FOVEAUX STRAIT SEABIRDS: ASSESSMENT OF ENVIRONMENTAL EFFECTS FOR PROJECT SOUTH

Wildlands

R5155a

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Contract Report No. 5155a

March 2020

Project Team:
Rachel McClellan - Report author
Alex Reid - Data collation, report author
Tom Pyatt - GIS analysis and mapping

Prepared for:
Sanford Ltd
PO Box 443
Shortland Street
Auckland 1140

Reviewed and approved for release by:

____
William Shaw
Principal Ecologist/Director
Wildland Consultants Ltd

CONTENTS

1.	INTRODUCTION		1
2.	METHODS		1
	2.1	Overview	1
	2.2	eBird database	4
	2.3	Fisheries observer database	4
	2.4	National aquatic biodiversity information system	5
	2.5	Important bird areas - seabirds	5
	2.6	GIS analysis	6
3.	IMPORTANT BIRD AREAS		8
4.	SEABIRDS OF THE RAKIURA-FOVEAUX STRAIT REGION		13
	4.1	Overview	13
	4.2	Penguins	16
		4.2.1 Blue penguin	16
		4.2.2 Fiordland crested penguin	17
		4.2.3 Yellow-eyed penguin	17
	4.3	Albatrosses and mollymawks	20
	4.4	Shearwaters, petrels, and prions	21
		4.4.1 Overview	21
		4.4.2 Sooty shearwater	21
		4.4.3 Common diving petrel	22
		4.4.4 Whenua Hou diving petrel	22
		4.4.5 Cape petrel	23
		4.4.6 Fairy prion	23
		4.4.7 Cook’s petrel	23
		4.4.8 Giant petrels	24
	4.5	Gannets and shags	24
		4.5.1 Foveaux shag	24
		4.5.2 Pied shag	27
		4.5.3 Spotted shag	28
		4.5.4 Other shag species	28
		4.5.5 Australasian gannet	29
	4.6	Skuas, gulls, and terns	29
		4.6.1 Southern black-backed gull	30
		4.6.2 Red-billed gull	30
		4.6.3 Black-billed gull	31
		4.6.4 Brown skua	31
		4.6.5 White-fronted tern	32
5.	ASSESSMENT OF POTENTIAL EFFECTS		32
	5.1	Overview	32
	5.2	Habitat exclusion	33
	5.3	Changes in benthos and water quality	34
	5.4	Changes in abundance of wild fish populations	35
	5.5	Provision of roosts	36

5.6 Disturbance 36
5.7 Foreign objects and debris 37
5.8 Entanglement 37
5.8.1 Overview 37
5.8.2 Examples in literature and media 38
5.8.3 Preliminary assessment of entanglement risk 39
5.9 Collision with marine farming structures 43

6. MANAGEMENT MEASURES 44
6.1 Overview 44
6.2 Minimise the loss of fish feed 44
6.3 Debris management 45
6.4 Disturbance 45
6.5 Biosecurity management 45
6.6 Lighting management 45
6.7 Mesh structures and maintenance 46
6.8 Other structures 48

7. CONCLUSION 48

ACKNOWLEDGMENTS 50

REFERENCES 50

APPENDICES

1. Important bird areas in the Rakiura-Foveaux Strait region 62
2. Scientific names and threat rankings of seabird species 71
3. Albatross taxonomic differences 74
4. Seabird colony locations 75

1. INTRODUCTION

Sanford Ltd are preparing a resource consent application to develop an offshore salmon farming area to the south-southeast of Ruapuke Island, in eastern Foveaux Strait (Figure 1). Ruapuke Island is approximately 11 kilometres from the location of the nearest salmon pens. Water depths in the proposed site are approximately 50-85 metres.

The salmon farming site will be developed in stages using an adaptive management approach, given that it may be the first offshore salmon farm in the region. The final farm layout at full development will consist of 10 pens (pens will be 120 metres in circumference) in five farming areas, each of which will have 26 hectares in the pens (Figure 1). The total area for pens and anchors being applied for each farmed area is 157 hectares. This will enable adequate distances between the five farming areas, and within areas between pens, to minimise cumulative environmental effects.

A key feature of the farming technology that will be used at the site is the ability of the above water pen to be submerged in severe weather events. Indicative pen construction is shown in Figures 2 and 3, and shows both above water and submerged options. These pens will have a circumference of 120 metres, a diameter of 40 metres, a depth of 25 metres in the centre and 20 metres at the side.

Sanford Ltd has commissioned Wildland Consultants to provide a report that reviews the bird species that are likely to use the general location of the proposed marine farming site and evaluates the importance of the site to those species. This report also assesses the potential effects and risks for the proposed farming operation on these bird species in the absence of constraints, and options for avoiding, remedying or mitigating potential effects.

2. METHODS

2.1 Overview

The proposed marine farming operation will be situated within Southland's Foveaux Strait, to the south southeast of Ruapuke Island and north of Rakiura/Stewart Island. The Rakiura-Foveaux Strait region, including the southern coast area of New Zealand's mainland, supports a high diversity and abundance of seabirds and many seabird breeding colonies. These are summarised in the following sections, using information derived from multiple sources.

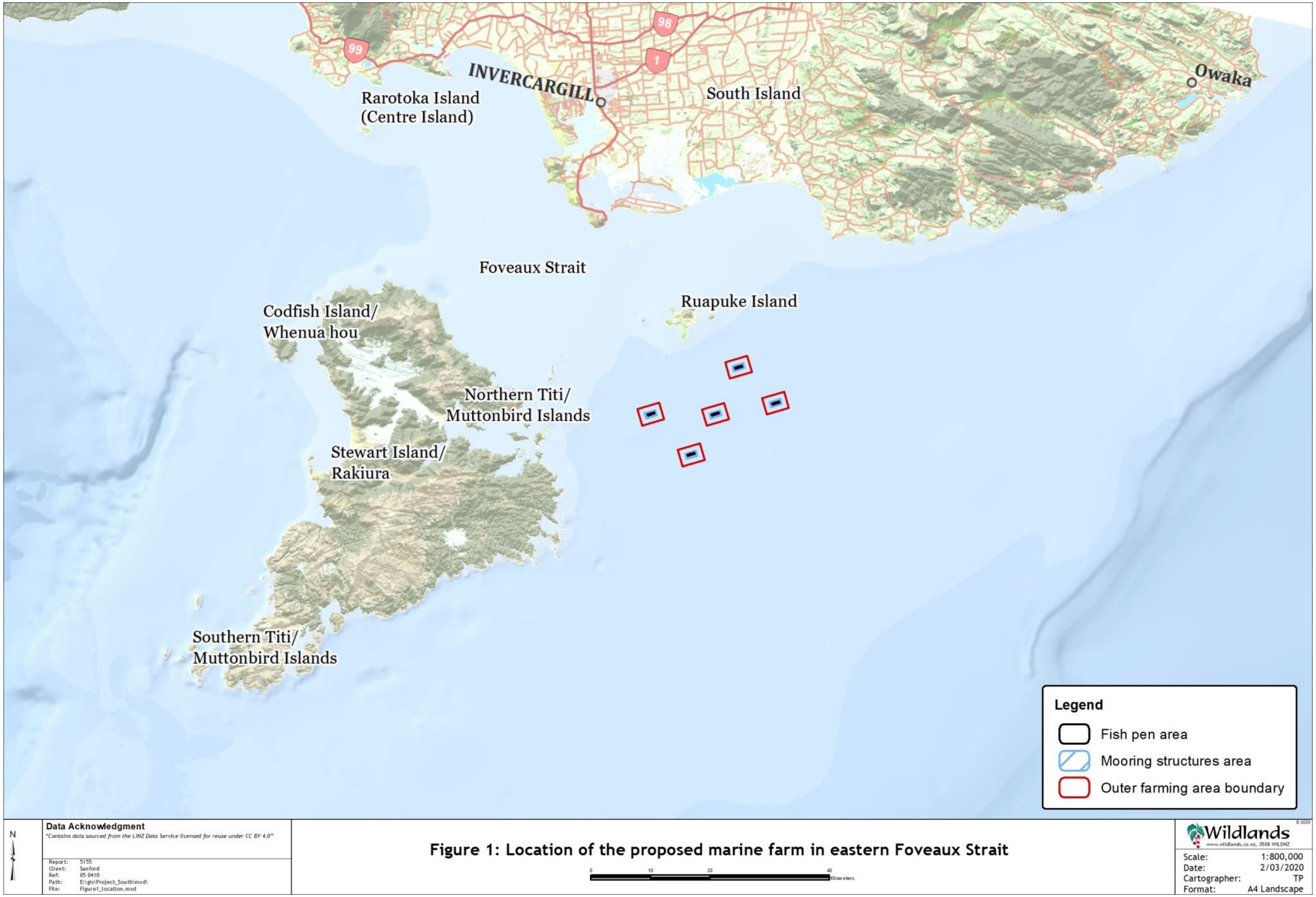

Figure 1: Location of the proposed marine farm in eastern Foveaux Strait

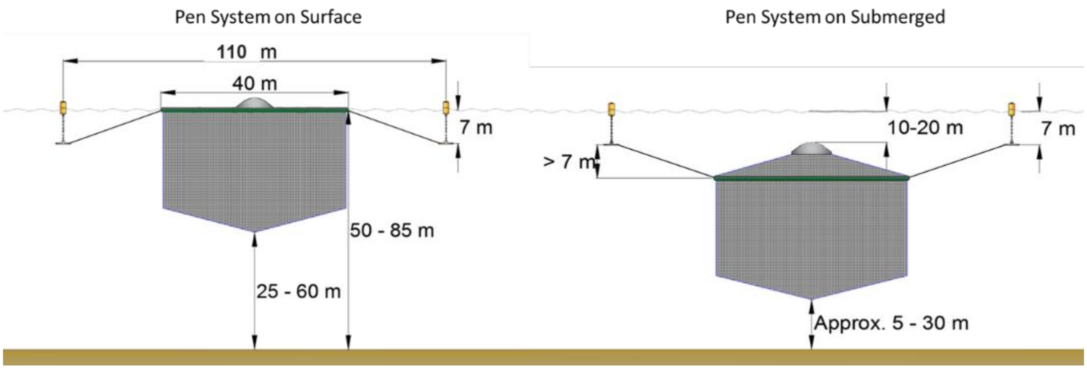

Figure 2: Diagram of indicative pen structure for the proposed Foveaux Strait salmon farming operation.

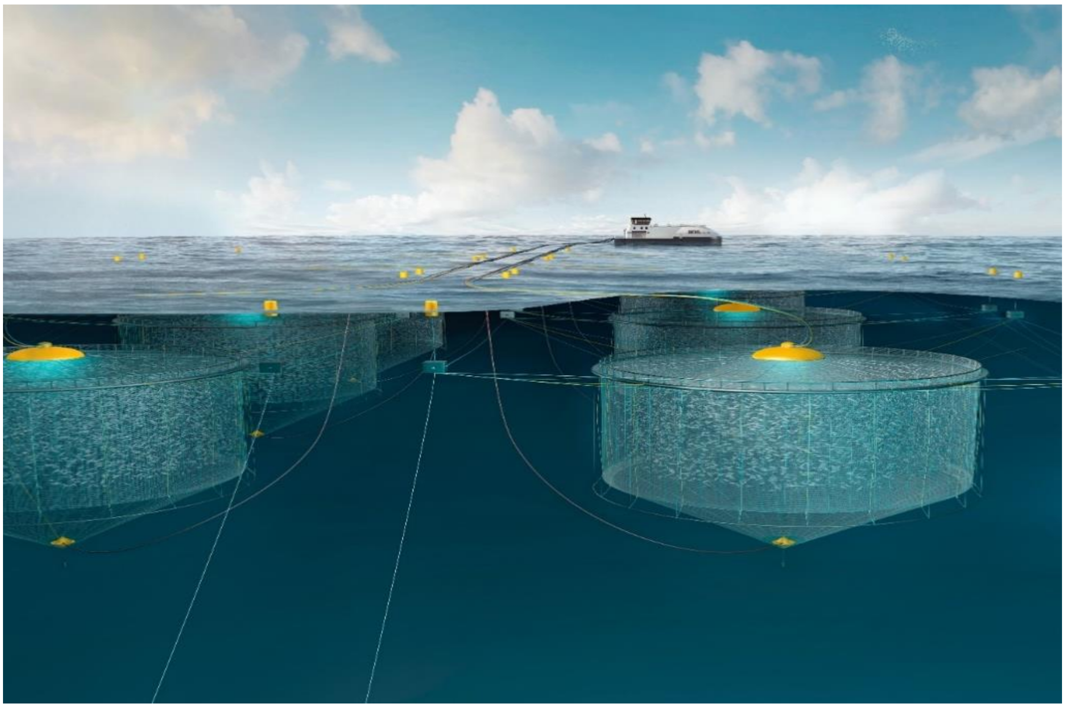

Figure 3: Diagram showing indicative pen layout - submersible option.

Seabird colony and 'at sea' records were obtained from four primary sources:

- The eBird global database (Cornell Lab of Ornithology).
- Seabird observations obtained by fisheries observers (Ministry of Primary Industries).
- Seabird breeding maps from the National Aquatic Biodiversity Information System (NABIS) (Ministry of Primary Industries).
- Important Bird and Biodiversity Area documents (BirdLife International/Forest and Bird).

These sources are discussed further below.

2.2 eBird database

eBird is a citizen science, global database, available online. Observations ranging from records of single birds through to checklists of all birds seen at a location are submitted to the website. The database now holds hundreds of millions of records from around the world.

Use of the data set requires an understanding of its limitations. Anyone can submit data to the website. In New Zealand, submissions come from a range of people, from not-so-skilled bird watchers to highly-experienced observers, or people working in environmental fields submitting data collected during field trips (such as Department of Conservation staff). Of all New Zealand's birds, seabird identification presents the greatest challenges to bird watchers, with a great diversity of species, many of which look similar from a distance. Records submitted to eBird do include some misidentifications.

eBird taxonomy and common names are often different to those used in New Zealand, meaning that people may potentially select the wrong species when entering data. Also, the taxonomy used by eBird differs from taxonomy used in the New Zealand Threat Classification System (Townsend *et al.* 2008). This is particularly the case for albatross species, where eBird albatross taxonomy recognises less taxa than are recognised in New Zealand. For example, northern royal albatross and southern royal albatross are treated as separate species in New Zealand, but are combined as royal albatross in eBird. Appendix 3 shows the differences in albatross taxonomy.

eBird records are biased towards locations that people visit regularly. In the case of records from the Rakiura-Foveaux Strait region, most records are from along the Foveaux Strait ferry route, and locations around Oban/Halfmoon Bay.

The accuracy of eBird map references is also unknown; bird records are entered at a particular map point, chosen by the observer, which may represent observations made at that site, but may also represent observations made along a route (such as a walking track, or the Foveaux Strait ferry route). This level of information is available on the website, but is omitted when mapping.

Results are freely available through searches by species or specific areas. Results summarised in this report were requested and downloaded in May 2019 (Sullivan *et al*. 2009; eBird 2019)[1]. These data have been used to describe 'at sea' seabird diversity and abundance.

2.3 Fisheries observer database

The Ministry for Primary Industries places observers on selected commercial fishing boats. The primary role of observers is to collect information on aspects of the quota management system such as catch effort and bycatch data. Observers began collecting seabird abundance data for the Department of Conservation in 2004. Numbers and species of birds observed in the proximity of fishing vessels are recorded using a

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[1] eBird Basic Data Set. Version: EBD_relMay-2019. Cornell Lab of Ornithology, Ithaca, New York. May 2019.

unique three- or four-letter code. Observations are generally made during the first fishing event of the day, and sometimes more frequently depending on the other duties of the observer (Yvan *et al.* 2011).

These observer data have been analysed by Yvan *et al*. (2011) for the Department of Conservation. The data are freely available for use with appropriate acknowledgment. The authors state that species identifications should be treated with caution. The authors also note that "All the data were collected from fishing vessels and the counts will depend on the distribution of the seabird taxa, how attracted they are to fishing vessels, the visibility of the birds, how readily they may be identified, and the distribution of observed fishing effort. In general, inshore species will be under-represented as observer coverage on inshore fishing vessels has been relatively low. Seabirds were identified to the most accurate taxonomic level possible. Because of the inherent difficulties of counting seabirds around vessels, the variation in the experience of observers, and changes in the protocol with time, the counts should be regarded as indicative only. The data will inevitably contain misidentified birds, and errors in transcribing the raw counts." As for eBird data, differences in taxonomies are evident, and described in Appendix 3.

These data have been used to describe 'at sea' seabird diversity and abundance.

2.4 National aquatic biodiversity information system

The Ministry for Primary Industries manages the National Aquatic Biodiversity Information System (NABIS), which includes data on seabird breeding and seasonal distributions. The locations of seabird breeding colonies and distributions identified in the NABIS database are scientific interpretations based on the best available information from published and unpublished sources. Species data are maintained periodically, as needed.

NABIS data have been used to develop seabird breeding colony maps for the Rakiura-Foveaux Strait region (Appendix 4). The latest data updates and the source material cited by NABIS are also provided.

2.5 Important bird areas - seabirds

The Important Bird (and Biodiversity) Area (IBA) concept was developed by BirdLife International, and has been in use for over 30 years. The identification of an IBA is based on a relatively simple set of criteria that can be applied both in terrestrial and marine environments. Over 12,000 IBAs have been identified worldwide.

Criteria for the identification of an IBA are:

- A_1 - More than threshold numbers of one or more globally threatened species.
- A_2 - More than threshold species complements of restricted-range species.
- A_3 - More than threshold species complements of biome-restricted species.
- A_4 - More than threshold numbers of one or more congregatory species, including:
  - A_{4i} >1% of the biogeographic population of waterbirds.
  - A_{4ii} >1% global population of seabirds.

- A_{4iii} >10,000 pairs, seabirds or 20,000 individuals, waterbirds.
- A_{4iv} > Threshold numbers at migration bottleneck sites.

In New Zealand, seabird IBAs were identified in three major documents which addressed the following seabird IBAs: at sea, coastal sites and islands, and rivers, estuaries, coastal lagoons and harbours. The identification process was undertaken by seabird scientist Chris Gaskin, on behalf of Forest and Bird (a partner of Birdlife International), and involved extensive published and grey literature reviews and communications with species experts. The two documents relevant to the Rakiura-Foveaux Strait region are 'Sites at sea' (Forest and Bird 2014) and 'Coastal sites and islands' (Forest and Bird 2015).

The IBA site descriptions include lists of breeding seabird species, which have been used to develop seabird breeding colony figures for the Rakiura-Foveaux Strait region (Appendix 4).

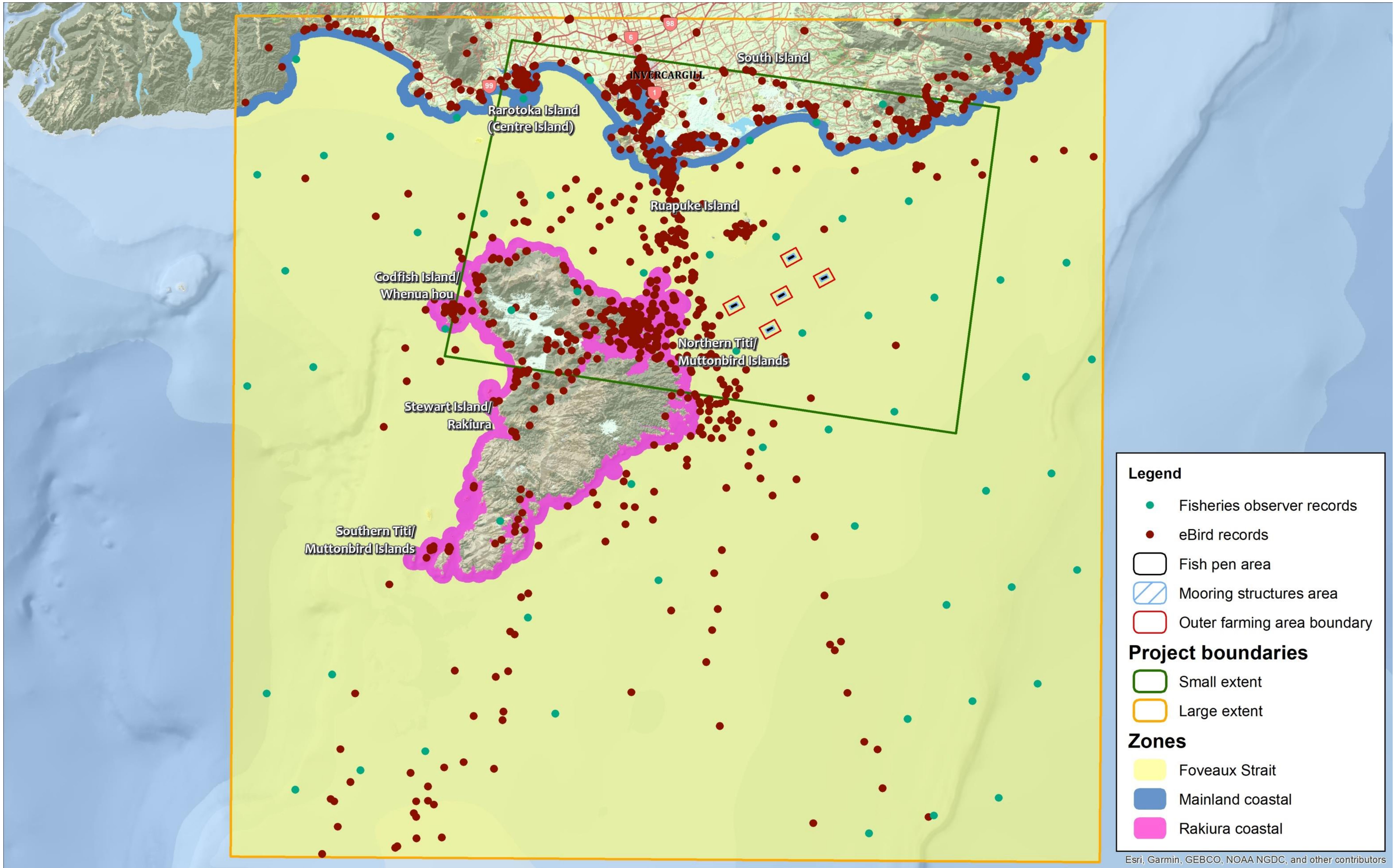
2.6 GIS analysis

Two project boundary layers - a small and large extent - were created in a Geographic Information System (GIS), and overlaid with both the eBird and fisheries observer databases to select relevant records. The small project extent, centred on Foveaux Strait, was chosen for the assessment of species diversity and abundances provided in this report as it was considered most relevant to the project, and contained over 18,000 eBird checklists, though the fisheries observer data set was considerably reduced.

Polygons were created within boundary layers to evaluate the records (Figure 4); 'Foveaux Strait', 'Mainland coastal', and 'Rakiura coastal'. Coastal polygons extend two kilometres from shore, and the Mainland coastal and Rakiura coastal polygons were terrestrial.

Many observations only record the presence of a species rather than a count of numbers seen. In such cases, the observation was included as a single bird. As a consequence, actual numbers will be under-estimates. All eBird records were filtered to exclude non-seabird species, e.g. swans, ducks, and kingfishers.

Key species or groups of species are described in the following sections. Figures showing breeding locations are provided for key species in Appendix 4, including published reference sources.



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Data Acknowledgment
"Contains data sourced from the LINZ Data Service licensed for reuse under CC BY 4.0"

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Figure 4: Locations of eBird and fisheries observer records

0 20 40 80 Kilometers

Wildlands
www.wildlands.co.nz, 0508 WILDNZ

Scale: 1:775,000
Date: 2/03/2020
Cartographer: TP
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3. IMPORTANT BIRD AREAS

Marine and terrestrial IBAs have been identified along much of New Zealand's coastline, using the identification criteria set out in Section 2.5 above. Terrestrial IBAs are described as important bird and biodiversity areas on land (Coastal Sites and Islands) that are internationally important for seabird conservation and known to support key seabird species. There are 140 of these in New Zealand. Marine IBAs (Sites At Sea) are presently limited to sites that are recognised as seaward extensions to seabird breeding colonies. There are 26 of these in New Zealand. Important areas for pelagic species such as migration hotspots, and remote marine areas, have not yet been identified.

Three 'Sites At Sea' marine IBAs have been identified for seabirds in the Rakiura-Foveaux Strait region, and 11 'Coastal Sites and Islands' terrestrial seabird IBAs, demonstrating the highly diverse community of seabird species in the area, as well as the abundance of seabirds (Figures 5 and 6). All IBAs have been identified on the basis of one or more of three criteria: A_{1}, A_{4ii}, and A_{4iii} (see Section 2.5 above). Globally threatened seabird species are those recognised on the IUCN Red List of Threatened Species[1], as opposed to the New Zealand Threat Classification System (Townsend *et al*. 2008).

