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Replacement of Akaroa Wharf: assessment of effects on marine mammals

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Replacement of Akaroa Wharf: assessment of effects on marine mammals

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Prepared for Christchurch City Council

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Executive summary

Christchurch City Council (CCC) proposes demolishing the existing Akaroa Wharf in French Bay, Akaroa Harbour, and rebuilding it to a new design on effectively the same footprint. The wharf deck will be raised by 500–600 mm to allow for sea-level rise and storm surges, and the configuration of attached floating pontoons changed to increase usability and reduce the current occasional congestion issues. It is expected that piles for the existing structure will be cut off at the seabed and new concrete and steel piles will be driven using a combination of impact and / or vibratory methods. The council has engaged Cawthron Institute (Cawthron) to assess the effects of the proposed demolition and reconstruction on local marine mammals.

The species of marine mammals identified as being potentially susceptible to any effects from the proposal are the resident endangered Hector's dolphin / upokohue and New Zealand fur seal / kekeno. Several other species also visit these waters each year, including southern right whales / tohorā, humpback whales / paikea and orca / maki, along with occasional visitors such as bottlenose dolphins / terehu, common dolphins / aihe and leopard seals / popoiangore.

Although all of the proposed demolition and construction activities were considered, pile driving was identified as the primary activity that could directly adversely affect marine mammals in the vicinity through high underwater noise levels. Preliminary underwater acoustic modelling work undertaken within the area of the wharf site suggests that unmitigated pile-driving noise is expected to be detectable throughout mid-harbour waters and all of French Bay. Given the potential for temporary hearing impairment of resident Hector's dolphins / upokohue, management actions are required to avoid these effects.

Several potential mitigation measures are discussed, and a combination of measures will be needed in order to achieve the recommended marine mammal observation zone. With appropriate actions in place, piling activities are expected to elicit only short-term, non-injurious behavioural responses or potential momentary masking (i.e. reduction in an animal's listening space) of any marine mammal within close proximity to construction activities.

Indirect effects of demolition and construction activities on marine mammals may result from physical changes to the habitat that adversely affect the health of the local ecosystem and / or impinge on important prey resources. However, given the location, the scale of habitats associated with the wider Akaroa basin within which the proposal is located and the duration of the proposed work, any indirect effects of project activities are not expected to be adverse or detrimental for local or visiting marine mammals in the region.

To ensure that the most appropriate measures are in place to minimise any potential adverse effects, the development of a marine mammal management plan (MMMP) by marine mammal and underwater acoustic experts, in consultation with the Department of Conservation (DOC), is recommended to accompany any application for resource consent and prior to commencing operations. This plan needs to consider the recommended best management practices, which include source noise reduction measures (e.g. bubble curtains), shut-down zones and seasonal consideration of piling stages. At the same time, the continuation of ongoing acoustic monitoring is recommended to verify *in situ* piling sound levels and to ensure the effectiveness of the management measures employed.

1. Introduction

1.1 Background

Christchurch City Council (CCC) is seeking resource consent to rebuild Akaroa Wharf in Akaroa Harbour in its existing location. Located within French Bay and in the central section of Akaroa Harbour, this main wharf is located 175 m to the south of the smaller Drummonds Wharf (Figure 1). The current Akaroa Wharf has reached the end of its design life, and it is no longer economically viable to maintain the existing structure. The new wharf structure needs to accommodate the modern needs of both commercial and recreational wharf users and will incorporate floating pontoons on both the northern and southern faces to meet demand for berth space.

The rebuild of the Akaroa Wharf will involve the demolition of the existing timber wharf, existing floating pontoons and associated structures. The existing buildings adjacent to the wharf will be left in their current state. The Akaroa Wharf will be rebuilt in the existing wharf's location with an option to shift the wharf north by 1.5–2.5m, if necessary. The new wharf will be approximately 185 m long and 8 m wide.

