagged birds, and the small number of nests (four) we found as a result, indicated that they breed widely in dense mature forest within the steep gorges and gullies of this rugged nature reserve. A nest consists of an underground burrow with an entrance hole so tiny that we were often unable to find it, even when we knew a radio tagged bird sat underground. Add to this the potential damage to nests that researchers could do in the fragile forest habitat meant that we rapidly concluded that counting birds at their nests was not an option. Plan B was required, which came in the form of an extremely bright halogen light.

Despite their at-sea aerial mastery, many seabirds that are nocturnal on their colonies are susceptible to being bedazzled by high-powered spotlights that can cause them to crash land. From the seabird researcher's perspective this is desirable in the sense that it provides a means of capturing birds on their way inland to burrows that are so difficult to find. With birds in the hand, and a method to reliably recapture birds, it is then possible to use a technique called mark recapture to estimate the size of the population. Mark-recapture involves marking many organisms (in this case with numbered and coloured bands), releasing them back into the population where they mix with unmarked individuals and through subsequent capturing, marking, and recapturing the size of a population can be calculated. In 2014 we trialled and succeeded in using spot lighting to capture New Zealand storm petrels on Hauturu at an open grassy site near the island's coast. The set up involves a large incandescent flood light pointing skywards after dark and a storm petrel *"boom box"* blasting out a recording of a calling bird made at a natural burrow. Storm petrels attracted to the light are then fixed with the beams of powerful LED torches that, in the right conditions, cause birds to become confused and brought to ground without injury in the soft grass. A total of 415 birds were captured using this technique and marked with colour-band combinations between 2014 and 2018. Subsequently birds were *"recaptured"* either by being re-caught at the spotlight site on Hauturu or photographed at sea near Hauturu and so two mark-recapture models developed. The land-based model suggests a New Zealand storm petrel population of 994 individuals, the at-sea model 1,630 individuals [157]. The discrepancy between these models lies in the fact that on land captures were biased to juvenile birds as adults are better able to avoid researchers' spotlights. We consider the at-sea model most representative of total population size.

New Zealand storm petrel capture using lights, Te Hauturu-o-Toi / Little Barrier Island. Photo by Edin Whitehead.

Chick from natural burrow 4. Photo by Stephanie Borrelle.

With a good benchmark on population size, we also set about figuring out the past and present population trend of this species using models that included mark-recapture estimates and storm petrel demographic parameters such as age at first breeding, adult, and chick survival, and how often birds breed. Models indicate that New Zealand storm petrel has likely expanded from as few as 300 birds at the time of the kiore, or Pacific rat, eradication from Hauturu in 2004, though how this species survived historically on the island is a puzzle. Before eradication, kiore would have been a major predator of storm petrel eggs, chicks and adults and experienced a population explosion following the removal of feral cats, another storm petrel predator, from Hauturu in 1980 [86]. It could have been that New Zealand storm petrels were able to find refuge in nesting sites away from predators such as on cliff faces or in the tree top clumps of epiphyte vegetation. Alternately it could simply be the case of a large population of birds, slowly being whittled towards extinction over a century or more. We will never know. However, what the story does tell us is the massive benefits that eradication of introduced mammals can have to our native ecosystems, many of which are often unforeseen. Debate raged in the early 2000s as to whether the removal of kiore, a taonga species to mana whenua, from Hauturu was culturally ethical. However, there can be no doubt that the transformation of Hauturu since rat removal has been profound with the forest transformed, the island's birdsong, both night and day, rising to new levels and a tiny seabird that we did not even know existed in the early 2000s likely saved from extinction.

Today, research on the New Zealand storm petrel is moving away from field-based research and more toward lab-based research, such as genetics, stable isotopes. The last critical question to challenge accurate conservation status for the species is whether Hauturu is the only breeding population in the world? With dozens of pest free islands off the northeast coast of the North Island, and sightings of storm petrels at sea from the Coromandel, 400 kilometres north to Manawatāwhi / Three Kings Islands, this leaves a big haystack to search for tiny storm petrel needles. Luckily, scientific advances in DNA analysis means it is now easier to search a species' genome than all the islands in its entire range for tell-tale signs of other breeding colonies. Recent field work has seen the

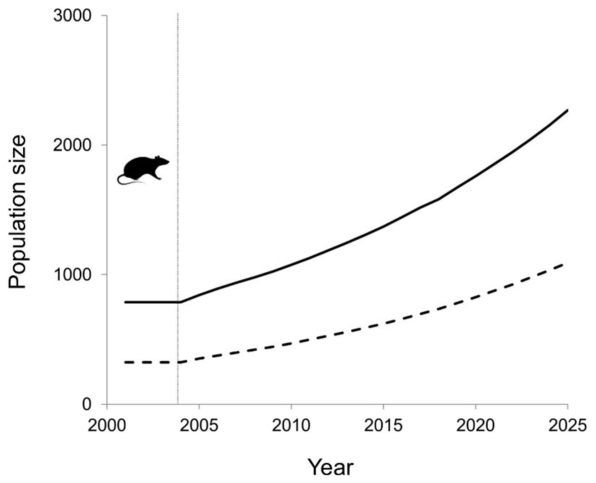

Figure 18. *Population trajectory of New Zaland storm petrels on Te Hauturu-o-Toi / Little Barrier Island following kiore eradication.*

New Zealand storm petrel team back at sea off Otou / North Cape and the Northland coast capturing storm petrels to collect blood samples. With these fresh samples from across the species' range, as well as those collected previously from Hauturu, whole genome techniques will be used to examine genetic diversity and population specific structure of this enigmatic little seabird that does not give up its secrets to easily.

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Successful at-sea capture of a New Zealand storm petrel, May 2021 off Otou / North Cape. Photo by Edin Whitehead.

Tarāpunga colony, Māori Rocks, Mokohinau Islands. Photo by Edin Whitehead.

5.5 Long-term trends in the populations of two colonial, surface-nesting seabirds

Peter Frost [1]

[1]*Science Support Service*

Almost all seabirds nest colonially, often concentrated at only a relatively few sites. Given this aggregation, counting the numbers of breeding pairs and following the changes through time would therefore seem to be relatively straightforward. Unfortunately, it is not. Of the 27 seabird species that breed within the wider Hauraki Gulf region, 15 nest in self-excavated burrows or under cover of some sort, frequently on steep slopes on often barely accessible islands, to which the birds are largely nocturnal visitors. This makes them particularly difficult to survey accurately.

The other 12 of the region's 27 breeding species nest aboveground, either on the surface or in trees. They are diurnally active and conspicuous both in their behaviour and colour (often predominantly white). While less demanding to survey than burrow-nesting species, determining population size and trend, a basic feature of any conservation management plan, is still challenging.

This section summarises what is currently known about the status and trends of two surface-nesting species in the region: tarāpunga / red-billed gull and tara / white-fronted tern. Both species have been subject to sporadic population surveys of varying scope and intensity over the past 70+ years. The sources of data are many and varied. Apart from reports of national or regional surveys of the red-billed gull [158, 159] and white-fronted tern [160], the principal sources have been the Classified Summarised Notes (CSN) of the Ornithological Society of New Zealand (OSNZ, now Birds New Zealand), published more-or-less annually in the journal Notornis between 1939 and 1962, then again from 1972 (covering the period 1963–1970) to 2003; the OSNZ's nest record card scheme; eBird (https://ebird.org/home); and sundry other sources, mostly unpublished. These are listed in Population status and trends of selected seabirds in northern New Zealand [143]. More recent surveys organised by the Northern New Zealand Seabird Trust in 2019-2020 and 2020-2021 summer seasons, have added invaluable additional information.

Tarāpunga / red-billed gull

The current population trend for the tarāpunga / red-billed gull is unclear, although the consensus is that the population is declining.

This assessment, however, is clouded by a lack of coordinated, long-term monitoring of the species at a range of sites, something that is needed to properly track inter-annual change.

Also, individual pairs do not necessarily breed every year, for whatever reason. This further complicates short-term assessments of population change. Bird movements into and out of the region, possibly affecting which colony sites are used in any one year, is particularly poorly known.

The red-billed gull is generally considered to be the most common gull in New Zealand. In 2014–16, a national survey of red-billed gull colonies carried out by Birds New Zealand and the Department of Conservation produced an overall estimate of 27,831 breeding pairs in New Zealand, well down from the 40,000 pairs estimated to have been present nationally in the mid-1960s [159]. Within the wider Hauraki Gulf region, 5473 nesting pairs were counted at 65 colonies, including one large colony, an estimated 1190 pairs at the Marsden Point Oil Refinery.

Red-billed gull colonies of differing sizes are widespread throughout the wider Hauraki Gulf region, although not every site is used each year and some sites may now have been abandoned. During the 2019 breeding season, 119 potential breeding sites were surveyed across the wider Hauraki Gulf region, with 1211 nesting red-billed gulls being found at 22 of them [161]. Fewer pairs were found nesting the following season, with 935 recorded at just 11 sites, including 100 pairs at four sites that were not occupied in 2019 (Fig. 19). Only one site used in 2019, Māori Rocks with around 200 pairs, was not surveyed in 2020. This suggests considerable fluidity in both colony size and location in this region.

The 2019 and 2020 results can be compared site by site with those obtained during the 2014-2016 national red-billed gull survey (Table 5). Of the sites covered in that study, 27 were also surveyed in the 2019. These supported 983 nesting pairs of gulls, just half the maximum number (1961 pairs) recorded in 2014-2016. Gull numbers recorded in 2020 show an even steeper

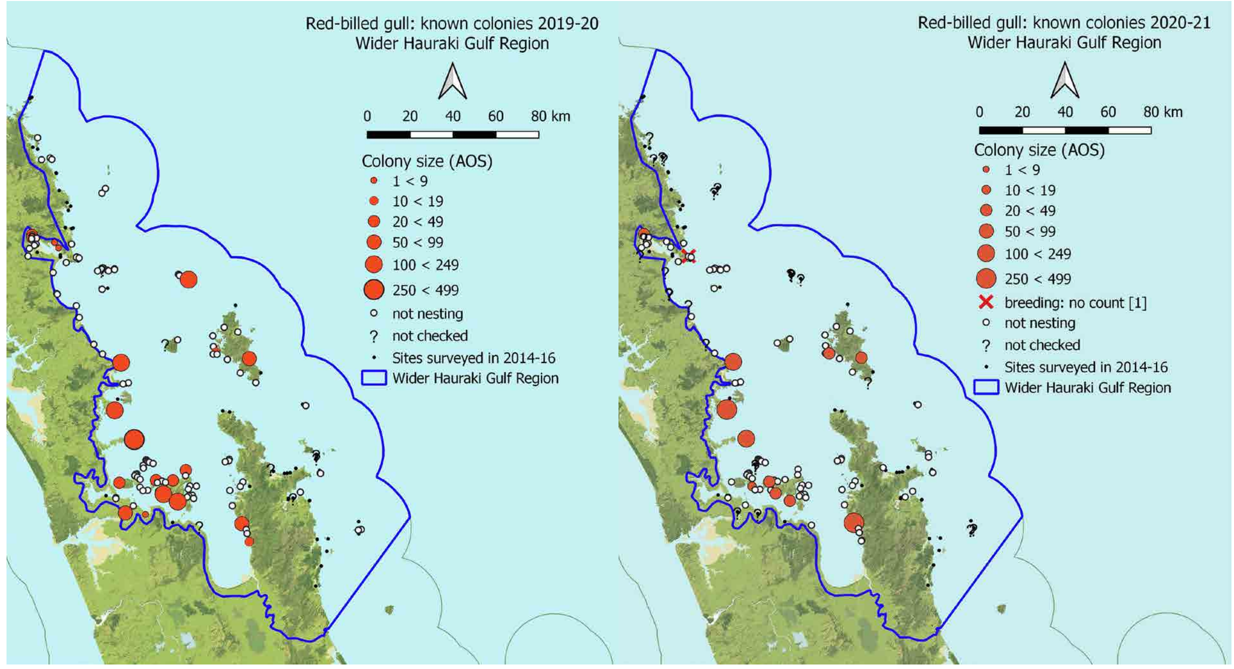

Figure 19. *Locations of red-billed gull colonies occupied during the 2019 and 2020 breeding seasons, along with grouped estimates of colony size, reported here as the number of apparently occupied sites (AOS). These represent the presence of one or two birds together at a likely nest site, even if a nest is not visible, or one that is occupied by one or more chicks with or without an adult present. The number of apparently occupied sites is taken to be equivalent to the number of nesting pairs.*

decline, 70%, from a maximum of 1881 recorded at 23 colonies in 2014-2016 to 557 nesting pairs at the same sites in 2020 (Table 5). Note, however, that the large colony at Marsden Point Refinery, estimated at 1190 pairs in 2015, was not surveyed in 2019 or 2020.

This apparent general decline extends further back, albeit with much uncertainty about the accuracy of earlier estimates. In the mid-1960s, the species reportedly bred at 35 sites within the wider Hauraki Gulf region, with some extremely large colonies being noted there earlier than that: e.g., Mokohinau islands, 2500–10,000 pairs; Taiharuru Rock, 600–700 pairs; Sugarloaf and High Peaks Rocks, >500 pairs [158].

Whereas these changes suggest that the red-billed gull population in the wider Hauraki Gulf region overall has declined, such a conclusion must be qualified. The available data are patchy, both spatially and through time. We know little about the inter-regional movements of red-billed gulls. Some may move in and out of the wider Hauraki Gulf region to breed, depending on local circumstances. Others may skip breeding in some years, as the species is known to do elsewhere in New Zealand [162], particularly if local environmental conditions are sub-optimal for breeding.

Like many long-lived, slow-reproducing seabirds, red-billed gulls may forego an uncertain breeding opportunity rather than risk compromising long-term survival and the prospects of future reproduction.

Understanding what changes, if any, are occurring regionally in the red-billed gull population is further complicated by the presence of a large non-breeding population. For example, non-breeding birds can comprise up to half the total population at Kaikōura, New Zealand's largest red-billed gull breeding colony [163]. Individuals can delay breeding for up to 4–6 years (sometimes longer), and then only breed intermittently once they start [163, 164]. In the short term, these features can mask more persistent, longer-term shifts in a species' circumstances (e.g., chronic failure of prey availability affecting nest success, recruitment, survival of different age classes; wider changes ocean productivity; and growing impacts of predators on nesting success). There is much to learn.

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Locality	Latitude	Longitude	2014	2015	2017	2019	2020
High Peaks Rocks, Poor Knights	-35.5466	174.7239	–	15	54	0	–
Sugarloaf, Poor Knights	-35.5665	174.7058	–	72	267	0	–
Parua Bay, Whangarei	-35.7777	174.4660	0	0	–	1	0
McLeod Bay Island	-35.8008	174.4878	39	0	–	6	0
Guano Rock	-35.8410	174.5940	–	4	–	0	0
Bird Rock, Mokohinau	-35.9023	175.1091	39	–	–	0	–
Burgess Island, Mokohinau	-35.9055	175.1142	39	–	–	0	–
Maori Rocks, Mokohinau	-35.9231	175.1616	0	20	16	200	–
Mangawhai Sandspit	-36.0912	174.5997	76	131	–	0	0
Opakau Island	-36.2021	175.2984	–	75	–	0	0
Junction Island, Aotea	-36.2335	175.3183	–	50	–	0	40
Mahuki Island	-36.2339	175.2979	–	–	72	0	0
Kaitoke Bay islet, Aotea	-36.2493	175.4859	–	94	–	50	40
Goat Island	-36.2652	174.7981	–	96	–	0	0
Phoenix Rock, Tawharanui	-36.3673	174.8331	–	188	–	0	0
Tara Rocks, Motutara Island	-36.4792	174.7931	79	79	–	200	250
Tiritiri Matangi Island	-36.6001	174.8969	100	340	300	310	190
Green Island	-36.6440	175.8473	12	–	–	–	0
Korapuki Island	-36.6587	175.8490	25	–	–	–	0
Motutakupu Island	-36.6846	175.3741	–	24	0	0	0
Rakino Island	-36.7186	174.9476	27	–	–	0	–
Horuhoru	-36.7235	175.1703	–	2	4	40	0
Needles Rocks, Whaiheke Island	-36.7773	175.0647	–	295	–	0	0
Pakatoa Island	-36.7898	175.1933	0	1	–	0	0
Tarahiki Island	-36.7901	175.2269	–	2	–	0	0
Rocky Island, Motuihe	-36.8005	174.932	0	–	–	0	16
Koi Island	-36.8269	175.0557	130	261	–	150	32
Okahu Bay wave break	-36.8463	174.8067	–	48	–	0	4
Pakuranga Road Bridge, Panmure	-36.9085	174.8584	–	–	10	50	80
Ruamahanga stack	-37.0164	175.5119	10	5	–	0	0
Offshore rocks N of Waiomu	-37.0165	175.5121	10	8	–	26	0
Hikunui Rock, Opoutere	-37.1116	175.8913	0	95	–	–	0

Table 5. *Comparison between years at sites where red-billed gulls were recorded breeding during the 2014-2016 National Red-billed Gull survey (with a few additional sites surveyed in 2017) with the numbers found in the 2019 and 2020 breeding seasons. Sites that were surveyed in the periods 2014–2017 and 2019–2020 but where no breeding was reported in one or both periods are omitted. A "–" indicates 'no survey'.*

Tarāpunga colony, Panmure Bridge. Photo by Shaun Lee.

Tara / white-fronted arriving at Horuhoru Rock colony with prey for chick. Photo by Edin Whitehead.

Tara / white-fronted Tern

As with the tarāpunga, the tara / white-fronted tern population appears to be undergoing long-term decline, although the exact magnitude and cause(s) are uncertain and unknown.

Frequent but unpredictable shifts in colony locations and size, the reasons for which are poorly understood, complicate efforts to reliably track population change.

Inter-annual movements of birds into and out of the region are likely because the region is not closed ecologically.

In brief, there is much still to learn about this distinctive herald of spring on our coasts. That the species is currently widespread and apparently common is no assurance of its future.

White-fronted terns breed colonially in a wide range of sites: rocky offshore islands and stacks; exposed reefs; ledges on cliffs or on steep slopes; sand spits, shingle banks and shell-sand islands in estuaries and along the coast; and on groynes and harbour piles. The species is widespread and, at times, locally numerous, as the distribution and reported sizes of white-fronted tern colonies at different locations within the wider Hauraki Gulf region shows (Fig. 20).

No survey has covered all known breeding sites in a single year, so the total white-fronted tern breeding population in wider Hauraki Gulf region is unknown. Recent surveys by the Northern New Zealand Seabird Trust found 1792 pairs breeding at 39 sites during the 2019–2020 breeding season [161], and around 2062 pairs nesting at 31 sites in 2020-2021 [165].

Prior to that, the only comparable data comes from the results of a 3-year national survey of white-fronted tern numbers and distributions carried out between 1995 and 1998 by the Ornithological Society of New Zealand [160], sustained by some for a few years after. Widest coverage was achieved in 1996–1997 when 36 sites within the wider Hauraki Gulf region were surveyed, finding at least 1791 pairs apparently nesting in 27 colonies (no count was made at one other active colony) [160].

Given the patchy coverage, however, the best available measure of population change is to compare the number of pairs apparently nesting in various past years with that recorded at the same sites in the 2019 and 2020 breeding seasons (Table 6). The number of sites in common, including those where no birds were nesting in one or both breeding seasons being compared, varied across the years. Apart from 22 common sites surveyed in 1997–98 and 2019–20, where the number of breeding terns apparently increased by just under 10%, from 782 to 855 pairs, all the other comparisons show declines of varying magnitude (Table 6).

Tara / white-fronted terns, Tawharanui. Photo by Chris Gaskin.

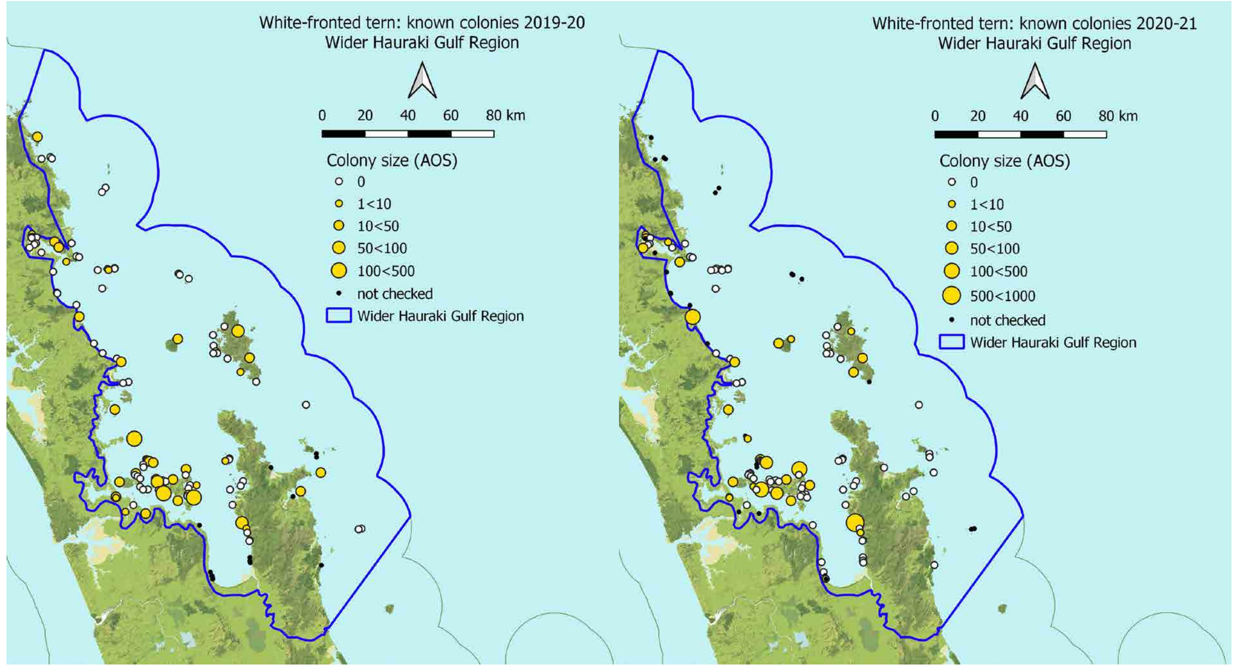
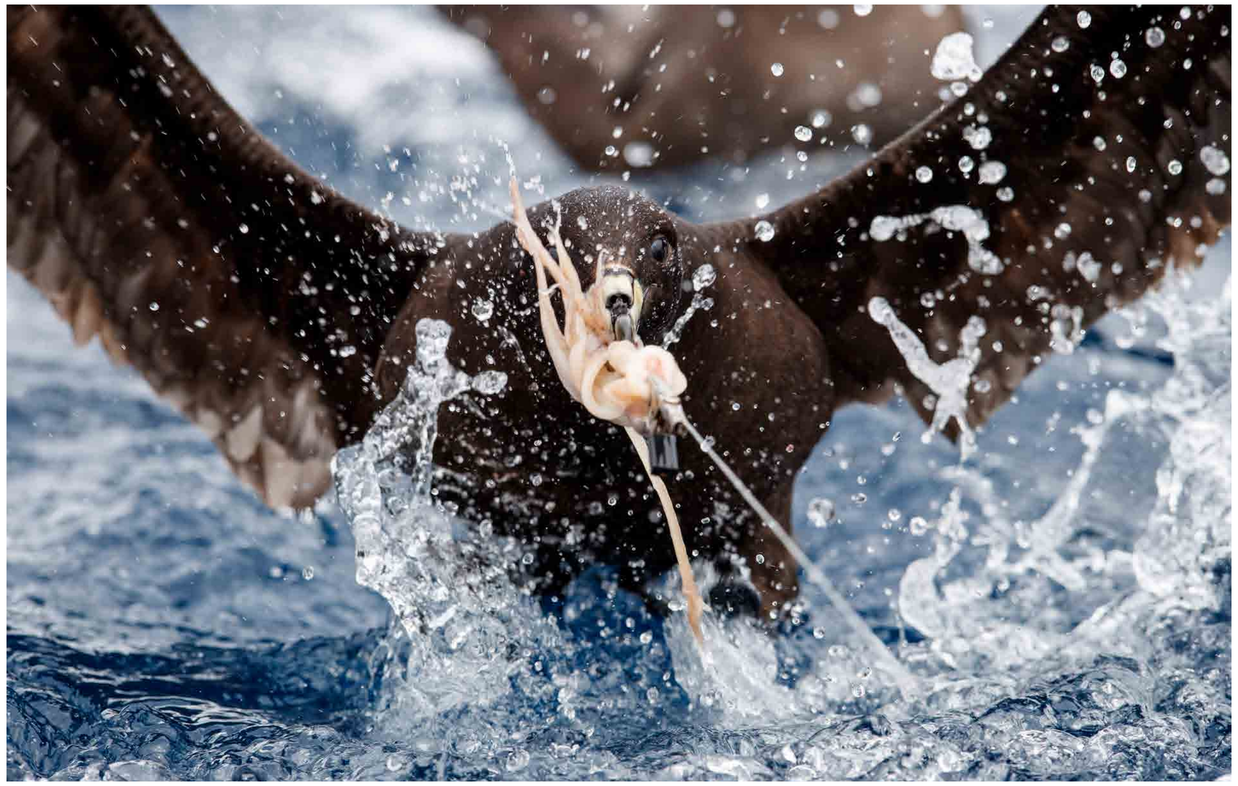


Figure 20. *Locations and sizes of active white-fronted tern colonies in 2019-2020 and 2020-2021 breeding seasons. The term 'AOS' refers to apparently occupied sites, likely nests occupied by one or a pair of apparently breeding birds, or sites occupied by one or more chicks with or without an adult present. Most of the sites along the mainland coast are on nearshore rocks.*

Base season	Base season count	2019 count	% diff.	N	Base season count	2020 count	% diff.	N
1996-97	1021	859	-15.9	24	1017	989	-2.8	22
1997-98	782	855	9.3	22	1946	962	-50.6	19
1998-99	1217	456	-62.5	17	1271	568	-55.3	17
1999-00	1267	331	-73.9	12	1267	327	-74.2	12
2001-02	1264	841	-33.5	14	1240	734	-40.8	13
2002-03	799	664	-16.9	13	769	253	-67.1	12

Table 6. *Number of pairs of white-fronted terns reported nesting in the wider Hauraki Gulf region 1996–2003, compared with those recorded at the same sites during the 2019–2020 and 2020–2021 breeding seasons. Only years in which there were more than 10 sites to compare are included in this analysis. The number of surveyed sites include ones at which no birds were nesting in one but not the other of the seasons being compared.*

This multi-year comparison does not establish definitively that the white-fronted tern population in the region has declined over the past 25 years or so, but it suggests compellingly that it has. Nevertheless, in a few cases where breeding has been followed at a location for several successive years, the surveys have shown the transient nature of the white-fronted tern's occupancy of individual sites, with a place being used in one year sometimes wholly or largely being abandoned the next. The reasons for these sudden shifts in colony location and size are poorly known: disturbance; increasing predation; flooding; and shifting food supplies have all been suggested, among others. This instability complicates identifying overall population trends. Some of the observed changes in numbers may also reflect sampling or counting errors rather than real changes in abundance. Differences in counting methods, dates and even times of day among surveys can all contribute to variations in the numbers recorded, complicating inter-annual comparisons. There is also often lack of clarity, for all colonial nesting species, as to what the reported numbers represent – birds present, pairs, apparently occupied sites, or actual nests. We need well-designed survey protocols to minimise these sources of error in the future. Not knowing the trends in species that are either ecologically important or which can serve as indicators of wider changes in ecosystem function can delay taking appropriate conservation action, potentially until it is too late or too costly to do so effectively. Sporadic population surveys and uncertain estimates amplify the problem.