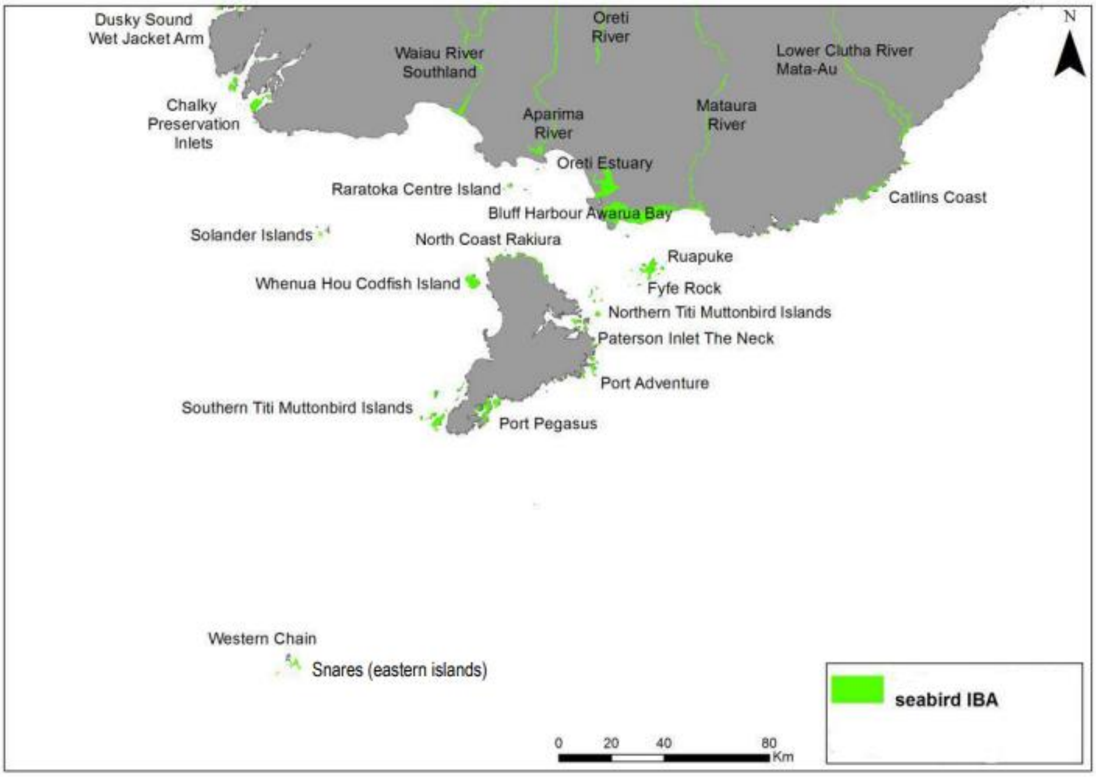

Figure 5: Important Bird and Biodiversity Areas (IBAs) for seabirds on land, in southern South Island and Rakiura/Stewart Island (Forest and Bird 2015).

[1] The IUCN Red List Categories define the extinction risk of species assessed. Nine categories extend from NE (Not Evaluated) to EX (Extinct). Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species are considered to be threatened with extinction.

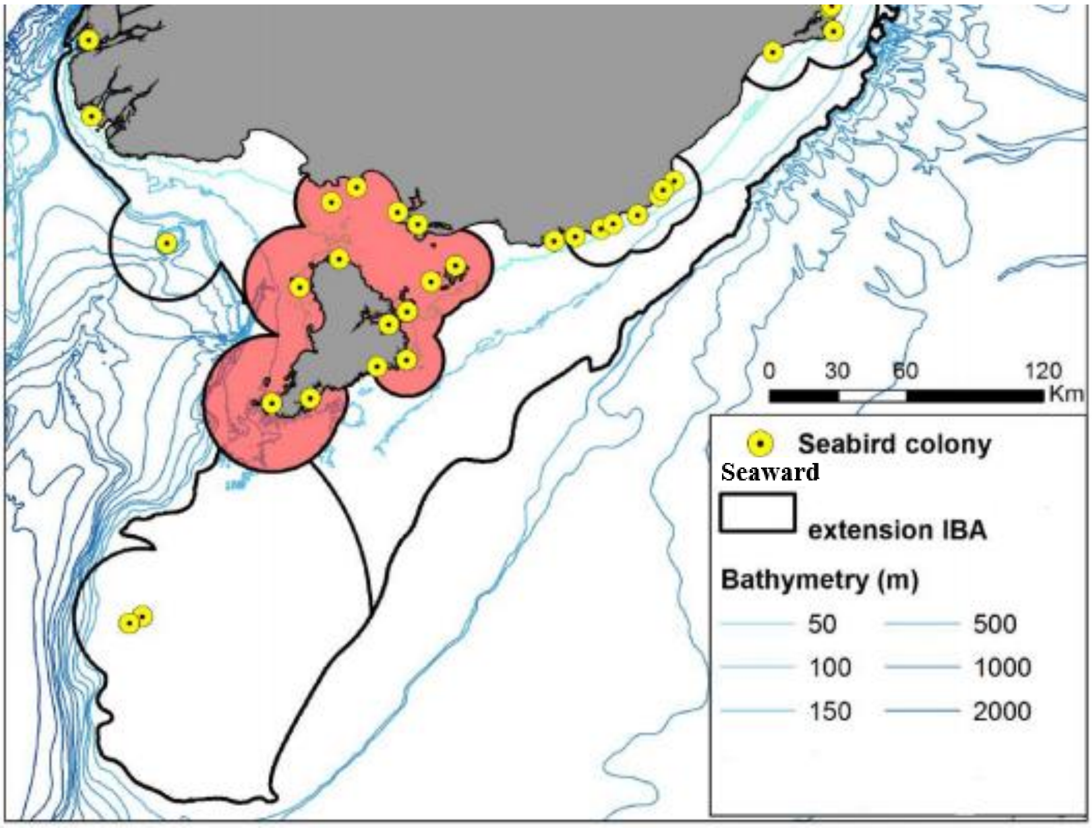

Figure 6: Important Bird Areas (IBAs) for seabirds at sea, in southern South Island and Rakiura/Stewart Island. The Rakiura IBA is displayed in red. The Southern South Island IBA is to the right and the Fiordland-West Coast South Island (South) IBA is to the left (Forest and Bird 2014).

Table 1 lists the ‘Sites At Sea’ marine IBAs, along with descriptions of values. The table notes where tracking data (for example, using GPS or GLS tags) supports the identification of trigger species; most are also supported by manual observations. Table 2 lists the ‘Coastal Sites and Islands’ IBAs. Appendix 1 provides the location maps for each IBA, taken from the respective documents.

Three terrestrial IBAs are in close proximity to the proposed location of the farming area. These are NZ 114 Ruapuke Island (which includes multiple islands including Green Island and Breaksea Islands in addition to Ruapuke Island), NZ115 Fife Rock, and NZ118 Northern Titi Muttonbird Islands. These IBAs are all within approximately 11 kilometres of the proposed farming area. Two IBAs support diverse communities of Nationally Threatened and At Risk seabird communities, and the third IBA, Fife Rock, supports a significant colony of Foveaux shag.

Table 1: Summary of 'Important Bird Areas' for seabirds - 'Sites At Sea'; Rakiura-Foveaux Strait region.

Important Bird Area (IBA)	IBA Number	Area	Trigger Species	At Sea Tracking	Activity	IBA Criteria Met
Southern South Island	NZ MO14	14,903 km^2	Yellow-eyed penguin	Yes	Foraging	A_1, A_{4ii}
			Fiordland crested penguin		Foraging	A_1, A_{4ii}
			Foveaux shag		Foraging, passage	A_1, A_{4ii}
			Northern royal albatross	Yes	Foraging, passage	A_1
			White-capped albatross	Yes	Foraging, passage	A_1, A_{4ii}
			Salvin's albatross		Foraging, passage	A_1
			Buller's albatross	Yes	Foraging, passage	A_1, A_{4ii}
			Hutton's shearwater	Yes	Foraging, passage	A_1
			Sooty shearwater	Yes	Foraging, passage	A_1, A_{4ii}
			Species group			A_{4iii}
Rakiura	NZ MO15	7,811 km^2	Yellow-eyed penguin	Yes	Local foraging, passage	A_1, A_{4ii}
			Fiordland crested penguin		Foraging	A_1, A_{4ii} *
			Foveaux shag		Foraging	A_1, A_{4ii}
			Northern royal albatross	Yes	Foraging, passage	A_1, A_{4ii}
			Southern royal albatross		Foraging, passage	A_1, A_{4ii}
			Antipodean albatross *	Yes	Foraging, passage	A_1, A_{4ii}
			White-capped albatross	Yes	Foraging, passage	A_1, A_{4ii}
			Salvin's albatross	Yes	Foraging, passage	A_1, A_{4ii}
			Buller's albatross	Yes	Foraging, passage	A_1, A_{4ii}
			Cook's petrel	Yes	Passage	A_1
			Mottled petrel	Yes	Passage	A_1
			Sooty shearwater	Yes	Foraging, passage	A_1, A_{4ii}
			Species group	Yes		A_{4iii}
Fiordland - West Coast South Island (South)	NZ MO16	9,573 km^2	Fiordland crested penguin		Foraging	A_1, A_{4ii}
			Mottled petrel	Yes	Passage	A_1
			Cook's petrel	Yes	Passage	A_1
			Sooty shearwater		Local foraging, passage	A_1
			Northern royal albatross		Local foraging, passage	A_1
			Buller's albatross	Yes	Local foraging, passage	A_1, A_{4ii}
			Salvin's albatross	Yes	Local foraging, passage	A_1, A_{4ii}
			Species group		Local foraging, passage	A_{4iii}

Table 2: Summary of 'Important Bird and Biodiversity Areas' for seabirds on land - 'Coastal Sites and Islands'; Rakiura-Foveaux Strait region.

Important Bird Area (IBA)	IBA Number	Area (ha)	Trigger Species (globally threatened, or abundant) (pairs unless stated)	IBA Criteria Met	Other Seabird Species Confirmed or Likely to be Breeding (= Breeding), and Others Recorded
Raratoka Centre Island (includes Pig Island)	NZ113	104	Yellow-eyed penguin: no data	A_1, A_{4ii}	Seven breeding: blue penguin, sooty shearwater, pied shag, spotted shag, southern black-backed gull, red-billed gull, white-fronted tern. Others recorded: broad-billed prion, black shag, little black shag.
			Foveaux shag: 89-239	A_1, A_{4ii}	
Ruapuke Island (includes multiple islands)	NZ114	1640	Yellow-eyed penguin: 43 adults	A_1, A_{4ii}	Nine breeding: blue penguin, sooty shearwater, broad-billed prion, fairy prion, pied shag, spotted shag, southern black-backed gull, red-billed gull, white-fronted tern Others recorded: little shag, black-billed gull, black-fronted tern.
			Foveaux shag 83-94	A_1, A_{4ii}	
Fife Rock	NZ115	<1	Foveaux shag: 305-334	A_1, A_{4ii}	Three breeding: southern black-backed gull, red-billed gull, white-fronted tern. Further information required.
Solander Islands	NZ 116	108	Fiordland crested penguin: 115-155	A_1, A_{4ii}	Ten breeding: mottled petrel, sooty shearwater, broad-billed prion, fairy prion, Australasian gannet, black shag, brown skua, southern black-backed gull, red-billed gull, white-fronted tern. Others recorded: northern giant petrel, cape petrel, subantarctic little shearwater, spotted shag.
			Southern Buller's albatross: 2,735-5,333	A_{4ii}	
			Common diving petrel: >60,000	A_{4ii}	
			Species group >10,000 pairs	A_{4iii}	
Whenua Hou Codfish Island	NZ117	1396	Fiordland crested penguin: 125-259	A_1, A_{4ii}	Eight breeding: blue penguin, sooty shearwater, broad-billed prion, common diving petrel, pied shag, southern black-backed gull, red-billed gull, white-fronted tern. Whenua Hou diving petrel.
			Yellow-eyed penguin: 44-100	A_1	
			Cook's petrel: 3,000-6,000	A_1, A_{4ii}	
			Mottled petrel: *c*.160,000	A_{4ii}	
			Sooty shearwater: *c*.173,000	A_{4ii}	
			Species group: >10,000 pairs	A_{4iii}	
Northern titi muttonbird islands	NZ118	c.474	Yellow-eyed penguin: 40-66	A_1, A_{4ii}	Eleven breeding: blue penguin, broad-billed prion, common diving petrel, white-faced storm petrel, pied shag, little shag, spotted
			Fiordland crested penguin: no counts	A_1	
			Foveaux shag: 90-477	A_1	

Important Bird Area (IBA)	IBA Number	Area (ha)	Trigger Species (globally threatened, or abundant) (pairs unless stated)	IBA Criteria Met	Other Seabird Species Confirmed or Likely to be Breeding (= Breeding), and Others Recorded
			Sooty shearwater: no counts	A_{4ii}	shag, brown skua, southern black-backed gull, red-billed gull, white-fronted tern. Others recorded: little tern.
			Species group: >10,000 pairs	A_{4iii}	
North Coast Rakiura	NZ119	c.655	Yellow-eyed penguin: 74-88	A_1, A_{4ii}	Eight breeding: blue penguin, sooty shearwater, pied shag, little shag, spotted shag, southern black-backed gull, red-billed gull, white-fronted tern.
			Fiordland crested penguin: no counts	A_1, A_{4ii}	
Patterson Inlet The Neck	NZ120	385	Yellow-eyed penguin: c.25	A_1	Nine breeding: blue penguin, sooty shearwater, pied shag, little shag, spotted shag, southern black-backed gull, red-billed gull, white-fronted tern, Antarctic tern.
Port Adventure	NZ121	576	Yellow-eyed penguin	A_1	Seven breeding: blue penguin, pied shag, little shag, spotted shag, southern black-backed gull, red-billed gull, white-fronted tern. Others recorded: Arctic tern.
			Fiordland crested penguin	A_1	
			Sooty shearwater	A_1	
			Species group: >10,000 pairs	A_{4iii}	
Port Pegasus	NZ122	1500	Yellow-eyed penguin,	A_1	Ten breeding: blue penguin, northern giant petrel, sooty shearwater, pied shag, little shag, brown skua, southern black-backed gull, red-billed gull, white-fronted tern, Antarctic tern. Others recorded: broad-billed prion, common diving petrel.
			Fiordland crested penguin	A_1	
Southern Titi Muttonbird Islands	NZ123	1400	Yellow-eyed penguin: 3-11	A_1	Thirteen breeding: blue penguin, broad-billed prion, fairy prion, white-faced storm petrel, common diving petrel, pied shag, little shag, spotted shag, brown skua, southern black-backed gull, red-billed gull, white-fronted tern, Antarctic tern.
			Fiordland crested penguin: no count	A_1	
			Sooty shearwater: *c.*1,750,000 (2 islands only)	A_{4ii}	
			Mottled petrel: *c.*31,000 (2 islands only)	A_{4ii}	
			Species group: >10,000 pairs	A_{4iii}	

4. SEABIRDS OF THE RAKIURA-FOVEAUX STRAIT REGION

4.1 Overview

The seabird community of the Rakiura-Foveaux Strait region is discussed in this section, with an assessment of effects in Section 5. The seabird community (including the southern South Island coast) has been mostly described from a combination of eBird and fisheries observer data (‘At Sea’ records), combined with breeding colony data compiled for the IBA project, and the NABIS database.

Seabird records obtained from the fisheries observer database and eBird are shown in Tables 3 and 4, respectively. Both data sets have been restricted to the ‘small extent’ centred on Foveaux Strait only (refer Figure 4). The two data sets show distinctly different populations of seabirds; eBird data include approximately 65 taxa, whereas the fisheries observer data is limited to only 18 taxa, which generally show strong attraction to commercial fishing vessels, mostly albatross taxa, sooty shearwater, and cape petrel. Species names and their threat classifications are provided in Appendix 2.

Table 3: Fisheries observer records of seabird species within Foveaux Strait (Department of Conservation data).

Common name	Foveaux Strait	
	Number of Reports	Number of Birds
Albatrosses		
Shy mollymawk	168	9,255
Salvin's mollymawk	50	2,269
Southern Buller's mollymawk	69	791
Tasmanian mollymawk	21	700
Southern/northern royal albatross	40	373
Black-browed mollymawk	15	193
Snowy albatross	6	104
Campbell Island mollymawk	3	28
Shearwaters, Petrels, and Prions		
Sooty shearwater	111	4,846
Cape petrel	178	3,234
Black-bellied storm petrel	1	10
Diving petrel	3	3
Grey petrel	1	20
Grey-backed storm petrel	2	13
Northern giant petrel	12	14
Skuas, Gulls, and Terns		
Southern black-backed gull	95	978

Breeding seabird distribution maps are provided in Appendix 4. These maps are indicative of the distribution and frequency of breeding locations. Breeding locations are well known for some species, such as Fiordland crested penguin, but poorly known for many other seabird species. NABIS data includes points and, in some cases, polygons, to depict a breeding area for seabird species, and these have been used if available. However, for IBA sites, where lists of breeding species are provided, a single point has been used centrally within the IBA site to indicate presence of a species; the number of colonies, or extent of colonies is not known. Other papers, both published and unpublished, have been used to improve breeding distribution data where possible. These are referenced in Appendix 4.

Table 4: eBird records of seabird species within Foveaux Strait, and coastal South Island and coastal Rakiura (data downloaded May 2019).

Common Name	Foveaux Strait		South Island Coastal		Rakiura Coastal		Total Number of Reports	Total Number of Observations
	Number of Reports	Number of Birds	Number of Reports	Number of Birds	Number of Reports	Number of Birds		
Penguins								
Southern blue penguin	153	741	6	8	186	1,353	345	2,102
Fiordland penguin	46	155	1	1	111	477	158	633
Yellow-eyed penguin	38	60	13	40	122	242	173	342
Snares crested penguin	10	10			1	1	11	11
King penguin			1	1			1	1
Albatrosses and Mollymawks								
Shy/white-capped mollymawk	497	9,208	12	41	240	3,889	749	13,138
Southern Buller's mollymawk	314	1,602	14	84	134	472	462	2,158
Salvin's mollymawk	136	503			91	328	227	831
Southern/northern royal albatross	188	493	4	7	82	421	274	921
Black-browed mollymawk	37	53	2	3	14	16	53	72
Snowy/wandering albatross	15	21			9	11	24	32
Chatham Island mollymawk	1	1					1	1
Grey-headed mollymawk			1	1	1	1	2	2
Shearwaters, Petrels, and Prions								
Sooty shearwater	493	87,008	22	10,068	196	20,540	711	117,616
Diving petrel	381	11,283	4	82	82	529	467	11,894
Cape petrel	262	1,539	4	8	92	548	358	2,095
Fairy prion	111	1,116			37	110	148	1,226
Cook's petrel	147	527	1	1	29	52	177	580
Northern giant petrel	126	192	2	2	110	243	238	437
Mottled petrel	63	213			17	185	80	398
Fluttering shearwater	55	168			13	15	68	183
Broad-billed prion	40	94			7	13	47	107
Hutton's shearwater	39	75			14	23	53	98
White-chinned petrel	32	64	1	1	17	50	50	115
New Zealand white-faced storm petrel	25	52			7	12	32	64
Short-tailed shearwater	25	36			9	14	34	50
Westland petrel	18	35			3	5	21	40
Buller's shearwater	27	32			2	2	29	34
Grey-backed storm petrel	19	28			10	15	29	43
Southern giant petrel	13	14	1	1	16	29	30	44
White-headed petrel	9	9			1	1	10	10
Grey-faced petrel	3	7					3	7

Common Name	Foveaux Strait		South Island Coastal		Rakiura Coastal		Total Number of Reports	Total Number of Observations
	Number of Reports	Number of Birds	Number of Reports	Number of Birds	Number of Reports	Number of Birds		
Pink-footed shearwater	4	4					4	4
Wilson's storm petrel	3	4			1	1	4	5
Subantarctic little shearwater	2	2			1	1	3	3
Black-bellied storm petrel	2	2					2	2
Grey petrel	2	2					2	2
Whenua Hou diving petrel					1	1	1	1
Southern fulmar					1	1	1	1
Antarctic prion					1	1	1	1
Gannets and Shags								
Foveaux/Otago shag	327	4,241	93	264	237	7,827	657	12,332
Spotted shag	186	657	83	449	164	1,813	433	2,919
Pied shag	94	254	38	79	114	710	246	1,043
Black shag	54	79	139	415	14	28	207	522
Australasian gannet	50	72	7	13	32	47	89	132
Little shag	45	117	230	974	52	203	327	1,294
Little black shag			2	4	1	2	3	6
Skuas, Gulls, and Terns								
Red-billed gull	283	3,945	319	5,432	248	5,550	850	14,927
Southern black-backed gull	278	2,270	421	14,200	205	1,476	904	17,946
White-fronted tern	252	2,726	146	1,162	201	2,074	599	5,962
Black-fronted tern	66	177	74	345	38	80	178	602
Brown skua	82	134			109	249	191	383
Black-billed gull	26	50	174	4,206	23	106	223	4,362
Parasitic skua	4	6	1	2	1	1	6	9
South polar skua	2	3					2	3
Arctic tern	1	2			2	3	3	5
Pomarine skua	1	1		1			1	2
Antarctic tern	1	1			2	2	3	3
Caspian tern	1	1	106	563	1	1	108	565
Gull-billed tern			7	12			7	12
White-winged tern			5	5			5	5
Common tern			1	1			1	1
Whiskered tern			1	1			1	1
Grand Total	**5,089**	**130,089**	**1,936**	**38,477**	**3,102**	**49,774**	**10,127**	**218,340**

The following sections discuss key species or groups of species:

- Penguins.
- Albatrosses and mollymawks.
- Shearwaters, petrels, and prions.
- Gannets and shags.
- Skuas, gulls, and terns.

Brief notes are provided on the potential for overlap of foraging ranges with the proposed salmon farming area. Potential effects are discussed in Section 5.

4.2 Penguins

Five penguin species have been recorded in the Rakiura-Foveaux Strait region. Three species are common: blue penguin (At Risk-Declining), yellow-eyed penguin (Threatened-Nationally Endangered), and Fiordland crested penguin (Threatened-Nationally Vulnerable). All three species have extensive breeding distributions in the region, shown in Figure 1, Appendix 4.

4.2.1 Blue penguin

Blue penguin (*Eudyptula minor*; At Risk-Declining) is relatively common, found around the New Zealand coastline, Rakiura, and the Chatham Islands. Numbers are thought to be in gradual decline, mostly due to the impacts of terrestrial predators. The breeding distribution shown in Figure 1, Appendix 4 will almost certainly be significantly under-represented. Blue penguins are likely to be present around much of the coastline of Rakiura and on many of the offshore islands. For example, examination of observer comments associated with eBird data indicate that breeding birds or chicks were recorded on Ruapuke Island, and Green Island to the east of Ruapuke, in 2012 (NZ114 Ruapuke Island IBA, within 10 kilometres of the proposed farming area).

Blue penguins are known to travel significant distances from their colony when foraging. Most recently, individual blue penguins with GPS loggers from Motuara Island in the Marlborough Sounds were found to travel distances of up to 214 kilometres from their burrows during foraging trips, whereas some individuals remained in local waters (Poupart *et al.* 2017). Their diet and foraging behaviours also vary between regions; however, arrow squid, followed by ahuru (*Auchenoceros punctatus*, a small species of morid cod) have been found to comprise the bulk of the meal mass for birds on Rakiura and Codfish Island (Van Heezik 1990; Flemming 2012). Blue penguin deaths are often recorded in large numbers around New Zealand and have been attributed to lack of food and climatic conditions.[1]

Blue penguins are typically demersal divers - feeding just above or on the sea floor - and are thought to use the sea bed to trap their prey (Chiaradia *et al.* 2007). They have been shown to dive to depths of 55 metres, but generally feed in shallower waters. For example, mean and maximum dive depths were recently calculated for different

[1] NZ Herald – Blue penguin die-off on Bay of Plenty coastline ‘biggest in years’. 24 April 2018

populations around New Zealand: Motuara Island (Marlborough Sounds), mean 11.5 ± 0.1 metres, maximum 31.7 ± 1.5 metres; Pearl Island (Abel Tasman National Park), mean 5.2 ± 0.4 metres, maximum 15.0 ± 1.5 metres; Adele Island (Abel Tasman National Park), mean 6.4 ± 0.3 metres, maximum 21.9 ± 1.5 metres; and Leisure Island (Tauranga), mean 6.1 ± 0.6 metres, maximum 16.3 ± 0.9 metres (Chilvers 2019). These depths indicate that the proposed farm location is unlikely to be used by blue penguins as it is in waters 50- 85 metres deep.

4.2.2 Fiordland crested penguin

Fiordland crested penguin (*Eudyptes pachyrhynchus*; Threatened-Nationally Vulnerable) is endemic to New Zealand and breeds in small colonies along the southwest coast on the South Island and around Rakiura, both on the main island and on offshore islands. The species is rare, and thought to number between 2,500-3,500 breeding pairs, and is in decline[1]. Fiordland crested penguins have not been recorded in the Ruapuke Island IBAs, but are present in the Northern Titi Muttonbird Islands IBA and the North Coast Rakiura IBA.

South Island populations have recently been found to be declining by as much as 2.6% per annum, although factors influencing the decline are poorly understood (Otley *et al*. 2018). Six possible theories that might explain the decline were examined by Otley (et al. 2018), two of which the authors considered required further research: environmental variability/climate change and fisheries interactions, and a third, terrestrial predation, which could be addressed through management. Historic accounts suggest the species once had a much greater range and numbers (Ellenberg 2013).