1.2 Scope of assessment

The Cawthron Institute (Cawthron) has been engaged to undertake a desktop assessment of the effects of the demolition and rebuild of the new Akaroa Wharf on marine mammals within Akaroa Harbour and the wider Banks Peninsula / Horomaka (hereafter Banks Peninsula) area. Specifically, this assessment of environmental effects incorporates the following components:

- Desktop characterisation of the existing immediate and wider environments in relation to:
  - Resident and transient marine mammal populations
  - Abundance and seasonal distribution information
  - Presence of important habitats (including nursing and feeding areas)
  - Known life history dynamics that make any species more vulnerable to stressors associated with the proposed works and subsequent operations.
- Evaluation of the range of potential effects on local marine mammal species from project activities (demolition, construction and operational phases) as well as cumulative effects.
- 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 (underwater noise).
- Recommendations for possible mitigation and monitoring options, where applicable.

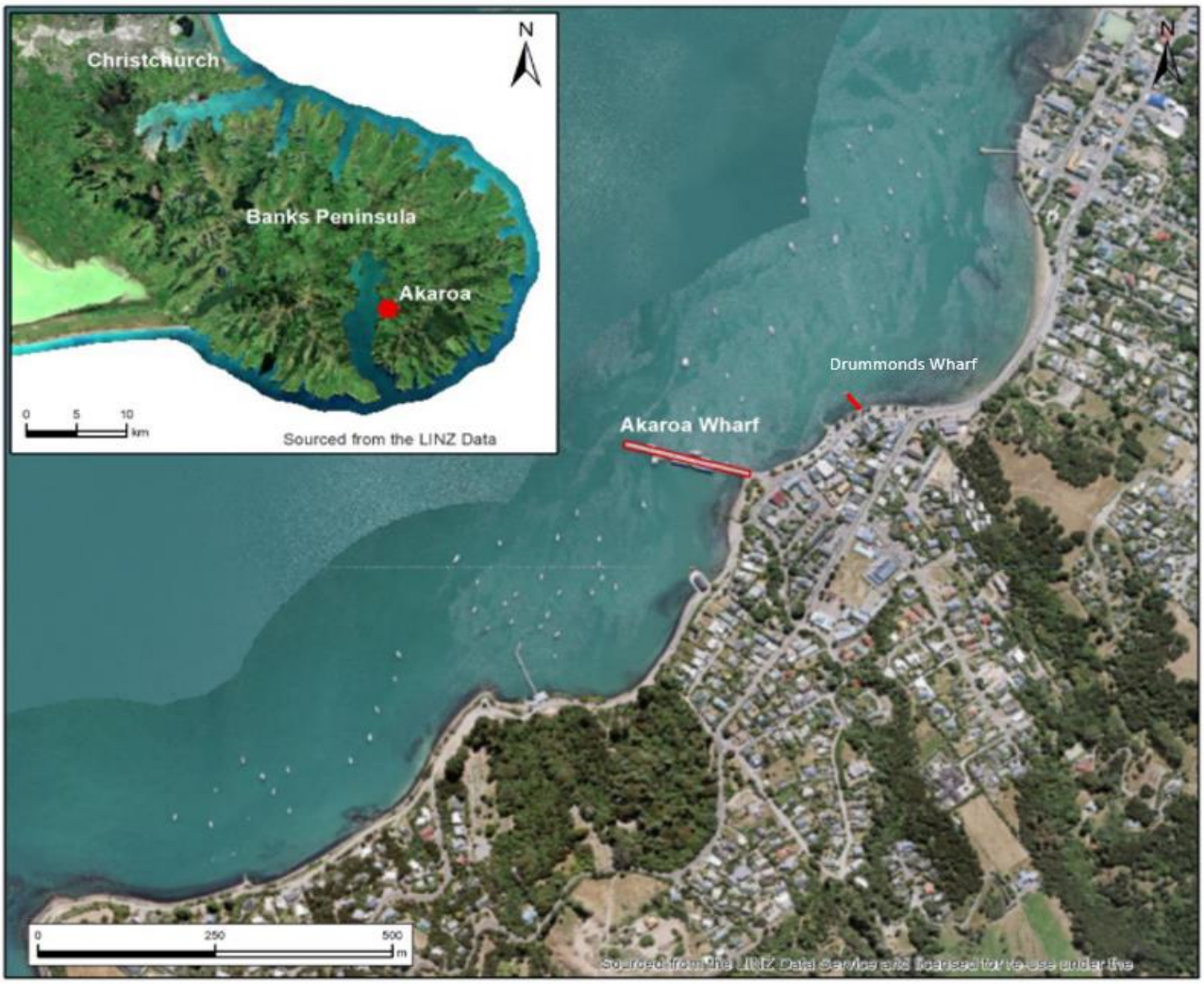


Figure 1. Location plan of Akaroa Wharf and Drummonds Wharf. Source: Christchurch City Council.