Tākoketai / black petrel engaging with bait on line during foraging experiments (no hooks) Photo by Richard Robinson, Depth NZ / NNZST.

5.6 Are seabirds losing out to fishing?

From Threats to Seabirds of Northern Aotearoa New Zealand [1]

Globally, commercial fisheries have had significant impacts on seabird populations. Long-line, gillnet (or setnet) and trawl fisheries have been notorious for pelagic seabird by-catch and depleting fish stocks. Seabirds are opportunistic foragers and are often drawn to discards and offal from working fishing vessels, and will also attempt to dive after baits, hooking themselves or becoming entangled in the line. Hooked birds are dragged down and drown as the line sinks. Birds can also be hooked during the haul, when attempting to take uneaten bait off hooks. Seabirds may also become entangled in nets as they are being hauled in or collide with net cables in trawl fisheries. Diving species are caught in setnets or drifting gillnets and drown. By-catch of seabird species, particularly wide-ranging pelagic foragers such as albatrosses and large burrowing petrels has been well-documented [1]. Black petrels have been identified as the species nationally most at-risk from interactions with commercial fishing vessels throughout New Zealand's Economic Exclusion Zone (EEZ) in recent years. Another species of concern in the region is flesh-footed shearwater, also a commonly caught species that is at risk of decline, now the third-most at risk from fisheries in New Zealand [166].

Black petrel caught by bigeye longline fisheries between 2018-19. Photo released by Fisheries NZ.

Tākoketai / black petrel banding at night. Photo by Ed Marshall.

Tākoketai / black petrels on Aotea / Great Barrier Island

Elizabeth (Biz) Bell [1]

[1]*Wildlife Management International Ltd.*

Black petrels are recognised at greatest risk of being adversely impacted by high rates by-catch in commercial fisheries within New Zealand's Exclusive Economic Zone and unknown level of by-catch in South American and international waters.

Ongoing long-term population study at the Aotea colony since the 1995/96 breeding season has highlighted a lack of understanding of juvenile survival and recruitment despite high breeding occupancy and high breeding success within the study burrows. New survey techniques could be used to determine these juvenile survival and recruitment estimates more accurately.

Robust survey methods determined the black petrel population estimate on Aotea to be over 6,000 breeding pairs in the core 1,000 ha of habitat around Hirakimata. Similar surveys are required to estimate the black petrel breeding population on Te Hauturu-o-Toi / Little Barrier Island as well as repeated surveys on Aotea to determine the trend in the black petrel population.

Black petrels forage widely within northern New Zealand and migrate to a small area of the eastern Pacific, but additional tracking of all age classes and breeding stages would help understand the behaviour and foraging action of black petrels at sea, particularly around both commercial and recreational fishing vessels and how this relates to fishing operations and current mitigation action to protect black petrels and other seabirds.

Black petrels (*Procellaria parkinsoni*) are a medium–sized endemic seabird that only breed on Te Hauturu–o–Toi / Little Barrier Island) and Aotea / Great Barrier Island). Black petrels are known by the name of tākoketai by Ngāti Rehua Ngāti Wai ki Aotea, the tangata whenua and mana whenua of Aotea. Black petrels are ranked as Nationally Vulnerable under the New Zealand Threat Classification System and Vulnerable on the IUCN Red List of Threatened Species [91, 167]. They are recognised as the seabird species that is at greatest risk of being adversely impacted by high rates by-catch in commercial fisheries within New Zealand's EEZ [166]. Black petrels breeding on Aotea are also exposed to threats, principally depredation by cats (*Felis catus*), rats (*Rattus sp.*) and pigs (*Sus scrofa*) [168].

A long–term research project aimed at quantifying population parameters of black petrels was initiated in 1995–96 [169]. Between 1996 and 2000, nine 40 m x 40 m study grids were set up within the largest known breeding colony on Hirakimata / Mt Hobson on Aotea and all burrows within these grids were marked [169-171]. These grid burrows and additional study burrows located within 10 m of the public walking tracks totalling 476 black petrel burrows are monitored annually [172].

Over the 26-year study to date, the average breeding occupancy rate is 60.1%, with an average breeding success (chicks fledged from eggs laid) rate of 72.4%. On average, an additional 21.8% of burrows are visited by non-breeding black petrels each season. Despite fluctuations over the duration of the study, both breeding success and occupancy by breeding birds appear to have downward trends. The average age of black petrels within the study area has increased from 6-9 years to 12-13 years. Over 4,800 chicks have been banded at the Hirakimata colony since 1996, but only 351 have been recaptured at the colony. These recaptures represent between 6 and 14% of each cohort banded between 1995 and 2021 with the most chicks returning from the 2011/2012 breeding

Tākoketai / black petrel with satellite logger attached. Photo by Biz Bell.

Fishers working with Tākoketai / black petrel field team banding fledglings. Photo by Biz Bell.

season. More effort to recapture returning chicks is required to determine whether chick survival and recruitment rate back into the breeding population is low or the current poor information is a result of low search effort. Building on a recent successful trial [173], there is a possibility that at-sea captures could account for birds that are less likely to be caught during burrow monitoring. For example, immature individuals or those that have failed to attract/find a mate or birds that have a failed breeding attempt and have subsequently returned to sea. To monitor the ongoing population-level impacts of commercial fisheries on black petrels, it is necessary to estimate both adult and juvenile annual survival rates to create accurate assessments of population trends and status. Changes to the population structure and age of birds over time could impact the breeding success and longevity of the colony. It is recommended that this long-term study by monitoring study burrows at the Hirakimata colony continues to assess and quantify demographic parameters and trends of black petrels on Aotea. In addition, the breeding population of black petrels on Te Hauturu-o-Toi / Little Barrier Island should be part of a long-term monitoring programme to allow comparison with the population parameters of black petrels on Aotea.

An accurate estimate of the global population size and trend of black petrels, and in particular the number of mature breeding pairs, is a key piece of information required to assign an appropriate New Zealand Threat Classification ranking as well as the risk posed by commercial fisheries [45, 166, 174]. Breeding black petrels are unevenly distributed across Aotea, with significantly higher densities of breeding birds found on high-altitude ridges under mature, unlogged, and unburnt native forest with reduced pig activity than at lower altitudes or in other vegetation types on the island [175]. Previous population estimates were obtained using several methods with varying results [85, 176-178]. Currently the population estimate used for the NPOA risk assessment for black petrels is 4,627 breeding pairs [166]. However, between the 2018/2019 and 2020/2021 breeding seasons, distance sampling was used to generate a more robust estimate of occupied black petrel breeding burrows across high- and medium-grade habitat above 300 m asl on Aotea. Medium-grade habitat away from the core habitat around Hirakimata proved to have very low numbers of black petrel burrows suggesting that the main breeding population of black petrels is concentrated within the central area of the island, around Hirakimata, in areas over 300 m above sea level. The transect survey data from this central area estimated the population estimate for breeding black petrels on Aotea to be 6,350 breeding pairs or 12,700 breeding adults [83, 179, 180]. Further distance sample transect surveys within the core area would strengthen these population estimates as well as using alternative methods to detect and quantify sparsely distributed, low density black petrel burrows in other medium- and low-grade habitat across the island.

Black petrels forage widely around northern New Zealand, the southern Pacific and the Tasman Sea [83, 181-184] and are known to dive to at least 34 metres [185]. During the winter months, black petrels migrate to a relatively small area of the eastern Pacific, off the coasts of Ecuador and the Galapagos Islands [83, 183].

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Toanui / flesh-footed shearwater research around the Hauraki Gulf

Patrick Crowe[1]

[1]*Wildlife Management International Ltd.*

Toanui / flesh-footed shearwater remains a species at high risk from fisheries in New Zealand and globally.

Research is being undertaken on islands throughout the Hauraki Gulf under the direction of the DOC's Conservation Services Programme (CSP) to learn more about the breeding biology of the flesh-footed shearwaters and ascertain how many pairs breed in New Zealand and population trends.

Toanui / flesh-footed shearwaters are a familiar sight around fishing boats, with a tendency to dive after discards and baited hooks. Because of this behaviour they have high by-catch rates in both commercial and recreational fisheries. This presents the biggest quantifiable threat to the species and has potentially caused a decline in populations around New Zealand.

Flesh-footed shearwaters breed on islands around the Hauraki Gulf with significant colonies found on the Marotere / Chicken Islands and multiple islands in the Mercury Islands group. Long-term monitoring projects were established on Mauimua / Lady Alice Island and Ohinau Island in 2016. A network of over 250 study burrows was established on each island and biannual trips to each island undertaken to band and monitor flesh-footed shearwaters breeding within these burrows. Occupancy is relatively high with 75-80% of adults breeding annually. Breeding success is typically 50-60%. Nearly 5,000 individuals have been banded since 2016 including over 1,500 chicks prior to fledging. Recapture data will help to build knowledge of adult survival, juvenile survival/recruitment back to colonies, age-at-first-return and age-at-first-breeding. These are all key demographic parameters which can be input into population models to assess by-catch risk and population trends. So far only five birds banded as chicks have been recaptured on Ohinau Island marking an earliest age-at-first return of four and five years old. It is expected that a greater number of birds banded as chicks will be recaptured in the coming years.

To further assess the risk of by-catch in fisheries, GPS tracking of adults breeding on Lady Alice Island was undertaken in 2017 and 2018. In addition, simultaneous GPS tracking of breeding adults on Ohinau and Lady Alice Islands occurred during incubation and chick-rearing in 2020 to determine if there was inter-colony as well as intra- and inter- seasonal variation in at-sea distribution and behaviour of flesh-footed shearwaters. The average length of incubation foraging trips was 11.8 days and 4665 km for Ohinau Island birds and 16.6 days and 4734 km for Lady Alice Island birds. The average length of foraging trips during early chick-rearing was 3.1 days and 1205 km for Ohinau birds, and 4.8 days and 1536 km for Lady Alice birds. Individuals that were tracked multiple times during chick-rearing generally exhibited a dual foraging strategy; undertaking one or two short (1–3 days) chick-provisioning, trips followed by one longer (≥4 days) trip to maintain their own body weight and condition.

There was considerable overlap of foraging areas between Ohinau and Lady Alice birds indicating that birds from different populations mix at sea during the breeding season. All birds from Ohinau Island foraged either down the east coast of the North Island or out towards the Louisville Seamount/ Ridge. During incubation, nearly half of Lady Alice birds foraged in the same area as Ohinau Island birds, while the remaining birds foraged inshore off the west coast of the North Island or offshore in the Tasman Sea. During chick-rearing, areas closer to each of the colonies had greater importance but many individuals still utilised some of the more distant, and presumably more productive, foraging locations used during the incubation stage. New tracking data collected since 2017 will be used to improve estimates of the at-sea distribution and habitat use of adult flesh-footed shearwaters during the breeding season. These improved estimates can then be used to improve spatially explicit models of by-catch risk and be used to help determine mitigation measures to help reduce the incidence of by-catch of flesh-footed shearwaters. The migration routes of adult flesh-footed shearwaters during the non-breeding season and juveniles post-fledging are still poorly understood and it is recommended that further tracking of birds during these life stages is carried out.

In addition to long-term monitoring, comprehensive surveys were carried out between 2017 and 2021 at several breeding populations around northern New Zealand to estimate and update population sizes. Collated population estimates suggest that the New Zealand population is likely to be around 20,000-25,000 breeding pairs with the majority of these being in colonies around the Hauraki Gulf [173].

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Fishers checking burrows with toanui / flesh-footed shearwater team on Ohinau Island. Photo by Pat Crowe.

Tākapu colony, Mahuki Island, Aotea / Great Barrier group. Photo by Edin Whitehead.

5.7 Tākapu / Australasian gannet and partitioning the Gulf

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Based on comparisons of recent and historical counts, populations of tākapu / Australasian gannet in and around the Hauraki Gulf appear stable overall.

Tākapu attending chicks feed on a range of torpedo-shaped prey most notably on anchovy, arrow squid, jack mackerel and pilchard. Birds at the outer Gulf colony of Mahuki Island also typically include saury and flying fish, characteristic of more oceanic feeding than birds at the inner Gulf colony of Horohoru.

Birds forage largely within the Hauraki Gulf Marine Park but avoid shallow, turbid waters landward of the inner Gulf islands and the southern part of the Firth of Thames.

There is a striking partitioning of the Hauraki Gulf between Horuhoru birds utilising waters of the inner and mid Gulf and Mahuki birds utilising waters mostly to the north of this. Foraging areas overlap in patches presumed to have a superabundance of prey and that are at some distance from their respective colonies.

Although individual birds will repeatedly visit foraging hotspots over successive trips some individuals will similarly show repeated trips to specific locations outside of these suggesting individually specific feeding strategies.

The greater dependence of birds at Horuhoru on the increasingly degraded inner gulf may account for the shift in population distribution to Mahuki Island in the outer Gulf.

Tākapu / Australasian gannets are one of the most visible and recognisable of our region's seabirds. Their relatively large size, striking black/white patterning and golden caps combined with their spectacular plunge diving feeding technique provide a signal to the presence of forage fish and squid. These associations attract fishers because they generally also indicate the presence of larger target predatory fish. They also signal the presence of cetaceans which drive these forage species closer to the sea surface making them available to tākapu.

Tākapu status

In common with all seabirds, tākapu must incubate and raise chicks on land while making regular trips to sea to feed to meet the nutritional needs of themselves and their growing chicks. The islands of the Hauraki Gulf support six breeding colonies namely Horuhoru (off Waiheke Island), Mahuki (off Aotea / Great Barrier Island), Māori Rocks (Mokohinau Islands) and the Motukawao Group (Motukaramarama, Motutākupu , and an islet west of Motuwi, western Coromandel islands). Somewhat irregular and infrequent counts over the last four decades suggest little change in total numbers of tākapu in and around the Gulf but some shifts in the population distribution. Colonies in the inner Gulf have decreased in size but the largest colony (upward of 6000 pairs) on Mahuki Island in the outer Gulf has increased substantially probably as a combination of reduced disturbance, local growth and immigration from other colonies [118, 143].

Tākapu diet

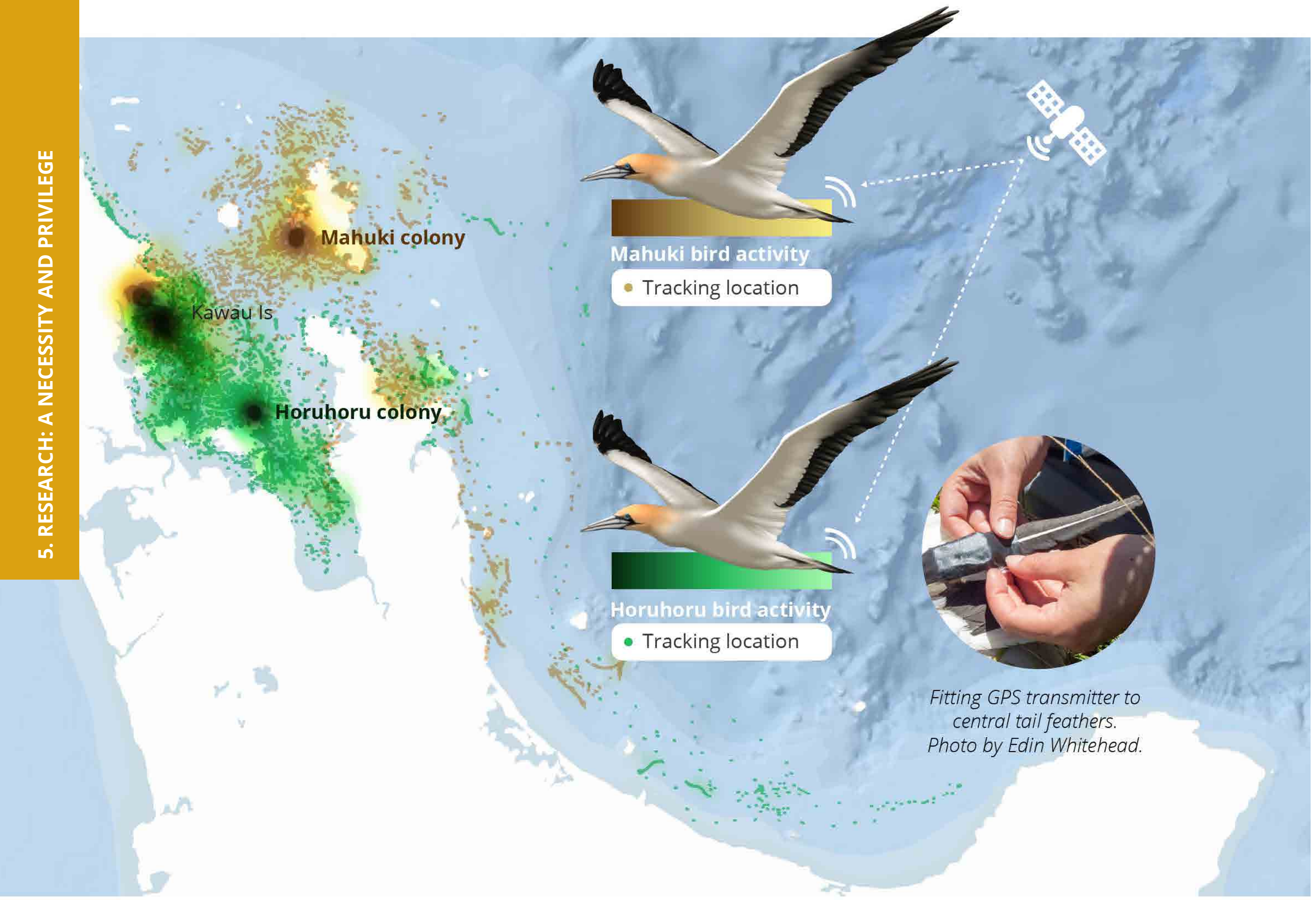
Tākapu are powerful fliers that when attending chicks collect food over trips that generally last one or two days. These birds generally remain inside of the continental shelf edge distributing foraging effort along the coast and in associated embayments. Consistent with historical studies, our recent studies have indicated that tākapu feed on a range of fusiform (torpedo-shaped) fish and squid that are known to school in coastal waters close to the sea surface. Collection of regurgitations from birds returning to nest sites in Northern New Zealand in the early 1980s showed birds feed predominantly on pilchard (*Sardinops neopilchardus*), other species included anchovy (*Engraulis australis*), saury (*Scomberesox saurus*), jack mackerel (*Trachurus novaezelandiae*), and squid (*Nototodarus spp.*) [186]. Our recent studies restricted to collection of samples from adults attending chicks at Mahuki Island in the outer Gulf and Horuhoru in the inner Gulf some 55 km to the south indicate a similar suite of species is taken. The five most frequently occurring forage species are anchovy, arrow squid, jack mackerel, pilchard and saury. Less important species include red bait (*Emmelichthys nitidus*), blue mackerel (*Scomber australasicus*), kahawai (*Arripis trutta*) and flying fish (*Exocoetidae*). Likely a reflection of the difficulty of swallowing, is the absence in tākapu diet of the laterally flattened (compressiform) fish, except for a small number of twin spotted demoiselles, (Chromis dispilus) less than 150 mm long. While we need to be cautious about interpretation because samples collected represent brief snapshots, time series of seabird diet data over time and comparisons among localities can highlight changes in the marine ecosystem due to prey-switching as availability of one species to another alters. Notable differences in the diet composition between historical collections and our more recent collections are the higher abundances of anchovy and the increased importance of jack mackerel and arrow squid. Marked changes within the recent diet series (2017 to 2020) was the replacement of the squid by redbait at Mahuki during the warm water anomaly of January 2018. The inter-colony differences between Mahuki and Horuhoru are characterised by the higher abundance of arrow squid (or red bait in 2018) and the presence of saury and flying fish in the diet of birds breeding at Mahuki Island. With a maximum ground speed in the order of 55 km/h and foraging trips lasting up to two or more days there is potential for substantial overlap in foraging areas by tākapu from the two colonies. These dietary differences are, however, likely a signal of Mahuki birds foraging in closer proximity to more oceanic waters consistent with the colony location and some separation of foraging areas.

Of the species taken by tākapu, three are also the target of the purse seine fishery within the region, namely jack mackerel, pilchard and blue mackerel. The size range of fish taken by tākapu is generally smaller than that targeted by the jack mackerel fishery but similar for pilchard and blue mackerel. Arrow squid are the target of a significant fishery, but this occurs outside of the Gulf caught by deep-water trawling and jigging in colder waters. If there is any local depletion of these fish species, we do not if and how this impacts tākapu. The severity of the impacts of this fishery on tākapu will likely be dependent on the availability of other forage species to tākapu and the persistence of patches of the locally depleted fish. These fish species are part of a larger population that exists outside of the Gulf and replacement from outside is possible.