Foraging ecology and diet of Fiordland crested penguin is relatively poorly understood. On Whenua Hou/Codfish Island, the species has been found to consume mostly ahuru (a morid cod) as well as red cod (Van Heezik 1990a), although the analytical methods used may have under-represented the level of squid in the diet. Most recently, breeding birds from the Fiordland region have been tracked, and were found to make extensive use of the continental shelf slope (200-1000 metres) within 42 ± 5 kilometres of the colony. Individuals mostly foraged in the epi-pelagic zone (mean modal depth 22 ± 2 metres). Isotopic analysis of blood indicated a diet based on squid (Poupart *et al.* 2019). Birds breeding in nearby IBAs such as Northern Titi Muttonbird Islands IBA and the North Coast Rakiura IBA are likely to be capable of reaching the proposed farm location for foraging.

4.2.3 Yellow-eyed penguin

Yellow-eyed penguins (*Megadyptes antipodes*; Threatened-Nationally Endangered) are endemic to southern New Zealand. Subantarctic yellow-eyed penguins are genetically different from those breeding on the South Island and around Rakiura. The species is rare, with a total population estimated to number approximately 1,700 breeding pairs, the majority of which are in the subantartic islands. The South Island supports *c.*600 pairs and there are an estimated 180 pairs on Rakiura, adjacent islands and Whenua Hou/Codfish Island (Darby 2003; Seddon 2013). On Rakiura, yellow-

[1] https://www.doc.govt.nz/nature/native-animals/birds/birds-a-z/penguins/fiordland-crested-penguin-tawaki/

eyed penguins mostly nest along the north east and eastern coasts (Seddon 2013), including the North Coast Rakiura IBA. Significant populations of yellow-eyed penguins are present on the adjacent Ruapuke island and Northern Titi Muttonbird Islands IBAs.

Populations of yellow-eyed penguin on the mainland increased to a peak of *c.*600 pairs in the late 1990s in response to pest management. The mainland population, which is monitored intensively, is known to undergo significant fluctuations, thought to be mostly driven by marine factors such as food availability, but also fisheries bycatch particularly in inshore setnets, and disease. However, there has been limited recovery from recent mortality events, and the mainland population was estimated to number 225 pairs in 2018-2019 despite continuing management, the lowest in *c.*30 years[1]. The most recent declines have included monitored pairs on the Bravo Islands in Big Glory Bay[2]. Rakiura populations appear to have declined at a similar rate to those on the mainland, but are monitored less intensively (Figure 7). In the previous breeding season, more than 400 yellow-eyed penguins in the South Island received care and rehabilitation at the Dunedin Wildlife Hospital, Penguin Place, and Penguin Rescue.

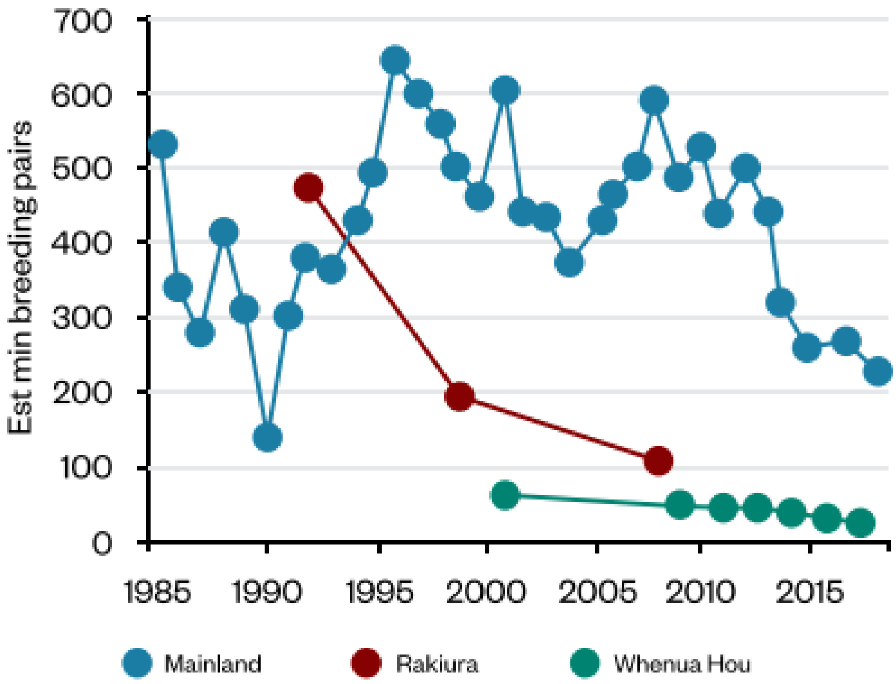

Figure 7: Estimate of the minimum number of breeding pairs for the northern population of hoiho. (NB: the 1999 and 2008 estimates for Rakiura exclude some of the outlier islands). Sourced from "Te Kaweka Takohaka mō te Hoiho"[3].

1 https://www.yellow-eyedpenguin.org.nz/penguins/population-recent-trends/

2 https://www.doc.govt.nz/news/media-releases/2019/hoihoyellow-eyed-penguin-nest-counts-down-for-1920-season/

3 Te Rūnanga o Ngāi Tahu, Department of Conservation Te Papa Atawhai, Yellow-eyed Penguin Trust Te Tautiaki Hoiho and Fisheries New Zealand Tini a Tangaroa. 2019: Te Kaweka Takohaka mō te Hoiho 2019-2029. A strategy to support the ecological and cultural health of hoiho. Draft for feedback. https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/birds/sea-and-shore/draft-te-kaweka-takohaka-mo-te-hoiho-2019.pdf.

Yellow-eyed penguins forage on the seafloor to depths of 150 metres, and up to 50 kilometres from the coast (Te Kaweka Takohaka mō te Hoiho 2019, see footnotes). This indicates that the depth at the proposed farm site is well within the diving capabilities of this species. Yellow-eyed penguin diet in the lower South Island has been shown to comprise seven fish species: sprat (*Sprattus antipodum*), red cod (*Pseudophycis bachus*), silverside (*Argentina elongata*), blue cod (*Parapercis colias*), ahuru (*Auchenoceros punctatus*), opal fish (*Hemerocoetes monopterygius*) and squid (*Nototodarus* spp.) (van Heezik 1990a, b; Moore and Wakelin 1997; Browne *et al.* 2011). Only blue cod and tarakihi (*Nemadactylus macropterus*) were identified in the diet of north west Rakiura birds (Browne *et al.* 2011). Fish taken are mostly juveniles.

Several studies have been undertaken on foraging behaviour of yellow-eyed penguins in Otago and Rakiura. Overall, yellow-eyed penguin foraging tends to occur in areas where bathymetry comprises areas of extensive, relatively gently-sloped continental shelf (Ellenberg and Mattern 2012). This describes the seafloor present in and around the proposed farm. Two of the most relevant studies are from Port Pegasus and Rakiura/Foveaux Strait.

At Port Pegasus, diving data was obtained from eight yellow-eyed penguins for one foraging expedition each, totalling 2,079 dives. The mean dive depth (± standard error) for all dives was 61.0 ± 6.1 metres (range 25-77 metres, maximum dive depth range 53-116 metres). Dives mostly fell into two depth categories, shallow dives of 3-20 metres (63%) and deep dives of 80-100 metres (16%; Chilvers *et al.* 2014).

Penguins from northwest Rakiura tracked between January 2005 and December 2006 foraged in the shallower Foveaux Strait waters. These birds travelled shorter distances, undertook shallower dives, and foraging trips were shorter than those from Port Pegasus or Whenua hou (summarised in Ellenberg and Mattern 2012, Chilvers *et al.* 2014). Later research showed that birds from these areas had a less diverse diet than birds on Whenua hou, and chick survival was very low due to starvation (Browne *et al.* 2011).

In late 2019, a strategic document to guide management of yellow-eyed penguins was released for public consultation, due in part to the recent rapid declines, and recognition of the need for immediate action to avert local extinctions. The document was compiled by Ngāi Tahu, Department of Conservation, Yellow-eyed Penguin Trust, and Fisheries New Zealand. Submissions closed on 20 September 2019. In addition, a detailed five-year action plan was also released[1]. The strategic document provides the following summary of marine threats:

Te āhua o nāianei / Current state
When hoiho head out to sea to fish they face a range of natural and human threats.

Overlap with fisheries means that hoiho are incidentally caught as bycatch, particularly in set nets. The extent of bycatch is uncertain and relies on voluntary reporting and observer coverage. There are limited tools and practices currently available to prevent bycatch in set nets.

1 https://www.doc.govt.nz/globalassets/documents/conservation/native-animals/birds/sea-and-shore/draft-te-mahere-rima-tau-2019.pdf

Changes to marine habitats and the ecosystem also impact hoiho. Starvation events are significant in some years, but their causes are not well understood. Prey may be affected by impacts to the seafloor where hoiho forage; sedimentation and run-off from land, which can affect water visibility or smother habitats; or by climate change. Fisheries, climate change and sedimentation are also likely to affect the wider ecosystem. Predation by sharks, sea lions and barracouta causes some natural mortality and injury to hoiho.

Less well known are the consequences of marine pollution, disturbance or noise, including those from marine activities. An oil spill would likely be devastating for hoiho and is a potential threat particularly due to the presence of shipping traffic moving between ports.

Current marine management practices are not well informed by Mātauraka Māori and do not consistently support mana whenua to actively practice kaitiakitaka with respect to hoiho and the marine environment.

4.3 Albatrosses and mollymawks

A diverse population of albatross and mollymawks is present within Foveaux Strait, as identified by both the eBird and fisheries observer data sets. Difficulties with accurate identification of certain taxa at sea, and the differences in taxonomical systems used by eBird and the fisheries database compared to New Zealand taxonomical usage, create some uncertainties about exact numbers of individuals and taxa present. For example, the Tasmanian albatrosses (Vagrant) recorded by fisheries observers are most likely to be the closely-related shy mollymawk.

No albatross breed in the immediate Rakiura region, the closest breeding grounds being the Solander Islands to the east, where a large southern Buller's mollymawk population is present. All albatross species are capable of travelling hundreds to thousands of kilometres to forage and have vast feeding ranges. A very small proportion of the foraging ranges of many species will overlap with the proposed farm location. Most species undertake extensive migrations after breeding to forage in areas distant from their breeding colonies. Albatross are not adapted to dive, and take a variety of food, mostly from the sea surface, often scavenging dead animals. Species differ in their diets, which range from large fish through to zooplankton.

The most common species present in Foveaux Strait from eBird and fisheries data are shy mollymawk (often called white-capped albatross; At Risk-Declining), southern Buller's mollymawk (At Risk-Naturally Uncommon), Salvin's mollymawk (Threatened-Nationally Critical), and royal albatross (two species, both At Risk-Naturally Uncommon; sightings are most likely predominantly southern royal albatross). Shy mollymawk, southern Buller's mollymawk, Salvin's mollymawk, and southern Royal albatross breed in the subantarctic islands, with the exception of the Solander Islands colony of Buller's mollymawk. They eat fish, squid, krill, and salps, and also offal from fishing vessels taken from the surface (Sagar 2013a,b,c). Fisheries pose a very high risk to each of these species as many are caught as bycatch in trawl and surface longline fisheries (Richard and Abraham 2013).

Along with Salvin's albatross, two other albatross taxa are also classified as Threatened-Nationally Critical: Gibson's albatross and Antipodean albatross. These three taxa are predicted to be undergoing declines of greater than 70% in three generations (Robertson *et al.* 2017). Neither subspecies is recognised in the eBird or fisheries databases, and they are subsumed in the wandering albatross/snowy albatross complex. Birds reported as snowy/wandering albatross in the tables above could actually be snowy, Gibson's, or Antipodean albatrosses, and all three can also be mistaken for royal albatross at sea by less experienced observers. Gibson's and Antipodean albatross are also killed as fisheries bycatch, and may also be affected by climatic changes altering prey distributions (Elliott and Walker 2013).

4.4 Shearwaters, petrels, and prions

4.4.1 Overview

Approximately 27 shearwater, petrel, and prion taxa have been recorded within the eBird data set. Species with more than 100 reports are cape petrel (probably comprising two different subspecies, one a migrant, the other At Risk-Naturally Uncommon), sooty shearwater (At Risk-Declining), Cook's petrel (At Risk-Relict), common diving petrel (At Risk-Relict), northern giant petrel (At Risk-Recovering), and fairy prion (At Risk-Relict). Of these, sooty shearwater was clearly the most numerically dominant species as reports generally comprise hundreds of birds. The other particularly abundant species was common diving petrel. Many of these species breed in the region (Figure 2, Appendix 4); others breed hundreds or thousands of kilometres distant, traveling to the region to forage, or passaging to other locations.

Key species are described in the following sections, including most commonly observed species, and species of particular conservation interest.

4.4.2 Sooty shearwater

Sooty shearwater (At Risk-Declining) is one of the most widely distributed and abundant seabirds in New Zealand, with at least 180 breeding sites. The population has been estimated at *c.*4.4-5.0 million pairs or up to 30 million birds (Waugh *et al.* 2013). The largest breeding populations in New Zealand are around Rakiura and on the Snares Islands. As many as 400,000 chicks are harvested annually as part of a customary take by Rakiura Māori on islands around Rakiura (Mckechnie *et al.* 2010). The species feeds over inshore and offshore waters and undertakes non-breeding season migrations to the northern Pacific. After breeding, birds migrate to the northern Pacific Ocean.

Extensive research has identified large-scale shifts in foraging distributions, thought to be a result of reduced prey and altered current systems in the northern Pacific brought about by climatic changes. A significant decline of 37% over 27 years has been reported from the Snares Islands, one of the largest colonies (Scott *et al*. 2008). High numbers of sooty shearwater are caught as bycatch in the trawl fishery (Richard and Abraham 2013).

Sooty shearwaters eat fish, squid, krill and amphipods, salps, and offal from fishing vessels taken from the surface and by diving (Cruz *et al*. 2001; Sagar 2013d). The average diving depth has been recorded at 16 metres with maximums beyond 60 metres (Shaffer *et al*. 2009). However, birds can reach extraordinary depths, the deepest recorded being 93 metres (Dunphy *et al.* 2015). The foraging habits of the species shows that its foraging range overlaps with the proposed farm.

4.4.3 Common diving petrel

Common diving petrel is a very small seabird that breeds all around New Zealand. Three subspecies are recognised. The southern diving petrel (At Risk-Relict) breeds on the Chatham Islands, the Snares, and around Rakiura. The total population of all subspecies combined is likely to number more than one million pairs. Large colonies are present on Little Solander Island and the Snares Islands. The species is considered to be stable.

Despite being a very small seabird (weighing around 130 grams), individuals are able to dive relatively deeply; one study recorded mean maximum dives of 10.9 ± 6.1 metres, and up to 22.2 metres (Taylor 2008). Another recorded an average maximum diving depth of 22 metres (Bocher *et al*. 2000). The species primarily feeds on krill and copepods, obtained by pursuit diving (Miskelly 2013a).

Recent tracking work on a colony off the Northland coast has shown that these small birds have vast foraging ranges during the breeding season. Post-breeding, the tracked birds undertook an extraordinary migration to the South Polar Front of 3,000-5,000 kilometres, where they remained for several months before returning to breed (Rayner *et al.* 2017). However, the species is commonly seen in inshore waters, as well as pelagic waters, and is likely to use the proposed farm site for foraging.

4.4.4 Whenua Hou diving petrel

Whenua Hou diving petrel (*Pelecanoides whenuahouensis*; Threatened-Nationally Critical) has been recently described as a new species (Fischer *et al.* 2018). The population was previously considered to belong to the South Georgian diving petrel, a widespread species that numbers in the millions. At sea it is likely to be indistinguishable from common diving petrels.

The species is found in a small area of sand dunes on Whenua Hou/Codfish Island, where approximately 150 burrows are known. It is likely to be the remnants of a much wider distribution that once included the Otago Peninsula, Rakiura, Enderby and Dundas Islands on the Auckland Islands, and the Chatham Islands (Fischer *et al.* 2018).

It is not known where the species forages, or what it consumes. However, tracking and dietary studies are underway, with field work completed in late 2019 (Facebook page: 'Flying Penguin Force'). The tiny population and its highly restricted distribution mean that it is very vulnerable to threats such as climate change (for example, storms damaging the sand dunes), oil/fuel spills, and weed invasion. It is not known if the species forages in the wider location of the proposed farming area.

4.4.5 Cape petrel

The New Zealand subspecies of Cape petrel (At Risk-Naturally Uncommon) breeds on the Snares, Bounty, Antipodes, Auckland, and Chatham Islands, and is commonly seen foraging from Cook Strait south. Numbers are poorly known, and estimated at 5,000-10,000 breeding pairs. The second subspecies breeds outside of New Zealand waters, and is much more abundant. Foraging distributions overlap. Cape petrels eat krill, amphipods, small fish and squid, and offal from fishing vessels. Large numbers congregate around trawlers. They take food from the surface, and rarely dive (Sagar 2013e). The foraging distributions of both subspecies are likely to overlap with the proposed farming location.

4.4.6 Fairy prion

Fairy prions (At Risk-Relict) are one of the most abundant and widespread seabird species in New Zealand, with a population numbering in the millions of pairs (Jamieson *et al.* 2016). Breeding populations are distributed from the Poor Knights Islands in the north to the subantarctic. The largest colony in New Zealand is on Takapourewa/Stephens Island, estimated at 1.4 million pairs (Jamieson *et al.* 2016). Few data exist for colonies around Rakiura; although more than 2,000 pairs are likely to be present on Herekopare Island and Kundy Island. Two estimates from 1941 were made on Green Island, east of Ruapuke Island, both of 1-1.5 million pairs; however, in 2012, scientists found little evidence of the species (footnote below, and references in Jamieson *et al.* 2016). The reasons for this dramatic decline are unclear. Weka are present on the island and are likely to have preyed on the species, however, it seems unlikely that weka could be responsible for such a decline[1].

Fairy prion is considered to be largely non-migratory, staying in New Zealand waters year-round, and feeding on or near the surface on krill, small fish, and squid (Miskelly 2013b). However, little research has been undertaken on foraging habits and distribution at sea. The species is observed regularly in inshore waters and its foraging distribution is likely to overlap with the proposed farm location.

4.4.7 Cook's petrel

Cook's petrel (At Risk-Relict) has a disjunct population, with birds breeding on Hauturu/Little Barrier Island, and Aotea/Great Barrier Island in the north, and Whenua Hou/Codfish Island in the south. Prior to human arrival, the species was found throughout the New Zealand mainland. A survey in February 2007 recorded approximately 5,000 breeding pairs on Whenua Hou (Rayner *et al*. 2008a). This represents a major recovery from almost complete extirpation due to predation by both introduced weka (*Gallirallus australis*) and Pacific rat (*Rattus exulans*), which were eradicated in 1980 and 1998, respectively (Rayner *et al*. 2008a).

Cook's petrels from Whenua Hou/Codfish Island have been found to forage during the breeding season in deep oceanic waters west of the South Island in the south Tasman Sea in association with the subtropical convergence zone, at a mean depth of

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[1] https://blog.tepapa.govt.nz/2013/01/08/green-island-1941-and-2012-in-the-footsteps-of-edgar-stead-part-8/

3,891 ± 144 metres. The same research also showed that birds were regularly active at night (Rayner *et al*. 2008b). It is not clear if the foraging range of Cook's petrels overlaps with the proposed farm location; it is possible that the species may be relatively rare at the location, given its preference for deep water habitats.

4.4.8 Giant petrels

The two species of giant petrel have both been recorded in Foveaux Strait and surrounds, the northern giant petrel in higher numbers than the southern giant petrel. Southern giant petrel (Migrant) regularly forages in New Zealand waters, but breeds elsewhere, for example the Falkland Islands, the Antarctic continent and South America. The population is estimated to number 30,575 breeding pairs (Patterson *et al*. 2008). Northern giant petrel (At Risk-Recovering) breeds on the Auckland, Campbell, Antipodes, and Chatham Islands within New Zealand, and also at a number of other locations around the southern hemisphere such as Macquarie Island and the Crozet and Kerguelen Islands. The species used to breed in small numbers at Port Pegasus, Rakiura. The population of northern giant petrel is estimated to be 11,210 pairs, an increase from a previous historical estimate (Patterson *et al.* 2008). Of this total, approximately 2,570 pairs breed in New Zealand waters (Szabo 2013a).

Giant petrels are expert scavengers, both on land and at sea, feeding on carcasses of birds, mammals, and fish. They also kill chicks and adult birds such as penguins, and are capable of killing adult albatrosses. Northern giant petrels, in particular, follow commercial fishing vessels (Szabo 2013a). At sea, giant petrels mostly surface-seize their prey, but have been observed diving to shallow depths of a couple of metres (van den Hoff and Newbery 2006). Both species are likely to be present in the proposed farming area.

4.5 Gannets and shags

Five species of shags are regularly present in the region: black shag (At Risk-Naturally Uncommon), Foveaux shag (Threatened-Nationally Vulnerable), little shag (Not Threatened), pied shag (At Risk-Recovering), and spotted shag (Not Threatened). Little black shag (At Risk-Naturally Uncommon) also appears in the eBird database, and has been recorded as a vagrant on Rakiura (Armitage 2013). Foveaux shag is endemic to Foveaux Strait, and is the most commonly reported shag species in the Strait and around Rakiura. All five species are well reported. Figure 3 in Appendix 4 is likely to be a significant underestimate for the breeding locations of several species.

4.5.1 Foveaux shag

Foveaux shag (*Leucocarbo stewarti*; Threatened-Nationally Vulnerable) belongs to the 'blue-eyed shag' complex, a group of approximately 16 *Leucocarbo* shag species spread throughout the colder zones of the southern hemisphere. The complex also includes king shag (*L. carunculatus*; Threatened-Nationally Endangered), restricted to the Marlborough Sounds, and another five New Zealand endemic species, all of which are Nationally Threatened or At Risk.

Foveaux shag is a relatively 'new' species, and was previously called Stewart Island shag (*L. chalconotus*). However, the Stewart Island shag was recently split into two species: the Otago shag (*L. chalconotus*), which breeds along the Otago coastline, and the Foveaux shag, endemic to Rakiura-Foveaux Strait region (Rawlence *et al.* 2014, 2016). Most of the national population may breed in the three IBAs closest to the proposed farming area (Table 3).

Table 3: Foveaux shag colony locations and sizes (Lalas 1983, Cooper and McClelland 1992, Cooper 1991, O'Donnell 2001 reported in NABIS).

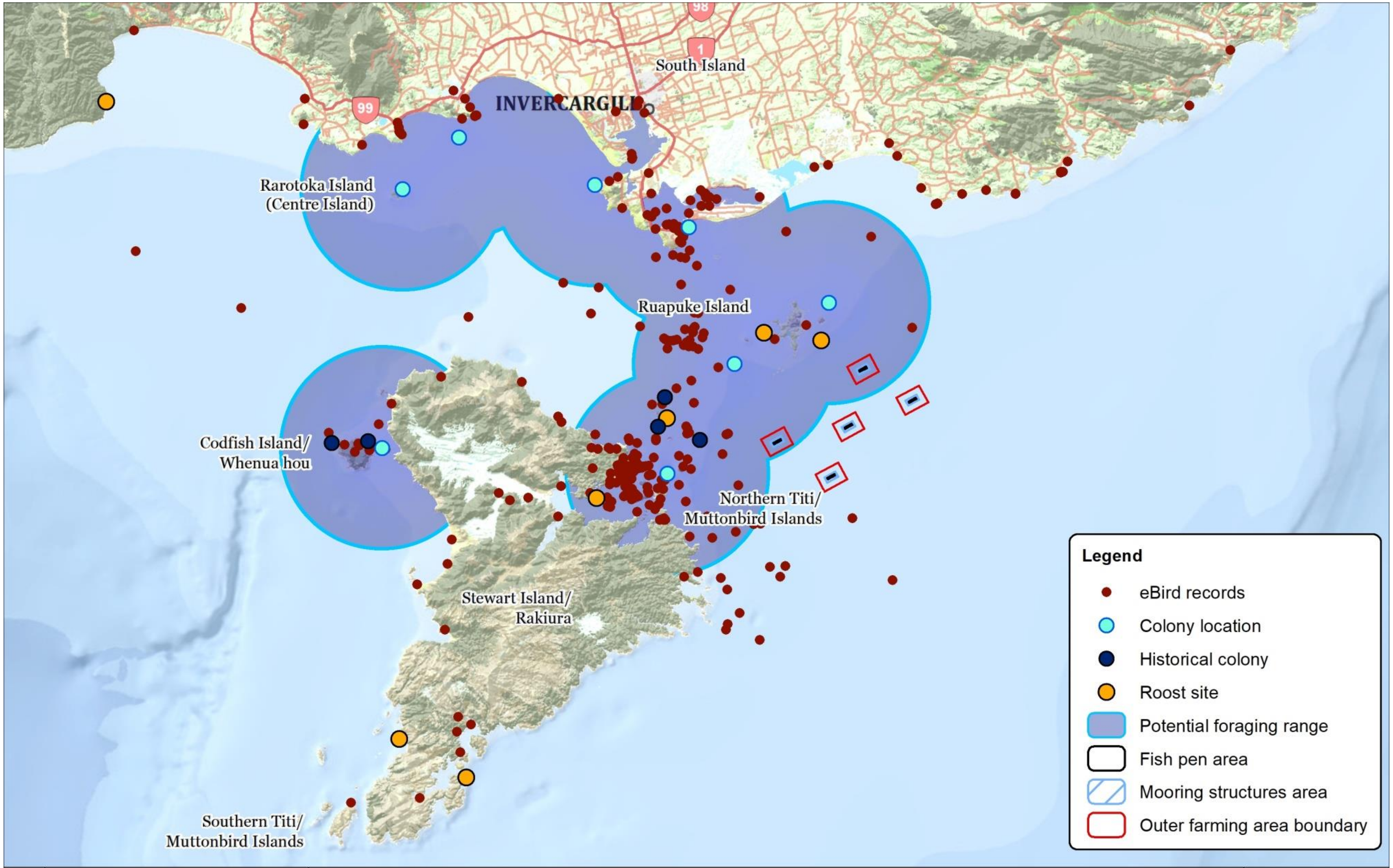
Colony	General Location	Count (date of count)
Rarotoka/Centre Island	Western Foveaux Strait	25 pairs (1989)
Pig Island	Western Foveaux Strait	Not recorded (2001)
Papakaha	Bluff Harbour entrance	65 pairs (1980)
Omaui Island	Bluff	65 pairs (1992)
High Rock	Whenua Hou/Codfish Island	75 pairs (1980)
Fife Rock	Ruapuke Island	305 pairs (1980)
Breaksea Islands	Ruapuke Island	5 pairs (1980)
Whero Rock	Northern Titi Muttonbird Islands	350-400 pairs (1980-1981)

Very little is known regarding population trends. The most recent reports of colony locations and sizes appear to mostly be *c*.30-40 years old (Table 3) and these estimates suggest a population of less than 2,500 mature birds. The national threat classification is based on the criterion of a "moderate, stable population (unnatural)" of 1,000-5,000 mature individuals, with the qualifiers of 'Conservation Dependent'[1] and 'Partial Decline'[2] (Robertson *et al.* 2017). It is not entirely clear how this classification has been derived, particularly the suggestion of historical decline and it is possible further unpublished population information exists. Rawlence *et al.* (2015) used modern and ancient DNA, radiocarbon dating, and Bayesian modelling to investigate the impacts of human arrival on the Otago and Foveaux shags. They found that the Otago shag has undergone dramatic declines from much of its eastern South Island distribution since human occupation, but that the Foveaux shag has remained largely untouched, although recent population trends remain largely unknown.

