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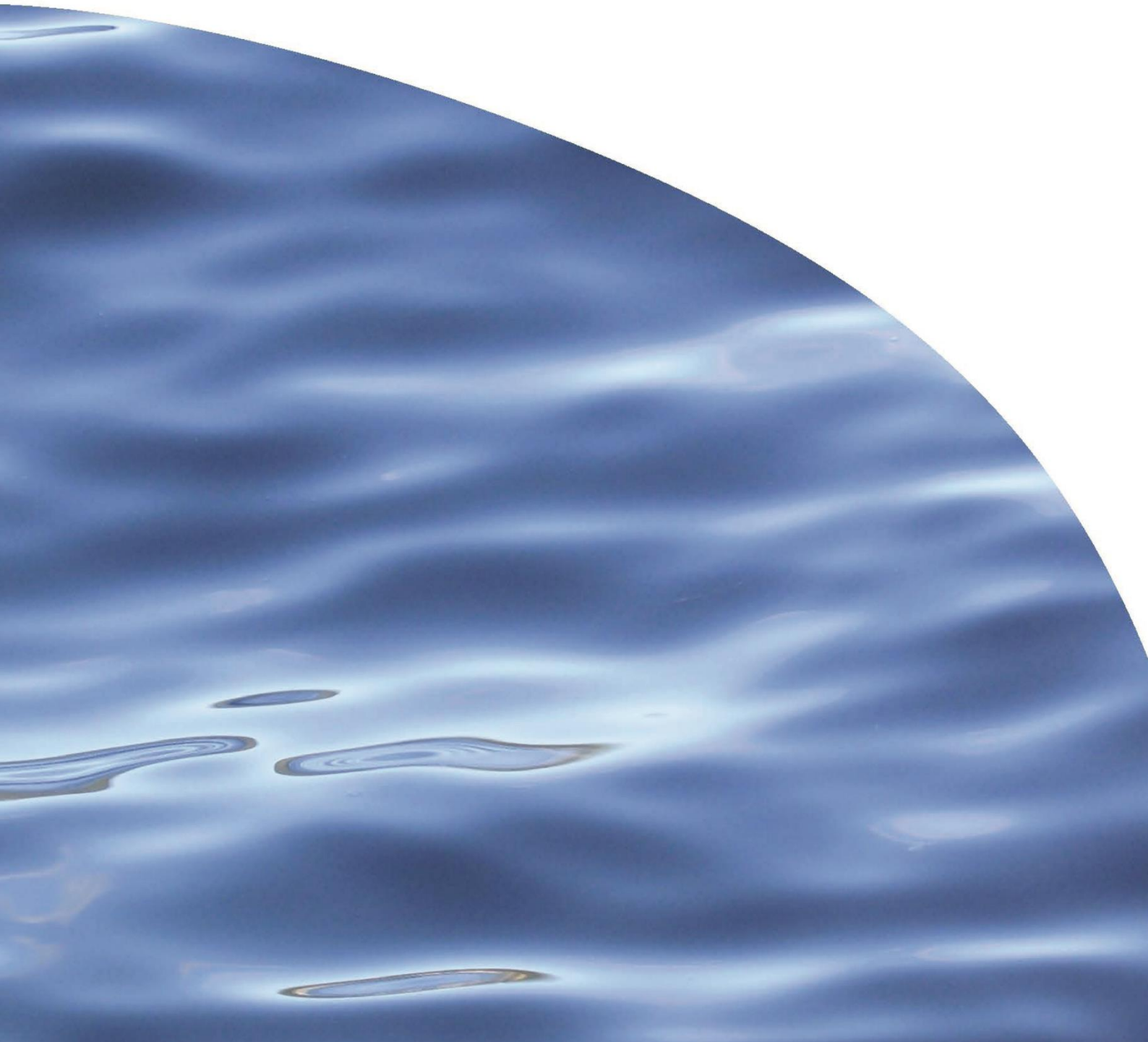
REPORT NO. 3413

PROJECT SOUTH: OPEN OCEAN SALMON FARMING MARINE MAMMAL ASSESSMENT



PROJECT SOUTH: OPEN OCEAN SALMON FARMING MARINE MAMMAL ASSESSMENT

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Prepared for Sanford Ltd

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EXECUTIVE SUMMARY

Sanford Ltd (Sanford) is preparing a consent application to develop an offshore salmon farm located inside Foveaux Strait and to the east of the Titi Islands. Details of the proposal are still being finalised but will likely consist of five farming areas of 157-ha each with ten polar circle pens. At full development, each site will contain less than 26 ha of grid and pens. As Foveaux Strait is a known migration corridor for several species of whales, Sanford has contracted the Cawthron Institute to provide a desktop description of marine mammal use of the proposed farm area and associated waters, an assessment of potential effects, and options to manage those effects.

The greater Southland and Foveaux Strait region, in association with Stewart Island waters, is considered an important area for a large number of New Zealand's cetacean and pinniped species. At least seven marine mammal species are considered year-round residents and / or seasonal visitors of these waters, with several baleen whale species migrating to and through Foveaux Strait each winter / spring, and more offshore species wandering into shallow regions over warmer months. The species with the highest potential to be affected by the proposal are New Zealand fur seals, New Zealand sea lions, bottlenose dolphins, southern right and humpback whales, and orca. While the proposed farmed areas represent similar habitats to those available across the wider Foveaux Strait region, they also potentially constitute part of the winter habitat important for southern right whales and forms part of humpback whales' northern migration corridor through the Foveaux Strait area. Southland and Stewart Island waters also support sub-populations of nationally endangered bottlenose and Hector's dolphins, as well as a new breeding colony of nationally vulnerable New Zealand sea lions, all of which need to be considered.

The main potential effects of the proposal are possible habitat displacement or avoidance and entanglement risk. Other impacts considered include underwater noise, artificial submerged lighting and trophic flow-on effects. The probabilities of impacts occurring are highly dependent on the farm structures (e.g. types / material of pens, use of predator nets, warp line configurations), farm management (e.g. taut nets and no loose ropes) and pen layout (e.g. scale, intensity, spacing between pens) as well as the species involved and their demographics (e.g. calves present, age). While the overall likelihoods of these effects are considered low to moderate, the potential consequences of a rare event (such as the death of an endangered species) means best practice management measures are required. The development of a Marine Mammal Management Plan (MMMP) prior to commencing operations is recommended to ensure that the most appropriate protective measures are in place to reduce any residual effects.

A recent international review of aquaculture and marine mammals acknowledges that there are still major knowledge gaps and uncertainty around how marine mammals will perceive offshore farm structures visually and acoustically, and importantly, the results of their reactions to farms. Monitoring is recommended to address some of these gaps, including the collection of baseline data on species' use of the proposal area and associated Foveaux

Strait waters while commencing a transparent database of marine mammal visual sightings (similar to overseas examples) to help inform how species might respond to the proposed farms.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1. BACKGROUND AND SCOPE

1.1. Proposed offshore marine farm

Sanford Limited (Sanford) are preparing a consent application to develop an offshore marine farm site within Foveaux Strait to grow King salmon (*Oncorhynchus tshawytscha*). The proposed site is located within water depths of 50–85 m and the closest farmed area is approximately 11 km southeast of Ruapuke Island (Figure 1).

The proposal is for five separate farmed areas, each of which will consist of ten grow-out pens in an overall configuration at full development shown in Figure 2. Circular floating pens of approximately 120 m circumference that can be fully submerged (i.e. during severe weather events) or raised as required have been proposed (Figure 3). The initial plan is not to use predator nets, and a surface containment net (e.g. 50-mm mesh) negates the requirement for thinner bird netting and poles. Each pen structure will be approximately 38 m wide (320 m with anchors) and extend 25 m deep (depending on submerged depth). Together with the barge and including mooring / anchor lines, each site will occupy 157.38 ha (Figure 2).

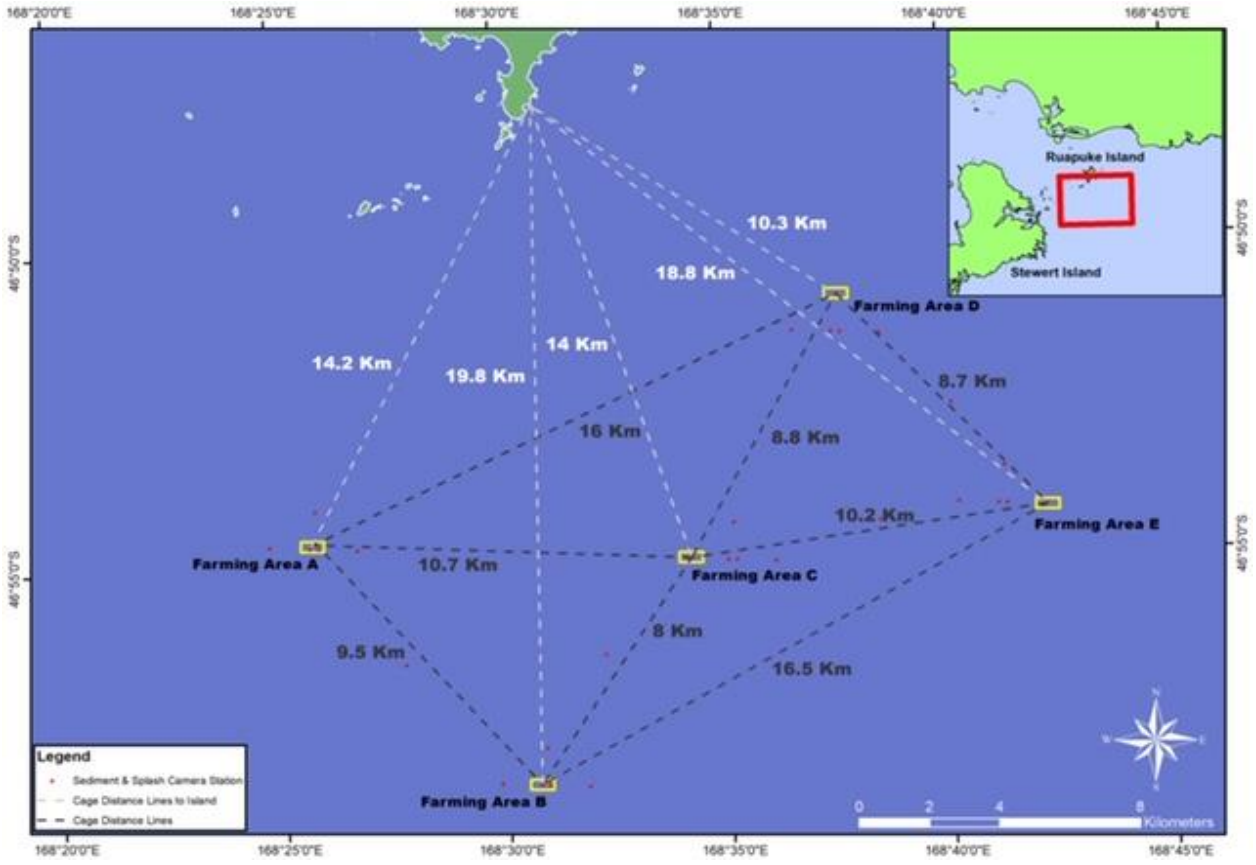

Figure 1. Proposed locations and distances of the five farming areas within Foveaux Strait relative to Ruapuke Island.