General patterns of tākapu foraging

During breeding tākapu act as central place foragers constrained by the need to return to the nest to take over incubation shifts from their partners or to brood and feed chicks. Tracking of tākapu attending chicks at Mahuki and Horuhoru using GPS loggers confirmed that these birds utilise mainly coastal and inshore waters. Breeding tākapu attending chicks ranged mostly in the order of 40 to 65 kms from their respective colonies although some travelled up to 300 km. Foraging areas were largely within the boundaries of the Hauraki Gulf Marine Park namely in the confines of the Gulf itself and along the north-east coast of the Coromandel. Several birds from Mahuki (December 2020) and Horuhoru (December 2019) had trips that extended down the eastern coast of the Coromandel into the Bay of Plenty and as far east as Cape Runaway, remaining in coastal waters on both outward bound and return trips. Exceptionally a few birds from Mahuki island foraged out towards and beyond the edge of the continental shelf to the northwest and west of Aotea / Great Barrier Island. In spite of the of the close proximity of the Horuhoru colony, there were only small number of tracking locations landward of Waiheke, Rangitoto and Motutapu Islands, the southern part of the Firth of Thames and Waitematā Harbour. This may reflect avoidance by tākapu of shallow, highly turbid waters with potentially high volumes of boat traffic where prey is likely in low abundance and difficult to see.

Foraging areas of Tākapu from two colonies in 2019.
Spatially separated but with overlaps in areas of presumed high food abundance (near Kawau Island).



Fitting GPS transmitter to central tail feathers. Photo by Edin Whitehead.

Prey of Mahuki birds carry more oceanic signal
(December 2019)

Tākapu / Australasian gannet with saury. Photo by Edin Whitehead.

Tākapu colony specific foraging

Although not complete, the spatial separation of Hauraki Gulf utilised by GPS tagged tākapu rearing chicks from the adjacent colonies of Mahuki and Horuhoru is striking. During January and December 2019 and December 2020 most Mahuki-based birds avoided the inner Gulf staying mostly north of the Whangaparaoa Peninsula. During November and December 2019 when birds from both colonies were tracked simultaneously most locations of Horuhoru birds were concentrated in inner and mid Gulf and clearly avoiding waters within 20-25 km of the colony at Mahuki. Notwithstanding this separation, during November and December 2019 there was a significant area of overlap in locations of birds from both colonies centred in the mid Gulf area around Kawau Island both around 40 km from the birds respective breeding colonies. This presumed foraging hotspot persisted for the two to three weeks of the tracking period. This same area was utilised in November-December 2020 by birds foraging from Mahuki although activity hotspots were concentrated to the northwest of the colony. Another notable but smaller activity hotspot of birds from Mahuki island in both 2019 and 2020 was within the large embayment between Ahuaha (Great Mercury Island) and the northern eastern Coromandel. This area was also utilised by birds from Horuhoru in 2019.

While there is potential for foraging areas to overlap, likely under conditions in which patches of superabundance of prey develop, separation of the foraging areas from adjacent colonies has previously been noted in other seabirds including northern Gannets [186, 187]. Such separation will minimise inter-colony competition for food as birds from one colony do not utilise waters likely depleted by birds from the adjacent colony. Despite the proximity of the waters along north-western Coromandel to Horohoru the relatively low density of foraging birds from this colony may reflect these birds avoiding foraging in waters heavily utilised by tākapu breeding at islands in the Motukawao group. Similarly, more northern movement of tākapu at Mahuki may be constrained by birds avoiding the hinterland of tākapu colonies further to north particularly at Māori Rocks, Mokohinau Islands and Poor Knight Islands.

Individual tākapu foraging patterns

Tracking indicates that persistent foraging hotspots for tākapu can develop and once detected, result in birds returning on successive foraging trips. This was noted for a number of birds with individuals in December 2019 returning repeatedly to the hot spot around Kawau Island. However, some birds return repeatedly to locations outside of activity hotspots suggesting individual preferences for particular locations. Explanations of observed patterns may involve a combination of colony level foraging traditions which maintain the general spatial segregation of foraging areas between colonies [186, 187], information gained about the location of prey gained by observing other successful individuals and individual- memory of the location of previously successful foraging [187, 188].

Accounting for shifting tākapu populations

Foraging of tākapu from Mahuki and Horuhoru indicate birds attending chicks are confined mainly to the areas of the Hauraki Gulf Marine Park with substantial spatial segregation in their use of these waters. It is likely that tākapu utilising the west Coromandel will be similarly confined and foraging by these birds will likely fill the relatively thinly exploited coast around the north-western and northern coast of the Coromandel Peninsula. Accordingly, foraging and breeding performance of tākapu from even relatively close nearby colonies would act as localised indicators of marine conditions and may also account for the apparent shift in population distribution of the Gulf's tākapu population from the increasingly degraded inner Gulf to outer Gulf [143]. It is likely that a range of other seabird species that breed at multiple locations within the Gulf show similar segregation of foraging areas utilised and this should be an important consideration when considering management options in mitigating impacts of human activities and restoring ecosystem function.

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At start of transect, Rakino Island and The Noises below. Photo by Rochelle Constantine.

5.8 Aerial surveys: A large-scale birds-eye view of seabird distribution

Olivia N. P. Hamilton[1], *Rochelle Constantine*[1,2]

[1]*Institute of Marine Science, University of Auckland / Waipapa Taumata Rau;* [2]*School of Biological Sciences, University of Auckland / Waipapa Taumata Rau*

Aerial surveys are an effective method for conducting a comprehensive survey of seabirds in the Gulf.

The systematic sampling scheme enables us to cover a large portion of the Gulf, sample across the entire environment, and produce unbiased estimates of the surface density of several seabird species.

We recommend using an aircraft as the primary research platform for ongoing monitoring of seabird foraging in the Gulf.

Surveys should be conducted frequently and across years to gather a representative dataset to determine species-habitat relationships using more advanced modelling techniques.

Knowledge of species occurrences, distributions, and density is vital for wildlife conservation and management and for developing robust area-based management plans. Systematic line-transect aerial and shipboard surveys have proven successful for surveying populations and communities of large marine vertebrates to investigate distribution patterns on meaningful scales and produce local and regional estimates of density and abundance [189, 190]. However, obtaining a comprehensive dataset for large marine vertebrates is challenging as many species exhibit dispersion within and between habitats. Designating sufficiently large survey boundaries that can be assessed in a single survey and repeated across seasons is necessary to understand the environmental drivers of dispersal for marine species; this is achievable with an aircraft and in the future with large drones (UAVs).

Seabirds often move within their local habitat but also many migrate beyond New Zealand waters and therefore are exposed to a suite of risks stemming from terrestrial and marine-based human activities. There is a lack of coordination of conservation efforts between different countries to ensure adequate protection of critical habitat [191]. Birds at their breeding sites are typically easier to access compared to at-sea capture, but the information is often species-specific and focused on breeding ecology. At-sea studies are comparatively challenging because of complex field logistics and financial demands. Given that seabirds spend most of their lives at sea and the myriad of conservation issues at hand, local and regional studies of their at-sea distribution and abundance should be of a high conservation priority.

As part of a broader study on the abundance and distribution of large marine animals, we conducted aerial surveys along 16 transects in a Cessna 207, fixed-wing plane flying at 500ft (152m) and a speed of 100 kt (185km/h) from November 2013 to October 2014 (Fig. 21) [192]. A dedicated seabird observer joined the flights approximately once a month and collected data using strip transect methods, recording all seabirds within a 217m-width from the aircraft measured by markers on the wing of the plane. These methods assume perfect detection of seabirds within the strip width, which is challenging when you have diving seabirds or when the flock is too large to do an absolute count. However, we used these methods over methods that use distance data to estimate the proportion of undetected birds because measuring distance is time-consuming and is an infeasible task when the density and diversity of objects are high, which is often the case for seabird surveys [193]. For each sighting, the observer recorded 1) the species or lowest taxonomic grouping; 2) group size, and 3) group composition.

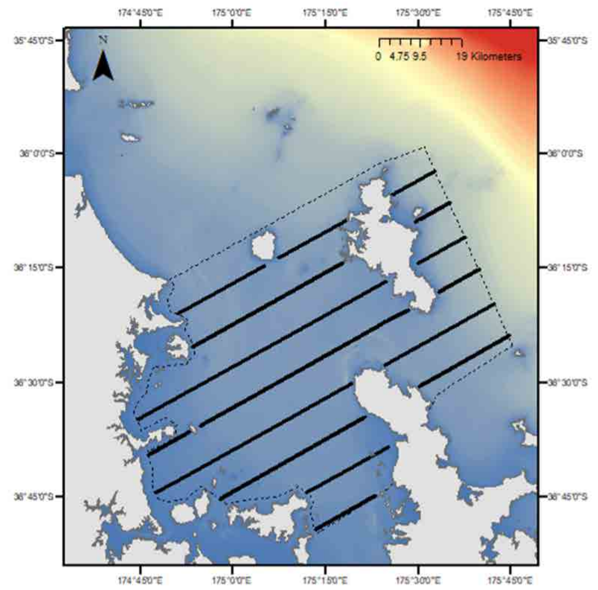

Figure 21. *Map of the Hauraki Gulf showing the transect lines (solid black). The dashed black line denotes the survey boundary. Bathymetry is shown in blue (shallow) to red (443 m maximum depth)* [192].

'On effort' during survey. Photo by Rochelle Constantine.

Tākapu / Australasian gannet work up south of Kawau Island. Photo by Clinton Duffy.

We modelled our seabird sightings data to try and determine which environmental variables could be used to predict where seabirds might be found. Unfortunately, this was not possible, probably because of the very high level of variation in seabird distribution and abundance throughout the Gulf and over the year-long study period. We used a model (kernel density estimation) to determine the core areas for nine seabird species (or clusters) by season. Here, we present two examples highlighting the value of data collected via aerial surveys, the seasonal kernel density maps of two contrasting seabird species, the tākapu / Australasian gannet (Fig. 22) and pakahā / fluttering shearwater (Fig. 23).

Aerial surveys were an effective method to rapidly cover a large geographic area and compile a comprehensive, multi-species dataset throughout the year. There were challenges associated with detecting and obtaining accurate counts of seabirds in areas where densities were high. These issues are typical when the research platform is an aircraft as the passage of travel is fast, necessitating rapid decision making. Under the current survey design, it was only possible to generate relative estimates of abundance and density. Future seabird surveys should utilise distance bands, i.e., sub-strips, which can be used as a proxy for distance data and therefore allow for the use of more advanced modelling techniques, thus improve the accuracy of density and abundance estimates.

To effectively survey the Gulf via aircraft – plane, drone, or helicopter – we suggest that dedicated seabird surveys occur on at least two surveys per month and across multiple years to sufficiently capture spatiotemporal patterns in distribution and facilitate an understanding of the large-scale environmental drivers. The Gulf supports a pelagic plankton-based ecosystem, with multi-species communities of large predators, including cetaceans, seabirds, sharks, and rays [192]. These communities have changed composition over the past ~10 years, which is most likely related to prey availability [194]. With seabirds highly vulnerable to environmental shifts, aerial surveys are a rapid and effective means to monitor changes to the seabird community in the Hauraki Gulf and inform conservation action. Long-term datasets will also be necessary to detect patterns in species-habitat relationships and identify critical seabird habitats.

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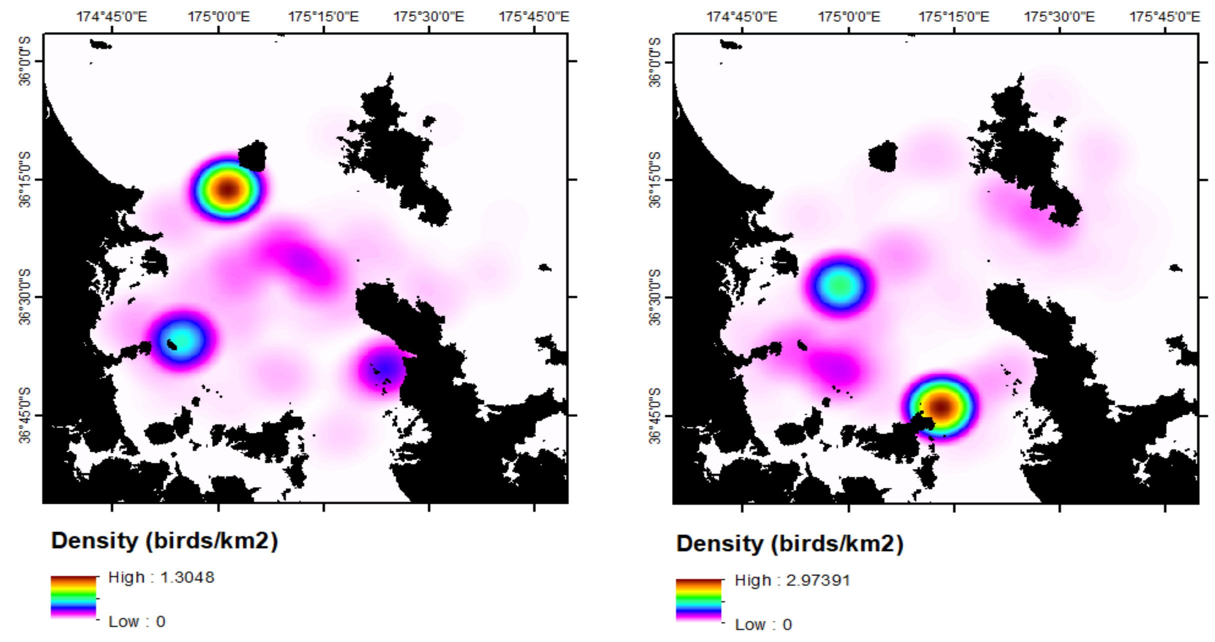

Figure 22. *Pakahā / fluttering shearwater density in spring-summer (left) & autumn winter (right) in the Hauraki Gulf.*

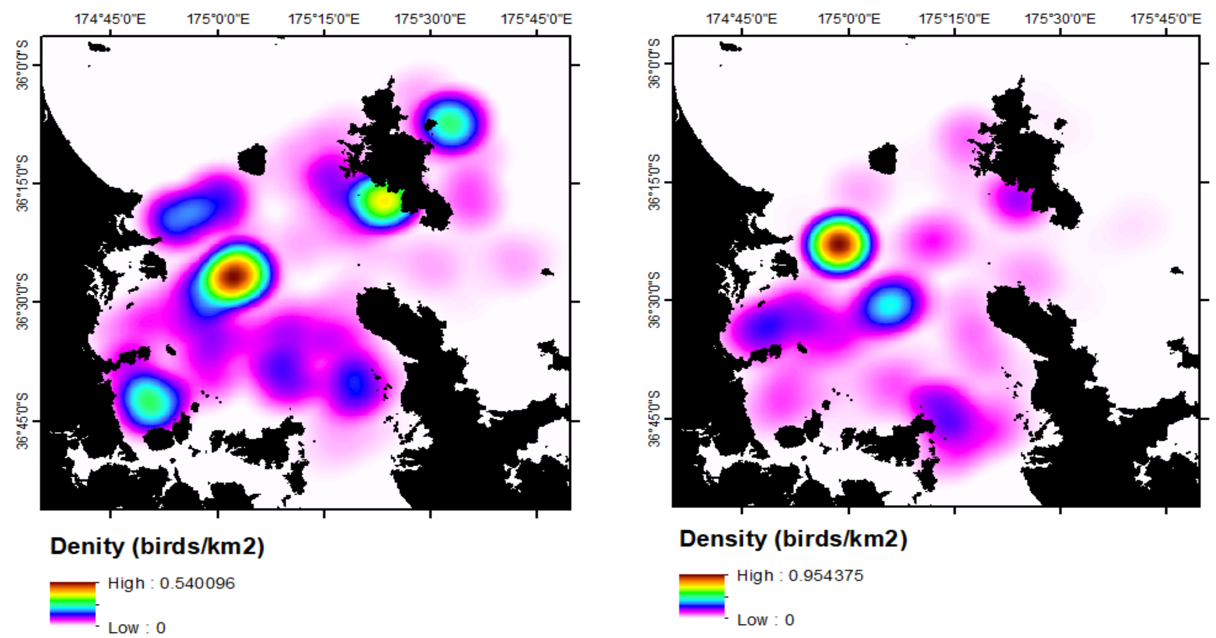

Figure 23. *Tākapu / Australasian gannet density in spring-summer (left) & autumn winter (right) in the Hauraki Gulf.*

Tākapu / Australasian gannets tracked, seen from above, and sideways!

Chris Gaskin[1]

[1]*Northern New Zealand Seabird Trust*

The previous sections show the value of complementary methods – GPS bird borne tracking of Australasian gannets in 2019 (Section 5.7) and aerial surveys in 2013-2014 (Section 5.8). Just how complementary these methods are can be seen in the maps derived from both sets of data for gannets showing a hotspot area just south and east of Kawau Island, despite the data being several years apart (see Section 5.7 (foraging) and Fig. 23). There is a third method used for understanding seabird foraging distribution. That from at-sea observations from boats following regular routes or transects over multiple years. Predictive modelling using seabird observations made in the outer Gulf from 2006 to 2013 were used to inform seabird distribution for the Hauraki Gulf Spatial Plan [195]. With an increase in data on seabird sightings, behavioural data and associations, future research modelling these aggregated datasets will be valuable in determining key habitats over a longer time frame. Future research should collect data on their survey tracks to allow for effort and sightings data to be factored into such analyses.

5.9 How adaptable are seabirds?

Chris Gaskin[1]

[1]*Northern New Zealand Seabird Trust*

There is a need to better understand the foraging distribution and behaviours and diet of several species during breeding and assess how any variability in foraging distribution and effort affects breeding success. Foraging plasticity by seabirds may buffer any potential impacts from changing prey distributions, not only through fisheries impacts but also climate change. As seabirds are long-lived and many are slow to mature, they may struggle to adapt to rapidly changing environmental conditions compared to species with shorter generation times. Also, burrow nesters (e.g., petrels, shearwaters, prions, little penguins) are extremely faithful to their colonies (natal site fidelity), which with prey-shifting could make the distances travelled to find food longer and unsustainable. Whereas surface nesters (e.g., gannets, gulls, terns) are better able to up stakes and set up nesting closer to their feeding grounds. The following examples look at how seabirds are coping with these changes.

Tākapu / Australasian gannets from two study colonies in the Hauraki Gulf appear to exhibit spatial separation in terms of foraging distributions, as described in Section 5.7. Recent aerial surveys [118] show there has been a marked increase of the population of the outer Gulf colony (Mahuki) with what appears to be a corresponding loss to inner Gulf populations (Horuhoru Rock and Motukawao Islands). Potentially, this reflects a changing distribution of certain food species between the inner and outer Gulf, species important for gannets and, also targeted by fisheries (e.g., pilchard, mackerel species, trevally, kahawai, saury).

Rako / Buller's shearwaters breed only on the Poor Knights Islands. While commonly seen within Hauraki Gulf, Northland, and Bay of Plenty waters, they also make long provisioning trips well beyond these areas. For the first few months of their breeding season Buller's shearwaters feed in close association with tightly packed trevally and kahawai, and the more mobile mackerel, work ups that are a major feature of north-eastern North Island waters. Then, from late January while provisioning chicks they follow tuna schools [41]. This foraging distribution, together with results of recent stable isotope studies showing feeding across three different trophic levels with krill, fish and squid identified in regurgitations [42, 196], suggests a degree of plasticity during breeding. Alternatively, given the discovery that they switch to following tuna, they target specific prey types at different stages of breeding, the same food that the tuna are pursuing.

Pakahā / fluttering shearwaters commonly forage around significant bathymetric and hydrodynamic features such as reefs, and around and between islands, within continental shelf waters in association with shoaling fish. Regurgitations from fluttering shearwaters show close correlation to the prey the fish are also feeding on (i.e., krill) [42, 196]. However, besides krill, fluttering shearwaters also feed on small bait fish, often feeding in association with fast-moving kahawai and skipjack tuna schools later in the season. Fluttering shearwaters breed across multiple sites in the inner and outer Hauraki Gulf, with the Taranga / Hen Island, Marotere / Chickens Islands and Mercury Islands their strongholds. These multiple sites allow us to monitor any differences in foraging effort and breeding success across the Hauraki Gulf.

Tītī wainui / fairy prions by contrast are something of a zooplankton specialist [196], although they do take larval fish. In northern New Zealand they breed only on the Poor Knights Islands in very large numbers. Their breeding success is largely dependent on their association with tightly packed schools of trevally, kahawai, and mackerel that we find around islands and prominent bathymetric features [42]. Any decline in occurrence and scale of these fish schools could impact heavily on this northern population.

Kororā / little penguins do not have the ability to fly and therefore are more restricted in their movements, most foraging trips are <24hrs when feeding chicks. As a visual forager their feeding can potentially be severely affected by increased turbidity during storm events. Also, with their foraging out from scattered small colonies along inhabited coastlines of the mainland and large islands (i.e., Aotea, and Waiheke and Kawau Islands) makes them susceptible to increase in toxic algal blooms in coastal waters from terrestrial runoff [118].

Kuaka / northern common diving petrels are another zooplankton and small fish specialist. However, unlike fairy prions, they do not associate with fish shoals. They are a central place forager with contrasting foraging behaviours to fairy prion, and, to lesser extent, fluttering shearwater. Recent tracking [74] has shown differences in foraging between birds breeding in the outer Gulf (Burgess Island, Mokohinau Group) and Tiritiri Matangi in the Inner Gulf (see Section 4.2, Fig. 9).

Tara / white-fronted terns are a visual forager and catch their prey (small fish, krill, and squid) close to the surface by aerial dipping. They can also move their nesting locations from season to season, unlike the burrow-nesting seabirds. Changes in prey availability and distribution may account for this ephemeral nesting behaviour, a case of the birds following the food [42].

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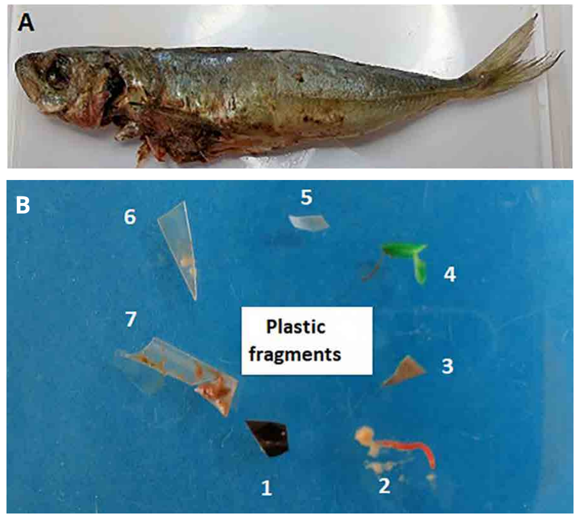
5.10 Unwelcome invasion – plastics in the Gulf

Plastic pollution is now ubiquitous through the world's oceans. This plastic debris ranges from large discarded manufactured products and fragments of these (macroplastics) and, with continued progressive break by mechanical abrasion and light, progressively smaller debris (so called meso-, micro- and nanoplastics). Smaller plastic debris also includes granules or pellets used in the production of plastic goods and abrasives used in cosmetics.

Depending on the nature of the plastic debris, marine organisms may get entangled or ingest this debris due to misdirected feeding. Ingestion may then cause partial blocking of the gut, disruption of digestion and a sensation of satiation. It may also be a route by which a range of toxic chemicals, those associated with the manufacture of plastics, or absorbed by these plastics may be introduced into the tissues of marine organisms. Reflecting the wide size range of this plastic debris direct ingestion may occur in organisms from zooplankton through to seabirds and marine top predators.



Jack mackerel recovered from tākapu regurgitation (A), and plastic fragments from fish stomach (B). Photos by Laith Jawad [249].

Pakahā / fluttering shearwater tangled in party balloon ribbon, found Pakiri Beach. Photo by Ian McLean.

Indirect plastic ingestion by tākapu / Australasian gannet

Nigel Adams [1], *Laith Jawad* [1], *Michel Nieuwoudt* [2]

[1] *Unitec Institute of Technology / Te Whare Wānanga o Wairaka,* [2] *University of Auckland / Waipapa Taumata Rau.*

Tākapu / Australasian gannets do not directly ingest plastic but can indirectly ingest it through the prey species they eat.