Foveaux shags are thought to abandon breeding sites after many years of use, and establish new colony sites (Watt 1975, Taylor 2000), and a number of historical colony locations are known. These are shown in Figure 8. Roost site records are also shown. Some roost site records, those in southern Rakiura and Te Waewae Bay, published in Rawlence *et al.* (2015, 2016), are significant distances from known colony sites. These roost sites may indicate the presence of colonies that have not yet been identified.

1 Conservation dependent = "The taxon is likely to move to a higher threat category if current management ceases" (Townsend *et al.* 2008).

2 Partial decline = "Taxa undergoing decline over the majority of their range, but with one or more secure populations (such as on offshore islands). Partial decline taxa (e.g. North Island kaka *Nestor meridionalis septentrionalis* and Pacific gecko *Hoplodactylus pacificus*) are declining towards 'Relict' status rather than towards extinction." (Townsend *et al.* 2008).



Data Acknowledgment
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Figure 8. Foveaux shag colony locations, roost sites, potential foraging ranges, and eBird records

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The diet of Foveaux shags has not been reported. Lalas (1983) recorded that Otago shags foraging in Otago Harbour mostly took cockabullies, flounder, and sole, and Chatham Island shags (*Leucocarbo onslowi*; Threatened-Nationally Critical) mostly took flatfish and opalfish. Flatfish also are a key prey of king shags foraging in the Marlborough Sounds. It is likely that Foveaux shag, like other *Leucocarbo* shags, focuses its foraging on the seafloor. It may also take flatfish, although no data are available.

The foraging areas of Foveaux shags are largely unknown. Lalas (1983) reported that Stewart Island shag regularly dived in waters 40-50 metres deep, and often up to 10 kilometres offshore. Taylor (2000) stated that Stewart Island shags foraged in shallow coastal waters within 15 kilometres of land. However, it is very likely that both of these statements refer to Otago shags. Foveaux shags mostly nest on offshore rock stacks, islets, and islands, in comparison to the mainland colonies of Otago shags, which may suggest differing foraging strategies. Other *Leucocarbo* shags are capable of diving very deeply, such as Kerguelen shag (*Leucocarbo verrucosus*) to 144 metres (Cook *et al*. 2013), Antarctic shag (*Leucocarbo bransfieldensis*) to 112 metres (Caseux *et al.* 2001), Crozet shags (*Leucocarbo melanogenis*), where the mean maximum dive depth for males was 93 ± 44 metres (Cook *et al.* 2007), and male imperial shags (*Leucocarbo atriceps*) where the mean maximum dive depth was 98.9 ± 5.3 metres (Quillfeldt *et al*. 2011). Foveaux shags are likely to be physiologically capable of benthic foraging at depths in the proposed farming area.

Figure 8 provides all eBird records for 'Stewart Island shag', which are presumably all Foveaux shags in this locality (eBird does not recognise the two different species). It also provides a 15-kilometre radius around each colony, as an indicative foraging range. However, Foveaux shags have two morphs: one being a pied morph and the other is a 'bronze' morph, which can be mistaken for pied shags or black shags respectively by less experienced observers. Furthermore, the accuracy of the locations is unknown; a manual check of the two observations out to sea south of Te Waewae Bay indicates that both observations were unlikely to be in that location, whereas the coastal observation in Te Waewae Bay is almost certainly accurate given the observer and description. Nevertheless, eBird records suggest foraging beyond 15 kilometres from the colony, and also suggest the presence of a colony somewhere around southern Rakiura.

In summary, three Foveaux shag colonies, representing approximately 75% of the total known population, may have foraging ranges that overlap with the proposed farming area. However, breeding distribution is not fully described, recent population data does not exist, diet is unknown, and foraging distribution is not well understood. Potential effects are discussed in Section 5 below.

4.5.2 Pied shag

In 2012, pied shag was considered to be in decline, numbering between 1,000-5,000 mature individuals, and was classified as Threatened-Nationally Vulnerable (Robertson *et al*. 2012). The status of the species has been revised recently based on an in-depth population review (Bell 2013), and is now considered to be At Risk-Recovering, numbering 5,000-20,000 mature individuals (Robertson *et al*. 2017).

Examination of counts indicates numbers are increasing, at least within two of the three disjunct populations, in northern North Island and central New Zealand. However, data were too sparse in the southern South Island/Rakiura region for trend analysis (Bell 2013). Pied shags are relatively common in Foveaux Strait, though sightings are less frequent than Foveaux shag (eBird records). Colony locations are shown in Figure 3, Appendix 4, but it is likely that other colony locations are present but unidentified. Pied shag colonies have been reported from two of the three IBAs closest to the proposed farming area.

Pied shags used the Rena wreck, salvage vessels, and buoys as roosts during the salvage operations (Riddell and Kessels 2014), indicating the distance the species is able to feed from shore (approximately 20 kilometres). This indicates that the proposed farming area is within foraging distance from adjacent colonies. The species' diet is poorly documented, but Powlesland (2013) notes that pied shag take fish from 6-12 cm in length including flounder, mullet, eel, goldfish, perch, goatfish, kahawai, wrasse, and common trevally. A Queensland study showed that they took prey ranging from 2-45 cm in length, and was largely dependent on fisheries discards of bycatch (Blaber and Wassenberg 1989). In the Marlborough Sounds, some pied shags appear to target vessels harvesting mussels, taking the small fish associated with the droplines as they are pulled from the water (Wildland Consultants 2019).

4.5.3 Spotted shag

Spotted shag (Not Threatened) is an endemic marine shag species, mostly found around the South Island, with a restricted distribution in the North Island (Robertson *et al*. 2007). The population is estimated at 10,000-50,000 pairs, with increases recorded around Banks Peninsula and Wellington Harbour in recent decades. When not breeding, spotted shags form large feeding and roosting flocks of up to 2,000 birds (Szabo 2013b). Figure 3, Appendix 3 is unlikely to show all of the colony sites. Spotted shag colonies have been reported from two of the three closest IBAs to the proposed farming location. The species is the second most common shag species seen in Foveaux Strait after Foveaux shag (eBird records).

Frost (2017) reports that spotted shag feed up to 16 kilometres offshore on small fish and marine invertebrates in waters >10 metres deep (Stonehouse 1967; Marchant and Higgins 1990). This indicates that the proposed farming area is likely to be within foraging distance from adjacent colonies. In one South Island study, the principal prey species of spotted shag was the small fish ahuru, followed by red cod (Lalas 1983).

4.5.4 Other shag species

Black shag (At Risk-Naturally Uncommon) and little shag (Not Threatened) have also been recorded in Foveaux Strait, but in lower numbers than the other three species. No records of colony locations were found for black shag, although these will be present. eBird records for black shag are largely restricted to the Oban/Paterson Inlet area. These species are more common in inshore waters, where they tend to dive in shallow water of only a few metres in depth.

4.5.5 Australasian gannet

Australasian gannets (Not Threatened) breed at various sites around the New Zealand coast, and in Tasmania and southeast Australia. Around 87% of the population occurs in New Zealand (Frost 2017). Aerial surveys have been undertaken of gannet colonies since the 1940s. The New Zealand population was estimated to be 46,004 breeding pairs in 1980-81, having increased from 37,774 pairs in 1960-61, and 21,033 pairs in 1946-47 (Wodzicki *et al.* 1984). Aerial surveys in 2000 have not been analysed but have been estimated to represent 55,000 pairs (Stephenson 2005), which would represent another increase. Ismar (2013) has suggested that the population is increasing at a rate of approximately 2% per year.

Australasian gannet has one breeding colony in the region, on Little Solander Island, approximately 130 kilometres east of the proposed farming area. This is the southernmost gannet colony in New Zealand, and one of only four around the South Island, the others being The Nuggets, Marlborough Sounds, and Farewell Spit. Approximately 20 pairs have been recorded on most visits between 1948 and 1986 (Cooper *et al.* 1986). The colony at The Nuggets, on the Catlins Coast, numbers only *c.*1-10 pairs. These two colonies are almost equidistant from the proposed farming area. eBird observations indicate the species is present in the area east of Rakiura but these birds could potentially come from either colony. Observation frequency is low, which is not unsurprising considering the very small populations present at each site.

Foraging ranges of Australasian gannets have been studied by several authors. For example, 21 gannets at the Cape Kidnappers colony travelled a mean distance from the colony of 55.6 ± 23.3 kilometres, with birds flying an average of 267.9 ± 120.6 kilometres during each foraging trip (Machovsky-Capuska *et al.* 2014). Australasian gannets have also been shown to undertake extensive non-breeding seasonal migrations. Geolocators attached to gannets at the Cape Kidnappers colony demonstrated that individual gannets flew to coastal waters of South Australia and Tasmania to overwinter, travelling up to 13,000 kilometres (Ismar *et al.* 2011).

The species regularly attends ‘boil-ups’ of dense fish schools brought to the surface by dolphins and predatory fish. It feeds on a variety of fish and squid, usually diving to less than six metres, although occasionally diving deeper (Machovsky-Capuska *et al.* 2011). Given their expansive foraging ranges, gannets could potentially feed in the location of the proposed farming area.

4.6 Skuas, gulls, and terns

Seventeen species of skuas, gulls, and terns have been recorded from the Foveaux Strait and surrounds (eBird data); some of the rarer species may be misidentifications. Foveaux Strait records are dominated by red-billed gull (At Risk-Declining), southern black-backed gull (Not Threatened), and white-fronted tern (At Risk-Declining). South Island coastal records include large numbers of black-billed gull (Threatened-Nationally Critical), which breeds in large colonies on Southland rivers, and at some coastal sites such as the Waiau River bar; lower numbers of individuals have been recorded out at sea and around Rakiura.

Other species of note recorded in significant numbers in Foveaux Strait include brown skua (At Risk-Naturally Uncommon) and the braided river specialist black-fronted tern (Threatened-Nationally Endangered). The breeding locations of several species, such as southern black-backed gull and white-fronted tern, are likely to be significantly underestimates (Figure 4, Appendix 4).

4.6.1 Southern black-backed gull

Southern black-backed gulls (Not Threatened) breed throughout New Zealand. The species has undergone massive population increases since European arrival and may now number more than one million birds. It is widespread throughout the Southern Hemisphere, even as far as the Antarctic Peninsula. It is an entirely unprotected species (Wildlife Act 1953), unlike most New Zealand seabirds (with the exception of some shag species which have partial protection). The gull is a well-known predator of eggs and chicks of shorebirds and braided river birds and is controlled in many areas of New Zealand to protect threatened bird populations.

Southern black-backed gulls are widespread and abundant within Rakiura region, but breeding locations are not well described; Figure 4, Appendix 4 will be a significant under-representation of their breeding localities. Colonies are reported from all three IBAs closest to the proposed farming area. The species is a generalist forager and scavenger and can travel significant distances to feed, often attending fishing vessels well off the coast. The proposed farming area will be well within foraging distances of local colonies.

4.6.2 Red-billed gull

Red-billed gulls (At Risk-Declining) are abundant in Foveaux Strait. The subspecies is endemic to New Zealand; other subspecies are found in New Caledonia and Australia, where it is known as silver gull. Red-billed gull is one of the most well-studied seabird species in New Zealand; the banding study led by Jim Mills in the Kaikoura colony since 1964 is one of the longest running studies of its kind in the world. In New Zealand, the species was listed as Threatened-Nationally Vulnerable in 2012 due to observed rapid declines (Robertson *et al.* 2012). However, in 2016, the listing was downgraded to At Risk-Declining.

Declines have been observed at several of the main colonies, including the largest colony at Kaikoura, where the species declined by 51% between 1983 and 2005 (Mills *et al.* 2008). At the Mokohinau Islands (wider Hauraki Gulf), another of New Zealand's largest colonies, 2,000-6,500+ pairs were recorded in the 1940s, but a recent national survey of colonies found only 58 nests in the island group (Frost and Taylor 2016). Given the lack of introduced predators at this site, the implication is that the species is being affected by at-sea changes in food availability. Close association between years of good productivity and high availability of krill (Mills *et al.* 2008) suggests that climate changes have the potential for significant adverse effects on this species. Predation by introduced mammals is a key threat where they are present.

A recent national survey for red-billed gull undertaken over the 2014-2016 breeding seasons located and described 243 colonies containing *c.*27,000 pairs. Only a few colonies were identified in the Rakiura region, and numbers are not well known.

However, colonies are reported from all three IBAs closest to the proposed farming area.

The reproductive performance of red-billed gulls at Kaikoura has been studied in depth. It was found to be closely tied to the availability of krill offshore (Mills *et al.* 2008), although earthworms, small fish, garbage, and kelp flies are also taken (Mills 2013). Mills (2013) notes that outside of the breeding season, the diet of red-billed gulls at Kaikoura is highly variable. Some birds still feed out to sea, including following fishing vessels for discards, but others remain in terrestrial habitats, feeding on the shore on small invertebrates, or scavenging from human sources including rubbish dumps. Aerial surveys have shown that feeding occurs up to 40 kilometres north and south of the Kaikoura colonies (Mills *et al.* 2008). The proposed farming area will be within foraging distances of local colonies.

4.6.3 Black-billed gull

Black-billed gulls (Threatened-Nationally Critical) mostly breed on braided and other gravel-bedded rivers in the South Island. Significant declines have been reported in Southland (McClellan 2009), and more recently in the South Island (Wildland Consultants 2015). Most of the population breeds in Southland; in 2016-2017, 33,703 nests were recorded in the region (Mischler 2018). This explains the high number of eBird observations associated with the mainland coastline. However, numbers of birds observed out to sea within Foveaux Strait are much lower.

During the breeding season, Southland's black-billed gulls concentrate their foraging in high quality pasture (McClellan 2008). The dispersal of Southland black-billed gulls after the breeding season is not well known, with only single incidents of Southland banded birds recorded from Blueskin Bay, Dunedin, Picton, Kaikoura and Nelson (R.K. McClellan unpublished data). It is likely that the majority of black-billed gulls migrate to northern locations after breeding, although some birds may remain on the Southland coast. It is likely that black-billed gulls forage out to sea during these periods, although foraging habitats during the non-breeding season are poorly known, particularly the extent of their use of the marine versus terrestrial environment. Fisheries observers have observed black-billed gulls up to 40 kilometres off the east coast of the South Island (P. Langlands, in litt.), suggesting that the species may also target krill, as per red-billed gull.

4.6.4 Brown skua

Four species of skua, a large predatory seabird, have been recorded in Foveaux Strait (eBird data). It is possible that some observations are misidentifications. They are oceanic birds, rarely seen from shore. Three species are migrants to New Zealand waters.

Brown skua (At Risk-Naturally Uncommon) breeds on New Zealand's subantarctic islands, on the Chatham Islands, and around Rakiura, and also at many other colder locations in the southern hemisphere. Locations and numbers of brown skua in the Rakiura region are not well known. eBird observations indicate a significant presence in Foveaux Strait. The species is often associated with stealing of food from other birds on the wing, scavenging, and even killing other adult birds such as gull species.

However, stable isotopic analysis also indicated a mixed diet of zooplankton, low trophic-level squid, and fish during the non-breeding season, with minimal reliance on seabird predation or fisheries (Phillips *et al.* 2006). This particular study was undertaken on brown skua from South Georgia, and it is not known how the findings might relate to brown skua around Rakiura and beyond. Brown skua may forage in the vicinity of the proposed farming area.

4.6.5 White-fronted tern

White-fronted tern (At Risk-Declining) is one of the most commonly observed species in the Foveaux Strait region (eBird data). It is likely that the number of breeding locations presented in Figure 4, Appendix 4 is significantly underestimated. The sizes of breeding colonies are largely unknown. Breeding locations have been reported from all three of the IBAs closest to the proposed farming area. The size of the national population is poorly known. However, however, its threat classification of At Risk-Declining is based on a population of 5,000-20,000 mature individuals (Robertson *et al*. 2017).

The species is not well studied. Some white-fronted terns, mainly young birds, migrate to Australia after breeding, while most remain in New Zealand coastal waters. White-fronted tern will forage many kilometres offshore on larval and small fish, and the farming area will be well within foraging distances of local breeding populations. The species is often seen attending ‘boil ups'. White-fronted terns are thought to be primarily threatened by predation by introduced pest mammals at breeding colonies, as well as predation by the indigenous black-backed gull. Human disturbance at breeding colonies may also be a problem.

5. ASSESSMENT OF POTENTIAL EFFECTS

5.1 Overview

Marine fish farms can have many potential effects on seabirds. This section provides a discussion of potential effects, based on a review of available literature. Potential effects of the proposed salmon farm on seabirds could include:

- Exclusion from foraging habitat by farm structures.
- Smothering of benthos affecting food sources.
- Alteration of water quality affecting food sources.
- Changes in abundances of prey, e.g. attraction of wild fish, enhancement of plankton populations.
- Provision of roosts.
- Disturbance by farming activities, including vessel movements to and from ports.
- Ingestion of foreign debris.
- Attraction by lights.
- Entanglement.
- Collision with marine farming structures.

The following sections discuss each of these potential effects and how they relate to seabirds in the Foveaux Strait region.

5.2 Habitat exclusion

The presence of an enclosed marine fish farm will stop seabirds from taking food from the surface or diving within the enclosed area. For pelagic Procellariformes species such as shearwaters, petrels and albatross, the area of an open ocean marine farm, in this case, 26 ha with pens and 157 hectares at full development,[1] will comprise only a very small proportion of the available foraging areas. For example, Figure 9 shows the foraging distribution of the small Cook's petrel during breeding, demonstrating the extensive distances and areas that pelagic species can cover. Many species will largely leave New Zealand waters after breeding, such as sooty shearwaters, which migrate to the North Pacific before returning to breed. For these species, the potential effects of exclusion are expected to be negligible.

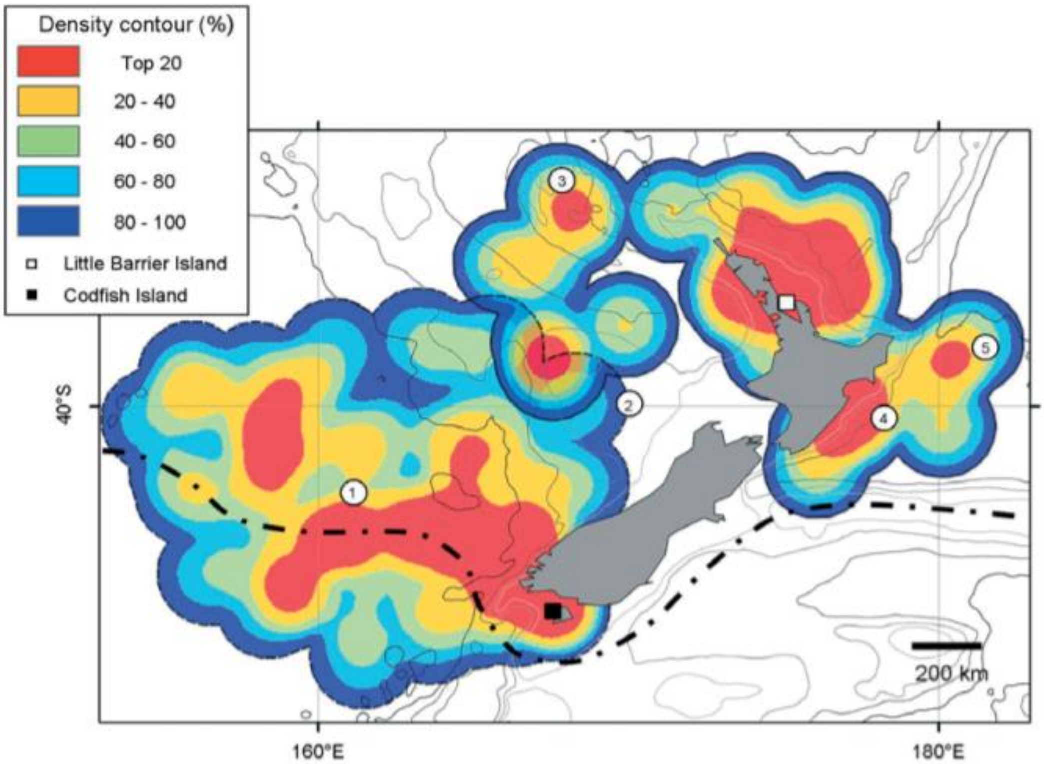

Figure 9: Kernel density distribution of breeding Cook's petrel from Little Barrier Island (n = 7, January 2007, enclosed by solid black line) and Codfish Island/Whenua Hou (n = 10, February 2007, enclosed by dashed black line). Bathymetric contours are 500, 1,000, 2,000, and 4,000 metres. Numbers show approximate locations of: (1) Tasman Basin, (2) Challenger Plateau, (3) Lord Howe Rise, (4) Hikurangi Trough, and (5) Hikurangi Plateau. Heavy dot-dashed line is the approximate summer location of the Subtropical Convergence (from Rayner *et al*. 2008).

[1] Pens only comprise a small proportion of each 26-hectare block, and so this will be an overestimate. Based on a pen with a 38-metre diameter, a 26-hectare block will comprise 1.1 surface hectares of actual pens in total.

Other seabird groups, such as gulls, terns, shags, penguins, and gannets, have smaller foraging distributions. Of these, effects on gannets will be negligible as they also have expansive foraging distributions, and may possibly benefit if the farm attracts or supports increased populations of wild fish (see Section 5.4).

Gull and tern species would be excluded from foraging within the area of the pens. This area represents a very small proportion of the potential foraging distributions around the various island breeding locations. For example, based on a 15-kilometre radius around Ruapuke Island, and assuming that 5×20 hectares of pens[1] will all fall within the resulting circle, the pens would comprise approximately 0.14% of the available foraging area. As for Australasian gannet, if wild fish populations are higher around the farm, gulls and terns may benefit from this. Pied shags and spotted shags would also be excluded from foraging by farm structures, but may also be attracted to the farm if wild fish populations are enhanced.

Benthic-feeding seabirds, for example, yellow-eyed penguin and Foveaux shag (assuming the latter is indeed a benthic feeder), could still feed under a farm if prey was present. However, if disturbance due to the presence of vessels, or the presence of the structures themselves, caused birds to stay away, this would also constitute exclusion (see Section 5.2). Yellow-eyed penguins have been observed foraging around salmon farms in Big Glory Bay, suggesting they are not excluded (Alison Undorf-Lay, Sanford, pers. comm.). However, the small area of pens involved compared to the possible foraging area (see calculations above) is likely to be very small, even for Foveaux shag. Examination of the foraging distributions of the Foveaux shag colonies that may overlap with the farm would confirm this assessment.

Benthic-feeding blue penguin are not considered to be an issue as they are unlikely to forage at the depths present in the proposed farming area.

5.3 Changes in benthos and water quality

Fish farms produce waste in the form of fish faeces and fish food lost outside the enclosure when over-feeding occurs. This accumulates on the sea floor and is dispersed beyond the pens by local currents, which may reduce water quality. This can result in a bigger footprint of enrichment than is indicated by structures on the surface. Waste can alter the benthos within this footprint which may change the availability of prey for seabirds, particularly those that feed on or above the seafloor, such as yellow-eyed penguin, and probably Foveaux shag[2].