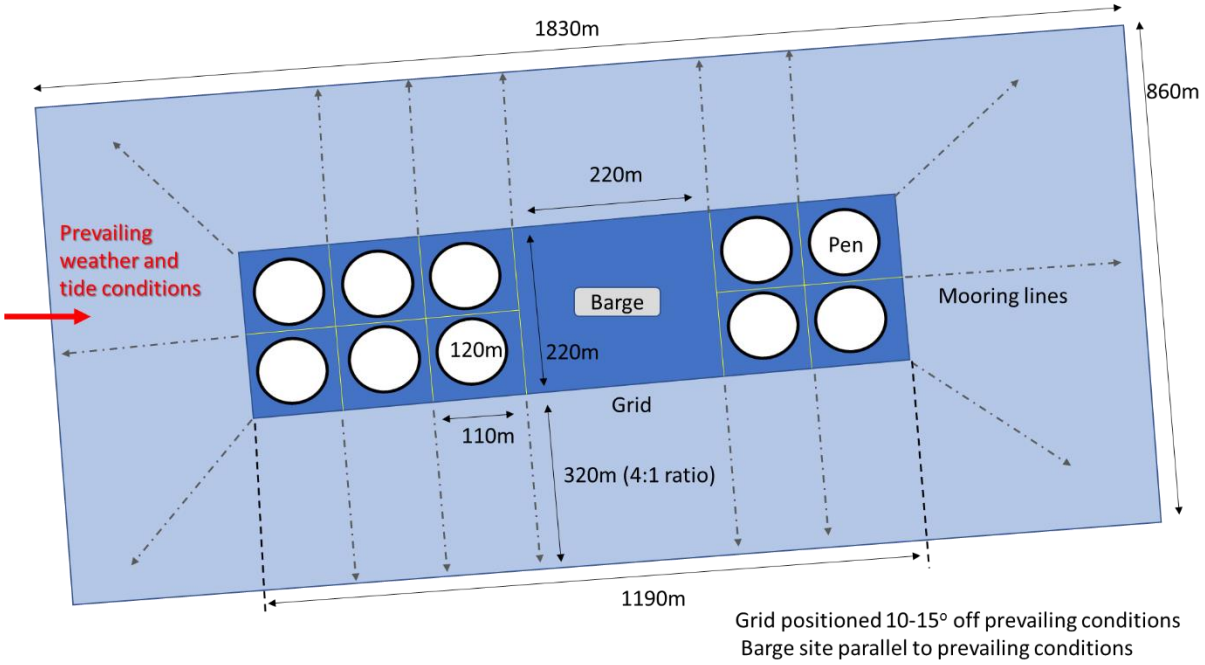

Figure 2. A schematic drawing of the proposed layout of the ten pens at each of the farming areas.

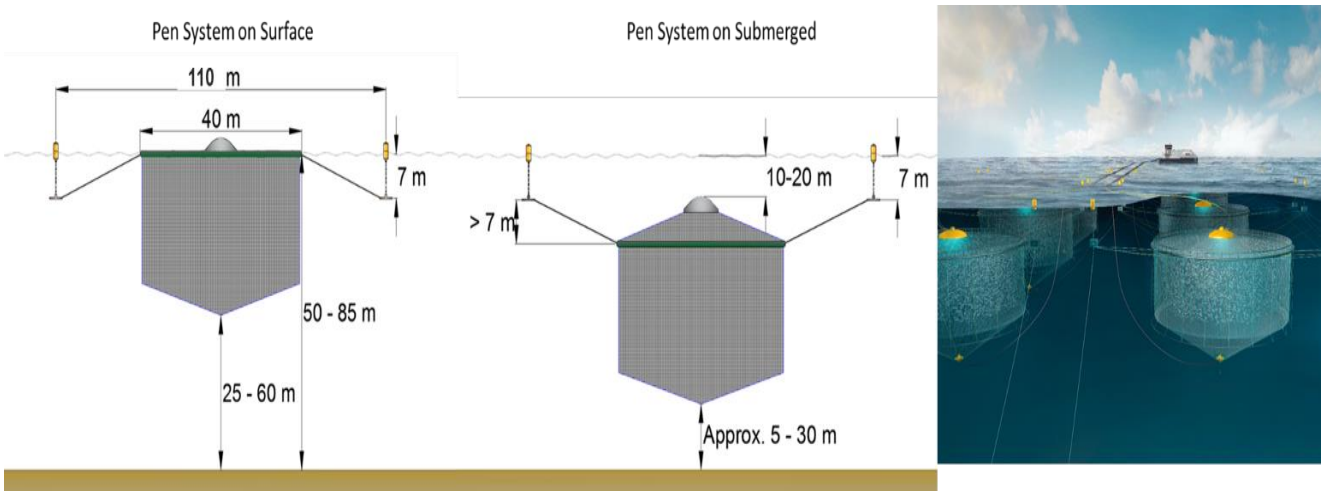

Figure 3. A diagram of AKVA Atlantis fully submersible sea pen structures that may be used in the proposed farming areas. The right-hand concept illustration shows the configuration of several pens with nearby feeding barge.

1.2. Assessment scope

The Cawthron Institute (Cawthron) has been contracted to provide a desktop assessment that describes the marine mammal populations found in the region of the application area and wider Foveaux Strait/ Southland region as well as the potential effects of the proposed farm on those populations and options for managing potential effects. The specific scope of this assessment consists of the following components:

1. a desktop review and description of marine mammals found in the proposal area
2. review and summary of the overall risk of any resulting effects in terms of their possible scale, duration / persistence, likelihood and possible consequences, while taking into consideration the findings of other assessments being undertaken for the project
3. recommendations for possible management options for avoiding, remedying or mitigating the potential adverse effects of the activity, and monitoring options where applicable.

2. DESCRIPTION OF EXISTING ENVIRONMENT

2.1. General approach

When considering potential implications of offshore developments on marine mammals, the appropriate scale of consideration is not just the level of the proposal, it needs to include the spatial scales relevant to the marine mammal species involved. For most marine mammals, normal home ranges can vary between hundreds to thousands of kilometres. For instance, while humpback whales may be considered only seasonal migrants through Southland waters, Foveaux Strait may represent an important corridor that this species makes use of to reach key habitats elsewhere. As a result, the importance of the proposal area needs to be placed in context of the species' regional and New Zealand-wide distributions. In this case, this regional scale includes Foveaux Strait, Southland and Stewart Island waters and referred to as the 'area of interest' or AOI for this report.

To date, several university research programmes have undertaken short-term, localised studies on various marine mammal species across Southland and Stewart Island since the mid-1990s. A list of the collated studies and information sources is available in Appendix 1. The few studies that have focused primarily on the wider Foveaux Strait region (e.g. MacKenzie & Clement 2019) have been extremely limited temporally (i.e. 1-2 surveys). In the absence of long-term and spatially-explicit baseline research on marine mammals in the proposal area, species information and sighting data were collated from existing studies undertaken across the wider Southland / Otago / Stewart Island region. In addition, opportunistic sightings reported to the Department of Conservation (DOC) (including the reports from public, tourism vessels, fisheries observers, seismic surveys, etc.) and strandings (previously collated through Te Papa National Museum and now DOC) were reviewed.

In the absence of detailed information on some mammal populations (e.g. growth trends, abundance, survival rates), the appropriate approach when assessing the potential risks to marine mammal species associated with various anthropogenic activities is to assess the species' life history dynamics (e.g. species-specific sensitivities, conservation status, life span, main prey sources) summarised from New Zealand and international data sources[1]. Collectively, this information is used to determine what is currently known about the relevant species' occurrence, behaviour, and distribution within the area of interest and used to evaluate those species most likely to be affected by the proposed project.

[1] Peer-reviewed journals, New Zealand Threat Classification System - NZTCS, National Aquatic Biodiversity Information System – NABIS (www.nabis.govt.nz/), International Union for Conservation of Nature (IUCN) Red List of Threatened Species (https://www.iucnredlist.org/)

2.2. General description of the Area of Interest (AOI)

Out of the more than 50 species of cetaceans (whales, dolphins and porpoises) and pinnipeds (seals and sea lions) known to live or migrate through New Zealand waters, at least 24 cetacean and 4 pinniped species have been recorded passing through Foveaux Strait as well as Southland and Stewart Island waters (e.g. the AOI). Figure 4 highlights all the various marine mammal species recorded within the AOI since the early 1970s. It is important to note again that a large majority of these sighting are opportunistic rather than systematic. Consequently, the number of sightings in these figures do not necessarily represent unique animals (i.e. same animal may be reported by multiple members of the public or reported on two separate days or years). As effort is not considered with opportunistic data, favourite fishing spots and tour boat tracks are likely to be overrepresented, especially during periods of more favourable conditions (e.g. summer, daylight periods).

Most sightings were reported between Bluff (mainland South Island) and Oban / Paterson Inlet (Stewart Island; Figure 5). The large number of reported sightings in this area is most likely a reflection of the number of marine ferry and tour trips undertaken between these locations. Other 'hotspots' for opportunistic records are known tourist destinations such as Te Waewae and Porpoise bays along with the coastal town of Riverton. Further offshore sightings likely represent either commercial fishing destinations or seismic survey locations, as both activities are required to carry marine mammal and / or fisheries observers on board in New Zealand waters (Figure 4). Therefore, the apparent distribution from these data may not adequately reflect the species' true distribution patterns as much as the pattern of anthropogenic activities operating within these areas.

For this assessment, less emphasis is placed on the location of sightings with more importance stressed on the presence and timing of the identified species in the wider region. The more prevalent species are listed in Table 1 and divided into three general categories that describe the current knowledge about their distribution patterns within the AOI. Species' information is likely to change as more systematic research becomes available, particularly for uncommon species:

- Resident—a species that lives (either remaining to feed and / or breed) within the AOI and surrounding waters either permanently (year-round) or for regular time periods.
- Migrant—a species that regularly travels through part(s) of the AOI but remain only for temporary time periods that may be predictable seasonally.
- Visitor—a species that may wander into the AOI intermittently. Depending on the AOI's proximity to the species' normal distribution range, visits may occur seasonally, infrequently or rarely.