A diet study of gannets in the Hauraki Gulf found one jack mackerel with seven plastic fragments in its gut which would have been transferred to the gannet once consumed.

Tākapu visually detect free swimming neritic fish and squid of around 60 mm to 350 mm cm long which are then caught by a combination of plunge diving and underwater swimming. Accordingly, gannets are unlikely to directly ingest plastics. However, the potential for secondary ingestion of plastic is likely if the prey on which they feed contain plastics.

As part of a study examining the diet of tākapu in the Hauraki Gulf we also analysed the stomach contents of 25 specimens of the Jack mackerel *Trachurus declivis* recovered from the regurgitations of breeding tākapu attending chicks at their Mahuki Island colony. One of these fish, towards the maximum size of fish taken by gannets, contained seven plastic fragments classified as either mesoplastics (6 items: 5-25 mm) or microplastics (1 item >= 0.001 – 5 mm) of a composition that floats. It highly likely these were ingested by the fish while feeding in the surface waters of the Gulf before itself being targeted by a foraging tākapu.

Our study [249] represents a direct observation of micro and mesoplastics and any associated contaminants being transferred up the food chain to a marine top predator whose feeding behaviour precludes direct ingestion of plastics. Other top predators in the Gulf including predatory fish and marine mammals are also likely to accumulate plastics and their associated persistent organic pollutants (POPs) in the same way. Furthermore, as Jack mackerel is the target of a commercial fishery in New Zealand waters, it indicates an avenue for the transfer of contaminated fish tissue to humans. The full extent and health implications of such ingestion for both marine organisms and people are not yet clear and warrant future investigation.

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5.11 Seabird fallout – the downside of bright city lights

Kerry Lukies[1]

[1]*Northern New Zealand Seabird Trust*

Artificial light at night can cause nocturnally active seabirds to become disorientated, exhausted, and can cause injury or mortality from light-induced collisions.

Just over half of the seabird species breeding in the region are vulnerable to light-induced collisions.

The increasing use of LED lighting (e.g., streetlights, external building lightings) in Auckland means that light-induced collisions of nocturnal seabirds in the region are likely to increase.

Artificial light at night (ALAN) can negatively impact the behaviour of nocturnally active seabirds by causing disorientation, exhaustion, and injury or mortality from light-induced collisions. Light attraction and disorientation are well documented in nocturnally active seabirds and ALAN has been found to disproportionately affect some petrels, prions, shearwaters, diving petrels, and storm petrels, and especially fledglings on their maiden flight [197-199].

Nocturnal seabirds have special adaptations that allow them to see in low light levels and it is this visual system that makes seabirds sensitive to short wavelength blue light (including white light), such as the light produced by LEDs [200-202]. There is a global shift toward the use of LED lights (e.g. as street lights) due to their energy-efficiency, but this may have a negative impact on nocturnally active seabirds due to their sensitivity to blue light (reviewed in [203]). Seabirds appear more attracted to artificial light on misty nights as water droplets in the air refract light and increase the lit-up area which can attract a higher number of birds [198, 204, 205].

Many of the seabirds in the wider Hauraki Gulf region are vulnerable to light-induced collisions. While most of these species breed on uninhabited offshore islands, birds may be attracted to brightly lit areas on the mainland (e.g. Auckland CBD) or to vessels as they pass or are anchored nearby [1]. Juvenile tītī / Cook's petrels are frequently grounded by lights in Auckland city and its northern suburbs [131, 206]. During the fledging period in March-April 2021, 148 juvenile Cook's petrels that were found grounded by artificial lights throughout Auckland were admitted to BirdCare Aotearoa [207]. As streetlights in Auckland continue to get upgraded to LEDs and ALAN remains unregulated in coastal areas, the light-induced collisions of nocturnal seabirds in the region are likely to increase.

ENDS

Lights of cruise ship sailing north, seen from Mokohinau Islands. Photo by Edin Whitehead.

Lights of Marsden Point and Ruakaka from Taranga / Hen Island. Photo by Edin Whitehead.

Washing a soiled tītī / Cook's petrel grounded by artificial light in Auckland city at BirdCare Aotearoa to help restore waterproofing. Photo by Dani Najera.

BirdCare Aotearoa

Seabirds found grounded by artificial light in Auckland should be taken to BirdCare Aotearoa (74 Avonleigh Road, Green Bay) or Native Bird Rescue (Waiheke Island) for rehabilitation.

Locations and time/date of where and when birds are found to be entered into a database and mapped to try and detect hotspot areas for fall out.

Extract from Pollution poster from the bilingual Threats to Seabirds poster series, NNZST. Artwork by Giselle Clarkson, text by Edin Whitehead.

Patrolling Pakiri Beach. Photo by Stefan Marks.

5.12 Beach patrols

Ian McLean [1]

[1] *Auckland Regional Representative, Birds New Zealand*

Data from the Pakiri beach patrols will help to confirm what species of seabirds regularly occur in the Hauraki Gulf waters, whilst providing some insights into the challenges they face.

This includes, recording of any mass seabird mortality events known as 'wrecks'. A 'wreck' is a period of exceptionally high mortality, sometimes involving just one species, or at other times of several species.

"Wrecks' may be caused by storms catching young birds a few days after leaving their nests, some are because of food shortage caused by climatic conditions, whilst other causes may include avian disease, biotoxins or pollutants.

Recording of any unnatural deaths due to fisheries by-catch, vandalism and litter is also very important, to help determine over time if these threats to our seabirds are increasing.

The Birds New Zealand Beach Patrol Scheme started in 1951 to establish a database of the wide range of seabird species occurring in New Zealand waters, including their distribution and abundance.

The Auckland Region of Birds New Zealand has undertaken regular beach patrols of Muriwai Beach on the west coast since 1960, with patrols 11 times a year (a monthly patrol from February to December). For many years beach patrols of Pakiri Beach (14 kms) on the east coast were largely irregular and ad hoc. In October of 2016, the Auckland Region decided to undertake two patrols of Pakiri Beach each year, with one in April or May and another in October. The data collected would provide information on the species occurring within the Hauraki Gulf, whilst providing a comparison to those species found on the west coast at Muriwai Beach.

Between October 2016 and June 2021, 9 out of 10 planned Pakiri Beach Patrols have taken place, (due to Covid 19 restrictions only one beach patrol could take place in 2020). A total of 27 species were found, including 20 species of seabird and 7 land bird species (Table 7).

Two toanui / flesh-footed shearwaters, having died after entanglement with fishing line. Photo by Karen Baird.

Species	Total
Seabirds	
Little penguin	51
Fluttering shearwater	47
Common diving petrel	33
Flesh-footed shearwater	25
Fairy prion	18
Buller's shearwater	11
Australasian gannet	9
Cook's petrel	8
Antarctic prion	7
Grey-faced petrel	6
Sooty shearwater	6
Pied shag	4
Black-backed gull	4
Hutton's shearwater	3
Red-billed gull	3
Little shearwater	2
Prion sp.	2
White-fronted tern	2
White-faced storm petrel	1
Slender-billed prion	1
Shearwater sp.	1
White-capped albatross	1
Land birds	
Australian magpie	6
North Island kākā	3
Pukeko	2
Tui	2
Mallard duck	1
Ring-necked pheasant	1
Domestic pigeon	1

Table 7. *A summary of the bird species and numbers found on 9 beach patrols on Pakiri Beach between October 2016 and June 2021.*

A detailed comparison is yet to be undertaken with results from our west coast patrol at Muriwai Beach where tube-nosed seabirds wash up frequently. However, breeding Hauraki Gulf species predominate at Pakiri Beach, there are few subantarctic species; only a single albatross and 7 Antarctic prions were found.

The little penguin is the most common species to be beach wrecked (51 birds) of which 36 were found wrecked in May 2018. Other species found in small wrecks include the flesh-footed shearwater (13 found on October 2020) and fluttering shearwater (16 also found in October 2020).

Several birds had died unnatural deaths:

- One black-backed gull was hooked and tangled in fishing line.
- One fluttering shearwater had both wings cut off at the carpal joint.
- Two black-backed gulls had been run over by an off-road vehicle.
- One fluttering shearwater was entangled in a balloon streamer with the remains of the balloon still attached.

Most unusually, two North Island kākā were found in April of 2019. The birds were less than 10 metres apart and were a male and a female bird as sexed from their different bill profiles. It seems that they had died whilst travelling between that mainland and a Hauraki Gulf island. Their remains where sent to Massey University for analysis, but no cause of death could be determined, due to the advanced state of decomposition.

Birds Auckland aims to continue regular patrols of Pakiri Beach to add to the database of beach wrecked birds and contribute to our knowledge of the seabirds of the Hauraki Gulf.

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Checking a ōi / grey-faced petrel beak against the profile diagram in manual. Photo by Ian McLean.

Details of the Beach Patrol Scheme can be found on the Birds New Zealand website: https://www.birdsnz.org.nz/schemes/beachpatrolscheme/

E AHA ANA TĀTOU? HE AHA NGĀ HUA? E TITIRO WHAKAMUA ANA.

WHAT ARE WE DOING? HOW WELL ARE WE DOING? LOOKING TO THE FUTURE.

Photo by Edin Whitehead.

NGĀ MAHI WHĀOMOOMO
6. CONSERVATION ACTIONS

Chicks are the most vulnerable to rat predation, takahikare-moana / white-faced storm petrel chick, Ruapuke / Maria Island, The Noises. Photo by Megan Friesen.

6.1 Safeguarding our treasures – island biosecurity

James Russell[1], with Pete Corson[2], Andrew Veale[3], Zachary Carter[1]

[1] School of Biological Sciences, University of Auckland / Waipapa Taumata Rau; [2] Quality Conservation; [3] Manaaki Whenua Landcare Research

Effective island biosecurity is the key to maintaining the natural values of the Hauraki Gulf's islands.

Agencies, commercial operators, users of the Gulf, and the public need to commit to the tikanga of keeping the islands pest free.

Eradication of introduced mammalian predators and herbivores has restored mammalian pest-free habitat to over half the island groups of the Hauraki Gulf. Every pest-free island is at risk of reinvasion and invaders that are left unchecked can rapidly decimate seabird colonies. The invasion of only a few Norway rats on to Ruapuke / Maria Island in 1959 led to the wholesale slaughter of hundreds of the resident white-faced storm petrel population, motivating the first eradication of rats in New Zealand the following year. Today, the biosecurity threats to islands are both large and small, including the spread of disease and microorganisms such as kauri dieback and myrtle rust. Participation in and adherence to rigorous island biosecurity protocols is required by all visitors to islands, not just to prevent eradicated animal and plant species reinvading, but equally as importantly, to prevent the introduction of new biosecurity threats.

Island biosecurity is the combination of actions that are undertaken to stop pests from getting to islands or from establishing populations on islands. It is as much a mind-set, a tikanga, as it is a rule book. The key elements of island biosecurity are advocacy/education, quarantine (pest prevention), surveillance, and incursion response. The first two are undertaken prior to departure/arrival, whereas the latter two are on-island activities. Advocacy/education attempts to inform people about pests, and values, to influence behaviours. Quarantine, or pest prevention, are the actions to minimise the chance of spreading pests, including inspections or checks of goods, choosing low-risk suppliers, or using operators with good biosecurity practices. A large effort is required to ensure pests are prevented from reaching islands. Stopping pests from getting to islands is the best use of resources. However, incursions are a reality and will continue. Surveillance is used to detect if there has been a breach of a pest onto an island. Normally, this involves a network of detection devices that are regularly checked with additional use of detection dogs and trained observers. Incursion response is about managing for any pest that has, or is suspected to have, arrived on the island. This includes preparation such as planning, training, preparing equipment and having pre considered agreements with stakeholders. Incursion response is the ambulance at the bottom of the hill and is an expensive and risky way of managing pests. Island Biosecurity is an ongoing commitment if we want to have pest-free islands.

Over the past twenty years biosecurity on Hauraki Gulf Islands has intercepted dozens of mammal incursions alone. Most of these incursions are by swimming rodents and mustelids (i.e., stoats, weasels and ferrets) but also include animals hitch-hiking on both large and small vessels. The damage of unchecked incursions can be rapid, and where breeding populations establish the hard-won gains from island eradications have been undone in less than a year. Contingency response must be undertaken with the same urgency and determination as wildfire or civil defence emergency. Biosecurity requires partnership between managing agencies, transport providers, concessionaires, and visitors. Substantial resources must be committed to perpetual vigilance and to this extent, biosecurity is well modelled by an actuarial insurance model of an annual fee (for surveillance) with an occasional, and typically unpredictable, large pay-out (for contingency response).

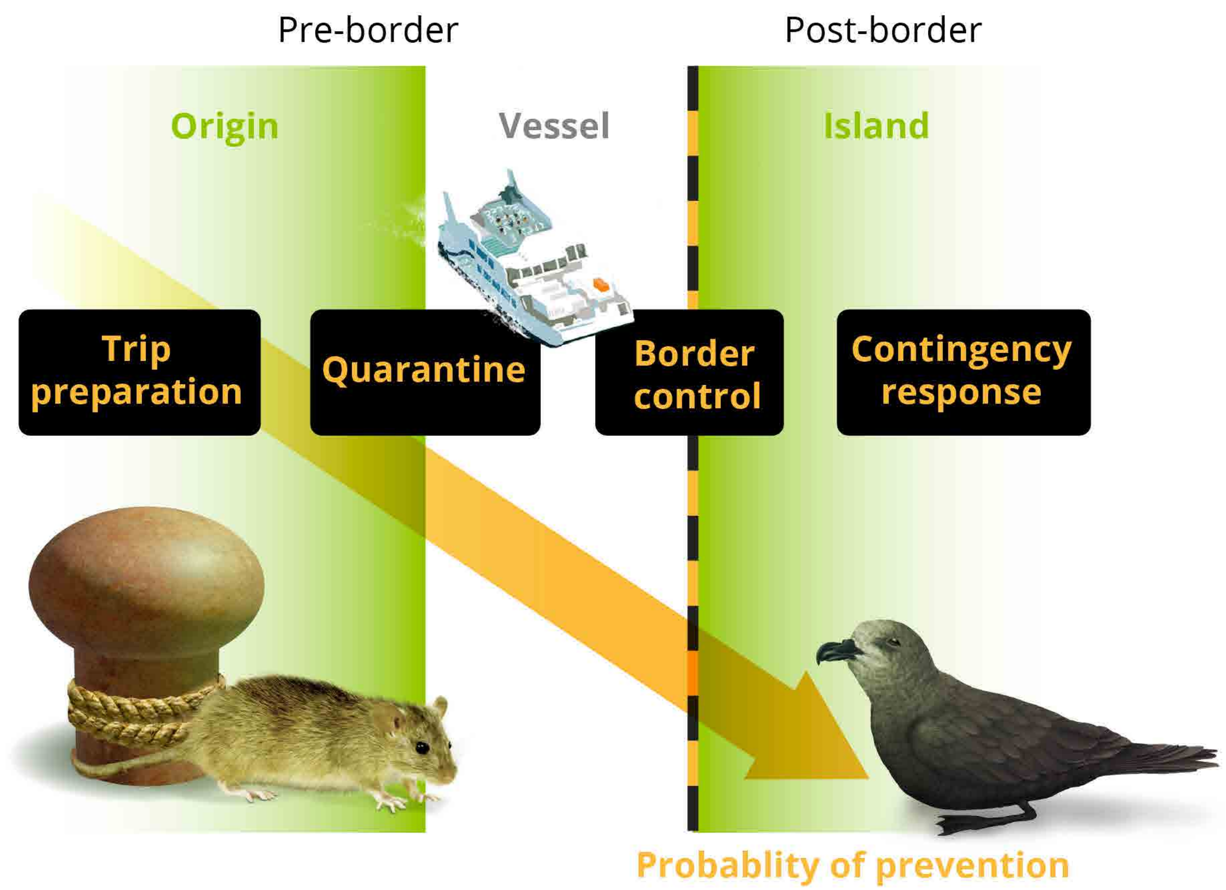

Figure 24. *To safeguard our island treasures all boat operators need to make sure their boats are pest-free, and so lessen the risk of incursions requiring costly eradications.*

Although invasive mammalian predators are the primary threat to seabirds on islands, other invasive species and disease pose major, and less well understood, threats. Invasive plants modify seabird nesting habitat, invasive ants disturb nesting adults and kill fledglings, and zoonotic diseases pose a growing risk to seabirds. These organisms are spread incredibly easily and can be disseminated in the pockets of jackets and backpacks, or on the underside of boots and tents.

They are also extremely difficult and expensive to control or eradicate. For some pest species there is no method to remove them once established. Most of the invasive plants and microorganisms found in New Zealand are not yet on our islands, and to keep this status every visitor to any island should strive for the highest level of biosecurity cleanliness. The biosecurity protocols in place around the Auckland region to manage kauri dieback set a minimum standard for visitors to islands, encouraging all outdoor clothing and equipment be clean of dirt and substrates and sterilised by disinfectant. As learnt during the COVID pandemic of 2020, pre-border prevention is far superior to post-border management. At the same time, the pandemic also taught that, when border incursions occur, a swift response can enable re-eradication.

With increased pest-control at sites within large islands and the mainland, predator-suppressed habitat is beginning to emulate the opportunities found on offshore islands, creating new possibilities for seabird recovery. The forests of Aotea / Great Barrier Island, Waitakere, Hunua and Moehau (Coromandel Peninsula) promise great returns for seabirds if reinvasion by pests, particularly cats, mustelids, and rats can be minimised. These forests were once home to many of the seabird species now found only on our small predator-free offshore islands. The Predator Free New Zealand movement excites the tantalising possibility of these species once again being found across their historic ranges, from the mountains to the sea.

ENDS

Fisheries liaison officer discussing mitigation equipment (tori line) with a long-line skipper. Photo supplied by DOC.

6.2 Reducing seabird by-catch

Long-line and trawl fisheries are reported to be responsible for most seabird by-catch in New Zealand. The high likelihood of overlap between seabird foraging and fisheries predicted for New Zealand waters, is one explanation for the by-catch in New Zealand fisheries [1]. Several measures have been adopted to reduce the levels of seabird by-catch, including the Protected Species Fisheries Liaison Programme (DOC), and cameras on fishing vessels (Fisheries New Zealand). With respect to the recreational fishery, Southern Seabird Solutions has produced resources to highlight the risk, and to provide guides to best practice for handling hooked birds.

Protected Species Fisheries Liaison Programme

Adapted from Liaison Programme Annual Report 2021 [208]

The Protected Species Liaison Project began in 2014-15 with an aim to increase the uptake of best practice mitigation for inshore and Highly Migratory Species (HMS) fishing vessels.

The Liaison Project currently has three Liaison Officers (LOs) in and around the Hauraki Gulf.

A key role of the LOs deployed on vessels is to support and educate fishers on recommended mitigation strategies and develop vessel-specific Protected Species Risk Management Plans (PSRMPs).

To effectively reduce the risk of interactions with protected species, it is important for fishing vessels to be using best practice mitigation and to follow steps laid out by both regulatory and non-regulatory measures. With the support of Fisheries Inshore New Zealand (FINZ), the DOC Conservation Services Programme (CSP) Protected Species Liaison Programme aims to increase uptake of best practice by-catch mitigation for inshore and Highly Migratory Species (HMS) fishing vessels. This will be achieved by building one-on-one relationships, providing advice, and providing fishers with protected species information.

The Liaison Programme began in 2014-15 with a focus on surface and bottom long liners. Over the years the programme has expanded to include inshore trawl and set net fleets, with opportunistic engagement in dredging, jig and Danish seine fisheries.

A fundamental component of the Liaison Programme is the deployment of Liaison Officers (LOs). Their role is to support and educate fishers on recommended mitigation strategies and develop vessel-specific Protected Species Risk Management Plans (PSRMPs). Liaison Officers also provide a vital interface between skippers, government, and researchers. The programme's Liaison Coordinator manages liaison activities, organises and provides materials, manages data from LO-fisher interactions, and ensures there is follow-up with vessel operators (especially regarding trigger point events and observer audits).

The Liaison Programme currently has five Liaison Officers (LOs), three of these are based in the region: one covering Northland, Leigh and the Coromandel, a second for Auckland, Bay of Plenty, Napier and Gisborne), and a third for harbour set netting for Auckland/Northland. The programme is currently working to improve harbour and coastal set net coverage and bring in Purse Seine (mostly Tauranga-based).

	No PSRMP on board	Yes, PSRMP on board	Total Active Vessels in FMA1 (2019-20)
Bottom Long Line	3	44	47
Surface Long Line	0	23	23
Trawl	0	13	13
Set Net	77	1	78

Table 8. *Protected Species Risk Management Plan (PSRMP) coverage for the inshore and Highly Migratory Species (HMS) fleets in Fisheries Management Area 1 (FMA1), in the 2019-2020 fishing year NB:2020-2021 fishing year is still in progress.*

Inter-agency collaboration is critical to the success of the Liaison Programme. Regulatory compliance checks by Fisheries Officers and non-regulatory auditing of PSRMPs by FNZ Fisheries Observers verify the steps that the vessel is taking to meet mitigation measures and serves to highlight areas for improvement. Additionally, the notification of trigger points (notable protected species captures) from fishers and MPI help the Liaison Programme and its LOs work through potential improvements in fishing practices. Inter-agency information flow and process maps will be updated for the coming year and reflected in the Liaison Programme manual.

The National Plan of Action – Seabirds 2020 [174] outlines a suite of Mitigation Standards that will be implemented for each relevant fishing method and will be reviewed annually by the Seabird Advisory Group (SAG). The Liaison Programme will play a central role in the implementation of these standards through the development of PSRMPs on each vessel. PSRMPs reflect how vessels demonstrate the use of best practice mitigation and includes actions to reduce or eliminate captures of other protected species taxa (e.g., marine mammals, turtles, sharks and rays) as relevant to the fishery.

Roll out of cameras on fishing vessels

Supplied by Fisheries New Zealand

In July 2021 the Minister for Oceans and Fisheries announced up to 300 inshore commercial fishing vessels will be fitted with on-board cameras by 2024 to monitor the bycatch of non-target species such as Hector's and Māui dolphins, black petrels, and Antipodean albatross.

The use of cameras was trailed in north-east New Zealand from 2015 to 2019 with a focus on the inshore trawl and longline fisheries targeting snapper. Trialling showed that fisher-reported seabird captures increased when cameras were in operation. A similar result was seen when cameras were installed on some fishing vessels that operate in Māui dolphin habitat.

When complete, the wider rollout of electronic monitoring using cameras will record activity on vessels responsible for about 85 per cent of the inshore catch by volume.

In July 2021 the Minister for Oceans and Fisheries, Hon David Parker announced up to 300 inshore commercial fishing vessels will be fitted with on-board cameras by 2024 as part of the Government's commitment to protect the natural marine environment for future generations.

Achieving adequate levels of observer coverage in inshore fisheries has been a challenge; current levels are often not sufficient to allow robust estimates from models and this limits the opportunities to evaluate the success of management measures. Traditional fisheries observer programmes tend to be cost-heavy, requiring significant resource input. The search for alternative, smart technological monitoring tools, that complement the existing observer services programme and provide confidence in the use of data from fisher self-reporting, led to the implementation of trials of Electronic Monitoring (EM).

The use of EM as a serious alternative to human fisheries observers is relatively recent in New Zealand fisheries, although trials were initiated in the early 2000s. From 2015 to 2019 a variety of video observation programmes were carried out with a focus on the inshore trawl and longline fisheries targeting snapper in Fisheries Management Area (FMA) 1, off the north-east of New Zealand.

The longline fishery trial in FMA 1, known as the black petrel EM project, has been the longest running camera programme in New Zealand and has been run in partnership between industry and government. The key aim has been to assess whether EM is a valid approach for monitoring seabirds captured on hooks. The haul of the catch is recorded using cameras onboard participating vessels, and the footage subsequently reviewed. Subsequent analysis of the reviewed footage found that fisher-reported seabird captures increased by a factor of two.