However, it is noted that significant benthic enrichment is not expected to occur much beyond the pens given the placement of the farming area in the strong currents within an offshore environment. This is likely to mean that the availability of prey species for yellow-eyed penguin and Foveaux shag are largely unaffected.

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[1] Note that pens only comprise a small proportion of each 20-hectare block, and so this will be an overestimate. Based on a pen with a 38-metre diameter, a 20-hectare block will comprise 1.1 surface hectares of pens in total.

[2] Blue penguin is unlikely to be affected by this proposal as depths at the site are generally beyond the diving range of the species.

However, it is important this be confirmed through a robust monitoring and staged development process. If benthic habitat changes were to have negative impacts on yellow eyed penguin and Foveaux shag prey, then the effects of waste may have more than minor effects on these two species given the proximity of the proposed farm to nationally important breeding colonies. The threat of benthic impacts changing prey populations is highlighted in the most recent yellow-eyed penguin management strategy (see Section 4.1.3 above).

5.4 Changes in abundance of wild fish populations

Pelagic and benthic wild fish can be attracted to marine fish farms to feed on fish food pellets or fragments of pellets that pass through the fish farm uneaten or partially eaten. Uneaten pellets and pellet fragments can alter the benthic environment, which can stimulate the productivity of benthic fauna and epifauna. This, in turn, provides food for benthic fish (Kutti *et al*. 2007).

Other factors may attract wild fish. Submerged lighting within pens to prevent maturation of salmon may potentially increase zooplankton and the abundances of wild fish. Fish and zooplankton may also be attracted to the biofouling of pen structures, including nets. The actual fish pellets can also attract a variety of gulls, shags, and some petrels and shearwaters (Surman and Dunlop 2015).

Forrest *et al*. (2007) found limited evidence for fish farms affecting the abundance of wild fish populations in New Zealand. Several shark species have been reported from the vicinity of salmon cages, and were thought to be either taking advantage of salmon mortality or the presence of aggregations of wild fish (Forrest *et al*. 2007). There is extensive literature on the effects of marine fish farms on wild fish populations overseas (reviews in Forrest *et al*. 2007, Holmer 2013). Wild fish populations have been shown to significantly decrease the amounts of waste food reaching the sea bed and some studies have suggested that fish farms may serve to increase regional fish biomass and maintain wild fish stocks beyond the vicinity of the fish farm (Forrest *et al*. 2007). Some ‘off-coast’ marine farms have been shown to support significant amounts (tonnes) of wild fish biomass, and up to 53 species (Dempster *et al*. 2002, Dempster *et al*. 2005, Dempster *et al*. 2009). Holmer’s (2010) review examines the implications of open ocean marine farming and considers that open ocean fish farming is also likely to attract wild fish populations, concluding that such effects are difficult to predict.

Such reviews do not consider the implications for bird populations. However, it is very likely that if wild fish populations aggregate at an open ocean fish farm with a degree of regularity, then the farm will also attract fish-eating seabirds, possibly including albatross species, shearwaters and petrels, Australasian gannet, and shag, gull and tern species. If this effect actually increases local wild fish populations from current levels, rather than only attracting fish from elsewhere, then it could be seen as a potential benefit to Foveaux Strait seabirds. However, it also follows that bird attraction to a marine farm will further increase the risk of avian interactions with the farm, particularly roosting, and also potential ingestion of artificial objects, entanglement, and collision (see the following sections regarding the extent of risk, and possible mitigation measures).

In an impact assessment of proposed finfish aquaculture on birds at the Houtman Abrolhos Islands off Western Australia, populations of pied cormorant, silver gull, and Pacific gull were considered very likely to increase as a result of increased wild fish populations associated with fish farm operations (Surman and Dunlop 2015). This was considered to comprise a negative outcome of fish farming as cormorants would compete for nesting space with more vulnerable bird species on the islands, and predation on the nests of other bird species would increase as a result of the larger gull populations.

Such an effect could potentially occur on seabird islands in close proximity to the proposed farming area, such as the Ruapuke Island, Fife Rock, and Northern Titi Muttonbird Islands Important Bird Areas. For example, if black-backed gull colonies on adjacent islands, including within the Important Bird Areas, increased in response to a more predictable food source within 10-20 kilometres, predation rates on other seabird species could increase, and black-backed gulls may outcompete others for nesting space. Conversely, if At Risk species were to increase, such as pied shag, red-billed gull, and white-fronted tern, the possibility of increased wild fish populations could be seen as a positive effect.

5.5 Provision of roosts

Provision of roosts for birds is generally considered to be a positive effect. Structures such as buoys and platforms provide places for birds to rest between foraging bouts, which may reduce energy expenditure, and possibly predation. Mussel farm buoys in the Marlborough Sounds are used extensively by a variety of seabird species, and appear to be favoured over terrestrial roosts, possibly because of perceived security from predation, or better visibility from surrounds compared to resting on the water (these factors are likely to be related). Any marine farm structure will require buoys and lighting systems for navigational purposes, and these will also provide roosting opportunities. Vessels that are moored at marine farms may also provide roost sites.

However, if a marine farm provides roosting habitat for numerous seabirds, it follows that this will increase the risk of avian interactions with the farm, such as potential ingestion of artificial objects, entanglement, and collision. Furthermore, if the farm provides predictable food sources in the form of aggregations of wild fish, or food pellet waste, then the provision of roosting habitat will act to amplify this effect by allowing birds to remain at the site for longer periods.

This roosting effect is largely limited to shags, terns, and gulls as other species rest on the sea surface (noting that shags, terns and gulls will also rest on the sea surface).

5.6 Disturbance

The presence of a fish farm, and the vessels and people attending the farm, have the potential to cause disturbance of breeding and foraging seabirds. This could have significant detrimental effects on breeding seabirds if an inshore marine farm is close to a seabird nesting location. However, if a marine farm is offshore, like this one, breeding locations will be unaffected. Furthermore, the foraging ranges of offshore-feeding seabirds are very large, and disturbance is likely to be negligible.

Boat traffic between the port(s) and the marine farm has the potential to disturb birds at breeding locations or roosting locations if vessels pass too close. This applies to surface-nesting bird species such as all shag, tern, and gull species. Disturbance of breeding birds can be avoided by maintaining sufficient distances (for example, 100 metres) from any surface-nesting breeding colony. However, this is not an issue here given the offshore site.

Vessel movements will also disturb birds on the water that are resting or foraging. This is a very short-term disturbance that is likely to have negligible adverse effect on individual birds and unlikely to have a significant effect on individuals Vessel movements may also attract certain species that seek out boats as potential sources of food.

5.7 Foreign objects and debris

Seabirds commonly ingest foreign objects, primarily plastics, mistaking them for invertebrates such as crustaceans or fish. Adults will regurgitate plastics when feeding chicks. Some seabird populations are believed to be in decline due to plastic ingestion, e.g. flesh-footed shearwater on Lord Howe Island, Australia (Lavers *et al.* 2014). Some studies have shown that all individuals of some seabird populations now contain plastic, e.g. short-tailed shearwater, Phillip Island, Australia (Carey 2011). Many seabird species present in Foveaux Strait are likely to ingest plastic waste in various forms, mistaking it for food.

Entanglement in debris lost from a poorly-maintained marine farm can also significantly affect seabirds, particularly broken or discarded nets or ropes. For example, entanglement accounted for 13-29% of observed gannet mortality in the German Bight (Schrey and Vauk 1987; in Sagar 2012).

Best practice maintenance of farm structures and best practice waste management processes will be important to minimise the possibility of debris being lost to sea and in turn, the possibility of adverse effects of the type discussed above. Such management measures are routinely implemented both in New Zealand and overseas.

5.8 Entanglement

5.8.1 Overview

Bird entanglement in permanent net structures could potentially occur within the nets holding the fish, the underwater predator nets used to reduce seal, shark and cormorant/shag predation, and the above water bird nets, used to stop birds diving into the fish pens. A more recent development in smolt and grower pens is a new, stronger mesh that eliminates the need to use predator nets which is not presently in use in New Zealand. The different sizes and colours of mesh are likely to have different entanglement risks for birds; the larger the mesh size on the bar, the greater the risk of entanglement. Netting that is more visible to birds and that is kept taut may be less likely to cause entanglements.

The Foveaux Strait salmon farm operation proposes to use the stronger mesh for the sides, bottom and top of all pens, negating the need for predator nets and bird nets. The pens will also be able to be submerged during bad weather.

Entanglement resulting in loss of adult birds from a population that was rare and/or threatened could lead to significant adverse effects on population stability. The extent and impact of such losses is dependent on the location of the farming area within the species' foraging range, the level at which the species is attracted to the potential food source, and the size and stability of the population. Of the possible effects of marine farms on seabirds, entanglement has the greatest potential significance.

5.8.2 Examples in literature and media

No seabirds have been reported entangled in aquaculture structures in New Zealand (reviews in Sagar 2012, Butler 2003, Lloyd 2003). Few published accounts exist of bird mortality in overseas fish farms. Papers that describe interactions between birds and fish farms are usually from the standpoint of birds as predators of fish, where incidental mortality of birds is not necessarily seen as an issue, and is not reported. Sagar (2012) cites Iwama *et al.* (1997), observing that drowning of birds, mostly cormorants, has occurred overseas. Two common cormorants (New Zealand's black shag is a subspecies of the same species) were reported drowned in underwater anti-predator netting in a paper examining predation of fish by cormorants (Carss 1993).

Raw data on wildlife interactions, including bird entanglements and other interactions, are available on the Global Salmon Initiative (GSI) website from member companies[1]. Summary data are reported as the total number of interactions divided by the total number of farm sites for each of the years 2013-2017 (where data exist). Entanglement rates appear variable between years, and possibly between countries. For example, Mowi, a company that operates in six countries, has reported rates per farm site per year of 0-0.71 birds in Canada (five years of data), no interactions in Chile (three years), 0-9.00 birds in the Faroe Islands (five years), 0-0.11 birds in Ireland (three years), 0.61-6.20 birds in Norway (five years), and no birds in Scotland (five years). Detailed analysis of data is not easily undertaken because only the most recent data is usually available on company websites. The species involved are generally not identified. Where species were identified, most cases involve gull species including kittiwakes, and occasional cormorants (noting that all data are sources from coastal salmon farms). The majority of species identifications are not available online.

Huon Aquaculture farms open ocean salmon and kingfish in South Australia, New South Wales, and Tasmania. The Tasmanian farms are located offshore at three locations around Bruny Island. As part of Huon's Aquaculture Stewardship Certification, the company reports on the mortality of birds[2]. At present, Huon Aquaculture appears to be the only company both undertaking open ocean fish farming and reporting on bird interactions.

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1 Information taken from https://globalsalmoninitiative.org.
2 All information is from the Huon Aquaculture website: https://www.huonaqua.com.au/.

From January 2016 to April 2018, 46 birds have been reported killed at farms in three different locations in southeast Tasmania (Table 5). These deaths have occurred almost exclusively due to entanglement. No further details are provided on the website.

Table 5: Bird species reported killed at three southeast Tasmania open ocean marine fish farms, January 2016 to April 2018.

Common Name	Number	Relevance to New Zealand
Southern black-backed gull	10	Same subspecies as in New Zealand.
Silver gull	15	Different sub-species to New Zealand red-billed gull.
Pacific gull	14	Not present in New Zealand.
Cormorant spp.	3	Huon Aquaculture reports three species at the farms; great cormorant (same subspecies as black shag), pied cormorant (different subspecies to pied shag), and black-faced cormorant (not found in New Zealand).
Shearwater spp.	3	Unknown.
Tern spp.	1	Unknown.

5.8.3 Preliminary assessment of entanglement risk

Accurate assessment of the entanglement risk for Foveaux Strait seabirds associated with an open ocean fish farm is difficult due to the absence of reports from New Zealand, the limited number of operational open ocean fish farms worldwide, and the lack of detailed reporting of bird entanglement from inshore fish farms around the world.

Furthermore, risk will vary with the type of fish-farming method. The primary difference between an ‘above the water’ farm, which usually has bird nets and predator nets, and this proposed farm that has the ability to submerge, is that this farm will have stronger 50 mm mesh across the top, as well as the sides and bottom, and is unlikely to have underwater predator nets.

An assessment of risk to species or species group from entanglement, based on Huon Aquaculture data and interpretation of feeding behaviours follows. The Huon Fortress Pens are an ‘above the water’ fish farm with bird nets and predator nets, but it is not known in which part of the structure birds were entangled. Based on these data alone, this particular farming method is likely to pose some level of risk to Foveaux Strait gull populations, and may also affect shag, petrel/shearwater populations, and tern populations although to a lesser degree (Huon’s entanglements to April 2018 comprise 85% gulls, *c*.7% cormorants, *c*.7% shearwaters, 2% terns; Table 4). The potential entanglement risk of a submerged farm is also discussed for each species or species group.

<u>Gull Species</u>

Black-backed gulls (Not Threatened) and red-billed gulls (At Risk-Declining) are attracted to salmon farms. Several colonies of both species are located within foraging distance of the proposed farming area, in adjacent Important Bird Areas, and possibly other locations. It is likely that both species will attend the proposed farm. Both species scavenge, and will also feed from the surface of the water on plankton, copepods, krill, and small fish.

Various gull species involved in entanglement in overseas fish farms, including Huon Aquaculture's open ocean farms. As noted previously, it is not known how the gull species became entangled in the Huon Fortress Pens. Gulls do not dive for food, so it seems most probable that gulls have been entangled in above water bird nets that cover the Fortress Pens. These nets have a mesh size on the bar of 60 mm. The smaller, stronger, tauter mesh of the proposed farm is likely to reduce the risk of entanglement above water.

Entanglement of the unprotected, superabundant black-backed gull is unlikely to be of conservation concern. However, the national population of red-billed gulls is in decline. Local population sizes are unknown but may be small, in which case mortality of this species may have negative effects in the immediate region.

Southland supports a very large breeding population of black-billed gulls (Threatened-Nationally Critical). These birds are unlikely to feed well out to sea during the breeding season. After breeding, the majority of the population is thought to migrate to other locations within the South Island and possibly the North Island. However, the presence of birds in Foveaux Strait suggests that some birds remain, and feed in marine habitats, and/or that some birds forage in the Strait during the breeding season. Their marine diet is poorly known. They may be less likely to attend the proposed farm than the other two species, but the possibility cannot be discounted.

Shag Species

Shag and cormorant species are attracted to salmon farms overseas, and have been reported entangled. Five shag species are known from Foveaux Strait, four have breeding populations within adjacent Important Bird Areas. Only black shag may be absent from the wider area of the proposed farm.

Shag species primarily dive for their food, and so could potentially become entangled in both above-water bird nets and below-water predator nets. The typically larger mesh size of below-water predator nets (100-120 mm on the bar) stops shag species from reaching the fish pens, but may allow entanglements to occur, as birds would be able to put their heads and upper bodies through, and possibly even wings. This farm will not have predator nets, relying instead on stronger 50 mm grower nets. This may eliminate the possibility of entanglements below water.

Shag species may still land on a farm accidentally, particularly during poor weather when visibility is reduced. However, the lack of bird nets combined with the use of stronger 50 mm mesh above the water is likely to reduce this risk. Furthermore, submergence of the farm during poor weather will further reduce entanglement risk.

Petrels and Shearwaters

Three 'petrels' (species not identified) have been entangled in Huon Fortress Pens. eBird and fisheries observer records have recorded 27 species of shearwater, petrel, prion, fulmar, storm petrel, and diving petrel (Procellariformes) in Foveaux Strait. Other species are likely to be present on occasion. The extent to which any of the 27 species will be attracted to an open ocean marine fish farm is not known.

It is not known whether species such as sooty shearwater (At Risk-Declining) and Salvin's albatross (Threatened-Nationally Critical) that are strongly attracted to fisheries vessels would also be attracted to the vessels attending fish pens, but it is a possibility. A variety of petrel and shearwater species may be attracted to the farm if increases in plankton and small and large fish were to occur around the farm.

Species such as sooty shearwater have significant diving capabilities (mean maximum dive depth of 39.2 ± 2.9 metres; Dunphy *et al.* 2015). Shearwaters and petrels that dive to obtain food could potentially get entangled in predator nets; the absence of a predator net would likely reduce entanglement risk. Even small species, such as common diving petrel (At Risk-Relict), show considerable diving ability (maximum dive depth 31 ± 6 metres; Bocher *et al.* 2000). Diving petrels feed on krill and copepods and so are unlikely to be attracted to salmon smolt. However, if the presence of a farm increased the abundance of krill and copepods, diving petrels may be attracted to the farm. Both southern diving petrel and Whenua Hou diving petrel (Threatened-Nationally Critical) are likely to be able to move freely in and out of a predator net of 100-120 mm. The inner nets, which range from 12.5-35.5 mm on the bar, are unlikely to entangle any petrel or shearwater species. The absence of predator nets at the proposed farm is likely to significantly reduce the potential for any species to become entangled, including the smallest species such as diving petrels.

It is possible that petrel and shearwater species could mistakenly land on top of bird nets, particularly in weather conditions when visibility is poor. Such species may have difficulty taking off again, particularly if nets are not taut. The use of stronger, tauter mesh in place of bird nets is likely to reduce the risk of birds being entangled, or being unable to take to the air. Reducing the risk further is the ability to submerge the farm during bad weather.

In summary, Fortress Pens in Tasmania have caught three 'petrels' to date. A similar rate of capture would be highly unlikely to have national population consequences for any Procellariformes species given the mostly large population sizes..

<u>Terns</u>

Huon Fortress Pens have caught one tern. White-fronted tern (At Risk-Declining) is the tern species most likely to attend the proposed farm, and could be attracted to the smolt and smaller wild fish. It may be at risk of entanglement within above-water bird nets or below-water predator nets. Its population size is estimated at a maximum of 20,000 mature birds, and the level of risk will depend on the rate of entanglement and the ability of the local population to absorb any loss. White-fronted terns are reported to be breeding at all three of the adjacent Important Bird Areas, although the population sizes are not stated. The use of stronger mesh in place of bird and predator nets is likely to reduce the risk of entanglement.

Albatross and Mollymawks

Albatross and mollymawks primarily take prey from the water surface, and may be attracted to the proposed farm if abundances of plankton, copepods, krill, and small fish were to be enhanced around the farm. Albatross and mollymawks have not been reported visiting the Huon Fortress Pens. Given their feeding habits, the risk of entanglement is likely to be very low, but cannot be ruled out. Individuals could potentially land on top of fish pens and be unable to take off again, particularly in bad weather with poor visibility. However, the use of stronger, tauter, smaller mesh in place of bird nets is likely to reduce the risk of entanglement and improve the ability of the large birds to become airborne again. Submergence during bad weather will eliminate risk during these periods. It is possible that albatross species that are attracted to fisheries vessels may be more likely to visit fish pens than other albatross species, although the activity and food sources are significantly different.

Penguins

The Huon Aquaculture website indicates the occasional presence of penguins around farms, although penguins have not been reported entangled. These are the same species as New Zealand's blue penguins (At Risk-Declining), and are common on Bruny Island where the farms are located. While it unlikely that blue penguins would forage beneath the proposed farm given the depths at the site, it is possible that penguins could take advantage of any increased abundances of small fish associated with the farm, and prey on pelagic fish. Blue penguins are very small, and could potentially become entangled in predator nets. However, the absence of predator nets may eliminate this risk.

Likewise, Fiordland crested penguin (Threatened-Nationally Vulnerable) and yellow-eyed penguin (Threatened-Nationally Endangered) could also potentially take advantage of increased wild fish populations. Both breed on adjacent islands. As both are larger species, their risk of entanglement within predator nets is likely be relatively low. The proposed farm will not use predator nets which is likely to eliminate risk of entanglement.

Gannets

Australasian gannet (Not Threatened) is known to frequent New Zealand King Salmon farms (McConnell and Pannell 2014). It feeds alongside mussel farms in the Marlborough Sounds, but was not observed feeding in them in a recent study (Wildland Consultants 2019). Australasian gannet is common around Tasmania but has not been reported from the Huon Fortress Pens.

Gannets feed by plunging into the water from a significant height, and can dive to about 15 metres. It is likely that the highly developed eyesight of gannets would allow them to see the mesh of smolt or grower pens, even of a submerged farm, reducing and possibly eliminating the appeal of diving for fish. Gannets could potentially be attracted to wild fish populations associating with the sea pens. The local gannet population is very small, and mortality due to entanglement could affect local population stability.

5.9 Collision with marine farming structures

Seabirds can collide with artificial structures while foraging. The development of offshore wind farms overseas has resulted in extensive literature on the risk to seabirds from collision with such structures. If the structure is associated with an attractive food source, such as commercial fishing vessels, the risk is considerably higher. For example, seabirds colliding with vessels and warp and netsonde cables of longline and trawling boats is a major source of mortality of many seabird species.

The presence of artificial lighting can also attract seabirds, increasing the chances of collision. An extreme case of this occurred with a trawler travelling in darkness on a calm, foggy night with strong ice-lights on and at dawn almost 900 prions, storm petrels, and diving petrels were found on deck, of which more than a quarter were dead (Black 2005). The attraction of fledgling petrel and shearwater species to urban areas due to artificial lighting has been known for decades. In the Canary Islands, one study reported nine seabird species being found grounded and several thousand individuals were released back into the wild (Rodriguez and Rodriguez 2009). Another study showed that more than 10,000 shearwaters, storm petrels, and Atlantic puffins *Fratercula arctica* had been found grounded in the village of Hirta, St Kilda, Outer Hebrides, attracted to the lights of buildings at night, and to street lamps along the shorefront (now no longer in use; Miles *et al*. 2010).

While the proposed farm is approximately 10 kilometres from the nearest seabird breeding islands, this is within the range at which effects have been observed elsewhere. Over 200 short-tailed shearwater fledglings were recorded grounded at a desalination plant under construction which was using powerful night lighting (Rodriguez *et al.* 2014). The location was approximately 15 kilometres from the nearest breeding colony.

Lights used at night on open ocean oil rigs in Western Australia have been found to result in aggregations of zooplankton. This attracts silver gulls (different subspecies to New Zealand’s red-billed gull), which undertake nocturnal foraging when preying on the aggregations (Surman and Dunlop 2015).

The risk of collision with marine farm structures could potentially affect any seabird species present. However, the extent to which an open ocean marine farm will pose a collision risk to seabirds will depend on a number of factors:

- The amount of marine navigational lighting required to ensure visibility of a farm at night to boats and ships, and the brightness of the lighting.
- The degree of attraction exhibited by individual bird species to light. For example, the smaller petrel and prion species are more likely to be attracted to lights. Nevertheless, larger species can still be affected (Westland petrel have been found disorientated in the township of Westport, R.M. pers. obs.).
- Whether a seabird species will forage at night (for example, some shearwaters, petrels and gulls).

- The degree that the marine farm acts as a source of food for seabird populations.
- The structure of a marine farm, such as size, height, and visibility (for example, overhead wires are less visible than larger structures).

Salmon farms can use underwater lighting to prevent salmon maturation. In general, the submerged lighting only illuminates the pens and is usually pointed downwards towards the seafloor, and has little spread outside of the pens. The proposed farm will use halogen downward lights that will not be visible from the surface. Such lighting arrangements are used on some farms in the Marlborough Sounds, and their effects on zooplankton have been examined as well as observations made on the presence of baitfish, birds and other organisms in three different reports. Pens with underwater lighting did not have significantly different levels of a variety of zooplankton than 'dark' pens (e.g. Cornelisen *et al.* 2013). The methods were unable to confirm whether the abundance of small fish was different between light and dark pens. One report noted the presence of six to 10 red-billed gulls within one illuminated pen (with no bird net), but methods were not set up to establish whether bird numbers varied between light and dark pens.

The effects of submerged lighting on zooplankton and bait fish has not been examined in an open ocean situation in New Zealand. If the lighting increases the abundance of bait fish outside the pens, it may act as an attractant for seabirds that take small fish from the surface or dive, potentially increasing interactions with the farm.

6. MANAGEMENT MEASURES

6.1 Overview

This section provides a brief summary of key actions that can avoid, remedy or mitigate the effects on open ocean fish farming on seabird populations:

- Minimise the loss of fish feed.
- Debris management.
- Disturbance.
- Biosecurity management.
- Lighting management.
- Mesh structures and maintenance.
- Other structures.

6.2 Minimise the loss of fish feed

Uneaten food pellets and poorly manufactured pellet fragments pass out of the fish pens and can alter the benthic environment which can stimulate the productivity of benthic fauna and epifauna. This, in turn, provides food for benthic fish. The loss of food pellets can also attract wild pelagic fish populations to the pens. These factors can attract seabirds to the pens, potentially increasing the risk of harmful interactions such as entanglement and collisions. It follows that feeding systems that monitor and minimise feed loss will lower the possibility of fish attraction or enhancement, and associated attraction of seabirds.

6.3 Debris management

All non-biodegradable waste must be collected, retained and disposed of at an approved sold waste facility onshore. This includes domestic waste on vessels, as well as materials associated with farming structures, feeding, and all other activities. Sanford has been awarded Best Aquaculture Practice four star rating for its farming practices and has environmental certification from the New Zealand Marine Farming Association, both demonstrate the company's adherence to industry Standard Operating Procedures and Codes of Practices associated with environmental management.