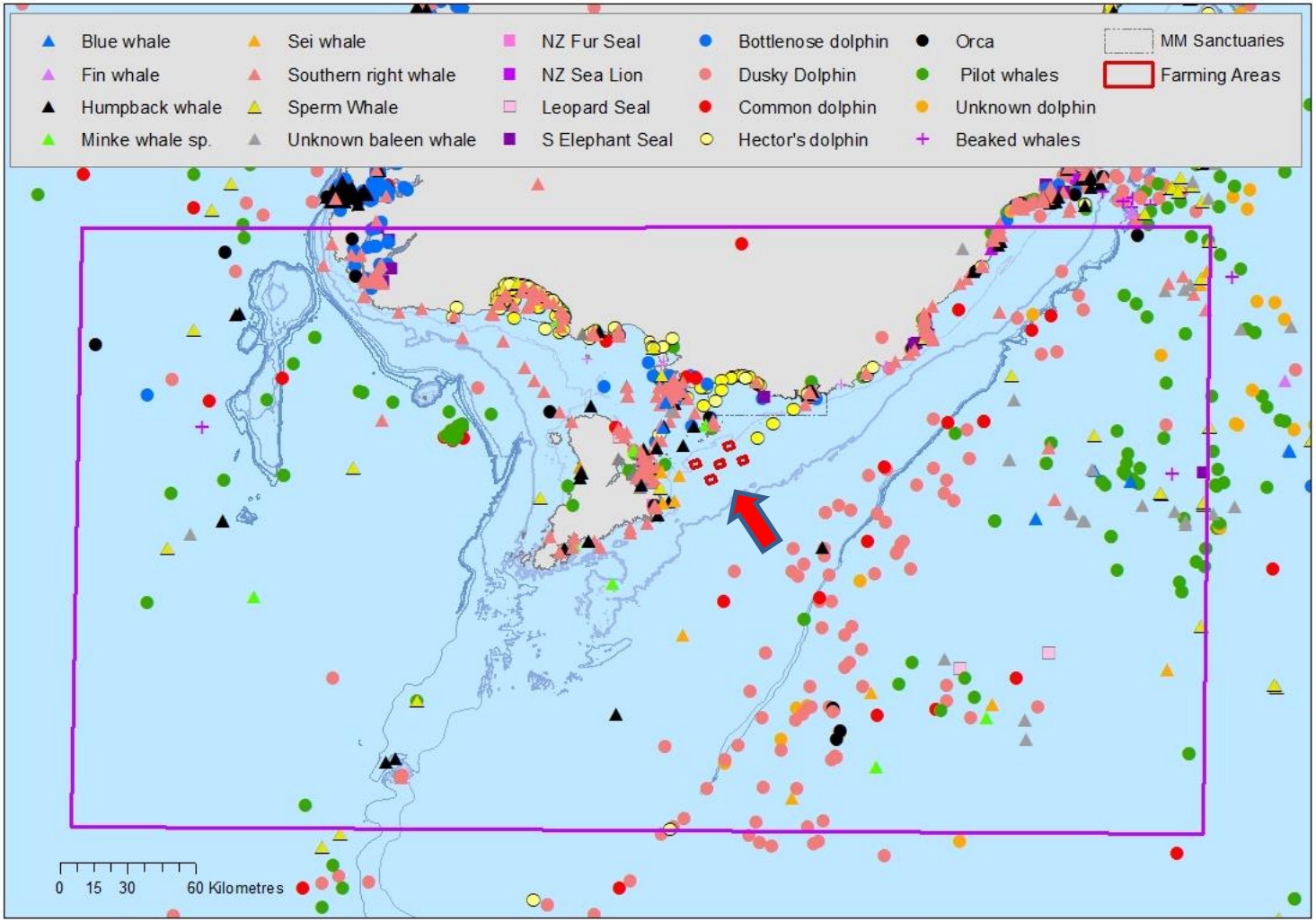

Figure 4. The spatial extent (purple polygon) of Foveaux Strait, Southland and Stewart Island waters considered and referred to as the area of interest. The relevant sighting and stranding data are displayed in more detail in Figure 5. The proposal farming areas are contained in the red polygons (indicated by arrow).

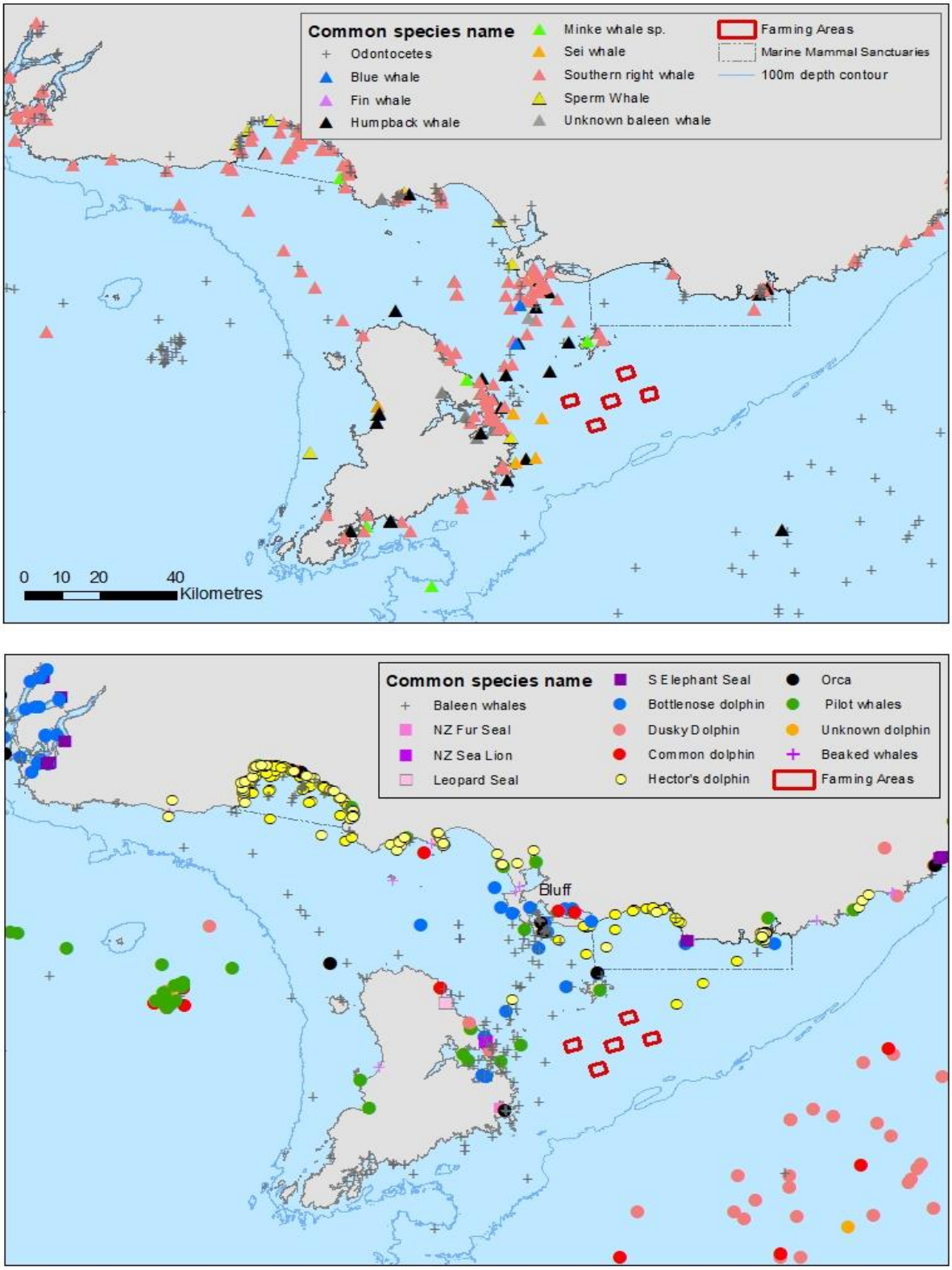

Figure 5. All Department of Conservation (DOC) reported marine mammal strandings (1912–2015) and opportunistic sightings (1977–2018) with in the Area of Interest. The spatial extent of these maps is more detailed than Figure 4 to help distinguish those species reported around Foveaux Strait waters. Migrating baleen whale species (plus sperm whale) are shown in the top image and toothed whales, dolphins and pinnipeds (seals and sea lions) are in the bottom image. The proposal farming areas are contained in the red polygons.

Table 1. Residency patterns of the marine mammal species most relevant to the proposal and known to frequent the Area of Interest. Species' conservation threat status is listed for both the New Zealand Threat Classification System (Baker et al. 2019) and international IUCN system (ver 3.1).

Common name	Species name	NZ threat classification		IUCN red listing	Residency category in AOI
RESIDENTS					
NZ fur seal	*Arctocephalus forsteri*	NZ native & resident, evaluated	Not Threatened	Least Concern	Year-Round Resident
NZ sea lion	*Phocarctos hookeri*	NZ native & resident, evaluated	Nationally Vulnerable	Endangered	Year-Round Resident
Hector's dolphin	*Cephalorhynchus hectori*	NZ native & resident, evaluated	Nationally Vulnerable	Endangered	Year-Round Resident
Bottlenose dolphin	*Tursiops truncatus*	NZ native & resident, evaluated	Nationally Endangered	Data Deficient	Seasonal to Semi-Resident
POTENTIAL OFFSHORE SPECIES					
Long-finned pilot whale	*Globicephala melas*	NZ native & resident, evaluated	Not Threatened	Data Deficient	Potential Offshore Semi-Resident
Sperm whale	*Physeter macrocephalus*	NZ native	Data Deficient	Vulnerable	Potential Offshore Visitor
Beaked whales	Ziphiidae species (7 species)	NZ native & resident, not evaluated	Data Deficient	Data Deficient to Least Concern	Potential Rare Offshore Visitors
MIGRANTS					
Southern right whale	*Eubalaena australis*	NZ native & resident, threatened	At Risk-Recovering	Least Concern	Seasonal Migrant
Humpback whale	*Megaptera novaeangliae*	NZ native, evaluated	Migrant	Endangered	Seasonal Migrant
VISITORS					
Dusky dolphins	*Lagenorhynchus obscurus*	NZ native & resident, evaluated	Not Threatened	Data Deficient	Seasonal Visitor
Common dolphin	*Delphinus delphis*	NZ native & resident, evaluated	Not Threatened	Least Concern	Seasonal Visitor
Orca (killer whale)	*Orcinus orca*	NZ native & resident, threatened	Nationally Critical	Data Deficient	Seasonal to Infrequent Visitor
Sei whale	*Balaenoptera borealis*	NZ native & non-resident, evaluated	Not Threatened	Not Threatened to Data Deficient	Seasonal to Infrequent Visitor
Blue whale	*Balaenoptera musculus* (sub-spp. *brevicauda* & *intermedia)*	NZ native	Data Deficient	Critically Endangered to Data Deficient	Seasonal to Infrequent Visitor

2.3. Species of concern

Several of the species highlighted in Table 1 and Figure 4 are known to be year-round or seasonal residents of the wider Foveaux Strait and Stewart Island regions. The more common species occurring within the AOI, and those therefore potentially affected by the proposed project, include New Zealand fur seal (*Arctocephalus forsteri*), New Zealand sea lion (*Phocarctos hookeri*), bottlenose dolphin (*Tursiops truncatus*), southern right (*Eubalaena australis*) and humpback whales (*Megaptera novaeangliae*) and occasionally, orca (*Orcinus orca*). A short summary of these and other relevant species is given below.

NZ fur seals are the only pinniped species regularly observed year-round on both mainland and Stewart Island rocky shores. Known breeding colonies and haul-out sites are found around most of Stewart Island and on most offshore islands within Foveaux Strait including both Ruapuke Island and the Titi / Muttonbird Islands (NABIS 2019). Fur seals are considered non-migratory but are known to easily and repeatedly cover large distances to find food. Some adults will travel out to open waters over winter while younger animals focus over shallower continental shelf waters. Fur seals are regularly observed around salmon farms in the Marlborough Sounds, hauling out on structures where possible and raiding pens for food. Sightings of fur seals around these salmon farms tend to peak soon after pups depart from colonies around late winter / spring months. There are no regular surveys of fur seal colonies in the AOI; hence, the current status of the populations in this area are unknown.