To support monitoring of fishing interactions with the critically endangered Māui dolphin, New Zealand implemented its first compulsory EM programme along the West Coast North Island (WCNI) between Whanganui and Kaitāia. As of 1 November 2019, inshore fishers using trawlers less than 29 metres long and set netters longer than 8 metres with a history of fishing in the area were mandated to carry cameras whilst fishing. This area represents the highest density of Māui dolphin distribution, as well as some low-density areas and potential habitat. This fishing footage is reviewed for protected species interactions (primarily for encounters with Māui dolphins but also including seabirds). Information collected from these footage reviews is then reconciled with fisher reporting to assess compliance to reporting regulations. The success of this EM programme has been used as the 'proof of concept' for the planned wider rollout of cameras in the New Zealand inshore fleet.

The wider roll-out announced in 2021 will be staged to prioritise those vessels that pose the greatest fisheries risk to protected species such as Hector's and Māui dolphins, black petrels, and Antipodean albatross. When complete, cameras will record activity on vessels responsible for about 85 per cent of the inshore catch by volume. The cost of the roll-out is expected to be $68 million over the next four years.

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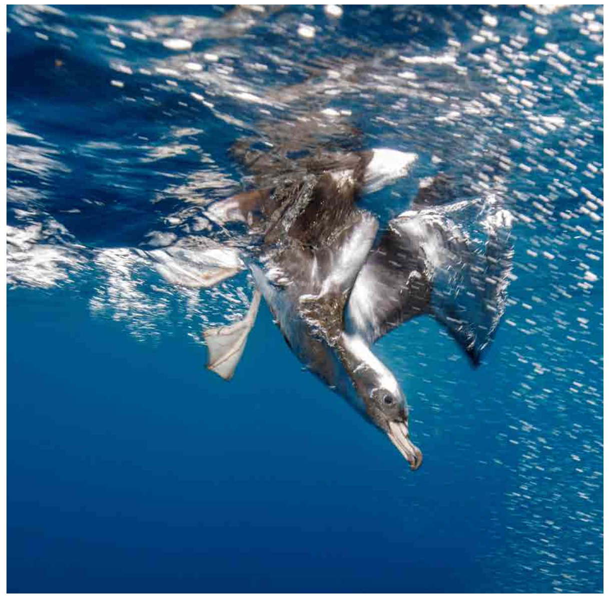
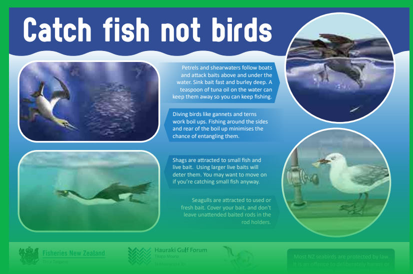


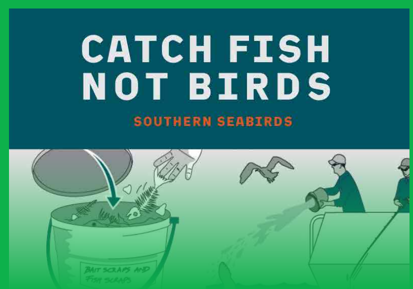
Toanui / flesh-footed shearwater chasing after bait underwater. Photo by Richard Robinson, Depth NZ.

Southern Seabird Solutions

Resources for recreational fishers



https://www.catchfishnotbirds.nz/post/poster-bird-behaviour-in-the-hauraki-gulf



https://www.catchfishnotbirds.nz/post/how-to-avoid-seabirds

https://www.catchfishnotbirds.nz/post/how-to-handle-a-seabird

Burrow-scoping for kororā / little penguins, Motuihe. Photo by Edin Whitehead.

6.3 Restoring resilience: seabird restoration

Kerry Lukies[1]

[1] *Northern New Zealand Seabird Trust*

Seabird populations have declined for a variety of reasons, primarily human-induced threats such as harvesting, habitat modification and introduced predators.

There are increasing opportunities to restore seabird populations as pest control efforts are expanded and enhanced in coastal areas by community groups, iwi, and local residents.

Restoring seabird populations can strengthen ecosystem resilience by re-establishing marine-derived nutrient input which is crucial when restoring islands and some mainland areas to fully functioning ecosystems.

Restored seabird populations present additional cultural, social and economic benefits to communities.

As we've seen, seabirds provide a vital link between land and sea by transporting marine-derived nutrients to terrestrial environments, a vital component of the ecosystems within which they reside (see Section 2.5 The nature of seabird islands).

Historically, seabirds would have been found throughout coastal Aotearoa New Zealand and on some inland mountain ranges. Habitat modification through burning, clearing for agricultural crops and livestock grazing, urbanisation, harvesting, and introduced predators have caused the local extinctions of many seabird colonies. Thirty-three of the 36 burrow and surface nesting petrel species in New Zealand have experienced a range-reduction due to human activities, primarily predation by introduced mammals, and consequently few inland burrowing seabird colonies still exist. It is because of the vast reduction in the distribution and abundance of seabird colonies that seabird-driven ecosystem processes such as marine nutrient input and cycling have been lost from much of New Zealand's coastline and areas of hinterland, rendering them less productive than they were in pre-human times.

An increasing number of New Zealanders are involved in predator eradication and habitat restoration activities throughout the country as the adverse effects of invasive predators on native species become more widely known. Community efforts have contributed to the predator-free status of many islands and an increasing number of mainland locations in Auckland where seabird colonies have re-established. Many of these islands and mainland sanctuaries are in public ownership and are managed by community groups in collaboration with Auckland Council (e.g., Tāwharanui Regional Park, Shakespear Regional Park) or DOC (e.g., the islands of Motuihe, Tiritiri Matangi and Motuora). Not all islands are publicly owned, however, with more than half of the islands in northeast Aotearoa New Zealand in private or

Māori ownership. Additionally, one-quarter of the 600 community environmental groups in Aotearoa New Zealand work to restore private, rather than public land. Given this, as more pest-free sites are established on privately owned or Māori land, the opportunity arises for more community-led seabird restoration projects on islands and the mainland.

Seabird restoration may occur for a variety of reasons: to re-establish populations to historic breeding sites, encourage breeding at locations recently cleared of pests, establish multiple breeding colonies of several species, prevent extinction, restore ecosystem function and resilience, or to restore cultural links. The poor conservation status and great diversity of seabirds in Auckland make their conservation a regional priority. Fortunately, many practical, cost-effective techniques exist for seabird restoration.

The role of seabird-driven ecosystem functioning has become better understood over the last fifty years, inducing a shift from species-specific restoration to a more holistic ecosystem-based approach. Seabird restoration can strengthen ecosystem resilience by re-establishing marine-derived nutrient input which is crucial when restoring islands and some mainland areas to fully functioning ecosystems. The restoration process takes time, but ultimately results in long-term ecological benefits for both the seabirds themselves and terrestrial ecosystems.

While most restoration projects will have an ecological focus, seabird restoration can present additional cultural, social and economic benefits to communities. Accessible seabird colonies can provide opportunities for education, community engagement and a connection to nature. Seabird restoration can benefit communities through ecotourism opportunities, for example, the tours to the Cape Kidnappers Australasian gannet colony [209] or visits to the only mainland colony of Royal Albatross at Taiaroa Head [210]. Some iwi would like to see seabird populations return to a level that creates cultural cohesion and restores cultural traditions.

Following the removal or exclusion of invasive predators, the restoration of seabird populations can be achieved through passive or active management. Passive restoration is based on the principle of removing the threat and letting the natural system restore itself, which in the context of seabirds means leaving populations to recover or recolonise an area without further human intervention. This differs from active restoration, where recovery is manipulated to encourage settlement. There has been a shift toward active management over the last few decades as the understanding of how seabird species respond to different management techniques has grown. Additionally, passive restoration may not sufficiently restore seabird-driven ecosystem function to the extent achieved through active restoration. Deciding which management technique to use must take account of the ecological, social, economic, and cultural factors involved in seabird restoration.

Community restoration projects with active seabird restoration projects:

- Tutukaka Coast
- Bream Head
- Tāwharanui Open Sanctuary
- Motuora
- Shakespear Open Sanctuary
- Tiritiri Matangi Island
- Motuihe
- The Noises
- Pakihi Island
- Glenfern Sanctuary (Aotea / Great Barrier Island)
- Windy Hill (Aotea / Great Barrier Island)
- Ngamotu Aroha Trust (Coromandel)

Restoring Resilience: A guide to seabird restoration for the Tāmaki Makaurau / Auckland region and wider Te Moana-ā-Toi / Tīkapa Moana / Hauraki Gulf will be available to community groups from November 2021.

Nest boxes for Pycroft's petrels, Motuora. Photo by John Stewart.

Tiritiri Matangi's seabirds

John Stewart [1]

[1] *Supporters of Tiritiri Matangi*

The monitoring on Tiritiri Matangi illustrates that:

> Annual breeding success can be highly variable.

> Great value for surface nesting seabirds to have at least the main nesting colonies in the region monitored every year.

> As predator control is established at mainland coastal sites it would be valuable to monitor the establishment of new and re-established breeding sites for both surface- and burrow-nesting species.

Tiritiri Matangi is a 220 ha Island located in the Hauraki Gulf about 4 km east of Shakespear Regional Park at the end of the Whangaparaoa Peninsula and about 25 km north of central Auckland. Much of the island's original vegetation was lost to farming but, since the 1980s, there has been a planting and restoration programme on the Island carried out by a partnership between the Department of Conservation and the Supporters of Tiritiri Matangi community group. The island has been designated as a Scientific Reserve. Introduced mammalian predators were removed in 1993.

In pre-human times Tiritiri Matangi would have been covered in native bush and probably supported large numbers of breeding seabirds of several species. Most of these would have been lost with the arrival of humans and predators and with the loss of forest cover to grassland enabling the introduction of farm livestock.

Some species survived the farming period, with a couple only on tiny nearby Wooded Island, including ōi / grey-faced petrel, pakahā / fluttering shearwater, kuaka / common diving petrel, karoro / southern black-backed gull, tarāpunga / red-billed gull, tara / white-fronted tern, kororā / little penguin and kāruhiruhi / pied shag. All these species continue to breed on the island, but their population sizes have undoubtedly fluctuated, in some cases dramatically. During a survey in the late 1990s of Wooded Island, a one-hectare islet 200 m north of Tiritiri Matangi, it was estimated that there were breeding populations of 1,000-10,000 pairs of diving petrels and up to 200 pairs of fluttering shearwaters [211].

Current populations

In line with the current restoration plan [212], the Supporters of Tiritiri Matangi initiated a programme of seabird monitoring in 2013. For surface-nesting seabirds the number of breeding pairs is counted. The results are given in Table 9.

Work has also commenced on monitoring some of the burrow-nesting species. Common diving petrels had been recorded nesting in small numbers right around the circumference of the Island prior to 2013. A small colony had established on a promontory immediately opposite Wooded Island by 2013, and since then 770 individuals have been banded at this site which continues to increase in area and burrow density. At least 100 pairs occur at two other sites and numbers appear to be increasing right around the Island. Nine of the 39 birds banded in 2013 were recaptured in 2020. With a recapture rate of 54% this equates to a minimum annual adult survival of 88%. Twenty nest boxes were installed in 2018 to allow monitoring of breeding success. Over the past two seasons 17 chicks fledged from 19 eggs laid in the boxes.

Nest boxes have recently been installed for little penguins which will facilitate checking on their breeding success. Casual records of grey-faced petrels and fluttering shearwaters suggest that the numbers breeding on the island have increased over the past ten years.

Overnight, during the breeding season, a sound system installed in 2017 has been playing calls recorded at the Cook's petrel colony on Te Hauturu-o-Toi / Little Barrier Island in the hopes of attracting some of the over-flying birds to land and breed on Tiritiri Matangi. So far there have been no records of any birds landing.

ENDS

Seabird restoration on Motuora

John Stewart[1]

[1] *Moturoa Restoration Society*

Work on Motuora, and at other sites, demonstrates that:

- It is feasible to establish new breeding colonies of seabirds using acoustic attraction and/or chick translocations.
- Establishing significant populations is likely to require many decades.
- Success rates for the establishment of new colonies will be increased with careful planning and management.
- Success or failure to establish new colonies may be site-dependent, but impacted by 'at-sea' factors, the wider availability and capacity of suitable breeding sites, and pressure for space at existing colonies.

As with many other islands in the inner Hauraki Gulf, the habitats on Motuora have been heavily modified since humans arrived bringing mammalian predators and replacing native forest with grassland for grazing livestock. About 75 ha of the 80 ha Island have now been replanted with native trees and a programme of reintroductions of invertebrates, reptiles, land, and seabirds is underway. Plans for the programme are documented in the Motuora Native Species Restoration Plan [213].

Projects are under way to introduce common diving petrel, fluttering shearwater, Pycroft's petrel and Australasian gannet. Grey-faced petrel and little penguin were already breeding on the Island in 2007.

Diving petrel chicks were collected from Wooded Island off Tiritiri Matangi over three years from 2007. A total of 190 chicks were translocated to Motuora and 178 of these subsequently fledged (24 in 2007, 62 in 2008, and 92 in 2009). The chicks were transferred to individual wooden nest boxes buried on an east-facing slope near the sea and fed daily with a blended mix of sardines, water, and vitamin supplement. During and after the translocations a sound system broadcast a recording from a diving petrel colony, and the nest boxes and their tunnel entrances were maintained free of vegetation. There was no evidence that any of the returning birds visited the nest boxes, and the adults and their nests were found under thick kikuyu grass. Birds continued to return to the site in small numbers for several more years, but were recorded from an inaccessible, near-vertical cliff area below the nest boxes. It is suspected that the diving petrels were unable to dig natural burrows in the hard clay soil where the nest boxes were installed.

Pycroft's petrel chick in nest box, Motuora. Photo by John Stewart.

	2013	2014	2015	2016	2017	2018	2019	2020
Red-billed gull	80-110	85-120	340	250-265	300	125-140	310-330	190-220
Black-backed gull		38-45	38-45	38-45	38-45	38-45	30-36	25
White-fronted tern	0	5-10	0	100-120	60+	1-2	160-180	6
Pied shag	7-9	7-9	7-9	7-9	12	12	8-10	10

Table 9. *Annual numbers of breeding pairs for the four most common surface-nesting seabirds on Tiritiri Matangi Island.*

Real and model tākapu /Australasian gannets, Motuora. Photo by Kay Milton.

A programme for Australasian gannets commenced in 2013. Decoys were distributed among hand-crafted nesting mounds and calls from a gannet colony were broadcast during daylight hours. There was immediate success with at least one chick fledging and the colony built up to 19 pairs over the next four years (see Table 10). There were 12 chicks in year four, but they all died shortly before fledging. Since then, the number of breeding pairs has fallen to four and, more recently two and one. The reasons for the decline are uncertain.

The gannet sound system also plays fluttering shearwater calls at night. Nest boxes have been dug in near the loudspeakers. Two pairs successfully raised a chick in 2015/16 and again the next year. There were four pairs in 2017/18, three pairs in the next two years and four again in 2020/21. All nesting attempts have resulted in a fledged chick.

From 2013 to 2015, 262 Pycroft's petrel chicks were translocated to the island from the colony on Whakau / Red Mercury Island. All the chicks fledged and the first bird, from the 2013 cohort, returned in December 2015. Fifty-two individuals have now returned along with two un-banded birds from elsewhere.

ENDS

Above and below: Acoustic attraction system on Tiritiri Matangi set up to attract tītī / Cook's petrels. Photos by John Stewart.

	Years since first established on Motuora								
	1	2	3	4	5	6	7	8	9
Diving petrel		1	1 or 2	1 or 2?	1 or 2?	0	0	n/a	n/a
Australasian gannet		1	10	12	12(0)	4(3)	3(1)	2	1(0)
Fluttering shearwater	2	2	4	3	3	4	n/a	n/a	n/a
Pycroft's petrel		1(0)	3	5(4)	10	15	n/a	n/a	n/a

Table 10. *Number of hatched (fledged) chicks by year since first established on Motuora (n/a indicates years beyond the 2020/21 season).*

6.4 Coastal development in Auckland and its impact on seabirds

Kerry Lukies[1]

[1] *Northern New Zealand Seabird Trust*

Coastal development puts pressure on seabirds by reducing the natural habitat available for nesting, increasing predators (both pests and companion animals), increasing artificial lighting and reducing water quality (e.g., through sedimentation).

Coastal seabirds need to be factored into development plans by enhancing and protecting areas of natural vegetation, engaging in predator control, keeping pets under control, reducing artificial lighting and controlling sediment runoff.

Tāmaki Makaurau / Auckland is Aotearoa / New Zealand's largest city with a population of 1.57 million people [214]. The city has a considerable coastline due to its isthmus landform, harbours and estuaries. Despite this, most seabird colonies in the region are restricted to inaccessible coastlines or island refuges where threats are less prevalent [215].

Coastal development can accommodate coastal birds in a variety of ways. Comprehensive ecological surveys undertaken prior to development will determine the presence of coastal birds that can then be incorporated into the resource consent conditions set by regional councils. Avian management plans, developed as part of the resource consent process, should allocate areas for coastal birds, and incorporate predator control, maintaining and enhancing vegetation, and controls on erosion and artificial lighting to protect birds nesting in coastal areas. Removing pests from coastal areas can significantly reduce the predation risk for seabirds [215]. Pet owners can also reduce seabird predation by keeping cats indoors, especially at night, and keeping their dog on the leash when walking in areas utilised by seabirds. Advocating for dog-free coastal areas will help protect seabirds, especially during the breeding season. Artificial lighting should be reduced in coastal areas as it can attract and disorient young seabirds, causing injury or mortality through light-induced collisions or leaving birds unable to get airborne again [216].

Active predator control measures should be compulsory for all marinas and boatyards in the region. At present there is no requirement for recreational and commercial fishing vessels active in the wider Hauraki Gulf to be pest/predator-free, vessels that could potentially anchor close to predator-free island sanctuaries and facilitate invasion by pests.

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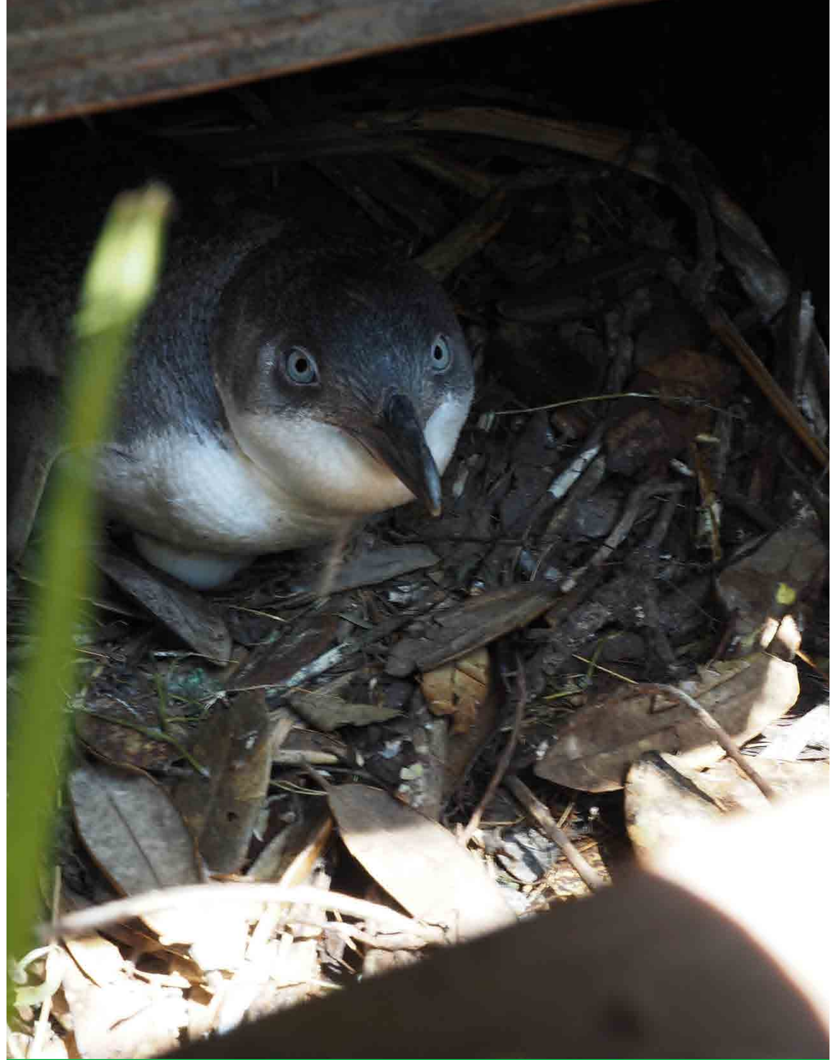


Kororā / little penguin in nest box. Photo by Spencer McIntrye.

One example of how seabirds can be incorporated into coastal development plans is the kororā / little penguin sanctuary at Napier Port. In 2020, the Port expanded its operation with a new wharf. Wharf construction would have disturbed c. 30 pairs of little penguins nesting in the Port's seawalls, therefore, an avian management plan was designed to mitigate the negative impacts caused by the development [217]. The Port, in association with penguin experts and iwi, developed an area of penguin nest boxes within the Port grounds where the little penguins breeding in the existing seawalls could be relocated. Speakers within the sanctuary play little penguin calls to encourage birds to remain within the sanctuary. The sanctuary area is surrounded by a fence to exclude dogs from accessing the colony and benefits from the existing pest control program within the Port grounds [217]. A sandy area within the sanctuary also provides nesting habitat for terns and gulls.

Successful relocation of a tarāpunga / red-billed gull colony in Auckland

Tim Lovegrove[1], *Paul Kennedy*[2]

[1] *Auckland Council,* [2] *Kennedy Environmental Ltd.*

A tarāpunga / red-billed gull colony became established at St Mary's Bay on Auckland's Western Reclamation at the Percy Vos Boatyard sometime after its closure in 1994. The location clearly suited the gulls. There was very little disturbance, and it was close to sufficient, but perhaps not ideal, food sources. These included local beaches, city parks and streets, and the nearby shallow reaches of Shoal and Ngataringa Bays in the Waitematā Harbour, which have extensive intertidal zones where the gulls regularly feed.

America's Cup and effects on the colony

The return of the America's Cup to Auckland in 2019-2020 brought changes to the Western Reclamation. To make way for the America's Cup syndicate bases, Panuku Development Auckland gained resource consent from Auckland Council to relocate the SeaLink car-ferry terminal from Wynyard Basin to the western side of the Western Reclamation. The chosen site for the new SeaLink terminal was the Percy Vos Boatyard. Clearly the red-billed gull colony would be displaced. The consent to develop the new SeaLink Ferry terminal included conditions to mitigate effects on the gulls. These included producing an adaptive management plan with objectives to mitigate for the loss of breeding habitat by providing an additional area where the red-billed gulls could breed and roost, and to monitor the gulls before and after development of the site.

Monitoring during 2018-19

The colony at the Percy Vos Boatyard was monitored for two breeding seasons before construction started. Our surveys showed that about 900 red-billed gulls were present, including about 340 breeding pairs. They occupied an area of about 300 m^2 on the old slipways and adjacent open ground [218].

Monitoring at the new site

Panuku Development provided a new coastal site for the gulls measuring approx. 400 m^2 with a similar elevation and aspect, located 150 m north of the Percy Vos Boatyard. The new site was separated from an adjacent works yard by a 1.8 m high mesh and PVC-lined fence placed on top of a line of heavy concrete blocks. During winter 2019, driftwood from the old boatyard was scattered around the new site to mimic habitat at the former colony. Various coastal plants were already present, providing a source of nest material. In August 2019, eight 3D-printed decoys made by Shaun Lee were installed. Some gravel mounds were also added to make the nesting habitat more varied [218].

Top: Decoy maker Shaun Lee on-site with gull decoys. Photo by Tim Lovegrove.
Bottom: Gulls nesting adjacent to decoys. Photo by Paul Kennedy.

Colonisation and breeding at the new site 2019-2020

The gulls quickly adopted the new site. By the end of November 2019, 918 adults, c.450 nests and 313 young were counted. By early December 2019, c.1,550 birds were present including 942 adults, 508 fledglings and 97 non-flying young [218].

During winter 2020 a drainage problem at the new site was improved by spreading c.10 m^3 of aggregate with a digger, some boulders were added, and the gull decoys redeployed. During the 2020-21 season, the gulls again bred successfully at the new site with 1,148 adults and c.549 nests counted in late November 2020. About a month later, 682 young were present and most of these probably fledged successfully [218].