2. Project overview

The new Akaroa Wharf will follow a similar form to the existing wharf but with the following changes:

- The wharf height will be raised to 3.06 m LVD-37 or 12.10 m CDD, which is 500–600 mm higher than the existing deck to allow for sea-level rise and storm surges.
- The proposed wharf will be approximately in its original location or, potentially, offset from its existing alignment by 1.5–2.5 m to the north.
- New floating pontoons will be arranged on the northern and southern faces of the main wharf. The pontoons will be accessed from the main wharf by gangways and small piled platforms.
- The southern floating pontoon will include infrastructure for diesel refuelling.
- A new crane will be installed on the western end of the wharf to assist commercial vessels with loading / unloading.
- The original 1887 abutment and associated reclamation will be partially removed to accommodate the increase in deck height and lateral shift of the wharf. A small area of reclamation, enclosed by a concrete 'L-wall' seawall, is proposed on the northern side of the point where the new wharf will meet the shoreline.
- Wharf materials will include reinforced concrete decking, steel-encased concrete piles, timber fender piles and timber deck elements, along with various wharf fittings (bollards, lighting, etc.).
- A small loading ramp will be constructed on the southern side of the Akaroa boat ramp. This will require temporary reclamation, disturbance of the seabed, placement of geotextile, granular fill and riprap protection, and 2–4 steel piles (610 mm diameter) will be driven along the southern side of the existing boat ramp to form a training wall to facilitate barge loading / unloading.
- The seaward approach to the Akaroa boat ramp will require dredging to facilitate barge access. The dredge channel will extend approximately 90 m from the shoreline and be approximately 30 m wide. In total, approximately 1,500 m^3 of seabed will be dredged, with the spoil removed / placed to the southwest of the dredge area. Dredging will be undertaken via mechanical excavator, either based on a barge, or from shore at low tide, or a combination of both.

Features of the proposal most relevant to this assessment include:

- Deconstruction and demolition of the main wharf are anticipated to take 2–3 months, including removing existing piles and structural detritus along the harbour floor. Piles will be removed or cut at seabed level using hydraulic shears
- Piling and deck construction activities of the main wharf are anticipated to occur in conjunction with the demolition of the wharf and take an additional 5–6 months.
    - The main wharf piles are anticipated to be installed by both barge from the water and piling rig (crawler crane) off the wharf. The piling gate (two piles) will be placed on the existing wharf deck and secured in place. The piling rig will pitch and place the steel piles (all piles are expected to be pitched and driven in a single length).

- The barge piling crew will undertake a similar operation with a piling rig operating from the marine-based barge. The marine-based rig will work from the outer end, install piles and then demolish the existing wharf until it meets up with the crawler crane rig.
- The piling rigs will not undertake piling concurrently, but the work fronts will advance together.
- A total of 44–55 steel-cased concrete piles approximately 710 mm in diameter will be installed into the underlying basalt for the wharf structure. Piles with a steel driving tip welded to their end will be driven using a combination of percussive, vibratory and, possibly, bored methods. If the required embedment cannot be achieved with percussive piling, the pile may need to be removed and a drill used to pre-drill a socket into the basalt before the pile is redriven.
- Eighteen temporary timber construction piles will be installed between the wharf and the Black Cat and Blue Pearl buildings to provide support during construction.
- Fender piles will be installed (number to be finalised; these will be driven into the seabed but not socketed into the basalt).