Recently, a breeding colony of **NZ sea lions** was discovered in 2011 at Port Pegasus (over 70 km away to the southwest) and is currently growing (Chilvers 2011). The population has been estimated roughly at 180 individuals (Roberts et al. 2017). Experts expect this population to undergo a substantial increase in numbers at Port Pegasus with the future establishment of a larger, colonial breeding colony. Regular haul-out sites for this species have been recorded on Ruapuke Island, along Stewart Island's western coastline including the outer regions of Big Glory Bay (in an area known as the Neck), and throughout the Catlins on the mainland (NABIS 2019, R. Cole, DOC ranger Southland, pers. comm.). Sea lion presence around current salmon farms in Big Glory Bay has not resulted in any known mortalities or injuries to date; but, finfish farms in Australia and South America report interactions, including fatal entanglements, with local sea lion species (Kemper et al. 2003; Sepúlveda & Olivia 2005). Any incidental mortalities could have a significant effect on the local population's continued recolonisation and recovery in Southland and Otago waters, given this species' current population size and ongoing threats (e.g. listed as *nationally vulnerable* by the New Zealand Threat Classification System (NZTCS): Baker et al. 2019; and *endangered* by the International Union for the Conservation of Nature (IUCN): Chilvers & Goldsworthy 2015).

While **southern elephant seals** and **leopard seals** have been observed around Stewart Island and Southland beaches, they are vagrant species to the AOI. There

have been a few reports of these species fatality entangling in salmon farms in Australia (SE Tasmania) in the 1990s (Kemper et al. 2003), but there have not been any interactions to date in New Zealand. Regardless, all pinniped species are given protection under the Marine Mammals Protection Act 1978.

The main resident dolphin species in AOI waters is **Hector's dolphins**. While there has been one 1970s stranding (unverified) and one unconfirmed sighting on or near Stewart Island, within the AOI this species is recognised as exclusively distributed within mainland coastal waters between Te Waewae Bay and Waikawa Harbour / Porpoise Bay (MacKenzie & Clement 2019). As a small sub-population (approximately 200 to 500 animals; MacKenzie & Clement 2019) that is genetically distinct from both the east and west coast South Island sub-populations, these semi-isolated dolphins are considered *national vulnerable* and *endangered* by the NZTCS and IUCN, respectively (Baker et al. 2019; Reeves et al. 2013). While their occurrence in the proposal area is likely to be extremely low, current population numbers means that any potential anthropogenic impacts, no matter how remote, warrant mention and consideration. Two Hector's dolphins have died from entanglements in salmon farms within the Marlborough Sounds and Akaroa Harbour (Cawthorn 2011; DOC stranding database).

Other residents include groups of **bottlenose dolphins** thought to range between Fiordland through Foveaux Strait and around Stewart Island and Otago (Brough et al. 2015). Very little is known about this possible 'southern' sub-population; however, a preliminary study suggests that a small subset of approximately 17 individuals (out of a potential larger population of at least 80 to 111 individuals) regularly visits Stewart Island's Paterson Inlet. Sightings of this southern sub-population, while made year-round, are more frequent over warmer spring, summer, and autumn months than the colder winter period within AOI waters (DOC database). Bottlenose dolphin are generalists in their feeding preferences and can be quite adaptive in their feeding styles. For instance, this species has been known to opportunistically interact with farms in Big Glory Bay and the Marlborough Sounds, even pulling salmon out through the bottom of pens. Bottlenose dolphins are one of the dolphin species commonly reported as fatally entangling in finfish farms from South Australia, Tasmania and the Marlborough Sounds (Kemper et al. 2003; Cawthorn 2011) and internationally (e.g. Italy – Díaz-López & Bernal-Shirai 2007). Bottlenose dolphins in New Zealand are current listed as *nationally endangered* by the NZTCS due to ongoing population declines in at least 1 and possibly 2 of the 3 regional sub-populations (Baker et al. 2019).

Various groups of **dusky dolphins** are regularly sighted in deeper, continental shelf waters off the Otago coastline and Stewart Island along with **common dolphins**, which are also observed within Foveaux Strait and associated inshore waters as well. Group sizes vary from 1 to 2 animals up to 500 dolphins. Sightings are almost exclusively reported between late spring (November) and autumn (April) when southern waters are warmer, suggesting these species may be potential seasonal visitors to the AOI. These trends fit with the larger movements of dusky dolphins

around the South Island in which animals appear to move north over colder periods and south during warmer months (e.g. Lusseau & Slooten 2002; Würsig et al. 2007). Common dolphins are known to feed within inshore waters during daylight hours and migrate into deeper shelf waters at night to take advantage of vertically migrating prey (e.g. Neumann 2001; Meynier et al. 2008). Little is known about the actual population sizes and movements of either species outside local study areas (i.e. Hauraki Gulf and BOP—Stockin et al. 2008 and Dwyer 2014; Kaikoura—Würsig et al. 2007). While neither is considered threatened in New Zealand waters, both species are documented as entangling in finfish farms in New Zealand and / or internationally (e.g. Kemper et al. 2003; Cawthorn 2011).

Groups of **orca** are not often reported throughout the year but when they are recorded, they are often observed multiple times over short time periods (several days to weeks) within AOI waters. It is thought that there are three overlapping sub-populations of orca: North Island, North + South Island, and South Island only. These sub-populations move seasonally around New Zealand coastal waters in search of prey (Visser 2000). As seasonally transient through AOI waters, this species likely wanders up and down the coastline taking advantage of those habitats where rays and other prey types may be more common (e.g. Hupman et al. 2014). Orca are currently listed as *nationally critical* by the NZTCS (Baker et al. 2019) based on general low abundance.

The general migrations of baleen whales through Foveaux Strait and along both the east and west coasts of the South Island commence in early winter (May / June) and cease again with their return to southern Antarctic waters by late spring (November / December). **Southern right whales** are by far the most prevalent species sighted within the AOI (Figure 4), and this region is also known for having the highest sighting concentration of right whales around New Zealand's mainland (Carroll et al. 2014). Historically, both Southland and Otago were important whaling sites (at least 11 stations) for this species (Dawbin 1986). While sightings indicate that southern right whales are observed year-round across the AOI, numbers generally peak between May and September as they gradually move into their traditional mainland wintering grounds (Patenaude 2003).

Right whale group sizes are generally small with 1 to 2 individuals. However, AOI waters are unusual in that this is the only region where reproductive, mixed (i.e. males and females) groups of 3–20 whales are regularly observed, suggesting this area may be the only known mainland mating habitat (Carroll et al. 2014). Southern right whales can be observed with newborn calves from August onwards, but only 10% of Southland sightings report having a calf in the group (Carroll et al. 2014). Southern right whales have been recently downlisted to *at risk-recovering* by the NZTCS (Baker et al. 2019), as their population numbers continue to grow. However, their preference for shallow bays and coastal waters overlaps with numerous anthropogenic activities in New Zealand's waters.

Humpback whales mainly migrate through AOI waters from May to August heading up both coastlines of the South Island (Dawbin 1956). They have been observed throughout Foveaux Strait as well as within sheltered waters on both Stewart Island and the mainland. While the location of their main migration corridor through Foveaux Strait is not known, this species appears to be more abundant during its northern migration within the AOI than south-bound humpbacks are on their return in spring months, with only the occasional sighting in October or November. Overseas, both humpbacks and southern right whales have been found entangled in finfish farm structures.

Four other species of baleen whales are also thought to occasionally visit AOI waters; **sei, blue, minke,** and **pygmy right whales**. Most whales are observed further offshore on shelf waters south or east of Stewart island, but both **sei** and **blue whales** are regularly reported around Stewart Island and Foveaux Strait. Most sightings of these species have occurred during the warmer months over summer and late autumn. The inconspicuous **pygmy right whale** has historically stranded in AOI coastal areas, and in particular around Paterson Inlet on Stewart Island. Very little information is available on this species or its occurrence in this region other than it is thought to concentrate in plankton-rich waters (Kemper et al. 2013). However, the most recent stranding on beaches off Stewart Island was in 2003. This species is listed as *data deficient* by the NZTCS (Baker et al. 2019) but has no known threats.

Potential offshore residents, migrants and visitors to AOI waters include **pilot whales**, **sperm whales,** and a few species of **beaked whales** (DOC databases; Baker 2001; Brabyn 1990). Medium to large groups of **pilot whales** were regularly observed throughout the year but tend to live more offshore (e.g. living near and / or along the edge of the continental shelf), only wandering into shallower AOI waters over warmer summer months. However, this species is known for its occasional large mass strandings (100s of animals) on beaches around Stewart Island and Southland (Brabyn 1991; DOC databases). Similar distribution trends are noted for **sperm whale**s with only the occasional inshore sightings over warmer periods. There are very few live sightings of any **beaked whale** species; which in general are fairly cryptic and solitary. However, the stranding records in this area suggest that these deeper water species may also occasionally visit AOI regions with warmer waters.

2.4. Species summary

Based on the available data, and in reference to both Section 6(c) of the Resource Management Act (RMA) and Policy 11(b) of the New Zealand Coastal Policy Statement (NZCPS), there is no evidence indicating that any of these species have home ranges restricted solely to Foveaux Strait and associated regions. Hence, the proposal area is not considered ecologically more significant in terms of feeding, resting or breeding habitats for most of these species relative to other regions within the greater AOI based on current knowledge.

The possible exceptions where the area may be more significant are the use of Foveaux Strait as a main migration corridor for several species of whales and southern right whales' use of these waters as potentially important winter mating habitats. Whales' migration pathways through Strait waters are not well-known but increasing numbers of humpback, southern right and blue whales have been documented in recent years around New Zealand as populations continue to recover from whaling impacts.

As discussed above, Foveaux Strait waters also support potential sub-populations of endangered species, such as Hector's dolphins, bottlenose dolphins and orca, as well as local recovering colonies of the vulnerable NZ sea lions. These species meet the criteria specified in Policy 11(a) of the NZCPS, which refers to avoiding any adverse effects on nationally and / or internationally recognised threatened species.

3. POTENTIAL EFFECTS OF FINFISH AQUACULTURE ON MARINE MAMMALS

Most consequential interactions between marine mammals and aquaculture result from a direct overlap between the spatial location of the facilities and important habitats (i.e. feeding or nursing) and / or migration routes of the species (MPI 2013). Existing management strategies have recommended avoidance of marine mammal interactions by siting new farms in areas that minimise the likelihood of overlap with migration routes or critical habitats (MPI 2013). This strategy has been successful to date as most farms have been located within more protected, inshore waters in regions with few resident populations of marine mammals. However, the expansion of aquaculture into open ocean waters means that this avoidance may no longer be an option. The movement of aquaculture to more offshore waters now means that interactions with baleen whales and larger pods of dolphins (e.g. greater than 50 animals) are more likely.