6.4 Disturbance

All surface-nesting bird species, such as gulls, terns, and shags, are vulnerable to disturbance to differing degrees. Some species are more likely to become accustomed to vessel movements than others. Vessel routes should avoid passing within 100 metres of islands, islets, and rock stacks with surface nesting birds, including locations on Rakiura. Navigation requirements and weather/sea conditions may override this in some locations. This is a conservative estimate, based on a safe distance for those species that are the most susceptible to disturbance.

6.5 Biosecurity management

Rigorous control of rodents should be standard practise on all vessels, and at ports, to minimise the possibility of mice or rats being inadvertently introduced to predator-free islands.

6.6 Lighting management

Many seabird species, particularly fledglings, can be attracted or disorientated by artificial light sources. This can lead to injury and mortality through collisions and groundings. Measures to avoid or minimise the attraction of seabirds to light sources have been provided in a number of publications. Four in particular have been reviewed and summarised, specifically:

- A recent review of global seabird mortality from attraction to artificial light sources on land[1]. These are largely applicable to a marine situation.
- The Department of Conservation's advice sheet for cruise ships, including management of light and handling of birds[2].
- The International Association of Antarctica Tour Operators (IAATO) guidelines to minimise seabirds landing on ships.

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[1] Rodríguez A., Holmes N.D., Ryan P.G., Wilson K.-J., Faulquier L., Murillo Y., Raine A.F., Penniman J.F., Neves V., Rodriguez B., Negro J.J., Chiaradia A., Dann P., Anderson T., Metzger B., Shirai M., Deppe L., Wheeler J., Hodum P., Gouveia C., Carmo V., Carreira G.P., Delgado-Alburqueque L., Guerra-Correa C., Couzi F.-X., Travers M., Le Corre M. 2017: A global review of seabird mortality caused by land-based artificial lights. *Conservation Biology 31*: 986-1001.

[2] https://www.doc.govt.nz/news/media-releases/2019/cruise-ships-protecting-seabirds/

- The Australian Government's light pollution guidelines for wildlife (see the Seabird Light Mitigation Tool box for further discussion)[1].

A summary of appropriate measures is as follows:

Avoidance of Potential Adverse Effects

- Do not install unnecessary lights.
- Turn lights off when they not required (for example, install automated features to turn off lights when they are not required).
- All windows on vessels or marine farming structures should be fitted with blackout blinds that are closed each evening before full dark.

Minimisation of Potential Adverse Effects

- Shielding of lights to prevent projection towards the sky.
- Reduce lights projecting towards reflective surfaces.
- Keep light intensity as low as possible.
- Consider reducing all lighting during fledging periods if possible.

Various modifications to the technical specifications for lights have been suggested, most of which have not been tested formally, as set out below:

- The attraction of birds to lights has decreased where lights have been changed from permanent lighting to flashing or strobe lighting

- The spectral composition of lights is thought to affect attraction; red, blue, yellow, and green light may be less attractive than white light (different authors have reported different results).

- A formal trial showed that high pressure sodium lights attracted fewer seabirds than light emitting diodes (LED), and significantly fewer seabirds than metal halide lights[2].

6.7 Mesh structures and maintenance

Bird entanglement in net structures could potentially occur within the nets holding the fish, the underwater predator nets used to reduce seal, shark and seabird predation, and the above water bird nets, used to stop birds entering the fish pens. Bird entanglement can result in injury or death.

Sagar's (2012) review suggests using mesh sizes of less than 60.0 mm to reduce bird entanglements. As an example, Huon Aquaculture's Fortress Pen system employs an above-water 'predator (bird) net' which has a mesh size of 60.0 mm[3], and a below-water 'predator (seal and shark) net' which is a heavy, taut 125.0 mm double-knotted

[1] Commonwealth of Australia 2019: National light pollution guidelines for wildlife including marine turtles, seabirds and migratory shorebirds. DRAFT. 98 pp.

[2] Rodríguez A., Dann P. and Chiaradia A. 2017: Reducing light-induced mortality of seabirds: high pressure sodium lights decrease the fatal attraction of shearwaters. *Journal for Nature Conservation 39*: 68-72.

[3] Huon Aquaculture website, accessed 1 June 2018.

mesh with a breaking strain of 1,200 kilograms. The inner net is 15.0-35.0 mm (Huon Aquaculture 2017). The inner nets are described as being higher and tauter, which keeps the nets well above the water, keeping birds away from the fish and fish feed. The way the farms are designed above water with moving wires and poles reduces suitable roost and perching sites. Nevertheless, the farms still entangle a variety of seabirds, mostly gulls. This suggests that the 60 mm above-water bird net is not performing well in terms of minimising the impact on birds, particularly gulls. However, it is not known what characteristics of the netting, such as mesh size, colour, and tautness are leading to seabird entanglements.

An Israeli paper (Nemtzov and Olsvig-Whittaker 2003) examined the influence of net type on bird mortality at 101 netted freshwater fish ponds using 11 net types (i.e. above-water nets) which varied according to mesh size, mesh colour, mesh material, and mesh thickness. The levels of mortality were primarily a function of net visibility: fewer birds were entangled and killed as mesh size reduced, and fewer were found dead in thick or dark-coloured netting. The study also found that most birds were found entangled in the tautest nets, which was thought to be a function of the visibility of the nets: the less taut, the more the nets moved, and the more visible they became. This appears to contrast to the general recommendation to ensure that nets are kept taut to reduce entanglements (e.g. Sagar 2012, Surman and Dunlop 2015). Disproportionally large numbers of dead birds resulted from use of thin monofilament netting (despite the smaller mesh size). National guidelines were developed that included a requirement for thick, dark-coloured material with small mesh sizes (<5 cm), and a total ban on the use of thin monofilament fish nets. The net type that entangled the least number of birds per hectare of mesh had the smallest mesh size of the 11 net types; it was 2-3 cm diameter, black, and made of woven nylon 1.8-2.0 mm thick.

It is not clear how such findings translate to nets underwater, but they are relevant to bird nets enclosing a marine farm above water. It suggests that the mesh size of the Huon Aquaculture bird nets may be too large, and a significantly smaller mesh size may be warranted. Nets should be of a dark colour, with thick mesh. The most appropriate level of tautness is less clear, but is possibly the easiest aspect to alter. In summary, the smaller the mesh size, and the thicker and more visible the mesh, the less likely it is to entangle birds.

No studies or descriptions of fish farms were found where an outer anti-predator net was absent. It is possible that structures that do not use predator nets on the outside of the farm would reduce seabird entanglements further, and possibly eliminate the risk.

This farm will use a stronger, 50 mm mesh on top of the pen instead of a 'bird net'. This net has a small mesh size and is naturally taut compared to a bird net. This is likely to reduce the risk of entanglement because it will be more visible and so easier to avoid, and if accidentally landed on, is less likely to entangle, and easier to become airborne again. Underwater predator nets will not be used, which is also likely to reduce the risk of entanglement. Lastly, the ability to submerge the farm during severe weather events is also likely to significantly reduce entanglement risk.

Regular checks of fish farm nets need to be undertaken to detect damaged sections quickly as these are likely to increase risk of entanglements. Repairs should be undertaken as soon as possible. Likewise, regular net cleaning to reduce biofouling may assist to reduce the attraction of the fish farm to wild fish.

6.8 Other structures

Collision with structures such as wires can lead to mortality. The use of structures such as wires which are difficult to see should be minimised, and where they are required, used in tandem with bird deterrents such as streamers or reflective discs.

The potential for collisions needs to be assessed alongside the management of lights at and around the farm, as lights have the potential to attract seabirds to the farm at night, increasing the chance of collision.

Roosting surfaces at an open ocean marine farm, such as the pen structures, buoys, and attending vessels, will provide gulls, terns and shags areas to rest between bouts of foraging. Roosts allow individuals to stay at the site for long periods, including overnight. This will likely increase the risk of negative interactions with the fish farm. Roosting surfaces should be minimised, and bird deterrents used where such areas are unavoidable if possible.

7. CONCLUSION

Foveaux Strait supports a high diversity and abundance of seabirds, and numerous seabird breeding colonies are present on offshore islands and rock stacks, and on Rakiura/Stewart Island. The 'Northern Titi Muttonbird Islands' and 'Ruapuke Island' Important Bird Areas support breeding populations of yellow-eyed penguins, Foveaux shags, blue penguins, pied shags, spotted shags, little shags, southern black-backed gulls, red-billed gulls, and white-fronted terns. 'Fife Rock' Important Bird Area supports a major Foveaux shag colony, and breeding populations of black-backed gull, red-billed gull, and white-fronted tern. The 'North Coast Rakiura' Important Bird Area supports a population of Fiordland crested penguin.

In most cases, the sizes of these populations are unknown, and relative regional and national importance cannot be assessed easily. In the case of yellow-eyed penguins (Threatened-Nationally Endangered), the first two IBAs may support c.60-90 pairs of the 180 pairs estimated in the region, or 3.5-5.3% of the national population. In the case of Foveaux shag (Threatened-Nationally Vulnerable), the three Important Bird Areas may support most of the national population.

Foraging distributions of all the above species may overlap with the proposed location for the salmon farm. The foraging distributions of many other pelagic seabird species will also overlap with the proposed farm.

Habitat exclusion is an unavoidable effect resulting from the presence of an open ocean marine farm. However, seabird species have extensive foraging ranges and the pens will comprise a very small fraction of the available foraging area. This is also assumed to be the case for yellow-eyed penguin and Foveaux shag.

Similarly, the potential for changes in the benthos from open ocean marine farm waste is also likely to have minimal effect on seabird populations, and because the effect is understood to be significantly reduced in the open ocean environment due to water depths and currents, and largely restricted to the vicinity of the pens.

The proposed farming areas may increase the wild populations of benthic and demersal fish in the immediate area. The extent of enhancement local fish populations is likely to be determined partly by the amount of fish food pellets lost from the farm. Pellet loss should be minimised by robust monitoring systems. Biofouling of pen structures, including nets, may also attract zooplankton and small fish, and this should be managed by regular net maintenance. Submerged lighting may also affect abundances of zooplankton and small fish within and immediately around open ocean fish pens.

These enhancements may in turn increase the attendance of seabird species which are attracted to the presence of wild fish and plankton. The increased availability of a predictable food source could potentially have a positive effect on Threatened and At Risk species. However, increases in some species, such as southern black-backed gull populations, as a result of a novel and predictable food source, may have negative effects on other indigenous seabird populations through predation and competition for breeding space. Increased attendance by seabirds also heightens the potential risk of negative interactions such as entanglement and collision. The extent of seabird attendance at a novel location such as an offshore salmon farm is difficult to predict, and requires monitoring.

Best management practices will reduce the risk of debris from the farm and attending vessels being lost to the environment. Rodent control should be standard practice on all vessels. Vessel movements to and from the farm should maintain a distance of 100 metres or more from all sites with surface-breeding seabirds, except where navigational safety requirements necessitate closer distances.

Entanglement and collision are likely to be the most significant potential effects of marine farming. Accurate assessment of the entanglement risk of an open ocean fish farm to Foveaux Strait seabirds is difficult due to the absence of reports from New Zealand, the limited number of operational open ocean fish farms worldwide, and the lack of detailed reporting of bird entanglements from inshore fish farms around the world.

However, the absence of underwater predator nets and above water bird nets at the proposed farm, the use of stronger, smaller 50 mm mesh on all sides, and the submergence of pens during poor weather, are all factors that are likely to significantly reduce the risk of entanglement.

Collision with structures such as wires can lead to mortality. The use of structures such as wires, which are difficult to see, should be minimised, and where they are required, used in tandem with bird deterrents such as streamers or reflective discs. Lighting at an open ocean marine farm may increase the risk of collision and should be minimised by reducing unnecessary exterior lighting, shielding of exterior lighting so that it shines downwards, reducing light intensity, and shading or covering windows on any attending vessels or permanent control centres. Lighting reduction is particularly important during fledging periods for petrel and shearwater species breeding on nearby islands.

ACKNOWLEDGMENTS

Mark James of Aquatic Environmental Sciences provided communication and coordination for Project South.

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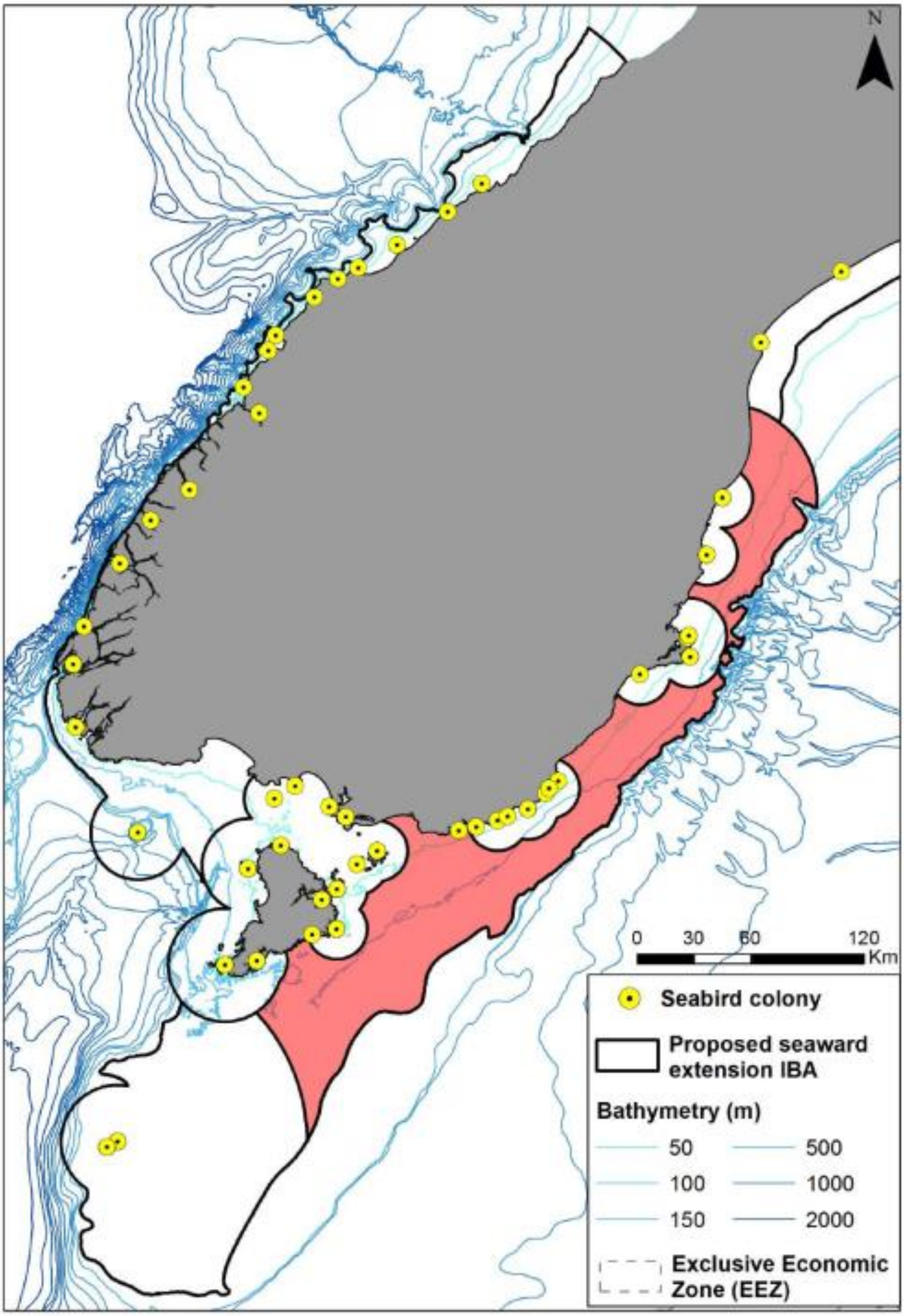
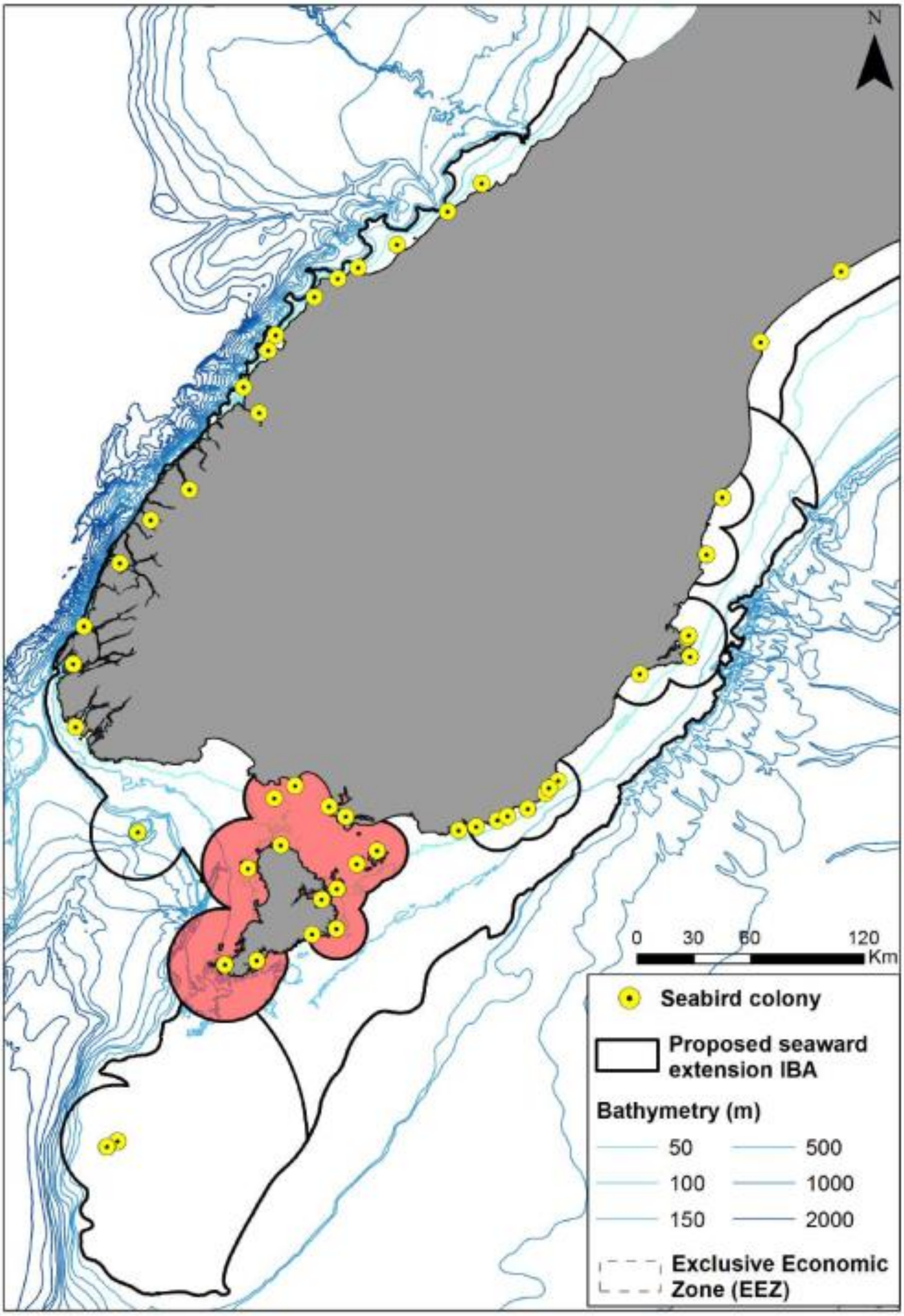
APPENDIX 1

IMPORTANT BIRD AREAS IN THE RAKIURA-FOVEAUX STRAIT REGION

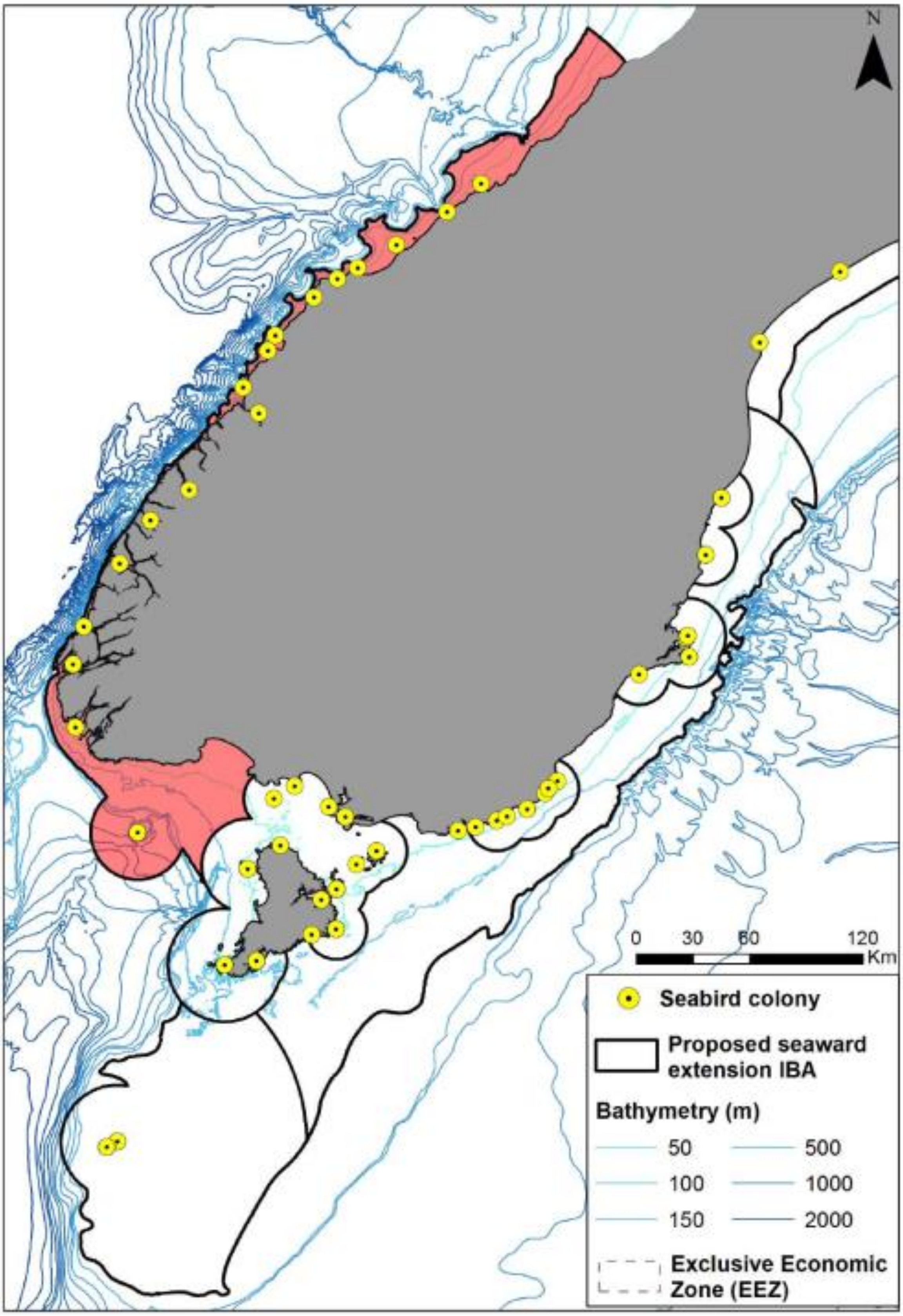
The following maps have been taken from Forest and Bird (2014) and Forest and Bird (2015). The first three show the 'Sites At Sea' Important Bird Areas (IBAs), and the following 11 maps show the 'Coastal Sites and Islands' IBAs.



Map 1: NZ M014 - Southern South Island IBA (red).

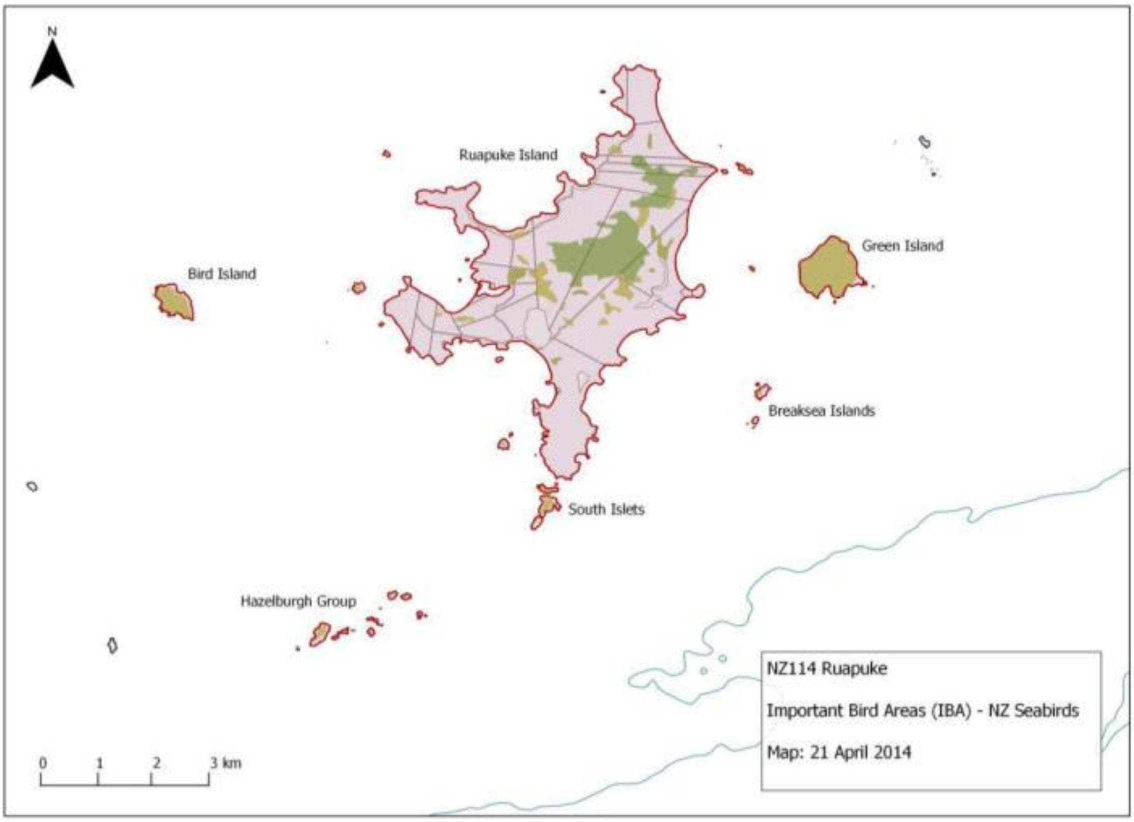


Map 2: NZ M015 - Rakiura IBA (red).