Longer term prospects

The seaward end of the Western Reclamation at Wynyard Point is being developed as a new area of public open space. The red-billed gull colony will be incorporated into plans to develop the new park on Wynyard Point. With protection, interpretation, and a viewing hide, this central-city red-billed gull colony could be a special feature of the new park for the public to see and enjoy.

ENDS

Tarāpunga / red-billed gull chicks in the Panmure colony. Photo by Shaun Lee.

Tarāpunga / red-billed gulls colony within the Marsden Point Oil Refinery. Photo by Chris Gaskin.

Marsden Point Oil Refinery

One of Aotearoa New Zealand's largest tarāpunga / red-billed gull colonies is within the Marsden Point Oil Refinery with an estimated 1190 pairs [159, 219]. While Refining NZ has a good track record in letting the gulls occupy areas for nesting within the refinery and maintaining a predator control programme, the closure of the refinery and the plant's transformation to an import terminal in 2022 is likely to see their displacement. To what extent is unknown at this stage. However, with Refining NZ's professed commitment to protecting our environment [220], and with the successful relocation of a gull colony at the Auckland waterfront shown to be possible if required, a secure future for these feathered Northland residents might be forthcoming.

North Port, Marsden Point Oil Refinery and Whangarei Heads, with Taranga / Hen Island in the distance. Tarāpunga / red-billed gull colony around the perimeter of the settlement pond system is within the circle. Photo by Northern Advocate.

NGĀ HUA
7. MEASURES

A few wing beats from extinction? Tara-iti / New Zealand fairy tern, Mangawhai Harbour. Photo by Jacob Ball.

7.1 How are seabirds faring?

If we look at trends over the ten years (2010-2020), seabirds breeding in the wider Hauraki Gulf region, would appear to be faring reasonably well with several species' populations shown to be increasing, largely through successful eradication of predators from islands across the outer Gulf. Some of these species also feed offshore in pelagic waters well outside the region. But these gains need to be tempered. For example, on Te Hauturu-o-Toi / Little Barrier Island the New Zealand storm petrel population has increased significantly since eradication of cats and rats. However, that island remains its only known breeding location. While New Zealand fairy tern can be seen as 'stable' at around 40 individual birds over the last ten years, it remains in a highly precarious state. It is Aotearoa New Zealand's rarest bird and survives through intense management. Amongst the remaining species with declining populations, spotted shags are limited to three small colonies, whereas white-fronted terns and red-billed gulls are generally accepted as decreasing, but rigorous regular surveys are required to get an accurate picture. How northern seabirds will fare in the future under climate change and increasing fishing and other pressures will come down to how adaptable they are.

Taranui / Caspian terns nesting on a shell/sand island in the Whangateau Harbour, 2015. In subsequent years the island was completely eroded during storm events and Caspian terns no longer breed in the harbour. Photo by Chris Gaskin.

Assessing the risk of species extinction

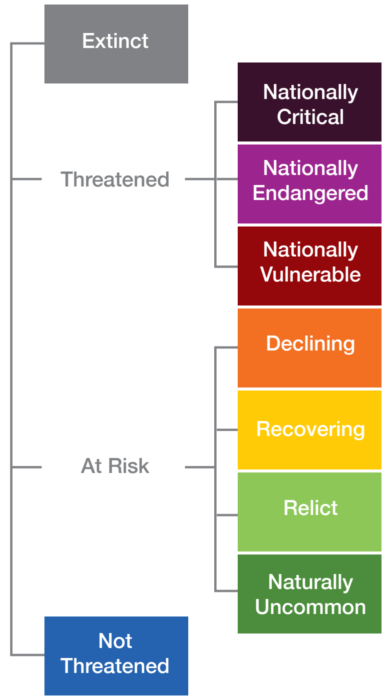
The New Zealand Threat Classification System (NZTCS) determines the conservation threat status using population factors, including the number of breeding pairs, past and predicted changes in population, and pressure from human-induced effects.

State of WHGR seabird populations

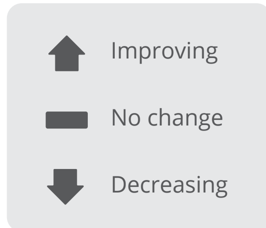
Table 11. *Threat status and trends 2010 to 2020 for seabirds populations in the wider Hauraki Gulf region.*

Species	Trend	Notes
New Zealand fairy tern	—	*C. 40 individual birds – intensely managed – see Section 5.3*
Spotted shag	↓	*3 small colonies – regular surveys – see Section 5.2*
Red-billed gull	↓	*Surveying difficult given ephemeral nature of breeding – annual surveys required – see Section 5.5*
White-fronted tern	↓	*Surveying difficult given ephemeral nature of breeding – annual surveys required – see Section 5.5*
Caspian tern	↓	*Loss of nesting areas due to storm events, human disturbance – regional survey required*
Little shag	↓	*No regional survey*
Black shag	↓	*No regional survey*
Sooty shearwater	↓	*Small colonies on several islands across the outer Gulf region – rarely surveyed*
Black petrel	—	*Extent of population outside study area on Aotea largely unknown – see Section 5.6*
Buller's shearwater	—	*New estimate – likely earlier overestimate – see Section 4.4*
Fluttering shearwater	—	*While abundant, a difficult species to survey given nesting in steep areas in dense vegetation – see Section 4.4*
Fairy prion	—	*While abundant, a difficult species to survey, nesting in crevices amongst rocks, and on cliffs. Only on Poor Knights Islands*
Black-winged petrel	—	*Very small populations within the WHGR*
Little penguin	—	*Populations on many predator free islands have not been surveyed – see also Section 4.4*
Australasian gannet	—	*Overall no change likely, however inner Gulf colonies decreased, outer Gulf colony (Mahuki) has increased – see Section 5.7*
Pied shag	—	*National census in 2013 highlighted strength of populations in the WHGR. Subject to fisheries bycatch and entanglement*
Little black shag	—	*No regional survey*
Southern black-backed gull	—	*No regional survey*
Black-billed gull	—	*Subject to predation, human disturbance and erosion of colony sites on east coast.*
Grey ternlet/ noddy	—	*Does not breed in WHGR but is a regular visitor roosting for months at 2 sites each year*
New Zealand storm petrel	↑	*Significant increase of population on Hauturu since eradication of predators – see Section 5.4*
Cook's petrel	↑	*Steady increase on Hauturu since eradication – extent of fledgling losses to light attraction fallout in city unknown*
Pycroft's petrel	↑	*Increases on Mercury and Mauimua / Lady Alice Island since eradications – see Section 4.4*
Grey-faced petrel	↑	*Multiple mainland colonies have shown increases with predator control, growing populations on several outer Gulf islands following eradications*
Flesh-footed shearwater	↑	*Reduction in bycatch, breeding on islands free of predators, or with predators removed – see Section 5.6*
Little shearwater	↑	*Significant populations on a number of islands across the outer Gulf region – no population survey*
Northern common diving petrel	↑	*Abundant and increasing rapidly following eradications on islands across outer Gulf, also Tiritiri Matangi.*
White-faced storm petrel	↑	*Dramatic increase on Burgess Island, Mokohinau Islands following eradication. Four populations on islands across WHGR.*

New Zealand Threat Classification System (NZTCS) 2016 [91]

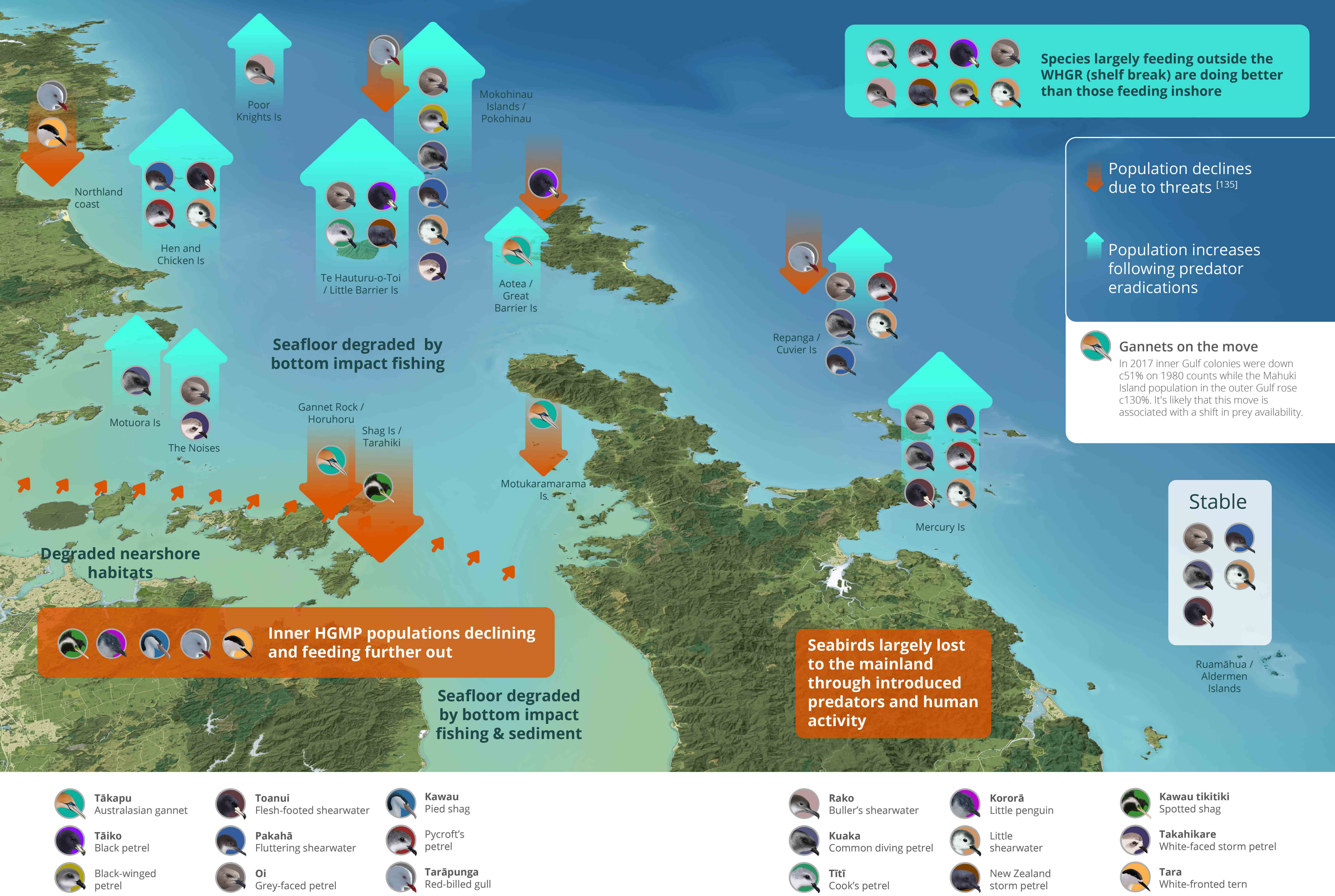


Trends WHGR 2010/2020



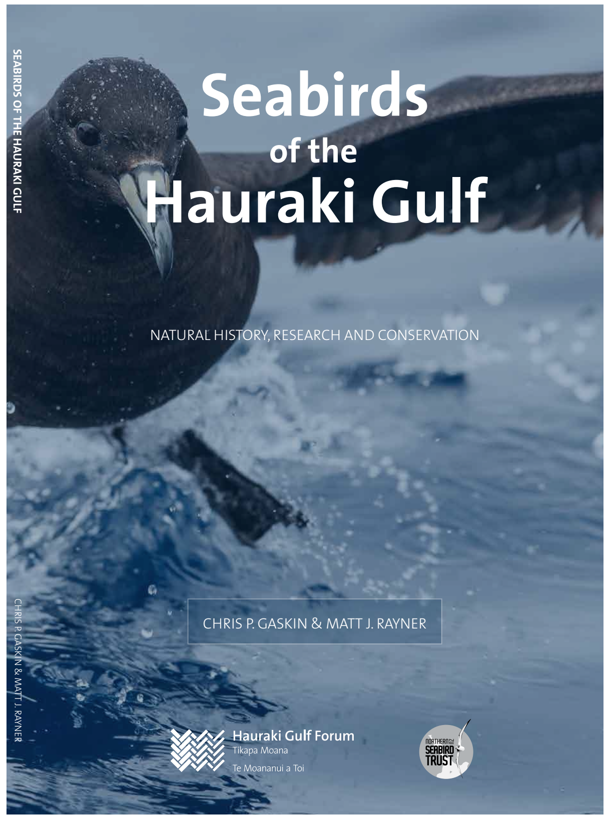
The NZTCS is a national classification and that species are doing better or worse nationally than in the WHGR.

An update to the NZTCS will be published in 2022.


Species largely feeding outside the WHGR (shelf break) are doing better than those feeding inshore
Population declines due to threats [135]
Population increases following predator eradications
Gannets on the move
In 2017 inner Gulf colonies were down c51% on 1980 counts while the Mahuki Island population in the outer Gulf rose c130%. It's likely that this move is associated with a shift in prey availability.
Stable
Ruamāhua / Aldermen Islands
Northland coast
Poor Knights Is
Mokohinau Islands / Pokohinau
Hen and Chicken Is
Te Hauturu-o-Toi / Little Barrier Is
Aotea / Great Barrier Is
Repanga / Cuvier Is
Mercury Is
Motuora Is
The Noises
Seafloor degraded by bottom impact fishing
Gannet Rock / Horuhoru
Shag Is / Tarahiki
Motukaramarama Is
Degraded nearshore habitats
Inner HGMP populations declining and feeding further out
Seafloor degraded by bottom impact fishing & sediment
Seabirds largely lost to the mainland through introduced predators and human activity
Tākapu Australasian gannet
Tāiko Black petrel
Black-winged petrel
Toanui Flesh-footed shearwater
Pakahā Fluttering shearwater
Oi Grey-faced petrel
Kawau Pied shag
Pycroft's petrel
Tarāpunga Red-billed gull
Rako Buller's shearwater
Kuaka Common diving petrel
Tītī Cook's petrel
Kororā Little penguin
Little shearwater
New Zealand storm petrel
Kawau tikitiki Spotted shag
Takahikare White-faced storm petrel
Tara White-fronted tern

7.2 Action on action plans and reports

In this section we look at two reports about seabirds in our region, the first made recommendations for future research and conservation action, the second, listed measures to reduce threats to seabirds and identified knowledge gaps. While recommendations made in the two reports may not themselves have instigated direct action, they do offer measures for how well we are doing with respect to understanding and protecting our seabirds.



Eight years on

In 2013 the Hauraki Gulf Forum commissioned and published *Seabirds of the Hauraki Gulf: Natural History, Research, Conservation* [43]. The strategic plan set out 15 topics and recommendations for research and conservation action. Table 12 summarises what has been achieved in the eight years since that report was published. The report was updated and rereleased in 2017 to coincide with the Hauraki Gulf Forum's seminar Taking Flight held at the Auckland Museum.

Table 12. *Strategic objectives that have been achieved in the eight years since presented in Gaskin & Rayner (2013).*

Strategic objectives

1. Distribution, size and status of seabird populations

- New population estimates for the populations on the NZ storm petrel [157], Buller's shearwater [110] and spotted shag (see Sections 5.3, 4.4, 5.2 respectively).
- Black petrels and flesh-footed shearwater populations continue to being monitored at current locations, but that work needs to be extended to other islands, and also locations on the mainland (e.g., Moehau Coromandel Peninisula) (see Section 5.6).
- Surveys have been conducted on several islands to locate populations of fluttering shearwater and while some have been located, largest concentrations remain something of a mystery and overall population estimate yet to be determined [118].
- Population monitoring has started for many species, including black-winged petrel, common diving petrel, Cook's petrel, white-faced storm petrel, and little, black and little black shags (see section 4.3).
- An aerial survey for Australasian gannet colonies in northern North Island was undertaken in November 2017 to provide an update on populations (previous in 1980), and included red-billed gull and white-fronted tern colonies [118].
- Two years of regional surveys for white-fronted terns (and also red-billed gulls) (see Section 5.5)

2. Seabird breeding biology

- Breeding biology of most of the species identified in the 2013 report have been, or are, the subject of ongoing studies (i.e., Buller's, fluttering and little shearwaters, fairy prion, common diving petrel and spotted shag). Also, white-faced storm petrel [221]

3. Seabird diet, foraging and community ecology

- Tracking studies have been conducted for Australasian gannet; black petrel; Buller's, flesh-footed and fluttering shearwaters; fairy prion; common diving petrel; spotted shag, and little penguin. Of these only tracking of black petrels has occurred for more than two years.
- Investigations into the diet of species that feed in association with fish shoals (workups) have been the subject of DOC Conservation Services Programme (CSP) contracts – through zooplankton collecting and from regurgitation samples collected from birds at colonies.
- Several projects utilise stable isotope and DNA analyses from faecal samples to determine seabird diet.
- Community long-term study of inner Gulf species – see Section 5.1

4. Assessing island biosecurity and at-sea threats

- A comprehensive review of threats to seabirds in Northern Aotearoa New Zealand was released in 2019 [1].
- Several studies have been funded through DOC CSP contracts that examine petrel and shearwater diving behaviour around fishing vessels, and their attraction to lights on ships.
- As above, an investigation into seabird diet has centred on determining possible indirect effects from fisheries on seabird populations.

5. Population genetics and taxonomy

- Key studies since 2013 have been for the Hauraki population of spotted shag [137] and NZ storm petrel. With the latter, while its taxonomic status had been confirmed, blood samples have been collected from birds have been captured in 2021 in the Far North to further investigate its overall population structure and level of genetic diversity.
- Discovery of extinct shag species through DNA analysis – Kawau kohatu [222]

6. Standardising seabird census, monitoring and research techniques

- Auckland Council has begun a programme of standardised seabird census and monitoring within the Auckland region – see Section 4.3.
- Population surveys conducted in both Northland and Waikato have adopted the same or similar methods used previously – e.g., Buller's shearwater population survey [110] used similar methodology as for Cook's petrel [86].
- However, the creation of an online manual on standardised survey methods (as recommended in 2013) has not been attempted.

7. Broad-scale wider Hauraki Gulf ecosystem research

- DOC CSP contracts as described above on fish shoal dynamics have at the same time identified a major knowledge gap in our understanding of the processes and productivity that influence seabird foraging in the Hauraki Gulf.

8. Field research facilities, field stations

- Very little has been achieved in terms of establishing a dedicated research base in the Hauraki Gulf. However, several locations are regularly used for seabird research. These are mostly islands with huts or established camps close to seabird colonies. They are either nature reserves (landing by permit only), or in private or Māori-ownership with access through permission of the owners.

9. Coordinated regional approach to seabird conservation management

- The recommendation in 2013 was to take a spatial planning approach to threats to seabirds with respect to island biosecurity, shipping routes, oil spills, overland flyways, and hotspot areas for seabird foraging within the +region. While the Hauraki Gulf Marine Spatial Plan process brought together multiple layers (using Sea Sketch) there has been little coordinated effort to map threats, or to generate marine protection scenarios.

10. Island biosecurity and predator control

- The recommendation for a coordinated approach to island biosecurity guided by threat-mapping has not been adopted.
- Whilst charter vessels servicing nature reserve islands are required to be certified pest free, there remain many boats (e.g., fishing vessels, recreational boats) anchoring close to predator-free islands for which there is no such requirement.
- NZ fairy tern has intensive monitoring and predator control in areas where they breed, but the population struggles to increase.

12. Minimising disturbance

- DOC staff from Aotea / Great Barrier Island improved the public track on Pokohinu / Burgess Island, Mokohinau Islands to create a loop route for visitors – taking in the old lighthouse keepers' house sites and the lighthouse. However, members of the public have been seen roaming across the island and off track in areas where small seabirds are nesting.
- General awareness about seabirds nesting and the fragility of burrows needs be improved, including with people working and undertaking research on Nature Reserve islands.
- There have been some community-led initiatives around potential dog predation of penguins, and the need for dogs to be kept on leashes (e.g., Leigh Penguin Group, Waiheke Island residents).
- Remains of fires continue to be discovered on Burgess Island, with one instance leading to an article about the dangers of fires to wildlife in the NZ Herald.

11. Fisheries interactions

- The roll out of cameras on fishing vessels operating within the wider Hauraki Gulf region has been painfully slow, nothing like the 100% coverage recommended in 2013.
- However, engagement with fishing skippers and crew has been positive as they have gained an appreciation of the birds' lives beyond their attraction to fishing vessels.
- Education resources around by-catch are available for both commercial and recreational fishers. However, an ongoing active programme to engage with the recreational fishery needs to be stepped up.

13. Enhancing seabird influenced ecosystems

- Promotion of seabird restoration has been largely through the Northern NZ Seabird Trust with funding from Auckland Council – actively working with community groups on both islands in the region and the mainland.
- Rats (ship rat and kiore) were eradicated from Rakitu Island, however, weka (an acknowledged seabird predator) remain. A pre-eradication survey detected a small number of grey-faced petrels attempting to breed at one site. A post-eradication surveys is scheduled for October-November 2021.
- The Noises Marine Restoration Project made a submission to the Government in response to the Hauraki Gulf Marine Spatial Plan (2021) for increased marine protection around the Noises Islands.

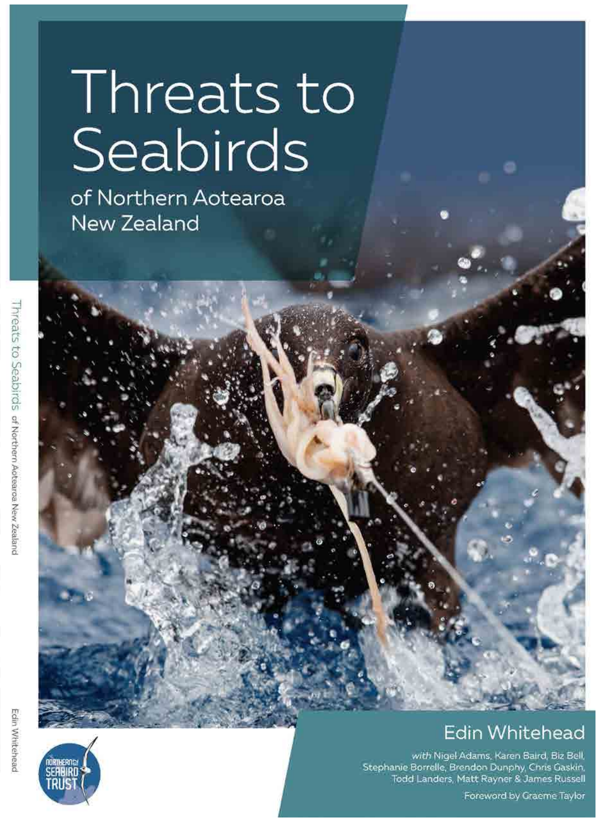
14. Engaging communities, working with tangata whenua on seabird conservation

- As above, community groups are becoming more engaged with seabird restoration.
- Three seminars focussing on seabirds have been held – 2017 (Hauraki Gulf Forum seminar, Auckland Museum), 2018, and 2019 (both run by the Northern NZ Seabird Trust at the NZ Maritime Museum).
- Follow-up hui between researchers and tangata whenua similar to the one held in 2011 (with Ngāti Rehua) have not eventuated. These should be a priority, especially with respect to the next recommendation – below.

15. Closer collaboration with tangata whenua

- This remains a priority for all seabird conservation work, not just around the question of sustainability of harvesting ōi (grey-faced petrel chicks) which was the focus of the 2013 recommendations.

Panel discussion during the highly successful, seabird focused Taking Flight Hauraki Gulf Forum Seminar 2017. Photo by Shaun Lee.



Threats to seabirds review

In 2019, the Northern NZ Seabird Trust, with the Hauraki Gulf Forum, released Threats to seabirds of Northland Aotearoa New Zealand [1]. Table 13 summarises what has been achieved since that report was published and current actions.