A recent global review of aquaculture and marine mammals by the United States' National Oceanic and Atmospheric Administration (Price et al. 2017) acknowledges that there are still very few empirical data on marine mammal responses to aquaculture or the results of their reactions to and with farms (if any), despite aquaculture's world-wide presence in nearshore regions for more than 20 years. The situation is complicated by the fact that the individual species involved is likely to influence the probability and nature of the interaction. Particular species of whales or dolphins will be highly sensitive to any disturbance while other cetacean species may even be attracted to the structures (e.g. Clement & Halliday 2014). In addition, some individuals within a given population such as juveniles, old, diseased, or disoriented individuals may be more prone to becoming involved in direct interactions, such as entanglements or collisions with certain gear types (Wilson et al. 2006; Kemper et al. 2003).

To date, documented effects of aquaculture on marine mammals are mainly habitat exclusion / displacement issues and entanglement in structures (e.g. Würsig & Gailey 2002; Kemper et al. 2003; Markowitz et al. 2004; Heinrich & Hammond 2006; Pearson et al. 2012). Depending on the size of the farm and nature of operations, other issues such as underwater noise, submerged lighting and possible flow-on effects due to alterations in trophic pathways may also apply (MPI 2013). These effects are reviewed in more detail below.

3.1. Habitat exclusion/displacement

As the proposed farms will consist of novel and stationary structures (albeit relatively small scale) located within the once completely open waters of Foveaux Strait, they may be perceived by marine mammals as physical, visual or acoustic obstructions that they may choose to ignore, investigate or avoid. As noted in the global review by Price et al. (2017), there is currently very little information on how marine mammals

might perceive farm structures within the open ocean environment, and even more uncertainty around their possible responses.

3.1.1. Baleen whales

Baleen whales, such as southern right whales or humpback whales, do not echolocate. They gather information about their environment mainly through normal audio and visual cues. Consequently, some individuals have been recorded swimming through finfish farms in Australia, destroying structures and / or entangling themselves while trying to follow their traditional migration routes (e.g. Pemberton et al. 1991; Kemper et al. 2003). Migratory routes of both humpbacks and southern right whales are thought to be culturally passed on, mainly from mothers to calves. Conversely, whales may travel by the farms ignoring them as they continue on their migration.

Alternatively, too much activity near sensitive habitats and / or migration corridors could also result in active avoidance by whales from historical habitats, particularly mother and calf pairs (e.g. Herman 1979; Glockner-Ferrari & Ferrari 1990). Avoidance behaviours may range from whales simply displacing themselves further offshore from farms to avoidance of vital resting and nursing habitats with (in a worst-case scenario) potential population repercussions (i.e. extra travel time causes reduced reproduction rates in pregnant females).

However, as is the case globally (Price et al. 2017), there are not enough data on whale populations within New Zealand to know how species like southern right whale might respond to these proposed farms while within mating groups, or the longer-term consequences of these responses.

3.1.2. Odontocetes and pinnipeds

More information is available on how echolocating species (e.g. bottlenose dolphins or orca) may respond to farm structures in their habitats as these species more generally occur year-round and utilise more inshore habitats where aquaculture development has historically taken place. Yet, the longer-term, biological consequences of their responses are still unclear and expert opinions are at times conflicting in some cases.

The only New Zealand studies to date were undertaken in Admiralty Bay (Marlborough Sounds). Multi-year studies have demonstrated that dusky dolphins seem unable to cooperatively herd small schooling fish (e.g. pilchards) when adjacent to or within mussel farm structures (Pearson et al. 2012). Collectively the evidence suggests that while these dolphin species are not displaced from the bay, they do not appear to be utilising habitats occupied by marine farms (210 ha) in the same manner as they do unoccupied habitats (3,166 ha) within Admiralty Bay. Yet, the significance of such ‘disruptions’ to their foraging and feeding success is currently unknown and may range from *less than minor* (i.e. discernible effect but too small to affect more than a few individual animals) to *more than minor* implications (i.e. the loss of a

primary food source begins to have population-level effects, such as reduced reproduction rates).

Alternatively, other marine mammal species may be attracted to the proposed farms. NZ fur seals are strongly attracted to salmon farms within the Marlborough Sounds with individuals regularly found resting on structures and / or attempting to feed on fish in the pens (D. Clement, pers. obs.). Finfish stock in the farms can also attract dolphins, such as bottlenose and dusky dolphins, due to these species' curious natures and the associated wild fish aggregations under and near farms. This attraction can have its own repercussions in the form of damaged nets / structures, stock loss and entanglement (see Entanglement, Section 3.2).

Based on the limited evidence available, the likelihood for habitat displacement or avoidance behaviours associated with the proposed farm is considered *low* for pinnipeds, dolphins and most whale species. However, the consequences of any displacement effects are highly uncertain at this stage due to lack of adequate data, particularly for whale species. Hence, the significance of this effect is also indicated as uncertain in Table 2.

Some species, such as bottlenose dolphins, fur seals and orca, are more likely to be attracted to the farm structure as a food source, and thus the risk of attraction is also considered *moderate* although subsequent consequences of this attraction fall under entanglement rather than displacement effects (see Section 3.2). These assessments are based on the relevant factors summarised below and in Table 2.

Spatial and temporal factors

- Several established breeding colonies of NZ fur seals occur relatively close (within 11 to 20 km from Ruapuke Island and Edwards / Jacky Lee islands) to the proposed farming areas. NZ sea lions have established haul-out sites on Ruapuke Island, Paterson Inlet and the Waikawa Inlet (Catlins) from 11 to 20 km away.
- Bottlenose, dusky and common dolphins travel through Foveaux Strait and utilise nearby coastal waters. Bottlenose are observed year-round while the other species are mainly sighted within generally warmer seasons.
- The proposal site represents the offshore extent of known Hector's dolphin distribution in Southland waters.
- Several different species of whales are sighted within Foveaux Strait and nearby coastal waters throughout the year, with more migratory species passing through the Strait from early winter (May) to late spring (November / December).
- Migration pathways of whales are not well-known but increasing numbers of humpback, southern right and blue whales have been documented in the AOI in recent years as populations continue to recover from whaling impacts.
- The proposed farm areas are not considered to be particularly rare and / or unique in terms of feeding, resting or breeding habitats. The exception is that this

area may represent important winter mating habitats for southern right whales and form part of the main migration corridor for humpback whales.

- The proposal areas are not significant in size relative to Foveaux Strait. Each farming area will collectively occupy 157 ha of water space (Figure 2), which represents a relatively small part of the overall home ranges of most resident and / or visiting species. These home ranges are large and overlap with similar types of habitats in other parts of Foveaux Strait and associated regions.

Known displacement / avoidance factors

- Current exposure to existing salmon farms within inshore or sheltered regions of Stewart Island has resulted in attraction of bottlenose dolphins, sea lions and fur seals to farming areas with no reported entanglements to date.
- Current farm structures in New Zealand (e.g. pens / warp lines) do not appear to exclude dolphins from moving through the proposal area, but are likely to affect some feeding strategies, while whales are expected to be excluded from within their boundaries entirely.
- Currently, finfish aquaculture is not known to generate intense or consistently loud underwater sounds nor involve large volumes of vessel traffic that may result in habitat displacement relative to other anthropogenic activities in the wider general area (e.g. the existing ferry lane).

3.2. Entanglement

The process of assessing entanglement risk follows the RMA and the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act, which essentially combines the likelihood of the occurrence (e.g. the number of whales / dolphins likely to adversely interact with a farm) versus the magnitude of effect (e.g. interactions could lead to death, injury, avoidance or have no negative effect at all). As discussed in the previous sections, there are few data on most marine mammal species within one or both of these categories (e.g. Price et al. 2017).

Within New Zealand, fatal entanglement of marine mammals in aquaculture structures has been a relatively minor issue to date (MPI 2013), despite over 50 years of marine salmon farming and several decades of oyster and mussel farming. However, it is unclear how this record relates to the frequency of physical interactions (including non-fatal injuries) taking place between species and the industry. Without records of the absence of species near farms and / or the lack of interactions of animals with farms (also known as negative data), we cannot quantify the real level of risk or place it in context (i.e. paucity of entanglements because farms are relatively benign or density of farms and reporting is too low to detect potentially injurious interactions; Price et al. 2017).

However, records of previous New Zealand entanglements along with oversea data (particularly from Australia) can inform which New Zealand marine mammal species

may be more vulnerable to entanglement risk as well as which farm configurations or gear may increase or reduce the risk. Operational aspects, in particular, can greatly influence the possible outcome (i.e. injury vs mortality) of any interactions and therefore, the overall risk (MPI 2013).

3.2.1. Baleen whales

Generally, larger whales are considered more susceptible to entanglement in marine gear from fisheries and aquaculture (e.g. ropes, buoys, nets) than other marine mammals with three species most commonly reported worldwide: humpback, minke and right whales (Benjamins et al. 2012; Young 2015). This known vulnerability towards entanglement as well as the extent to which the proposed farm areas overlap with winter habitats of southern right whales and migration routes of humpback whales make these species the primary whales of interest for this proposal.

Worldwide, there are fewer than ten whales recorded as being entangled and/or damaging finfish farms, most of which were humpback whales: Australia (n = 2, released alive; Kemper et al. 2008), British Columbia (n = 3, fatal entanglement; n = 2, released alive, FOC database 2018), Scotland (n = 1, fatal calf entanglement; Ryan et al. 2016) and Chile (n = 1, fatal calf entanglement; Hucke-Gaetea et al. 2013). To date, there are no reported entanglements of whales within any New Zealand salmon or other finfish farms, although there are two records of whales being fatally entangled in mussel farm lines (n = 1, Great Barrier Island; n = 1 Coromandel Peninsula). However, as the marine farming industry and populations of whales continue to increase in New Zealand, the probability of interactions is also expected to increase along with the associated risk of entanglement.

The exact mechanism of entanglement is still under debate: whether the whales cannot detect the gear or a curious whale deliberately interacts with gear because the structures are not recognised as a potential threat (Benjamins et al. 2014; Price et al. 2017). As mentioned in the previous section, a suspected southern right whale in Australia collided with and damaged a salmon cage in Tasmania (Pemberton et al. 1991) while a humpback broke through a net and swam into a tuna feedlot in Port Lincoln (South Australia, Kemper & Gibbs 2001). Global reviews have also noted that younger, less experienced animals (calves and juveniles) were found to be more at risk of entanglement compared to adult whales, perhaps due to inexperience or a more inquisitive nature (e.g. Benjamins et al. 2014; Knowlton et al. 2012). Individuals engaged in feeding, mating or resting may also have an increased risk of entanglement as they are distracted and less focused on the possible presence of unfamiliar structures in the water column.

3.2.2. Odontocetes and pinnipeds

Odontocetes, or toothed whales and dolphins, use sonar clicks to explore their environment and hunt for prey. Their echolocation capability means that they can detect structures and objects in the water column three-dimensionally, unlike baleen whales (e.g. Madsen et al. 2005; Markowitz et al. 2004). However, despite this ability,

odontocetes still entangle with finfish farms due to their attraction to the caged fish as an easy food source or to the associated aggregations of wild fish around farms.