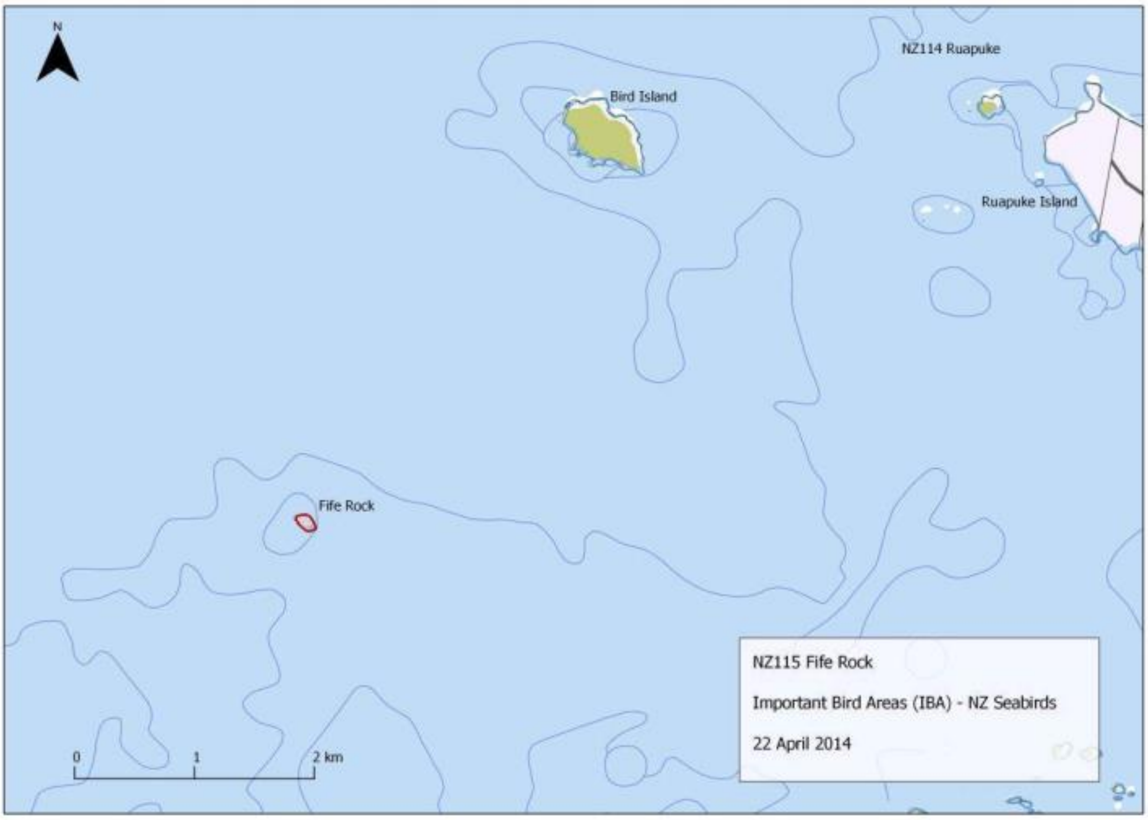


Map 3: NZ M016 - Fiordland-West Coast South Island (South) IBA (red).

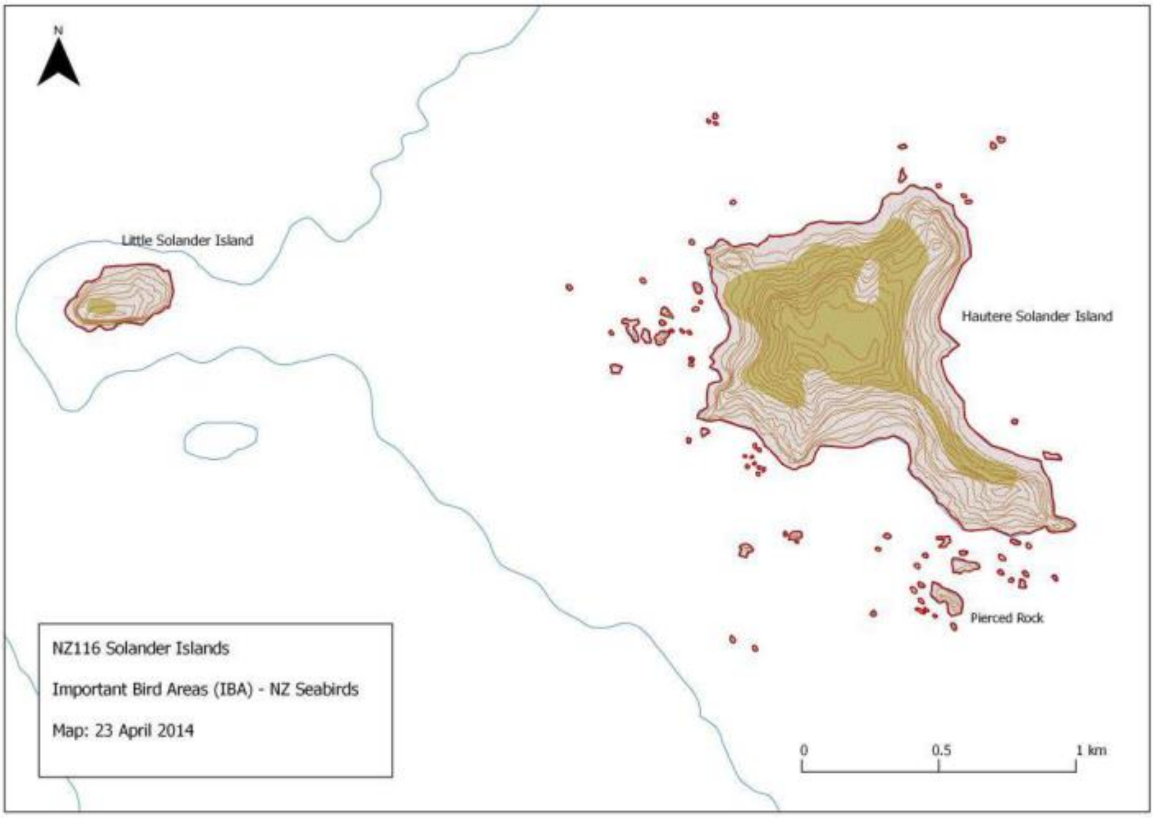
Map 4: NZ113 - Raratoka Centre Island (including Pig Island) IBA (red).



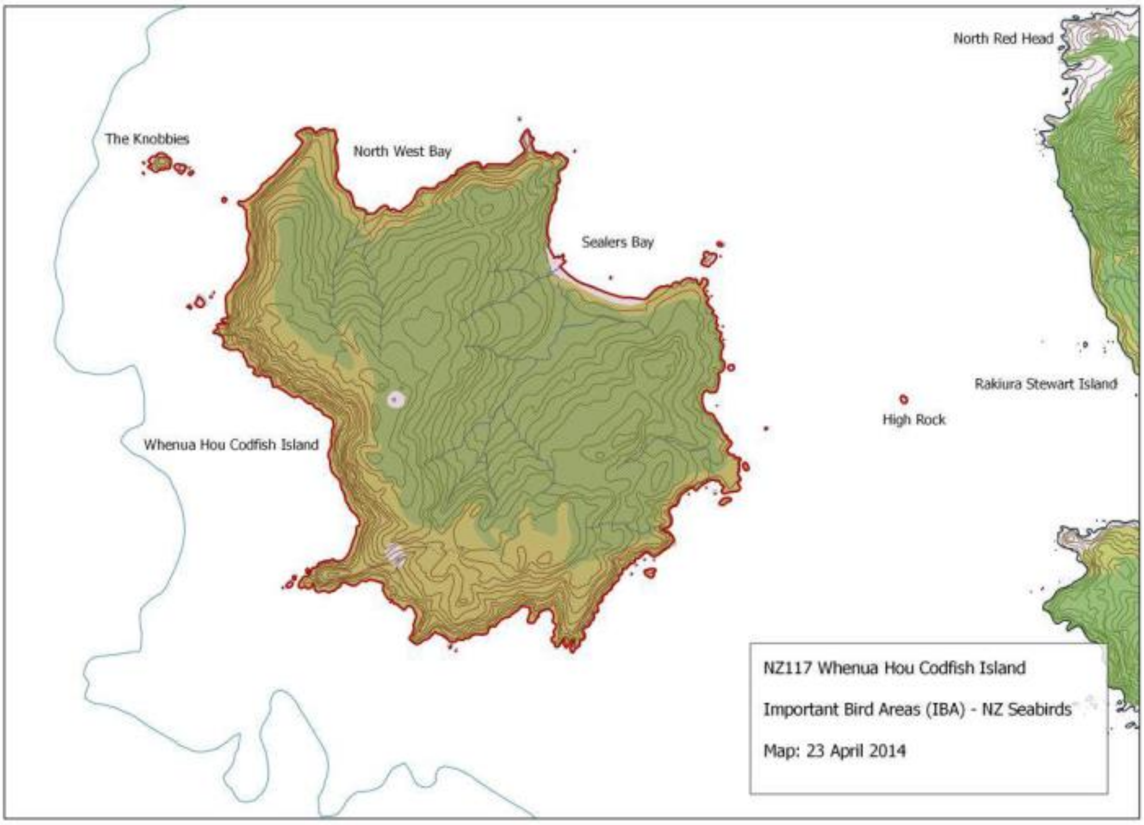
Map 5: NZ114 - Ruapuke Island IBA (red).



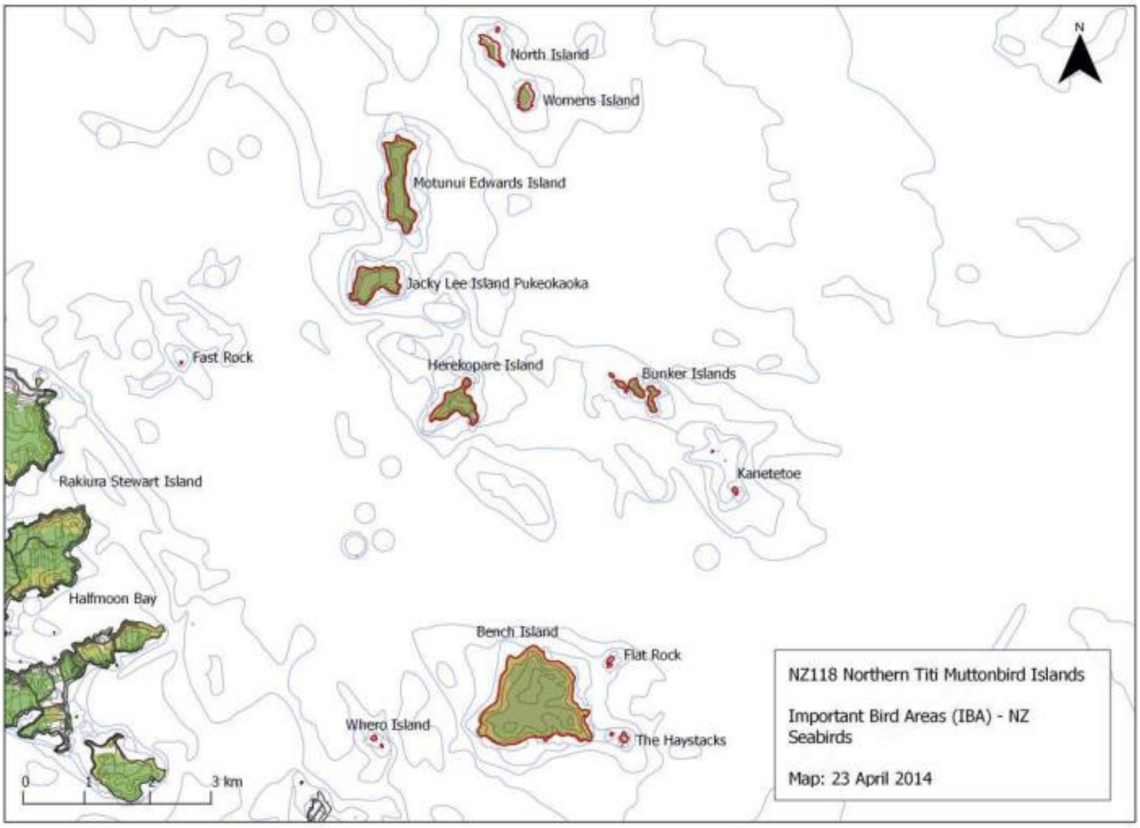
Map 6: NZ115 - Fife Rock IBA (red).



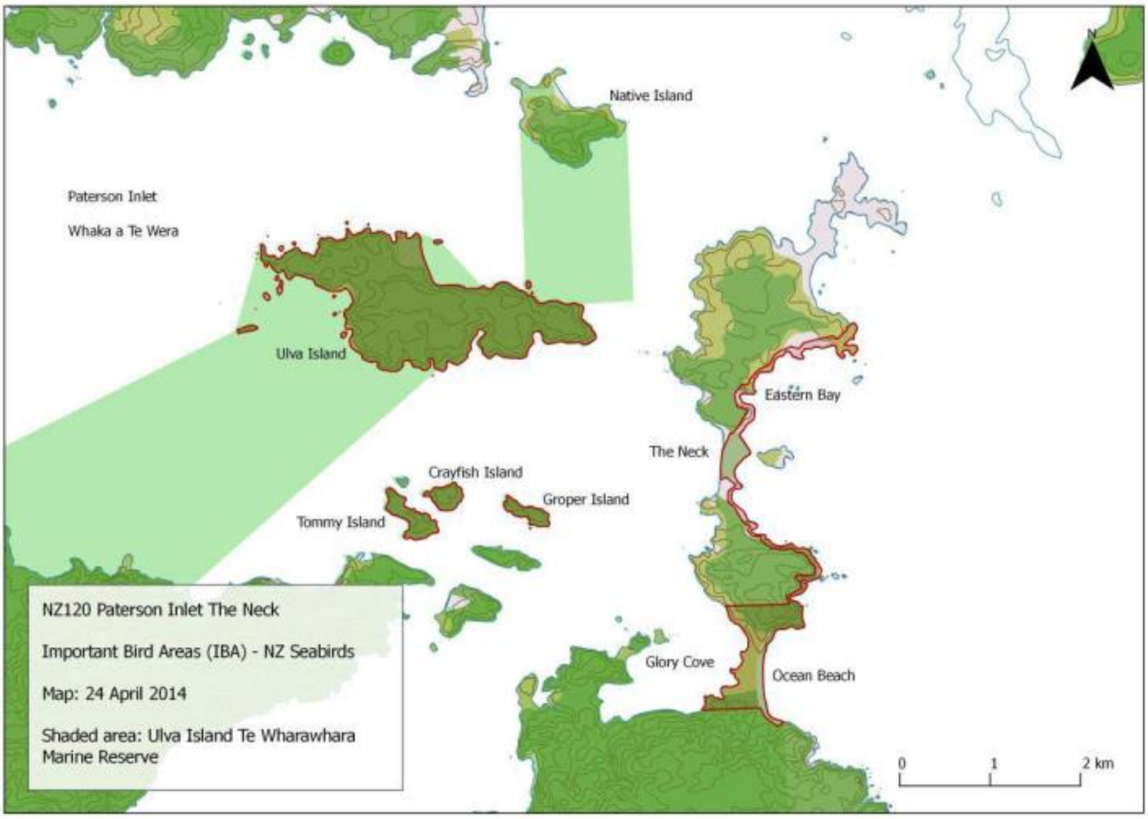
Map 7: NZ116 - Solander Islands IBA (red).



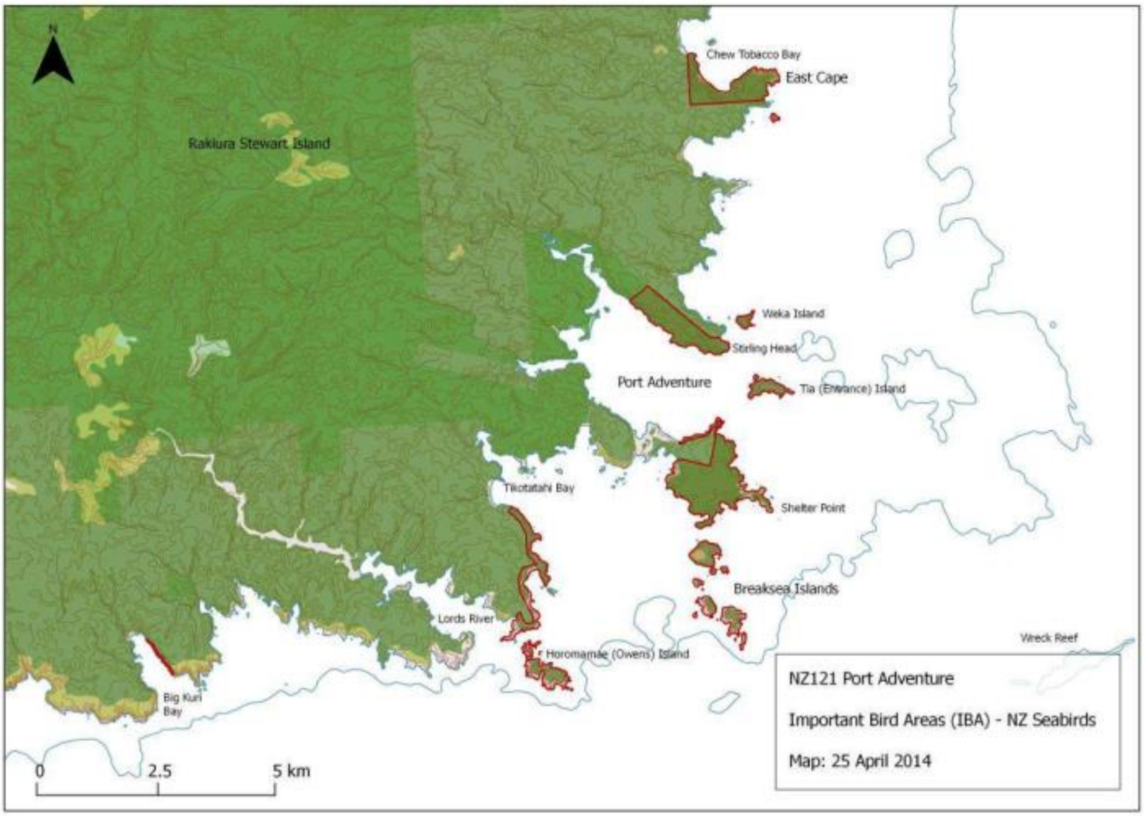
Map 8: NZ117 - Whenua Hou Codfish Island IBA (red).



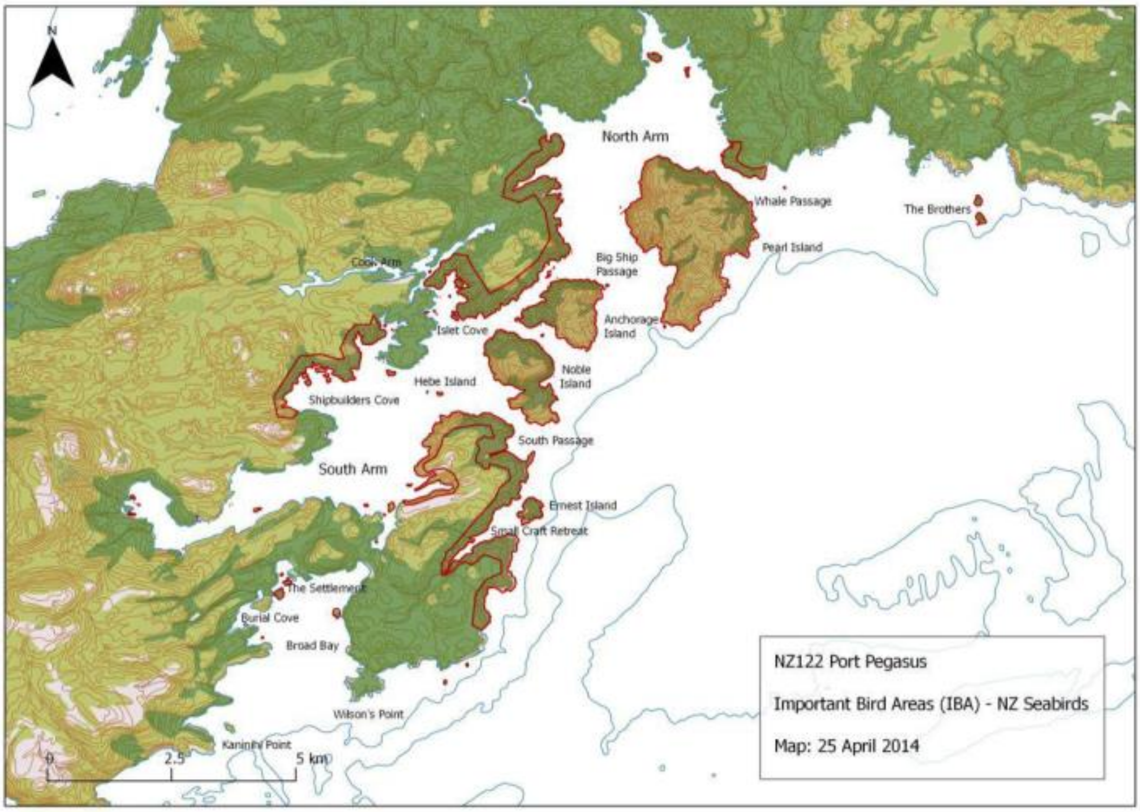
Map 9: NZ118 - Northern Titi Muttonbird Islands IBA (red).



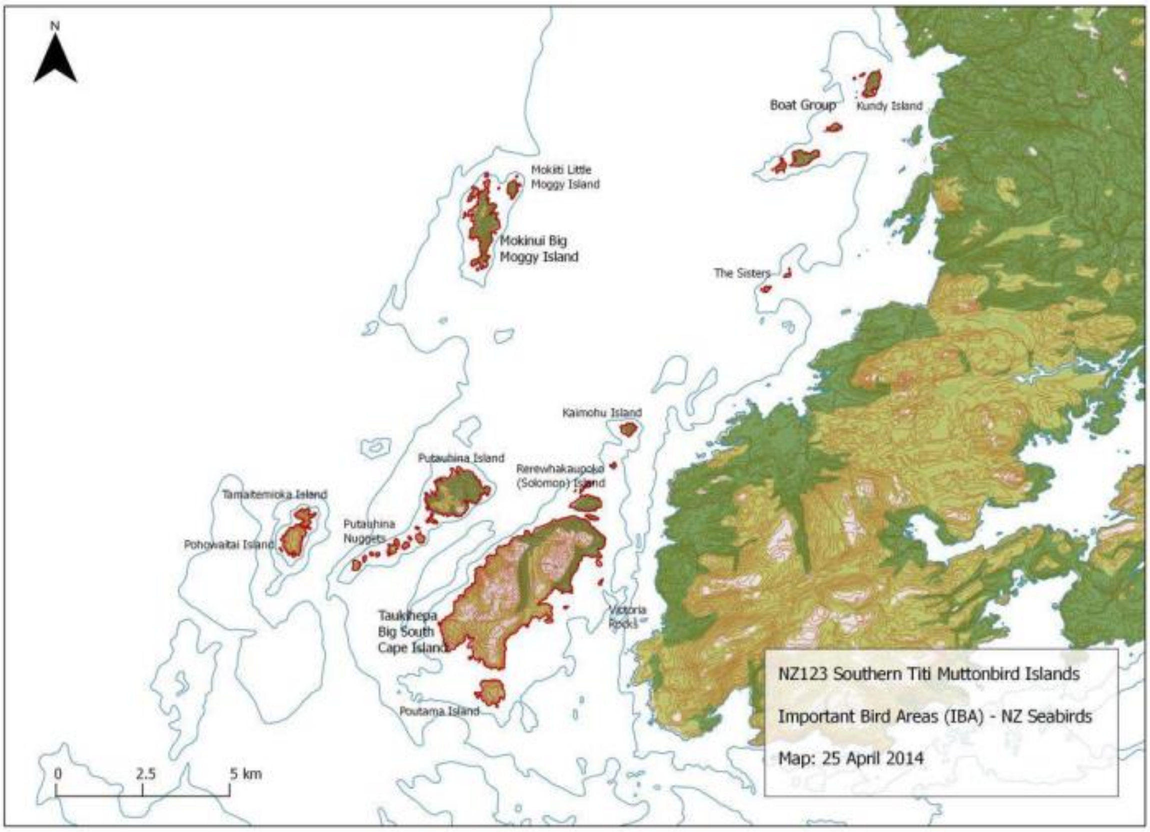
Map 10: NZ120 - Paterson Inlet The Neck IBA (red).