Table 13. *Measures and knowledge gaps presented in the Threats to seabirds of Northland Aotearoa New Zealand* [1] *– two years on and what has been or is being achieved?*

Measures to reduce threats

1. Invasive alien species and biodiversity

- Maintaining the wider Hauraki Gulf region's islands' predator- and predator-free status is a massive ongoing challenge.
- Predator-free Aotea / Great Barrier Island and marinas around Tāmaki Makaurau has not been achieved, although the Tū Mai Taonga project, a community and mana whenua led initiative to remove feral cats and intensify rat management in/at north Aotea, starts in 2021.
- Weeds are largely known and managed on islands where seabird breed, with important control programming underway through DOC on Poor Knights, Taranga /Hen, Marotere / Chickens, Te Hauturu-o-Toi / Little Barrier Island and the Mercury Islands. Community groups support efforts in many inner Gulf locations.

2. Fisheries

No fisheries exclusion zones have been implemented

- See Section 8.1 (this report) for a seabird lens on the Government's response to the Hauraki Gulf Marine Spatial Plan.

No Marine Protect Areas (MPA) for seabirds have been considered.

3. Pollution

- Trial litter / contaminant capture devices have been installed for runoff in Tāmaki Makaurau / Auckland.
- Coastal clean ups continue to be regularly undertaken although not continuous across the region.
- Light pollution has been the subject of a DOC contract that investigated seabird attraction to the lights used by fishing vessels. DOC have provided the cruise industry with guidelines on how to manage seabirds that are attracted to lights on board ships.

4. Disease

- There has been no research to assess disease prevalence amongst the region's seabirds.
- Strict protocols govern the sterilisation of equipment used by seabird field researchers between sites and species.

5. Climate change

- An attempt has been made to establish a colony of tara-iti / NZ fairy terns at a new site at Tapora in the Kaipara (west coast) as nesting sites on the Hauraki Gulf coast are subject to storm events.
- Ongoing studies are investigating species' responses to environmental stresses.

6. Direct human impacts

- Dog and cat control remain a major issue in coastal areas across the region
- Tara-iti / NZ fairy tern is species the most vulnerable to encroaching coastal development – e.g., removal of mangroves in estuaries for aesthetic reasons.
- There are no controls over boat speeds around seabirds' rafting at sea.
- Important Bird and Biodiversity Areas (IBA) are not recognised in regional planning. An exception is the example set by Marlborough District Plan 2021.

Knowledge gaps

1. Populations

- New population estimates for several species – rako / Buller's shearwater, NZ storm petrel, tākoketai / black petrel, toanui / flesh-footed shearwater, tākapu / Australasian gannet, tara / white-fronted tern, tarāpunga / red-billed gull.
- Priority sites for ongoing monitoring have been identified – see Sections 4.3, 4.4, 5.5 and 8.4 (this report).

2. Foraging ecology

- Tracking and diet studies ongoing for several species – kororā / little penguin, Buller's, fluttering and little shearwaters, tītī wainui / fairy prion, Australasian gannet
- Identification of significant marine areas for seabirds through at sea observations and tracking studies

3. Trophic ecology

- Preliminary investigations for all recommendations have been undertaken through DOC Conservation Services Programme contracts or university research projects.

4. Behaviour

- As above, research studies are underway for monitoring breeding success for a number of species.
- Identification of physiological tolerance to fluctuations in temperature and prey availability has not been attempted but is under investigation.

5. Management

- The Northern NZ Seabird Trust has prepared a seabird restoration guide for community groups and other agencies – see Section 6.3.
- See Section 8.2 for discussion on marine planning for highly mobile marine mega-fauna such as seabirds.

6. Invasive alien species and biodiversity

- There has been no development of a remote monitoring systems for early warning of predator incursions on islands despite the availability of remote monitoring devices and systems.
- Support for local community action on predator control has increased considerably throughout the region with the advent of Predator Free 2050 and subsequent Mahi mō te Taiao Jobs for Nature funding (Ministry for the Environment).

7. Fisheries

- Ongoing tracking studies are enabling us to identify areas of overlap between seabird foraging and fisheries.

2. Fisheries

No fisheries exclusion zones have been implemented

- See Section 8.1 (this report) for a seabird lens on the Government's response to the Hauraki Gulf Marine Spatial Plan.

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E TIRO WHAKAMUA ANA

8. LOOKING TO THE FUTURE

Ministers Parker and Verrall announce the Government response to Sea Change – Tai Timu Tai Pari. Photo by Peter Miles.

8.1 Revitalising the Gulf – Government action on the Sea Change Plan

Supplied by the Department Of Conservation & Ministry for Primary Industries

The Sea Change Tai Timu Tai Pari Hauraki Gulf Marine Spatial Plan (the Marine Spatial Plan) was published in 2017. It is New Zealand's first marine spatial plan and seeks to improve the waiora (health) and mauri (life force) of the Hauraki Gulf. The Sea Change Plan made over 180 proposals for the Hauraki Gulf and its catchments across land, freshwater and marine domains.

The Gulf is important to all New Zealanders and is a cornerstone of our economic, environmental, cultural, and social wellbeing. It is a taonga treasured for its natural environment, cultural significance, the kaimoana and jobs it provides, and as a place for recreation and enjoyment. Its waters and islands support a diverse range of species from seabirds to seabed dwelling corals.

The Government Strategy, Revitalising the Gulf – Government action on the Sea Change Plan, responds to the Sea Change Plan's call to action. Revitalising the Gulf sets out a package of fisheries management and marine conservation actions to restore a healthy Hauraki Gulf.

It seeks two outcomes:

- Effective kaitiakitanga and guardianship in the Gulf; and
- Healthy functioning ecosystems that:
  - underpin the wellbeing and prosperity of people who live, work and play in the Gulf,
  - sustain healthy fisheries that replenish and enhance the pātaka kai (food basket) for customary, recreational, and commercial uses,
  - regulate, support and sustain the Gulf, and
  - support resilient and diverse habitats and marine life.

Government is committed to respecting the integrity and value of current and future Treaty settlements when delivering these outcomes.

1. **Fisheries management:** In 2022, Government will deliver New Zealand's first area-based fisheries plan, tailored to the unique needs of the Hauraki Gulf. The Fisheries Plan will include a management objective to reduce by-catch of protected species. This is accompanied by specific management actions focused on:
   - improving information on by-catch,
   - supporting the development and uptake of seabird mitigation, and
   - maintaining the black petrel electronic monitoring programme.

   It will also deliver wider seabed habitat protection by:
   - restricting trawling and other fishing methods,
   - increasing shellfish abundance through harvesting restrictions and catch limits, and
   - supporting increased participation of mana whenua and stakeholders in local fisheries management decisions.
2. **Active habitat restoration:** This year (2021), Government will develop a Habitat Restoration Guidance Framework and make this resource widely available to restoration groups or individuals. The Framework will guide new investment and restoration initiatives.
3. **Aquaculture:** Government will promote a prosperous aquaculture industry with increased Māori participation. By 2023, it will have worked with local councils to identify barriers to aquaculture and support new opportunities for aquaculture infrastructure and research and innovation.
4. **Marine protection:** Government will establish 18 new marine protected areas using a suite of marine protection tools. New tools include:
   - High Protection Areas[3] which prohibit harmful activities and support customary practices by mana whenua, and
   - Seafloor Protection Areas that will ban activities harmful to the seafloor.

   These measures will see an almost threefold increase (from 6.6 percent to 17.6 percent) in the Gulf's marine protection (including the cable protection zone). This will allow for the recovery of some of its most biodiverse regions.
5. **Marine biosecurity:** Government will support alignment of biosecurity programmes through the Top of the North Partnership.
6. **Protected species:** Government's existing protected marine species programmes will be expanded, including work to:
   - mitigate terrestrial biosecurity threats to burrow-nesting seabirds on island refuges,
   - improve by-catch measures, and
   - prioritising research and monitoring of protected species.
7. **Ahu Moana:** The concept of 'Ahu Moana' describes collaborative mana whenua and local community management of nearshore areas. Government will support Ahu Moana pilots to test collaborative ways of working and understand the barriers to such initiatives. Government will develop an Ahu Moana Framework by 2023 to support future initiatives, based on lessons from the pilots.
8. **Governance:** A Cross-Agency Implementation Group, made up of representatives from the Department of Conservation (DOC) and the Ministry of Primary Industries (MPI) / Fisheries New Zealand (FNZ) will guide the Strategy's delivery. The Cross-Agency Implementation Group will monitor Treaty settlement developments to ensure the Strategy's actions continue to uphold Māori rights and interests.

Ongoing research, monitoring and reporting will provide important information on progress and identify areas where Government needs to adapt its management approach to ensure it remains effective.

The marine environment does not exist in isolation and is affected by activities on land. Other Government initiatives, such as the Essential Freshwater package and the Productive and Sustainable Land Use package, will address freshwater and sedimentation issues caused by land use practices.

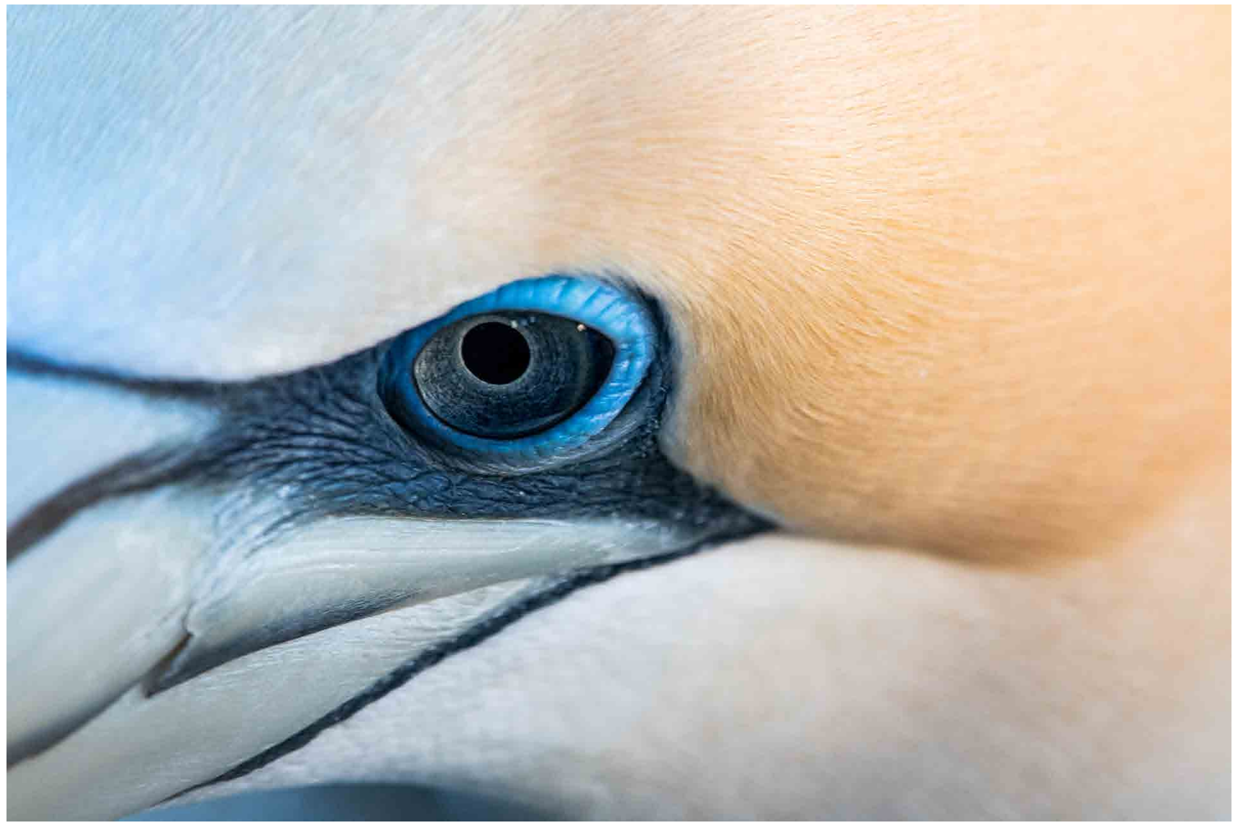
ENDS

You can read more about Revitalising the Gulf and its actions on the DOC and MPI websites:

https://www.doc.govt.nz/revitalise-the-gulf

https://www.mpi.govt.nz/fishing-aquaculture/sustainable-fisheries/strengthening-fisheries-management/revitalising-the-gulf-government-action-on-the-sea-change-plan/

[3] The technical assessment of the Sea Change Plan's marine protection recommendations can be found here: https://www.doc.govt.nz/globalassets/documents/our-work/sea-change/marine-protection-technical-document.pdf.



Tākapu / Australasian gannet eye. Photo by Edin Whitehead.

Revitalising the Gulf through a seabird lens

Chris Gaskin [1]

[1] *Northern New Zealand Seabird Trust*

In highlighting priority research on protected species in the Gulf, the Government Strategy, *Revitalising the Gulf – Government action on the Sea Change Plan* identifies the various research and monitoring objectives that are required to improve understanding of protected marine species in the Gulf, their threats, and the effectiveness of our interventions. It also stresses that new research and monitoring initiatives must consider the ecosystem effects of changes in the distribution, behaviour, and abundance of protected species, as well as changes in the food webs of which they are a component, thus, enhancing understanding of the waiora of the Gulf ecosystem [224, 225].

Priority research for seabirds identified in the Sea Change Response Plan 2021 includes:

- The influence of long-term trends in pelagic primary and secondary productivity on the behaviour, distribution and reproductive success of seabirds and cetaceans inhabiting the Gulf,
- The biology and ecology of forage fish (particularly anchovy, pilchard, sprats and mullet),
- The terrestrial habitats of (shorebirds and) seabirds (for example, burrow-nesting seabirds, such as petrels, shearwaters, and little penguins) and improving our understanding of these habitats, (including whether changes in vegetation at breeding sites are adversely affecting shorebird species),
- The effects of suspended sediments on seabird (and shorebird) foraging behaviour,
- The establishment of population trends of seabirds (and shorebirds), and sustainable levels of harvest of birds [224, 225].

However, in identifying proposed protected areas, and the focus on benthic habitats like reefs, there is little recognition of the full surface to benthic biodiversity around 'static' areas. For example, as proposed for HPA 8a / SFA 8b (Mokohinau Islands) and HPA1 / SFA6 (Te Hauturu-o-Toi / Little Barrier Island/Cradock Channel) [224].

Significant bathymetric features within the Hauraki Gulf Marine Park, such as Tatapihi / Groper, Māori, Navire and Simpson Rocks and associated reefs and pinnacles (Mokohinau Islands); NW Reef northwest of Hauturu; and Horn Rock in the Cradock Channel, generate conditions favourable for shoaling fish and at times vast aggregations of seabirds.

As above, highly visible seabirds, their foraging, and the shoaling and schooling fish they associate with are a major feature of north-eastern North Island waters. Impossible to ignore when you are on the water and surrounded by them. But these regular, dynamic events have not been taken into account for current marine planning.

Taking a wider perspective, some seabird species also feed in more pelagic or open waters following cetaceans, both dolphins and whales, or highly mobile tuna, kahawai and mackerel species. Others feed on krill swarms where no surface fish shoaling is evident, and on zooplankton and larval fish along current and tide lines.

For most highly mobile seabirds, the Sea Change Response Plan (2021), other than to recognise priority research areas as noted above, comparting to fixed benthic habitats does little to address ecosystem-wide pressures for most species. It will, however, benefit some benthic feeders such as penguins and shags.

The Sea Change Response Plan 2021, while addressing direct effects from fisheries for a small number of seabird species (by-catch through death and injury of black petrels for example), fails to address indirect effects from fisheries that could potentially affect many other species breeding in the region. For example, with respect to the purse seine fishery, it states:

"Purse seine vessels fish the surface and subsurface zone and do not typically contact the seabed. Furthermore, purse seine fisheries generally have low levels of by-catch and based on observer and fisher reports, relatively few interactions with seabirds and marine mammals, although mass capture events can occur. We consider that the main concern in the Sea Change Plan is not with purse seining as a method but rather with the sustainability of bulk harvest fisheries in general." [225]

This contrasts markedly with *Sea Change – Tai Timu Tai Pari Hauraki Gulf Spatial Plan 2017* which recommended an urgent review of purse seining, as follows (Management Actions 7 & 8):

"Undertake an urgent review of purse seining within the Hauraki Gulf Marine Park, to be completed in 2018, including:

1. *Potential impacts on seabird foraging behaviour and breeding success.*
2. *Potential impacts on ecosystem health of the Hauraki Gulf Marine Park, including impacts on the food chain and other fish stocks.*
3. *The value of the harvested fish in the marketplace and within the ecosystem.*
4. *The appropriateness of the total allowable commercial catch and quota management area.*
5. *The potential impacts of withdrawal of bottom trawling and Danish seining from the Hauraki Gulf Marine Park on catch levels.*
6. *The location of voluntary closure areas and possible expansion to the southern east coast part of the Hauraki Gulf Marine Park."*

In the interim, prior to the completion of the review, no new purse seining vessels are to operate within the Hauraki Gulf Marine Park [79].

That tentative, precautionary approach has been set aside in favour of fish stock management. The rationale being that because small pelagic fishes, such as blue mackerel and jack mackerel, are migratory, it is considered the total allowable catch to be the most effective management measure for ensuring their sustainability. Which begs the question, sustainable for whom?

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Impossible to ignore? Tītī wainui / fairy prions and shearwaters, Mokohinau Islands. Photo by Edin Whitehead.

Free-ranging rako / Buller's shearwater is an abundant species across the whole wider Hauraki Gulf region. Photo by Edin Whitehead.

8.2 Marine protection for highly mobile marine species

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Marine Protected Areas (MPA) have the potential to provide adequate protection to seabirds at a local scale. Knowledge of the distribution and density of seabird populations is necessary to determine the degree of exposure to harmful human activities and develop a robust area-based management plan.

Currently, there are no at-sea protection measures for seabirds in the Hauraki Gulf, which is of concern given that many populations are at risk due to high anthropogenic-induced mortality.

Ongoing monitoring of seabirds in the Gulf is necessary to identify critical habitats in time and space and manage commercial and recreational activities within these spaces appropriately.

Conservation issues are exacerbated for large marine predators including seabirds that migrate between countries and through international waters. These conservation issues are amplified for species that depend on coastal habitats for some or all their lives because human activities are the most intense in these regions [226]. Marine predator hotspots often overlap with areas of economic, social, or cultural value as both are centred around productive marine environments [227, 228].

While threats such as marine pollution and climate change will require societal changes at a global scale, many of the threats posed to large marine predators may be mitigated or at least minimised through spatial protection [229-231]. However, a major challenge in conservation and management is addressing how to implement protection in areas of ecological, social, and economic value where differing views on the use of ocean resources can be a source of conflict [232]. International agreements, such as the Convention on Migratory Species or Ramsar Convention on Wetlands of International Importance, can be useful for connecting international protection measures for species that move between countries, but they have no legal standing meaning that efforts in one country may be undone by a lack of effort in another country e.g., habitat degradation through land modification, lack of fisheries by-catch mitigation [191, 233].

There are several cases where large marine predators e.g., marine mammals, seabirds, and sharks have been used to direct conservation efforts through the establishment of Marine Protected Areas (MPA), each with varying degrees of protection [231, 234, 235]. MPA are commonly designed to protect species that do not move too far and certain habitat types, leaving large parts of the marine environment unprotected as most MPA are too small to be effective [236, 237]. Area-based management, such as multi-use MPA, has become a common management strategy that is based around ecosystems [238-240]. This requires the identification of areas where management of activities such as fishing can be balanced with the ecosystem remaining largely intact, which is a tricky task for managers as marine ecosystems can be quite dynamic. The declaration of large MPA is more commonplace in recent years [241], providing some protection for wide-ranging predators [242]. As with most wide-ranging marine predators, seabirds provide challenges when identifying and designating protected areas that are science-informed, sufficiently large to be effective, and able to be monitored and enforced [229, 243].

Many of these MPA represent *"paper parks"* because conservation goals are not met due to poor planning, and a lack of regulation, surveillance, and enforcement [244]. The Hauraki Gulf Marine Park is Aotearoa New Zealand's only Marine National Park (Hauraki Gulf Marine Park Act 2000) and is an example of a *"paper park"*. Over the past 20 years, there has been an almost complete failure to provide adequate protection to the Gulf from recreational and commercial pressures stemming from human activities on land and at sea [36]. This prompted the development of the *Sea Change Tai Timu Tai Pari – Hauraki Gulf Marine Spatial Plan*, which is New Zealand's first spatial plan that aims to improve management of the multi-use Marine Park using an ecosystem-based approach. Whilst there have been considerable efforts in the Gulf to restore islands and eradicate introduced predators that have decimated some seabird populations [107], and progress on mitigating by-catch, there are still conservation challenges for seabirds in the Gulf [1]. An area that is poorly understood is how shifts in phytoplankton productivity affect prey availability, but seabirds can be useful indicators of how productive the ecosystem is as they have high demands for good quality prey [74]. Recent research revealed seasonal differences in the types of zooplankton in the Gulf [245] and prey availability strongly influences where we find cetaceans and sharks [192], therefore it is likely that prey also drives seabird habitat use and distribution.

There is much to be gained from distribution studies of large predators as their presence and abundance can inform on the entire ecosystem [246], but these must be well resourced and information shared between researchers and governments where they share species. Despite their iconic status and potential to act as indicators of the health of an ecosystem, data covering the full distribution of seabirds are often lacking. By considering distribution patterns over time and within and between habitats, it is possible to use an informed conservation approach to ensure marine spatial planning that is dynamic and effective for all large marine predators in the Gulf. Only then will we be able to restore the Mauri of the Gulf and ensure a healthy ecosystem.

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Common dolphins at speed, west of the Mokohainu Islands. Photo by Edin Whitehead.

Study species kuaka / common diving petrel – see Section 4.2 (Question 2). Photo by Kerry Lukies.

8.3 Integrative methods for seabird research and conservation

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An integrative approach to seabird biology can help realise the immense potential these species have as indicators of ocean change.

It will increase the efficacy of conservation efforts in a rapidly changing world where conservation programmes are often fiscally constrained, requiring:

Better description of the environment (both biotic and abiotic) in which seabirds reside – what set of conditions allow chicks to be successfully raised?

Integrated modelling of seabird responses to environmental change – what magnitude of response from seabirds elicit the need for management action?

Predictive demographic modelling to map population fate into the future – how will species fare under different scenarios?

Physiological data are increasingly used in research assessing seabird health and have good potential for incorporation into conservation management. Crucial to this integration is the validation of physiological tools (are they answering the questions we ask of them?) and identifying the most powerful and cost-effective approaches to use in long-term monitoring. Our current research is trialling several physiological data streams alongside tracking work, remote sensing of oceanic conditions, and breeding success of a number of different species to validate these tools.

Once validated for species of interest, physiological methods will enable us to perform a more rapid assessment of seabird population health than demographic methods, gathering more information from less time in the field. Done in conjunction with long-term monitoring, this will enable us to predict what environmental conditions may impact on breeding success and engage in more adaptive management. However, this must be balanced with prioritising conservation actions for species of concern.

Seabirds are often touted as perfect 'environmental sentinels' or 'indicator species'. However, to utilise them as such, we need to perform these integrative studies to ascertain the at-sea areas they use (where they are indicating for), what prey species they rely on (what food-webs do they indicate for), and the directional relationships between environmental cycles such as the El Niño Southern Oscillation and breeding success. While some assumptions can be made where work has been done internationally on similar species, this work is extremely context dependent, and must be performed within our own unique oceanic systems to be useful. In addition, given our local diversity of seabird species, identifying the most effective ones to monitor as 'sentinels' is also key.

There are several priority areas for this research:

1. Better description of the environment (biotic and abiotic): satellite monitoring, remote sensing, prey abundance, diversity, nutritional profile, and dynamics
2. Integrated model of seabird responses to environmental change: ground-truthed/validated against chick performance. Increase of scale (multiple colonies, regional/national) and scope (species studied). Include performance of each bird species, time energy budgets, and behavioural and physiological capacity to buffer stress levels e.g., allostatic loads.
3. Predictive demographic modelling: trends to optimise conservation responses, mechanistic and/or predictive habitat modelling to identify shifts in future distribution limits (both at-sea and breeding habitat).