Fatal entanglements of dolphins in finfish farms have been reported from Australia (Kemper & Gibbs 2001; Kemper et al. 2003), British Columbia (Figure 6 – FOC 2015), Scotland (Ryan et al. 2016), and Italy (Díaz-López & Bernal-Shirai 2007) as well as New Zealand (MPI 2013; Cawthorn 2011). There have been 10 dolphin entanglements reported in salmon farms between 1987 and 2018 (A Baxter – DOC Nelson, DOC stranding database). Entangled species include dusky dolphin (n = 7), Hector's dolphin (n = 2), and bottlenose dolphin (n = 1). Almost all animals were found or believed drowned in predator nets or during operational changes (i.e. switching out predator nets) when nets were no longer under tension.
New Zealand's entanglement rates are significantly lower than other countries such as British Columbia or Australia (see Figure 6). However, we have no data to place these rates in context as most aquaculture farms are not required to monitor or report marine mammal presence (absence) or minor interactions (i.e. non-fatal) with their structures and/or vessels. Evidence from overseas reports demonstrate that entanglement risk can increase if farms are poorly designed, installed or maintained (e.g. Kemper & Gibbs 2001; Allen & Bejder 2003; Kemper et al. 2003; Groom & Coughran 2005; Díaz-López & Bernal-Shirai 2007).

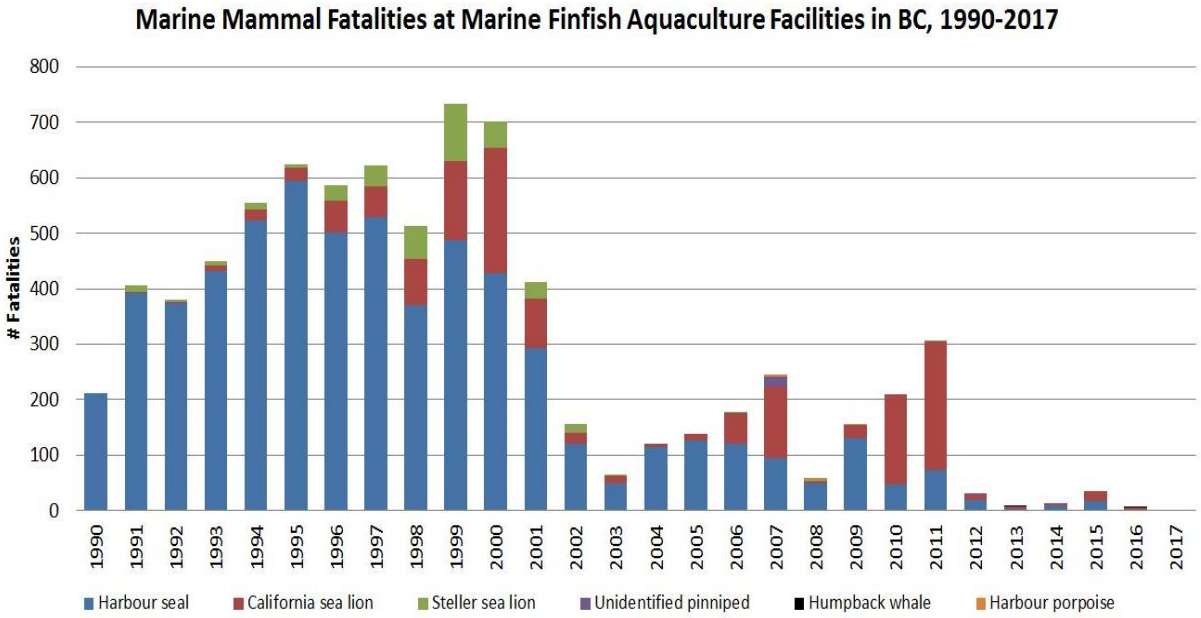

Figure 6. Marine mammal interactions with marine finfish aquaculture sites in British Columbia listed by species and year as reported through Fisheries and Oceans Canada (http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/mar-mam/index-eng.html).

Pinnipeds

The marine mammals most at risk of entanglement with finfish farms are pinnipeds, and within New Zealand, fur seals. Pinnipeds are thought to be strongly attracted to

the farmed fish as a food source, and as current farms are mostly located within embayments and sheltered inshore areas, they also serve as convenient haul-out sites for the animals. An increased pinniped presence can cause major problems for farmers through direct predation, destruction of gear, fish escapements through damaged nets and reduced fish growth and performance (Kemper et al. 2003). Consequently, salmon cages in the Marlborough Sounds, for example, are surrounded by predator nets that are designed to prevent predator access to the fish stock and the farm structures.

Despite seals' attraction to farms, there have been only six reported fatal entanglements of NZ fur seals in salmon farms within the Marlborough Sounds (but several hundred live releases). As with the dolphin incidences, almost all involved entanglement in predator nets or between predator nets and the salmon cage, and several of the events involved juvenile seals. Existing salmon farms in Big Glory Bay (Stewart Island) have regular visits and interactions with bottlenose dolphins, NZ fur seals and NZ sea lions. However, these current farms do not use predator nets outside the fish pens (SeaFarm System). This factor may account for the zero marine mammal entanglement record in this bay to date (A. Undorf-Lay, Sanford, pers. comm.). Overseas, pinniped predation is a much greater problem and often includes species of fur seal and sea lions (e.g. Kemper et al. 2003; Sepúlveda & Olivia 2005; FOC database 2018). Finfish farms in both Australia and South America report regular interactions, including fatal entanglements, with local sea lion species (e.g. Kemper et al. 2003).

Based on the above evidence, it is likely that both pinniped species will visit and interact with the proposed farms. In the case of NZ sea lions, the issues of low population size and a fairly isolated population structure make this species more vulnerable to adverse interactions than other species. Hence, the entanglement of one individual could have much larger scale and longer-lasting repercussions on the population's recovery, making a previously minor effect much more serious and broader in its implications (MPI 2013). However, most entanglements of pinnipeds occur when farms, or more likely predator nets, are not properly maintained (e.g. Tanner 2007), and thus appropriate management actions can help reduce the chances of entanglement significantly.

Overall, the likelihood for a fatal entanglement is considered *low* for all species and can be reduced by implementing best practice management measures. The consequence of such a rare event would be highly dependent on the animal(s) involved as several of the species are considered threatened or endangered, resulting in potentially serious regional or population level repercussions. While pinnipeds and dolphins (mainly bottlenose and dusky) are considered the species most at risk in regard to this proposal, evidence suggests that the risk can be reduced through appropriate farm design and best practice operational procedures as discussed above. The entanglement of baleen whales, particularly southern right and humpback whales, has also been considered due to the more offshore location and

scale of the proposal. This assessment is based on the relevant factors summarised below and listed in Table 2.

Spatial and temporal factors

- Several established breeding colonies for NZ fur seals occur relatively close (within 11 to 20 km from Ruapuke Island and Edwards / Jacky Lee islands) to the proposed farming areas. NZ sea lions have established haul-out sites on Ruapuke Island, Paterson Inlet and the Waikawa Inlet (Catlins) from 11 to 20 km away.
- Bottlenose, dusky and common dolphins travel through Foveaux Strait and use nearby coastal waters. Bottlenose are observed year-round while the other species are mainly sighted within generally warmer seasons.
- The proposal areas represent the offshore extent of known Hector's dolphin distribution in Southland waters.
- Most migratory whales occur in the area for a limited period each year; mainly in the winter months and spring months, and most only remain for a day or less (the exception being southern right whales).
- Most baleen whale species (with the possible exception of southern right whales and south-bound humpback whales) do not feed while migrating, hence individuals are less likely to be 'distracted' and vulnerable to entanglement.
- Migration pathways of whales are not well-known but increasing numbers of humpback, southern right and blue whales have been documented in recent years as populations continue to recover from whaling impacts.
- Southland waters may potentially represent important winter mating habitats for southern right whales.
- The proposed farm areas are not significant in size relative to Foveaux Strait waters. Each farming area will collectively occupy 157 ha of water space (Figure 2),

Entanglement factors

- Possibility of entanglement for NZ fur seals, NZ sea lions, humpback and southern right whales, and bottlenose, Hector's and dusky dolphins within New Zealand farms based on previous entanglement incidences in New Zealand and overseas.
- Higher entanglement possibility during construction, regular maintenance of nets or decommission periods, but this risk can be reduced with recommended management actions (see Section 4).
- Most entanglements in New Zealand salmon farms have occurred in or with predator nets.
- Current exposure of relevant dolphin and pinniped species to similar types of farms within other New Zealand regions have resulted in only a few reported entanglements in finfish farming gear. However, there are no means to assess risk due to the lack of context data (e.g. absences and effort).

- Evidence from overseas and within New Zealand demonstrates that entanglement risk can be reduced through proper siting, appropriate design and maintenance features, and strict operational procedures and protocols.

3.3. Underwater noise disturbance

Associated closely with habitat exclusion is habitat degradation in the form of underwater noise disturbance. Noise has the potential to negatively affect cetacean species since they rely heavily on underwater sounds for communication, orientation, predator avoidance and foraging. Depending on the overlap in the hearing range of a species, anthropogenic noise can mask important intra-species communication noises as well as interfere with other acoustic cues such as predators or nearby vessels (e.g. Lammers et al. 2013; Erbe 2002; Gerstein & Blue 2006).

Potential effects associated with increases in underwater noise include auditory damage, behavioural changes such as avoidance of (and / or attraction to) the area, and acoustic masking (e.g. Southall et al. 2007; Weilgart 2007; Wright et al. 2007). For example, Chilean dolphins (*Cephalorhynchus eutropia*) in an area of intensive aquaculture in Chile were found to respond to vessel noise by bunching, increasing speed, and increasing reorientation rate (Ribeiro et al. 2007). Too much noise disturbance or masking could theoretically affect reproductive success if the noise is generated near an important breeding ground and is ongoing for an extended period (Todd et al. 2015).

No research has assessed the types or levels of noise associated with ongoing farm activities (including maintenance and harvesting) or the possible effects of other noise-producing activities near salmon farms. However, MPI (2013) noted that the level and persistence of any underwater noises associated with a finfish farm are expected to be minimal relative to other underwater noise sources. However, underwater noises associated with farms will vary according to farm features (e.g. type, size), habitat characteristics (e.g. location, depth, types of bottom sediments, shape of coastline) and compounding factors, such as the number of farms and / or other noise sources in nearby regions. Richardson (1995) also noted that marine mammal reactions to anthropogenic noise differ depending on the species (and even between individuals of the same species), characteristics of the noise (i.e. variability and rate of change, ambient levels) and local environmental factors.

In this case, any effects of anthropogenic noise generated from the proposed salmon farm and associated operations are expected to be *nil to negligible* on local marine mammal species (Table 2). Any additional noise from farm operations and vessels will likely attract species such as fur seals and bottlenose dolphins to the farms; the greater risk of any attraction to farm structures is potential entanglement issues. Southern right whales may also be attracted, given their curious nature, or may avoid the area depending on the scale of operations and resulting noise levels.

3.4. Artificial lighting

To date, the few studies overseas or within New Zealand that have focused on the effects of submerged lights associated with finfish farms suggest they attract large aggregations of schooling baitfish to the pens that in turn may increase night-time predation by marine mammals and other species (e.g. SAD 2010; McConnell et al. 2010; Cornelisen & Quarterman 2010; Cornelisen 2011). Cornelisen (2011) found the footprint of submerged artificial lights is mainly confined within the cage structures and to mid-water depths.