Map 11: NZ121 - Port Adventure IBA (red).



Map 12: NZ122 - Port Pegasus IBA (red).



Map 13: NZ123 - Southern Titi Muttonbird Islands IBA (red).

SCIENTIFIC NAMES AND THREAT RANKINGS OF SEABIRD SPECIES

The following table provides the scientific names of all species mentioned in the text, and the national classification (Robertson *et al.* 2017) according to the National Threat Classification System (Townsend *et al.* 2008) as well as the IUCN Red List global classification. An asterisk '*' marks those species where taxonomical issues exist; the table also provides taxa which may be present, but 'lost' given the coarse taxonomy used by eBird and the Fisheries Observer databases (indented). Common names and scientific names are those used in Robertson *et al.* (2017). Alternative names are given in some cases.

Common Name	Species Name	National Threat Classification	IUCN Threat Classification
Penguins			
King penguin	*Aptenodytes patagonicus*	Vagrant	Least concern
Fiordland crested penguin	*Eudyptes pachyrhynchus*	Threatened-Nationally Vulnerable	Vulnerable
Snares crested penguin	*Eudyptes robustus*	At Risk-Naturally Uncommon	Vulnerable
Yellow-eyed penguin	*Megadyptes antipodes*	Threatened-Nationally Endangered	Endangered
Blue penguin	*Eudyptula minor*	At Risk-Declining	Least Concern
Albatrosses			
*Snowy (wandering) albatross	*Diomedea exulans*	Migrant	Vulnerable
Antipodean albatross	*Diomedea antipodensis antipodensis*	Threatened-Nationally Critical	Endangered
Gibson's albatross	*Diomedea antipodensis gibsoni*	Threatened-Nationally Critical	
*Northern royal albatross	*Diomedea sanfordi*	At Risk-Naturally Uncommon	Endangered
*Southern royal albatross	*Diomedea epomophora epomophora*	At Risk-Naturally Uncommon	Vulnerable
Grey-headed mollymawk	*Thalasarche chrysostoma*	Threatened-Nationally Vulnerable	Endangered
*Black-browed mollymawk	*Thalassarche melanophris*	Coloniser	Least Concern
Campbell Island mollymawk	*Thalassarche impavida*	Threatened-Nationally Vulnerable	Vulnerable
*Southern Buller's mollymawk	*Thalassarche bulleri bulleri*	At Risk-Naturally Uncommon	Near Threatened
Shy (white-capped) mollymawk	*Thalassarche cauta steadi*	At Risk-Declining	Near Threatened
Salvin's mollymawk	*Thalassarche salvini*	Threatened-Nationally Critical	Vulnerable
Chatham Island mollymawk	*Thalassarche eremita*	At Risk-Naturally Uncommon	Vulnerable
Shearwaters, Petrels, and Prions			
Southern giant petrel	*Macronectes giganteus*	Migrant	Least Concern
Northern giant petrel	*Macronectes halli*	At Risk-Recovering	Least Concern
Antarctic fulmar	*Fulmarus glacialoides*	Migrant	Least Concern
*Cape petrel	*Daption capense capense*	Migrant	Least Concern

Common Name	Species Name	National Threat Classification	IUCN Threat Classification
Snares Cape petrel	*Daption capense australe*	At Risk-Naturally Uncommon	
Grey-faced petrel	*Pterodroma macroptera gouldi*	Not Threatened	Least Concern
White-headed petrel	*Pterodroma lessonii*	Not Threatened	Least Concern
Mottled petrel	*Pterodroma inexpectata*	Not Threatened	Near Threatened
Cook's petrel	*Pterodroma cookii*	At Risk-Relict	Vulnerable
Antarctic prion	*Pachyptila desolata*	At Risk-Naturally Uncommon	Least Concern
Broad-billed prion	*Pachyptila vittata*	At Risk-Relict	Least Concern
Fairy prion	*Pachyptila turtur*	At Risk-Relict	Least Concern
White-chinned petrel	*Procellaria aequinoctialis*	Not Threatened	Vulnerable
Westland petrel	*Procellaria westlandica*	At Risk-Naturally Uncommon	Endangered
Grey petrel	*Procellaria cinerea*	At Risk-Naturally Uncommon	Near Threatened
Buller's shearwater	*Puffinus bulleri*	At Risk-Naturally Uncommon	Vulnerable
Flesh-footed shearwater	*Puffinus carneipus*	Threatened-Nationally Vulnerable	Near Threatened
Pink-footed shearwater	*Puffinus creatopus*	Vagrant	Vulnerable
Sooty shearwater	*Puffinus griseus*	At Risk-Declining	Near Threatened
Short-tailed shearwater	*Puffinus tenuirostris*	Migrant	Least Concern
Fluttering shearwater	*Puffinus gavia*	At Risk-Relict	Least Concern
Hutton's shearwater	*Puffinus huttoni*	Threatened-Nationally Vulnerable	Endangered
Subantarctic little shearwater	*Puffinus elegans*	At Risk-Naturally Uncommon	Least Concern
Wilson's storm petrel	*Oceanites oceanicus exasperatus*	Migrant	Least Concern
Grey-backed storm petrel	*Garrodia nereis*	At Risk-Relict	Least Concern
NZ white-faced storm petrel	*Pelagodroma marina maoriana*	At Risk-Relict	Least Concern
Southern diving petrel	*Pelecanoides urinatrix chathamensis*	At Risk-Relict	Least Concern
*Whenua Hou diving petrel	*Pelecanoides whenuahouensis*	Threatened-Nationally Critical	
*South Georgia diving petrel	*Pelecanoides georgicus*	N/A	Least Concern
Gannets and Shags			
Australasian gannet	*Morus serrator*	Not Threatened	Least Concern
*Foveaux shag	*Leucocarbo stewarti*	Threatened-Nationally Vulnerable	Vulnerable
Stewart Island shag	*Leucocarbo chalconotus*	N/A	
Black shag	*Phalacrocorax carbo novaehollandiae*	At Risk-Naturally Uncommon	Least Concern
Little black shag	*Phalacrocorax sulcirostris*	At Risk-Naturally Uncommon	Least Concern
Little shag	*Phalacrocorax melanoleucos brevirostris*	Not Threatened	Least Concern
Pied shag	*Phalacrocorax varius varius*	At Risk-Recovering	Least Concern
Spotted shag	*Stictocarbo punctatus punctatus*	Not Threatened	Least Concern

Common Name	Species Name	National Threat Classification	IUCN Threat Classification
Gulls and Terns			
Brown skua	*Catharacta antarctica lonnbergi*	At Risk-Naturally Uncommon	Least Concern
South polar skua	*Catharacta maccormicki*	Migrant	Least Concern
Pomarine skua	*Coprotheres pomarinus*	Migrant	Least Concern
Arctic skua	*Stercorarius parasiticus*	Migrant	Least Concern
Southern black-backed gull	*Larus dominicanus dominicanus*	Not Threatened	Least Concern
Red-billed gull	*Larus scopulinus novaehollandiae*	At Risk-Declining	Least Concern
Black-billed gull	*Larus bulleri*	Threatened-Nationally Critical	Endangered
Gull-billed tern	*Gelochelidon nilotica*	Vagrant	Least Concern
Caspian tern	*Hydroprogne caspia*	Threatened-Nationally Vulnerable	Least Concern
Whiskered tern	*Chlidonias hybridus javanicus*	Vagrant	Least Concern
Black-fronted tern	*Chlidonias albostriatus*	Threatened-Nationally Endangered	Endangered
White-fronted tern	*Sterna striata striata*	At Risk-Declining	Near Threatened
Antarctic tern	*Sterna vittata bethunei*	At Risk-Recovering	Least Concern
Arctic tern	*Sterna paradisaea*	Migrant	Least Concern
Common tern	*Sterna hirundo longipennis*	Vagrant	Least Concern

ALBATROSS TAXONOMIC DIFFERENCES

Various taxonomies for albatross are in use, which recognise between 14-24 different species. eBird and the fisheries observer databases tend to result in relatively coarse lists of taxa, and do not recognise subspecies, and sometimes combine species. The Department of Conservation recognises the most species and subspecies (Robertson *et al.* 2017), and their list is relatively similar to that used by the Agreement on the Conservation of Albatrosses and Petrels (ACAP; an international organisation that works to protect albatrosses and petrels by coordinating international activities to mitigate threats to their populations).

This table shows the general differences between the three taxonomies, and also demonstrates the differences between the common names.

ebird/Fisheries Observer Common Name	ACAP Common Name	Robertson *et al.* (2017) Common Name	Robertson *et al.* (2017) Species Name (Species and Subspecies)	Robertson *et al.* (2017) Threat Classification
Wandering albatross	Wandering albatross	Snowy albatross	*Diomedea exulans*	Migrant
	Antipodean albatross	Antipodean albatross	*Diomedea antipodensis antipodensis*	Threatened-Nationally Critical
		Gibson's albatross	*Diomedea antipodensis gibsoni*	Threatened-Nationally Critical
Royal albatross	Northern royal albatross	Northern royal albatross	*Diomedea sanfordi*	At Risk-Naturally Uncommon
	Southern royal albatross	Southern royal albatross	*Diomedea epomophora*	At Risk-Naturally Uncommon
Black-browed albatross	Black-browed albatross	Black-browed mollymawk	*Thalassarche melanophris*	Coloniser
	Campbell albatross	Campbell Island mollymawk	*Thalassarche impavida*	Threatened-Nationally Vulnerable
Buller's albatross	Buller's albatross	Southern Buller's mollymawk	*Thalassarche bulleri bulleri*	At Risk-Naturally Uncommon
		Pacific (northern Buller's) mollymawk	*Thalassarche bulleri platei*	At Risk-Naturally Uncommon
White-capped albatross	White-capped albatross	Shy mollymawk	*Thalassarche cauta steadi*	At Risk-Declining
	Shy albatross	Tasmanian mollymawk	*Thalassarche cauta cauta*	Vagrant
Salvin's albatross	Salvin's albatross	Salvin's mollymawk	*Thalassarche salvini*	Threatened-Nationally Critical
Chatham albatross	Chatham albatross	Chatham Island mollymawk	*Thalassarche eremita*	At Risk-Naturally Uncommon
Gray-headed albatross	Gray-headed albatross	Grey-headed mollymawk	*Thalassarche chrysostoma*	Threatened-Nationally Vulnerable
Light-mantled albatross	Light-mantled albatross	Light-mantled sooty albatross	*Phoebetria palpebrata*	At Risk-Declining

APPENDIX 4

SEABIRD COLONY LOCATIONS

The following seabird colony maps are indicative of the distribution and frequency of breeding locations. Information sources are provided in the table below.

Common Name	Sources of Information
Yellow-eyed penguin	Forest and Bird 2014; NABIS 2016
Fiordland crested penguin	Forest and Bird 2014; NABIS 2016
Blue penguin	Van Heezik 1990; Flemming *et al.* 2013; Forest and Bird 2014; Chilvers 2019
Northern giant petrel	
Cook's petrel	Forest and Bird 2014; NABIS 2016
Mottled petrel	Forest and Bird 2014
Sooty shearwater	Waugh *et al.* 2013; Forest and Bird 2014; NABIS 2016
Broad-billed prion	Forest and Bird 2014; Jamieson *et al.* 2016
Fairy prion	Forest and Bird 2014; Jamieson *et al.* 2016
Whenua Hou diving petrel	Forest and Bird 2014; NABIS 2016
Southern diving petrel	Forest and Bird 2014
New Zealand white-faced storm petrel	Forest and Bird 2014
Foveaux shag	Forest and Bird 2014; Rawlence *et al.* 2014; NABIS 2016
Otago shag	Rawlence *et al.* 2014
Black shag (Otago)	Hand 2013
Pied shag	Hand 2013; Forest and Bird 2014
Spotted shag	Forest and Bird 2014; Rawlence *et al.* 2019
Little shag	Forest and Bird 2014
Brown skua	Forest and Bird 2014
Black-billed gull	NABIS 2016
Red-billed gull	Forest and Bird 2014; Frost and Taylor 2016
Southern black-backed gull	Forest and Bird 2014
New Zealand Antarctic tern	Forest and Bird 2014
Caspian tern	NABIS 2016
Black-fronted tern	NABIS 2016
White-fronted tern	Hand 2013; Forest and Bird 2014

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Figure 1. Penguins

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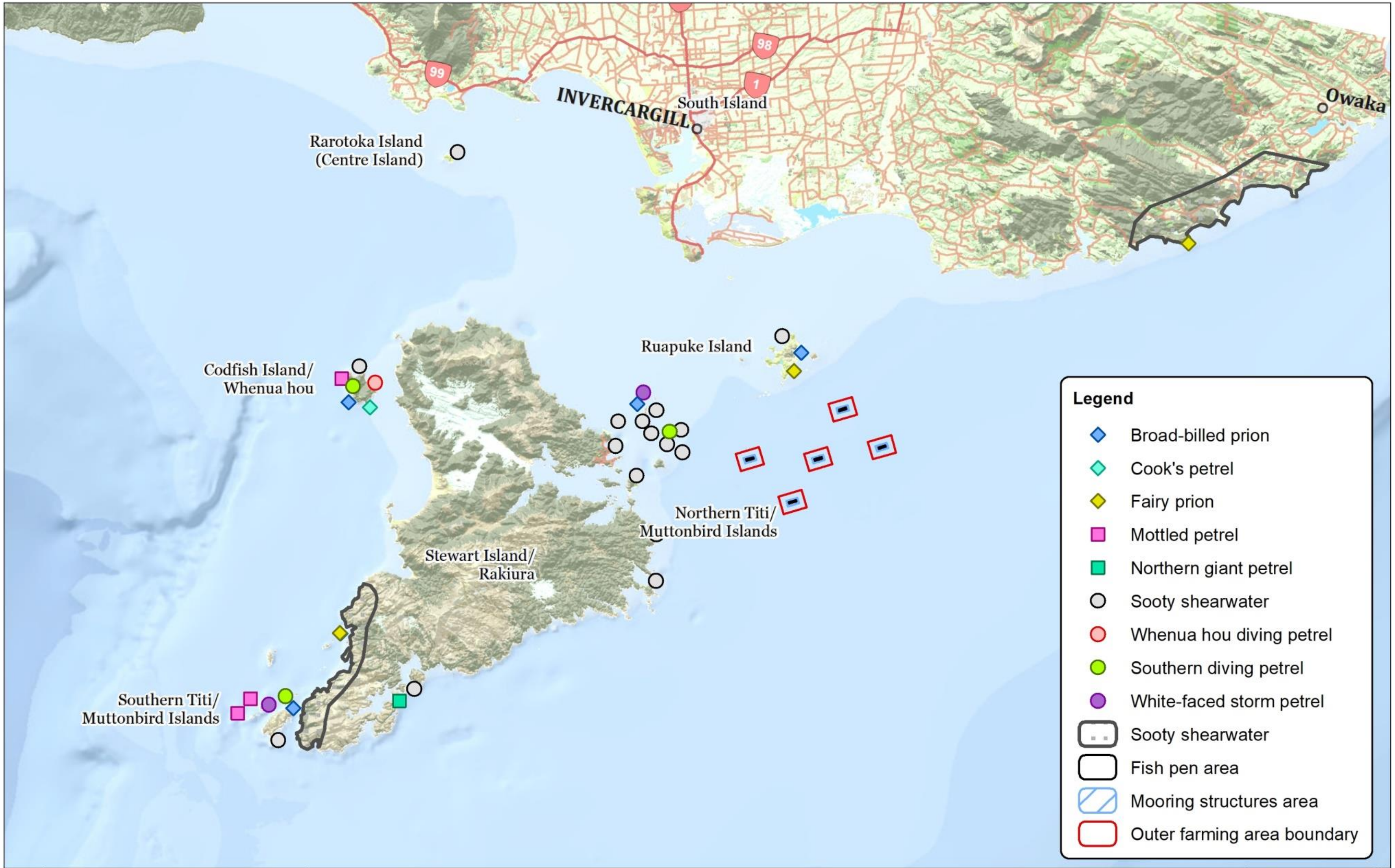

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Figure 2. Shearwaters, petrels and prions

0 10 20 40 Kilometers

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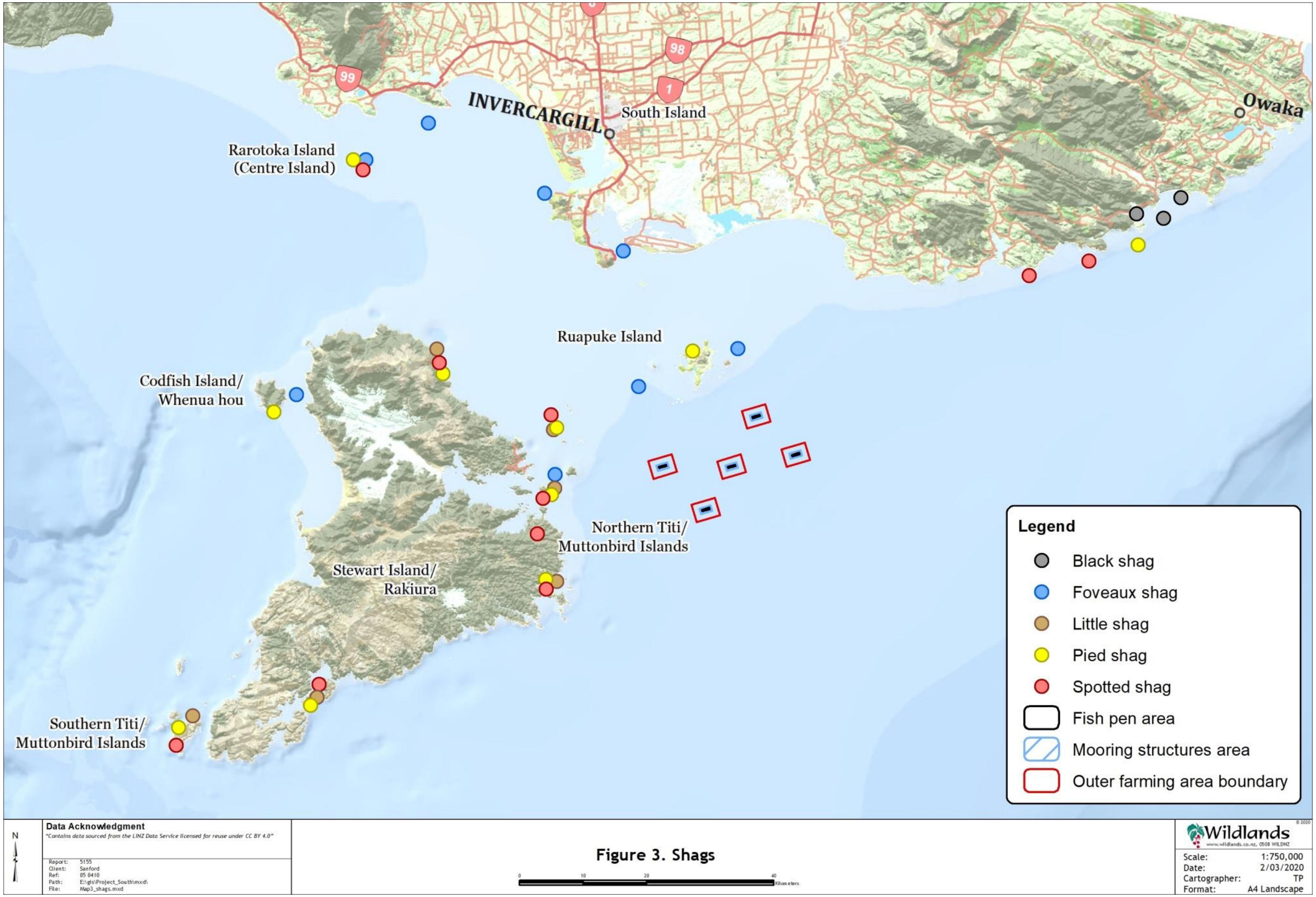
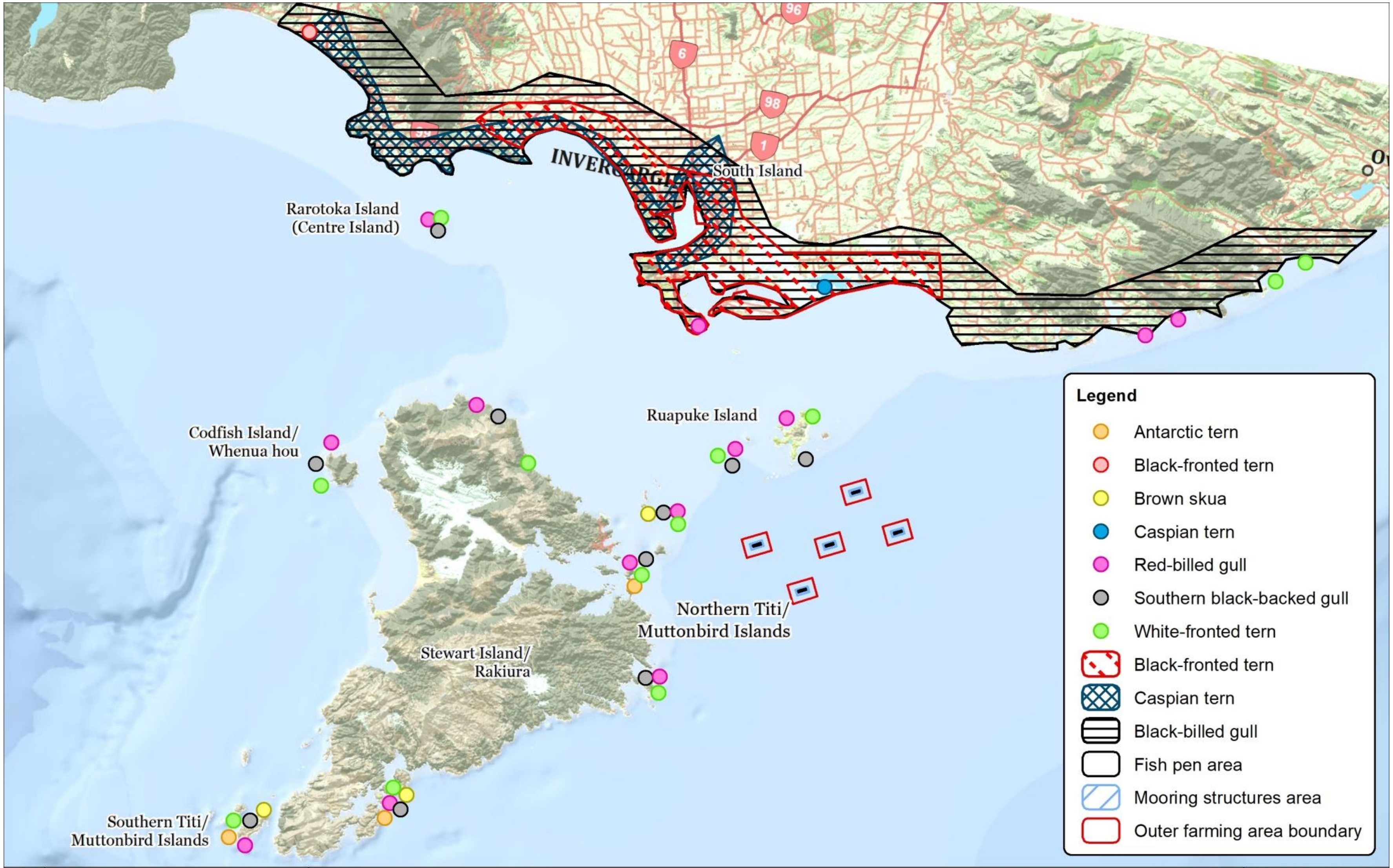
Scale: 1:800,000
Date: 2/03/2020
Cartographer: TP
Format: A4 Landscape


99
98
1
INVERCARGILL
South Island
Owaka
Rarotoka Island
(Centre Island)
Ruapuke Island
Codfish Island/
Whenua hou
Northern Titi/
Muttonbird Islands
Stewart Island/
Rakiura
Southern Titi/
Muttonbird Islands
Legend
Black shag
Foveaux shag
Little shag
Pied shag
Spotted shag
Fish pen area
Mooring structures area
Outer farming area boundary
N
Data Acknowledgment
Figure 3. Shags
Wildlands
Scale: 1:750,000
Date: 2/03/2020
Cartographer: TP
Format: A4 Landscape



N

Data Acknowledgment

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Report: 5155
Client: Sanford
Ref: 05 0410
Path: E:\gis\Project_South\mxd\
File: Map4_gull_tern.mxd

Figure 4: Skuas, gulls and terns

0 10 20 40 Kilometers

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Scale: 1:750,000
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Wildlands

Providing outstanding ecological services to sustain and improve our environments

Call Free 0508 WILDNZ
Ph: +64 7 343 9017
Fax: +64 7 3439018
ecology@wildlands.co.nz

99 Sala Street
PO Box 7137, Te Ngae
Rotorua 3042,
New Zealand

Regional Offices located in
Auckland, Hamilton, Tauranga,
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