Nonetheless, using the case studies described in Section 4.2 our examples illustrate the power of physiological and integrative methods for assessing seabird population health. Looking at stress as a sub-lethal measure of population health will enable more responsive management of populations without having to wait for years of breeding failure, or chick and adult mortality to indicate a problem. Stress levels of seabird chicks reflects conditions within the foraging grounds of the adults of that colony. This gives us a tool to help predict and prevent mortality because of at-sea environmental conditions, by engaging in adaptive management strategies for threatened species with greater resolution and responsiveness than is currently available.

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Processing samples for integrative research, field lab Mokohinau Islands. Photo by Edin Whitehead.

8.4 Our Ocean's Sentinels – looking ahead

Chris Gaskin[1]

[1] *Northern New Zealand Seabird Trust*

Future research across the wider Hauraki Gulf region, i.e., Northland, Auckland and Waikato, needs to be planned strategically, coordinated appropriately, and embrace the long-term.

A structured programme developed around key seabird species that can be monitored easily at several sites, in some cases simultaneously to allow comparisons in foraging, diet and breeding success between populations.

At-sea monitoring stations established to detect changes in the frequency, nature of species interactions and oceanographic factors related to development of the concentrations of seabird prey species.

Relevant expertise so that Mātauranga Māori (Māori knowledge) values and practices are integrated into every stage of the programme.

Seabird species in the region are distributed in accessible colonies across the Gulf, feed on a range of prey from zooplankton to fish and squid caught from inshore to more oceanic waters at a range of depths. This offers the exciting possibility of utilising these birds as sensitive indicators of change in the marine environment at different spatial and temporal scales. Seabird breeding and foraging performance should reflect changes in the distribution and abundance of key prey species and hence key trophic interactions within food webs upon which they and potentially other marine predators depend. A maritime take on the 'canary in the coalmine' scenario[4].

Future research across the wider Hauraki Gulf region needs to be planned strategically, coordinated appropriately, and embrace the long-term. One approach would be to establish a network of long-term monitoring stations from which effective management actions could spring. Two strands of research conducted on the islands and at-sea, mutually informed by Mātauranga Māori values and practices, would inform future marine management for the wider Hauraki Gulf region.

By building on findings from recent research, here and overseas, a structured programme can be developed around key seabird species that can be monitored easily at several sites, in some cases simultaneously to allow comparisons in foraging, diet and breeding success between populations. In considering which species to monitor, the better the species' conservation status the more reliable they will be as ecological sentinels.

While the network envisaged would be across the whole Hauraki Gulf, from Northland through to the east Coromandel islands (i.e., within Northland, Auckland, and Waikato regions), there is some emphasis on the outer reaches of the Gulf to provide balance to the ongoing debate about marine protection and management issues with its current focus on nearshore and benthic habitats, and the inner Gulf close to Tāmaki Makaurau Auckland.

The results from recent research highlight the value of integrative assessments of seabird breeding biology. By drawing on tracking, behavioural modelling, diet and stable isotope trophic data, and physiology, it will be possible to show that neighbouring colonies differ in responses to localised habitat conditions over 10's of km. For example, using physiological measures that potentially reflect foraging effort at an individual foraging trip level, as well as integrating the foraging effort over longer periods. Through

[4] An allusion to caged canaries (birds) that miners would carry down into the mine tunnels with them. If dangerous gases such as carbon monoxide collected in the mine, the gases would kill the canary before killing the miners, thus providing a warning to exit the tunnels immediately.

Zooplankton sampling around fish shoals, Mokohinau Islands. Photo by Chris Gaskin.

long-term monitoring we can detect trends, and by using physiological data we can see how changing environmental conditions will impact population health and reproductive success rather than waiting to observe the outright mortality of chicks. This will support agile management, allowing us to know when to act, and when we should be worried about future colony viability. Other monitoring methods can be adopted, e.g., repeat population surveys based on burrow counts and monitoring of state of occupancy and breeding activity, in addition to diet sampling.

Seabirds are generally constrained to foraging in the upper part of the water column and when prey is concentrated. These favourable feeding conditions are often associated with the activity of other marine predators in multi-species associations. At-sea monitoring stations would be established to detect changes in the frequency, nature of species interactions and oceanographic factors related to development of the concentrations of seabird prey species. Taking a multi-level approach is required to understand such a dynamic system.

Complementary research

This network of terrestrial and marine based seabird monitoring would be complementary to other seabird research conducted throughout the region through individual, institutional, and tangata whenua research interests, and government contracts. While a network of long-term monitoring stations would track a selected group of species representative across the region, each of the region's 27 breeding species have their own stories to tell. Some, for example, the two most threatened species NZ fairy tern and NZ storm petrel, have working groups to oversee their research and conservation; black petrel and flesh-footed shearwater research is conducted largely through DOC and MPI contracts due to fisheries by-catch concerns. The Hauraki spotted shag, is another of high concern and the subject of restoration efforts and monitoring.

Pressures these seabirds face

Pressures that affect both seabirds and the ecosystems they inhabit are:

- Fisheries can reduce the abundance of forage fish and may also change the community structure of fish schools resulting in smaller and less frequent workups which reduces food (i.e., krill and smaller fish) availability. This could result in negative impacts on the seabird populations that rely on those prey.
- Climate change – the effect of long-term regional scale changes, for example:
    - In distribution, availability, and abundance of zooplankton (e.g., the decade long decline in phytoplankton production along the Northeast North Island [247].
    - Increased likelihood of extreme heat and storm events that cause nest desertion by adults or chick mortality in surface nesting species.
    - The development of toxic algal blooms.
- Increased turbidity – storm events, sedimentation plumes from terrestrial sources, at-sea activities such as dredging, dumping, sand mining and demersal destructive fishing can resuspend benthic sediments which can cause turbidity. Turbidity causes reduction in productivity by reducing light penetration of the water column. It also reduces the underwater visibility of prey for foraging seabirds.
- By-catch – seabirds in the region are caught in several fisheries, bottom and surface longline, trawl and set net [1]
- Pollution including plastics, already documented from the gut contents of fish captured by an Australasian gannet.

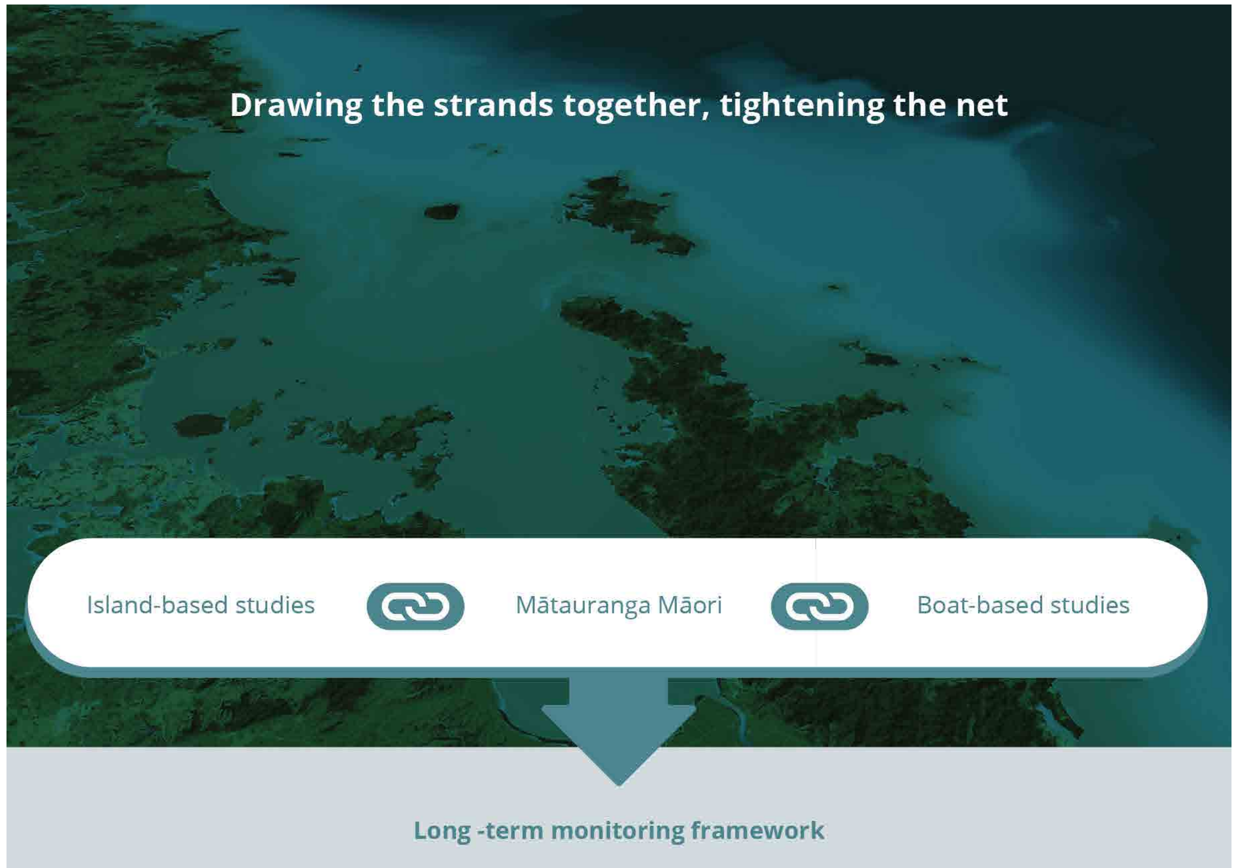
Measures

The following are the specific biological/ecological the proposed network wishes to monitor:

- Diet/prey differences among seabird colonies/ islands (are energy flows changing?)
- Changes in seabirds' foraging distribution and behaviour (are seabirds working harder to raise a chick in a depleted environment? Are they flying further, diving deeper?)
- Shifts in seabirds' nesting locations, population trends (are seabirds declining, holding on, or (hopefully) increasing?).
- Spatial separation of foraging by birds from different colonies (how do seabirds use the Gulf? What will happen when numbers increase?
- Physiological responses to ocean change (can seabirds cope with changing environment? When would we need to intervene?).
- Changes in zooplankton occurrence across the Gulf.
- Changes in occurrence and diversity of fish school activity at sampling stations.
- Changes in local conditions (temperature, productivity, current flows).
- Correlation of breeding success/mortality to storm events/ toxic algal blooms
- Benefits of educating all people about marine biodiversity and sustainability.

In developing an effective tool to assess long term changes to the Gulf's marine ecosystem the research undertaken must be integrated for modelling purposes. Likewise relevant expertise must be involved into every stage of the programme so that Mātauranga Māori values and practices are integrated. Māori kaitiaki and pakeha stewardship roles must be strengthened and walking in parallel.

This proposal, as with most research, requires collaboration through all stages of planning and implementation. The first steps recommended could be a hui using what is outlined here as a starting point for discussion, and depending on the outcome, followed by a pilot project. One that would draw on local and international expertise to advise on best practice for setting up a monitoring network that would deliver on the measures listed above.



TE PAE TAWHITI
9. FUTURE MEASURES

Taranga / Hen Island with Marotere / Chickens Islands beyond. Photo by Edin Whitehead.

In future years we need to be able to measure progress in our understanding of the region's seabirds and Te Moananui-ā-Toi / Tīkapa Moana / Hauraki Gulf through their eyes. Measures or indicators to be evaluated in five and ten years are set out as below:

Kaitiakitanga

- Are tangata whenua – iwi, hapū across the wider Hauraki Gulf region engaged in all stages of seabird research and conservation?
- Are Mātauranga Māori values and practices integrated?
- Are there training opportunities for rangatahi, especially those of school leaving age, for learning a range of techniques used in seabird research, and gain familiarity with the general biology and key interactions among marine wildlife?
- Are Māori kaitiaki and pakeha stewardship roles strengthened and walking in parallel?

Strategic planning

- Is seabird research conducted strategically across the wider Hauraki Gulf region and coordinated appropriately?
    - Has a long-term region-wide monitoring programme been established (i.e., within Northland, Auckland and Waikato regions) and is this resourced sufficiently? See Sections 4.3 & 8.4. Does this monitoring programme include an integrative approach to seabird biology? See Sections 4.2 and 8.3.
    - Is the Auckland Council continuing to support the seabird monitoring programme initiated in 2018? See Section 4.3.
    - Are dedicated aerial surveys occurring with at least two surveys per month and across multiple years to capture spatiotemporal patterns in distribution of marine mega-fauna (including seabirds)? See Section 5.8.
- How many long-term studies of individual species have been established, or are ongoing? See Section 4.1.

Marine spatial planning

- What are the benefits for seabirds through the implementation of Revitalising the Gulf – the Government's response to the Sea Change Plan? See Section 8.1.
- While ongoing monitoring of seabirds in the Gulf is necessary to identify critical habitats in time and space, we have enough knowledge to manage commercial and recreational activities within some spaces appropriately. Are highly visible and abundant seabirds given full recognition in the identification of new proposed marine protected areas (MPA)? See Sections 8.1 & 8.2.

Fisheries

- Has there been a reduction in seabird by-catch rates for both the commercial and recreational fisheries? see Sections 5.6 & 6.2.
- Are cameras installed on 100% of vessels in the inshore commercial fisheries fleets? See Section 6.2
- What research has been conducted into investigating potential indirect effects from both commercial and recreational fisheries? See Sections 8.1 & 8.4.
- Have seabird foraging distributions been overlaid with the distributions of fish species targeted by many commercial fisheries, with data drawn from catch and vessel reporting?
- Set netting is one of the most non-selective fishing practices and known to catch seabirds that dive for prey, especially flock feeders. Have set nets been banned from all inshore coastal areas, and over reefs where seabirds are known to gather in large feeding flocks?
- Has the review of purse seining, as recommended in Sea Change – Tai Timu Tai Pari Hauraki Gulf Spatial Plan 2017 (Management Actions 7 & 8), been completed?
- Given the widespread concerns about this fishery, should the precautionary approach be that no purse seining vessels operate within the Hauraki Gulf Marine Park until such a review has been completed?

Coastal development

- Are coastal seabirds (penguins, gulls, terns and shags) factored into new development plans? By enhancing and protecting areas of natural vegetation, engaging in predator control, keeping pets under control, reducing artificial lighting and controlling sediment runoff? See Section 6.4.

Pollution

- Artificial light at night (ALAN) is a threat to some seabirds in the region. See Section 5.11.
    - Has the extent of fallout from ALAN on seabirds for Tāmaki Makaurau / Auckland city been recognised at Council level and what measures have been adopted to reduce the problem?
    - Is there compliance on light use in coastal and marine areas within Auckland – as per E24 Lighting Auckland Unitary Plan?
    - Is there public awareness of the problem and procedures in place to collect grounded birds and deliver to bird rescue centres?
    - Has an ALAN fallout database been established for locations and time/date of where and when birds are found? Data can be mapped to try and detect hotspot areas for fall out.
- Is there recognition of the potential impacts on seabirds and other marine life in assessing areas for sediment disposal from harbour / estuary dredging, and for sand mining? If so, what mitigation measures have been introduced? See Section 4.4

Biosecurity

Effective island biosecurity is the key to maintaining the natural values of the Gulf's islands – see Section 6.1.

- Have all nature reserve islands retained their predator-free status?
    - Have there been any incursions?
    - If so, have these been detected quickly?
    - And were all predators eliminated?
- Breeding colonies in coastal areas need protection from disturbance, particularly from beachgoers and dogs, but also from introduced predators such as cats and stoats. Have there been improvements in human behaviours around seabird colonies, measured by successful breeding seasons? Is there a programme of predator control for nesting seabirds in coastal areas of the mainland and the inhabited islands of the Gulf?
- Because seabird colonies are generally occupied during breeding months and/or can shift to new locations between years, protective measures (including public education) need to be flexible. Are timing of nesting and shifting colonies factored into disturbance mitigation and public education?
- How many marinas, boatyards and wharves in the region have active pest and predator control programmes? With no requirement for recreational and commercial fishing vessels active in the wider Hauraki Gulf to be pest/predator-free, there is a risk to predator-free island sanctuaries from vessels harbouring predators. See Sections 6.1 & 6.4.

Ecological surveys

- Have full ecological surveys been completed for Taranga / Hen Island, Motukino / Fanal Island (Mokohinau Islands), Repanga / Cuvier Island? While all fauna and flora need to be assessed, an emphasis on the recolonisation made by seabirds will serve to highlight the full potential of seabird restoration following predator eradications. See Section 2.5.
- Have there been surveys for islands such as Channel Island in the Colville Channel, Motukawao Islands (off Coromandel), many smaller islands off Aotea / Great Barrier Island, and Whatupuke and Mauipane / Coppermine Island (Marotere / Chickens Islands) (which have not been surveyed for winter and spring nesting species)?
- Has a basic inventory of the region's sites been undertaken for breeding seabird species and their population sizes?

Seabird restoration

- Has the pool of iwi/hapū-led and community ecological restoration groups across the region which include seabirds in their restoration plans increased?

Species-specific

Tara-iti / New Zealand fairy tern – See Section 5.3

- Is the tara-iti population increasing?
- Has the artificial site at Tapora on the Kaipara Harbour been successful in attracting nesting birds?

Kororā / Little penguin

- Have population surveys for kororā for predator-free islands across the region been conducted? These are needed to fully assess the overall population and understand trends.
- Has further tracking been conducted at selected localities to investigate overlap with potential dredge dumping and sand-mining areas, high boat traffic areas? See Section 4.4. Also, to assess overlap with proposed MPA. See Section 8.1.

New Zealand storm petrel – Section 5.4

- Has another breeding population been found on another island or islands?
- Have further mark-recapture surveys been undertaken on Hauturu?
- What is known about this species' breeding and foraging ecology?

Tākoketai / Black petrel – See Section 4.3 & 5.6

- Has full extent of the tākoketai breeding population on Te Hauturu-o-Toi / Little Barrier Island been completed, following on from the 2015-2016 estimate [85]?
- Has tracking of tākoketai for immature/ non-breeders within and outside New Zealand waters been undertaken?
- As there are conflicting reports of tākoketai foraging behaviour and timing [56, 84, 185, 248] and how this can impact on fishing operations and recommended mitigation action, has further work on diving behaviour and locations of foraging activity been conducted?

Ōi / grey-faced petrel

Most of the global population of ōi breed in colonies on the North Island's north-eastern coast and offshore islands. Ōi are a species subject to traditional harvesting, for example on Ruamāhua / Aldermen Islands.

- Has a programme for establishing base-line population estimates for all the larger islands across the region?
- The case study in Section 4.2 showed that chicks on Auckland's east coast at Te Hāwere a Maki / Goat Island take longer to grow and fledge from the colony than those on the west coast (Te Henga / Bethells Beach). Also, those east coast chicks are much lighter in weight at fledging. How widespread is this trend on the east coast? Does this occur every year and at every site across the wider Hauraki Gulf region and beyond?

Tītī / Pycroft's petrel

- Pycroft's petrel is an endemic species to the wider Hauraki Gulf region. They have increased after rat eradication but there is almost no data on population sizes or trends. Have quantitative surveys been completed for this species across the region, especially for Marotere / Chickens and Taranga / Hen Islands?

Tītī / Cook's petrel

- Has a repeat of the 2007 Cook's petrel census on Te Hauturu-o-Toi [86] been undertaken?

Rako / Buller's shearwater – See Section 4.4

- The new population estimate for rako on Poor Knights Island is a repeatable quantitative study of the breeding population, providing critical baseline data to determine population trends for this potentially important marine indicator species. Has a repeat survey ten years on from the first been conducted?
- Is the proportion of non-breeders (e.g., pre-breeders, birds missing years, failed breeders) in the population better understood?

Toanui / Flesh-footed shearwater – See Section 5.6

- Have ongoing tracking for toanui, combined with new diet studies through both regurgitations and faecal samples, and monitoring of breeding success been conducted?
- Green Island (Mercury Islands) is a very difficult island to survey, although a more robust population estimate is required. Has suitable survey methodology for that site been undertaken?

Little shearwater

- Little shearwaters, like Pycroft's petrel, have increased after rat eradication but there is almost no data on population sizes or trends. Have quantitative surveys been completed for this species across the region, i.e., Marotere / Chickens and Taranga / Hen Islands, Mercury islands, and Poor Knights Islands?

Pakahā / Fluttering shearwater

- Fluttering shearwaters are a very abundant species across the wider Hauraki Gulf region. Has it been established where they all breed, that is beyond the anecdotal assessment that the main populations on Marotere / Chickens, Taranga / Hen Islands, Mercury and Ruamāhua / Aldermen Islands?

Surface nesting species – See Sections 5.5 & 5.7

- Have the region-wide surveys of tarāpunga / red-billed gulls and tara / white-fronted tern (conducted in 2019 and 2020 - see Section 5.5 this report) been conducted annually.
- Has a first regional survey for tara-nui / Caspian terns been conducted, and is there a commitment to repeating at regular intervals?
- Has there been a feasibility study for using drones to provide accurate colony counts for surface nesting seabirds – Tākapu / Australasian gannet, red-billed gull, black-billed gull, karoro / southern black-backed gull?

Shags – See Sections 4.3 & 5.2

- Have Auckland Council / Auckland Museum continued with annual parekareka / spotted shag surveys?
- Have regional surveys for all other shag species been continued – kāruhiruhi / pied shag, kawau paka / little shag, kawau / black shag and kawau tūī / little black shag?

Kororā coming ashore at Burgess Island, Mokohinau Islands. Photo by Adrien Lambrechts.

Celestial seabirds. Rako / Buller's shearwaters against the Milky Way, overhead at Poor Knights Islands. Photo by Edin Whitehead.

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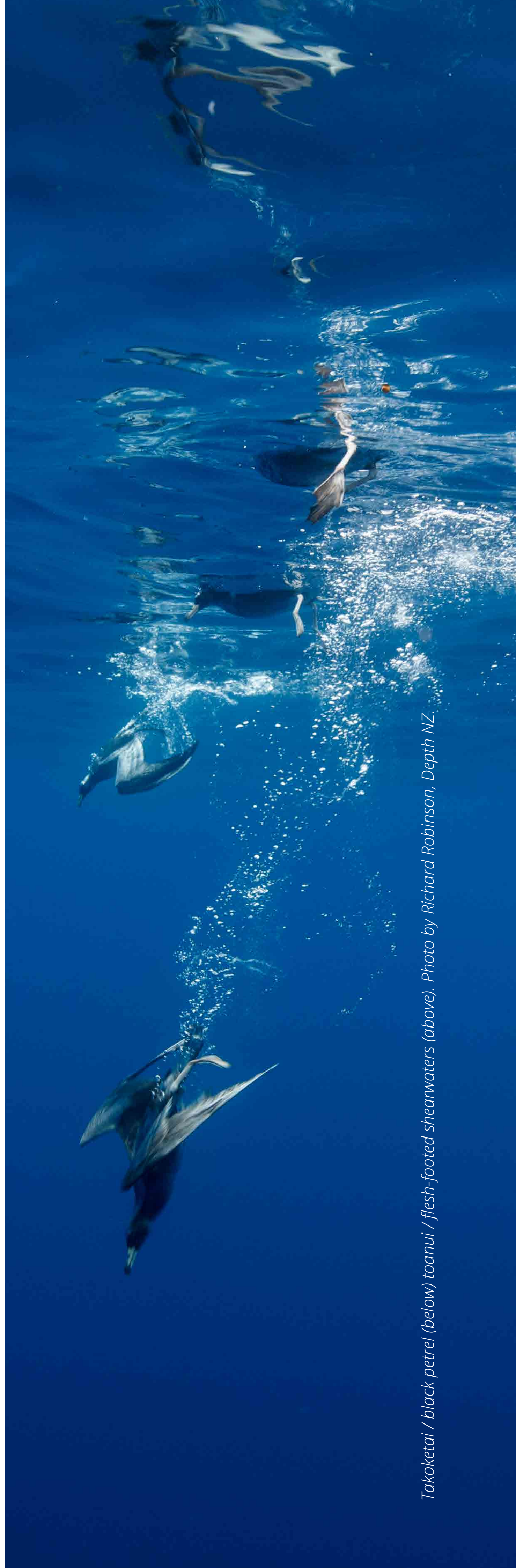

Tokoketai / black petrel (below) toanui / flesh-footed shearwaters (above). Photo by Richard Robinson, Depth NZ.

Tītī wainui / fairy prions. Photo by Edin Whitehead.


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