As a result, marine mammals will more likely be attracted to any increase in noise and activity of caged or wild fish in response to the lights rather than the lights themselves. The effect of this attraction then becomes more of an entanglement issue (Table 2). Cornelisen (2011) suggests minimising any lighting effects by ensuring only the minimum of lighting necessary is used to achieve the farms' outcomes.

3.5. Possible flow-on effects due to alterations in trophic pathways

There is the potential for wider, more indirect ecosystem effects on marine mammals due to aquaculture in the form of food-web alterations (Black 2001; Kaiser 2001; Würsig & Gailey 2002; Kemper et al. 2003). There are numerous studies quantifying the impacts that salmon farms can have on the benthos and water quality in New Zealand waters (e.g. Keeley et al. 2009; MPI 2013). If farms are situated in suitable conditions, this impact is likely to be localised to within several hundred metres of the farm. If the farm is in an area with insufficient current or too close to particularly sensitive habitats, the result may be significant for the local ecosystem. However, there is currently no documented research or evidence for how the indirect effects of finfish farming on local ecosystems may affect New Zealand marine mammals and / or their prey.

In general, the large-scale home ranges and generalist feeding-strategy of most marine mammals ensure that any localised impacts to potential prey resources do not often have any substantial flow-on effects to the population. The only marine mammals expected to occur around near the proposed farming areas with any regularity are NZ fur seals. However, this species likely forages throughout Foveaux Strait and off the nearby continental shelf edge (e.g. Chilvers & Goldsworthy 2015). The lack of any marine mammal species foraging extensively within this region of Foveaux Strait means that even if there are some localised effects on prey resources, then they are likely to have a *nil to less than minor effect* on the relevant marine mammal species (Table 2).

Table 2. Summary of potential effects on relevant marine mammal species within the Area of Interest from the proposal.

Potential environmental effects	Spatial scale of effect on marine mammals	Persistence / duration of effect for marine mammals	Consequence(s) for marine mammals	Likelihood of effect	Avoidance Factors / Management Options (see Section 4 and Table 2)	Significance level of residual effect
Habitat / prey disturbance from farm structures and associated activities	**Medium to Large** Limited to immediate waters and habitats adjacent to the farm(s)	**Persistent** Farm structures will be permanent for the length of consent; most species only present in area for hours to days	**Individual to Regional Level** Local avoidance / abandonment by sensitive species / individuals; or age groups (e.g. mating groups)	**Low -** Avoidance	• Record (visual, acoustic or both) and report the type and frequency of marine mammal interactions (including absences and effort) to build a local / regional picture	**Less than Minor to Minor**
			Individual Level: Pinnipeds / dolphins may approach site	**Moderate -** Attraction		**Nil to Negligible**
Entanglement in farm structure and / or debris	**Medium to Large** Limited to immediate area and habitats within and adjacent to the farm(s)	**Persistent** Farm nets and ropes will be permanent for the length of its consent; most species only present in area for hours to days	**Regional to Population Level** Death or injury of endangered or threatened species	**Low**	• Avoid or minimise operational changes (i.e. predator nets), installation or decommission during critical migration periods • Avoid loose ropes, no predator nets, keep all lines under some degree of tension • Make lines easily detectable and investigate methods to stiffen • Avoid overlap or crossing of warp lines between pens	**Less than Minor**
			Individual Level Death or injury of non-threatened pinniped or dolphin	**Low**		**Negligible**
Increase in underwater sound from farm structures / vessels	**Small to Large** Dependent on types of noise produced and frequencies	**Short to Persistent** Farm permanent; noise sporadic and potentially more seasonal	**Individual to Regional Level** Individual avoidance by whales or certain age groups; local attraction of pinnipeds and some dolphins	**Low -** Avoidance **to Moderate -** Attraction	• Minimise above-water and underwater noise to reduce the exclusion (or attraction) of wildlife	**Nil to Negligible**
Attraction to artificial submerged lighting	**Small to Medium** Dependent on types of lights and location within the farm	**Short to Persistent** Farms permanent; seasonal lighting at night-time only	**Individual** Local attraction of pinnipeds and some dolphins	**Low to Moderate**	• Minimum amounts of lighting and proper positioning to reduce the attraction of wildlife	**Nil to Negligible**
Flow-on trophic effects to marine mammals	**Medium to Large** Limited to immediate waters and habitats adjacent to the farm	**Short to Persistent** Dependent on trophic effect; potential seasonality	**Individual Level** Local avoidance; individuals may approach for foraging opportunities	**Not Applicable to Low**	• Ensure proper site placement	**Nil to Less than Minor**

Definition of terms used in table:

- Spatial scale of effect: Small (tens of metres), Medium (hundreds of metres), Large (> 1 km)
- Persistence of effect: Short (days to weeks), Moderate (weeks to months), Persistent (years or more)
- Consequence: Individual, Regional, Population level
- Likelihood of effect: Not Applicable (NA), Low (< 25%), Moderate (25–75%), High (> 75%)
- Significance level: Nil (no effects at all), Negligible (effect too small to be discernible or of concern), Less than Minor (discernible effect but too small to affect other animals), Minor (noticeable but will not cause any significant adverse effects), More than Minor (noticeable that may cause adverse impact but could be mitigated), Significant (noticeable and will have serious adverse impact but could be potential for mitigation).

3.6. Cumulative impacts

The likelihood of most of the above effects occurring is dependent on the scale and intensity of the finfish farms within the proposed farming areas (five sites x 157 ha each); which in this case, represents a relatively small part of the overall types of habitats needed for the various functional requirements of the different marine mammal species, as discussed throughout this report. Other anthropogenic activities also affect the environment in which Southland marine mammals live including: bycatch in fisheries; bottom disturbance (e.g. fishing dredges and trawls); commercial shipping to and from South Port, tourism and ferry boating impacts, and the underwater noise associated with most of the above activities.

Few studies to date have researched the potential cumulative effect of multiple anthropogenic activities on marine mammals. As a result, attempts to regulate any of these issues, individually or cumulatively, are currently extremely difficult as little is known about their biological significance for any species of marine mammal. The review by Price et al. (2017) indicated that there is a need globally for a formal risk analysis of potential aquaculture interactions in comparison to other marine activities such as fishing, shipping, boating, military operations, etc. Additional work is also needed to assess whether overseas modelling frameworks being developed to address cumulative effects, such as the interim Population Consequences of Disturbance Model (IPCoD; Donovan et al. 2016), could be expanded to include other sources of disturbance and to be applicable for different marine mammal species.

4. MANAGEMENT OPTIONS AND MONITORING

4.1. Management of effects

Overall, the likelihood of any potential adverse impacts from aquaculture activities affecting local and visiting marine mammals is assessed as *low to moderate* (Table 2). This assessment is based on the types of effects, their spatial scales and durations, and consideration of the uncertainty around species' information available in the region. Based on this uncertainty, and given that some of the possible consequences of rare events (i.e. entanglement) could have severe regional and / or population level effects (i.e. injury or death of an endangered or threatened animal), staged development and a comprehensive monitoring and management response is warranted here, and several recommended actions are listed in Table 3.

If the farms are consented, a Marine Mammal Management Plan (MMMP) should be developed by an experienced marine mammal expert in consultation with DOC prior to commencing operations to ensure that the most appropriate protection measures are in place, as is required for Best Aquaculture Practices' (BAP) international certification requirements (e.g. Standard 7.2: Wildlife Interaction Plan). This plan should at least outline in some detail: (i) a dis-entanglement protocol in the unlikely event that there is an entanglement (e.g. BAP standards 7.2, 7.4, 7.6), (ii) any implemented open ocean management procedures that will need to be reviewed for effectiveness during operations (e.g. standardised sighting protocol, e.g. BAP standards 7.2, 7.7) and (iii) timelines for any subsequent reporting requirements (e.g. BAP standards 7.2, Table 3).

There are a range of best management practices (BMPs) regarding the set up and operation of marine farms that should be considered corresponding to a staged development plan. The chosen farm structure types (e.g. pen material, use of predator nets) and design (e.g. spacing between farms and pens, warp layout) play an important role in the possibility of impacts occurring. The purpose of these BMPs are to help reduce risks of entanglement and other adverse effects (Table 3). Note that BMPs are suggested even where effects are expected to be negligible. Many of these practices are already reflected in the Finfish Aquaculture Environmental Code of Practice (ECOP) developed by the New Zealand Salmon Farmers Association and their more recent Sustainable Management Framework (SMF) for New Zealand Salmon (AQNZ 2015). Several of these BMPs also align with the BAP certification standards for salmon farms and requirements as indicated in Table 3, if Sanford intends to comply with this international certification process (BAP 2016).

Table 3. Proposed best management goals and practices (BMP) to minimise the risk of any adverse effects of the farms on marine mammals. DOC = Department of Conservation, ES = Environmental Southland (Southland Regional Council), SMF = AQNZ Sustainable Management Framework (2015), BAP = Best Aquaculture Practices (2016).

Management goal	BMP	Reporting
1. Minimise the exclusion of marine wildlife from their critical habitat, or modification of such habitat	1a. Record marine mammal interactions (either visually, acoustically or both) to build a baseline occurrence in waters near farms.	• Record and report the type and frequency of marine wildlife interactions (including absences and effort), in a standardised format (SMF 3.6.4; BAP 7.2 and 7.3). • Records provided to DOC, ES and made publicly available (e.g. web).
	1b. Minimise above-water and underwater noise to reduce the exclusion (or attraction) of marine mammals.	• Keep records of the extent to which any reduction techniques were successful or unsuccessful (BAP 7.9); encourage research into effects.
2. Minimise the attraction of marine wildlife to farms	2a. Minimise wastage during feeding to reduce associated attraction of fish.	• Nothing required, encourage or support specific research into effects (SMF 3.3.1 and 3.5.2).
	2b. Collect and appropriately store and dispose of fish mortalities to reduce marine mammal attraction.	• Continue to record and report the type and frequency of fish mortalities and/or subsequent predation interactions in a standardised format.
	2c. Minimise artificial lighting to reduce attraction of prey fish.	• Nothing required, encourage or support specific research into effects.
3. Aim to minimise entanglement with a goal of zero mortality	3a. Avoid loose rope / nets. Keep all nets / lines weighted and under some degree of tension. Investigate methods to stiffen lines / nets with rigid or semi-rigid cores.	• Self-checking as part of MMMP with up-to-date records available to DOC and ES (SMF 3.2.3).
	3b. Investigate methods to make lines / nets more easily detectable in the water column; type, colour, texture, reflectivity.	• Self-checking as part of MMMP with up-to-date records available to DOC and ES.
	3c. Farm cages - implement regime for net inspection (semi-rigid or well-tensioned net material, no billowing), maintenance (e.g. repair holes), and replacement to minimise the potential for adverse effects.	• Self-checking as part of MMMP with up-to-date records available to DOC and ES (BAP 7.2 and 7.5).
	3d. Avoid predator exclusion nets if possible. If used, ensure appropriate design, enclosed at the bottom (base of net), and use net mesh sizes < 6 cm.	• Self-checking as part of MMMP with up-to-date records available to DOC and ES (SMF 3.2.3).
	3e. Minimise potential for loss of rubbish and debris from farms and recover lost material.	• Self-checking as part of MMMP with up-to-date records available to DOC and ES (SMF 3.4.1 and 3.4.2).
	3f. Record all entanglement incidents regardless of outcome (e.g. injury or mortality) and make publicly available soon after (BAP 7.7).	• Records available to DOC and ES. In case of a fatal incident, carcass(es) recovered, given to DOC, and steps taken in consultation with DOC to reduce the risk of future incidences (SMF 3.2.3 and 3.6.4).

4.2. Monitoring approaches

Further information on marine mammal use of the waters near the proposal area should be collected. Based on opportunistic data, this assessment has been able to make some broad generalisations about what species likely use Foveaux Strait waters and when. However, more information should be collected on how the foraging strategies of local species, such as bottlenose dolphins, or movements of southern right and humpback whales might be affected by these proposed farming areas. The collection of this additional information, followed by the proposed staged development of the farms, will enable management actions to be refined over time, and more clarity on the nature of any residual effects to be obtained (see Table 2).

If the proposal is consented, then prior to farm development we recommend passive acoustic underwater monitoring be undertaken for at least the whale migration periods (May to December), although a full year would be more useful. Passive acoustic recorders (i.e. moored underwater acoustic recorders) are an established technique internationally for the monitoring of vocalising marine mammals. The recorders automatically listen and record any underwater sound at frequencies likely to be from marine mammal vocalisations from tens of metres up to tens of kilometres away. We recommend the use of an acoustic array (3-4 recorders) in order to triangulate and track the actual location of vocalising animals to help assess what densities of whale and dolphin species travel to and through this region of the Strait. The advantage of using passive acoustic moorings is that they can 'listen' for the presence of any marine mammals both day and night and when sea conditions are not favourable for visual sightings. In addition, acoustic recorders can provide data on any underwater noise generated from the farms and associated operations (e.g. feeding, vessels) relative to other anthropogenic activities in the area.

As the farms are being developed, we also recommend benchmarking the levels of any interactions with marine mammals (injurious and non-injurious) through a visual sighting database collected by the farms' staff to provide a more realistic picture of species-specific risk with these farms. The Price et al. (2017) review emphasises that there is a …[global] *lack of scientific reporting on entanglement frequency, severity of resulting injuries and mortality rates associated with interactions, effective deterrent methods, and technological innovation to reduce interactions and decrease harm if contact occurs*. In order to quantify the current level of marine mammal interactions with finfish farms in southern New Zealand waters, companies with farms in Southland waters as well as industry as a whole should be taking the approach of farmers in British Columbia (FOC database 2018) and some Australia companies (NSW 2018; see Appendix 2). These companies monitor and electronically report all visual sightings and interactions with marine mammals (including when they do not see animals) near the farm or while travelling to and from the farm in a transparent (i.e. open to the public) web-based database. These records include fatal entanglements, injuries, and all other interactions (e.g. rubbing ropes, bumping against structures).

Such databases can be used by industry and government to evaluate the significance of any changes in trends (e.g. occurrence, interactions) and provide the first evidence of how various New Zealand marine mammals species interact with offshore aquaculture, rather than relying on anecdotal and / or expert opinions. These monitoring approaches also align with several of the BAP standards and requirements, if Sanford intends to comply with these international certification standards (BAP 2016).

5. CONCLUSIONS

This report describes the local and visiting marine mammals that use and / or are influenced by Foveaux Strait and its associated ecosystem. In particular, information on the various species was reviewed for any life-history dynamics that could make them more vulnerable to salmon farming activities or where proposal farming areas may overlap with any ecologically significant feeding, resting or breeding habitats. The marine mammals most likely to be affected by the proposed project include those species that frequent Foveaux Strait waters throughout the year or on a semi-regular basis. These species are NZ fur seals, NZ sea lions, bottlenose dolphins, southern right and humpback whales, and orca. Other species including Hector's dolphin, dusky and common dolphins, several species of baleen whale, pilot whales, beaked whales, and sperm whales were also considered in this assessment because of their records of occurrence in the general area, their known species-specific sensitivities (e.g. underwater noise); and / or potential public and iwi concerns.

The open waters of Foveaux Strait are not currently considered significant habitats for any marine mammal species, with the possible exception of southern right whale as part of their potential winter mating habitats and part of humpback whales' northern migration corridor. Instead, these waters represent similar habitats available to these marine mammals utilising the wider Southland region. It is important to note that several of the above listed species are nationally and / or internationally recognised as threatened species that live in semi-isolated sub-populations or recovering colonies, and thus need to be considered in regard to Policy 11(a) of the NZCPS.

Based on the direct and indirect potential effects highlighted in this report, the overall effects of the salmon farms on marine mammal species within Foveaux Strait waters ranged from negligible to minor when considered with the recommended management actions. There remains some uncertainty in respect to the level of effect for some impacts given the lack of systematic data on marine mammals in the proposal area. There are also still considerable knowledge gaps around how marine mammals will perceive more open ocean farm structures visually and acoustically, and importantly, the results of their reactions to such farm blocks. The recommended management and monitoring actions, along with the proposed staged development approach, would enable some of these gaps to be reduced prior to and during the farms' development.

The development of a Marine Mammal Management Plan (MMMP) is also recommended to ensure that the most appropriate protective measures for local and visiting marine mammals are in place. Such a programme will serve the dual purpose of collating the information necessary to assess the actual level of interaction risk between salmon farms in this area and the relevant New Zealand marine mammals while assessing the effectiveness of any management measures put in place. Through the staged development of the farms these measures can then be amended, if necessary, over time.

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7. APPENDICES

Appendix 1. Sources of marine mammal data and information

Only broad-scale, regional information is available for most marine mammals using the general Southland region and area of interest (AOI). Some finer-scale studies have been undertaken out of Te Waewae Bay, Porpoise Bay and various areas around Stewart Island. The studies and databases used to make summaries and assessments of the various marine mammal species discussed in this report are listed below:

- Department of Conservation opportunistic database and stranding record database (formerly maintained by Te Papa National Museum)
- National Aquatic Biodiversity Information System (NABIS)
- Scientific research through Department of Conservations:
    - L Chilvers – several projects with NZ sea lions on Stewart Island and offshore, sub-Antarctic islands
    - L Boren - several projects with NZ fur seals around the South Island and sea lions around Stewart Island
    - J Roberts (NIWA) – NZ sea lions' use of Port Pegasus waters on Stewart Island
- Scientific research through Cawthron Institute / Proteus Wildlife Consulting / Marine Wildlife Research:
    - Hector's dolphin aerial surveys for abundance and distribution through the south coast of the South Island – 2019, 2012
- Scientific research through University of Otago:
    - A Auge - PhD on NZ sea lions off Otago
    - T Brough – various bottlenose dolphin studies within Fiordland, Stewart Island and off Otago
    - C Lalas (and associated students) - NZ sea lions and NZ fur seals at Stewart Island, Otago and offshore, sub-Antarctic islands
- Scientific research through University of Auckland:
    - EL Carroll – several projects on southern right whales around New Zealand mainland and offshore, sub-Antarctic islands
- Scientific research through Texas A&M University (USA):
    - B Würsig (and associated students)– several dusky dolphin projects with Admiralty Bay, off of Kaikoura and the rest of the South Island
- Orca Research Trust - various Visser publications and sighting database
- Berkenbusch K, Abraham ER, Torres L 2013. New Zealand marine mammals and commercial fisheries. New Zealand Aquatic Environment and Biodiversity Report No. 119. 110 p.

Appendix 2. An example of marine mammal sightings collected from an Australian experimental finfish farm off New South Wales (NSW 2018; https://www.huonaqua.com.au/wildlife-interactions/).

Report period		Observations while travelling (to and from Lease)				
Start	**Finish**	**Humpback**	**Calf**	**Dolphin**	**Seal**	**Observations**
4/12/2017	17/12/2017			pod		
18/12/2017	31/12/2017					
01/01/2018	14/01/2018					
15/01/2018	28/01/2018					
29/01/2018	11/02/2018			pod		
12/02/2018	25/02/2018			pod		
26/02/2018	11/03/2018			pod		
12/03/2018	18/03/2018			26		
19/03/2018	25/03/2018				1	Seal on empty pen
26/03/2018	08/04/2018			Pods of 50		
09/04/2018	22/04/2018			29		
23/04/2018	06/05/2018			235		
07/05/2018	20/05/2018	1				East of lease
21/05/2018	03/06/2018	4	1	20		Whales breached east of lease
04/06/2018	17/06/2018	9	1	150		East of lease
18/06/2018	01/07/2018	22		40		East of lease travelling north
02/07/2018	15/07/2018	15		70		On way to lease
16/07/2018	30/07/2018	3				On way to lease
31/07/2018	12/08/2018			2		In Providence Bay

Report period		Observations around Marine Aquaculture Research Lease (in and around Lease area)							
Start	**Finish**	**Humpback**	**Calf**	**Dolphin**	**Seal**	**Observations**	**Nature of interactions**	**Entanglements**	**Comments/Tasks carried out**
4/12/2017	17/12/2017							Nil	Feeding and Pen Maintenance
18/12/2017	31/12/2017							Nil	Feeding and Pen Maintenance
01/01/2018	14/01/2018			1	3	5 x Grey Nurse Sharks	Seal on walkway. Sharks between nets	Nil	Feeding and Pen Maintenance
15/01/2018	28/01/2018			2	2	2 x Whaler Sharks	Seals feeding on fish. Sharks inside net	Nil	Pen repairs/feeding after storm event
29/01/2018	11/02/2018					1 x Great White Shark	Shark around Pen 1603	Nil	Feeding and Pen Maintenance
12/02/2018	25/02/2018		10		2		Seal on walkway Pen 1603	Nil	Feeding and Pen Maintenance
26/02/2018	11/03/2018					2 x Whaler Sharks	Removed from Pen 1601	Nil	Feeding and Pen Maintenance
12/03/2018	18/03/2018			15		1 x Bull Shark	Diver observation on outside of pen	Nil	Feeding and Pen Maintenance
19/03/2018	25/03/2018							Nil	Feeding, Bathing and Pen Maintenance
26/03/2018	08/04/2018			60	4		1 seal around pen	Nil	Feeding and Pen Maintenance
09/04/2018	22/04/2018				1		1 seal around pen	Nil	Feeding and Pen Maintenance
23/04/2018	06/05/2018				8	1 (observed on lease)	1 seal around pen	Nil	Feeding, Pen Maintenance and bathing
07/05/2018	20/05/2018							Nil	Feeding, pen maintenance and moorings
21/05/2018	03/06/2018	1			5		1 seal around pen	Nil	Feeding, bathing and pen maintenance
04/06/2018	17/06/2018	9	2	20	13	Whales 100m off pens	1 seal around pen	Nil	Feeding, bathing and pen maintenance
18/06/2018	01/07/2018				4		1 seal around pen	Nil	Harvest
02/07/2018	15/07/2018	1			1	Whale near NW special mark	1 seal around pen	Nil	Pen maintenance
16/07/2018	30/07/2018							Nil	Site maintenance
31/07/2018	12/08/2018							Nil	Site maintenance