- Floating pontoons (north and south) will be installed, including the piled platforms, gangways and associated services (water, power and fuel on the southern pontoon only). It is expected that approximately 12–16 steel piles (710 mm diameter) will be required.
- Along the southern side of the existing Akaroa boat ramp, 2–4 steel piles (610 mm diameter) will be installed to form a training wall to facilitate the barge loading / unloading.
  - The dredged channel will extend approximately 90 m from the shoreline and will be approximately 30 m wide. In total, approximately 1,500 m^3 of seabed will be dredged, with the spoil removed / placed to the southwest of the dredge area.
  - Dredging will be undertaken via mechanical excavator, either based on a barge, or from shore at low tide, or a combination of both.

3. Description of existing environment

3.1 General approach

All relevant available literature on marine mammal species off Banks Peninsula, with a particular focus on Akaroa Harbour, was collated and reviewed (see Appendix 1). The aim of this literature review was to compile a marine mammal species occurrence list, a summary of threat status and relevant demographic information. Sources included published and unpublished articles, reports and reviews. In addition, public sighting data from the Department of Conservation (DOC) marine mammal database were also reviewed. As this database is limited to records received by DOC from a number of different sources, it is not considered comprehensive and should be interpreted as a minimal list of species that occur in a given area.

CCC also commissioned a short-term *in situ* survey to collect information on underwater noise levels and supplement marine mammal information for the mid-Akaroa Harbour region from mid-June 2023 to the end of August 2023. More information on the acoustic programme, methods and findings are included in Pine (2023).

We note that throughout this report, the Māori names for marine mammal species are used according to the DOC in-house style guide. For those species for which there is regional variation in Māori names, this report uses the English common name.

Data limitations

It is important to note that a large number of the sighting records for species other than Hector's dolphin / upokohue are collected opportunistically from public sources (e.g. DOC sighting and stranding databases) rather than systematically from research studies. Consequently, the number of sightings does not necessarily represent unique animals (i.e. the same animal may be reported by multiple members of the public or on separate days / in separate years) or their regular distribution patterns.

Sighting (or the lack of sighting) records of pinnipeds were not considered a useful indicator for their occurrence patterns. Pinniped data tend to be either biased high, due to the animals' haul-out behaviour (e.g. leopard seals / popoiangore are aggressive and territorial), or biased low, as their regular or expected occurrence goes unreported (e.g. New Zealand fur seals / kekeno). Instead, the locations of known pinniped haul-out sites and breeding colonies are considered more informative.

Cetacean stranding records are similar in that they are a broad indicator of occurrence and supplemental to sighting records, rather than evidence on their own. Records include animals that have stranded alive and then later died, or animals that have died at sea and washed ashore. The latter makes it more difficult to determine their normal distribution range, as once dead, their final destination is dependent on current flows and tides.

3.2 Species summary

According to the DOC marine mammal database (Table 1, Figure 2) and previous marine mammal reviews of this area (i.e. Clement 2016, 2018; Sneddon et al. 2017; see also Appendix 1), the types of marine mammals sighted around Banks Peninsula include:

- Dolphins: Hector's dolphin / upokohue, bottlenose dolphin / terehu, common dolphin / aihe, dusky dolphin
- Toothed whales: orca / maki, pilot whale, pygmy sperm whale, beaked whale
- Baleen whales: southern right whale / tohorā, humpback whale / paikea, blue whale, fin whale
- Pinniped: New Zealand fur seal / kekeno, leopard seal / popoiangore.

Table 1. Species most frequently reported in the Banks Peninsula region between 1948 and 2023. Data source: Department of Conservation marine mammal database. Note that data on the New Zealand fur seal / kekeno are not included in this database.

Species	Number of sightings	Percentage frequency (based on all regional sightings)
Hector's dolphin / upokohue	949	89.53
Southern right whale / tohorā	33	3.11
Humpback whale / paikea	25	2.36
Orca / maki	15	1.42
Leopard seal / popoiangore	13	1.23
Unknown cetacean	6	0.57
Pilot whale	5	0.47
Blue whale	3	0.28
Fin whale	3	0.28
Bottlenose dolphin / terehu	2	0.19
Pygmy sperm whale	2	0.19
Arnoux's beaked whale	1	0.09
Common dolphin / aihe	1	0.09
Dusky dolphin	1	0.09
New Zealand sea lion / whakahao	1	0.09

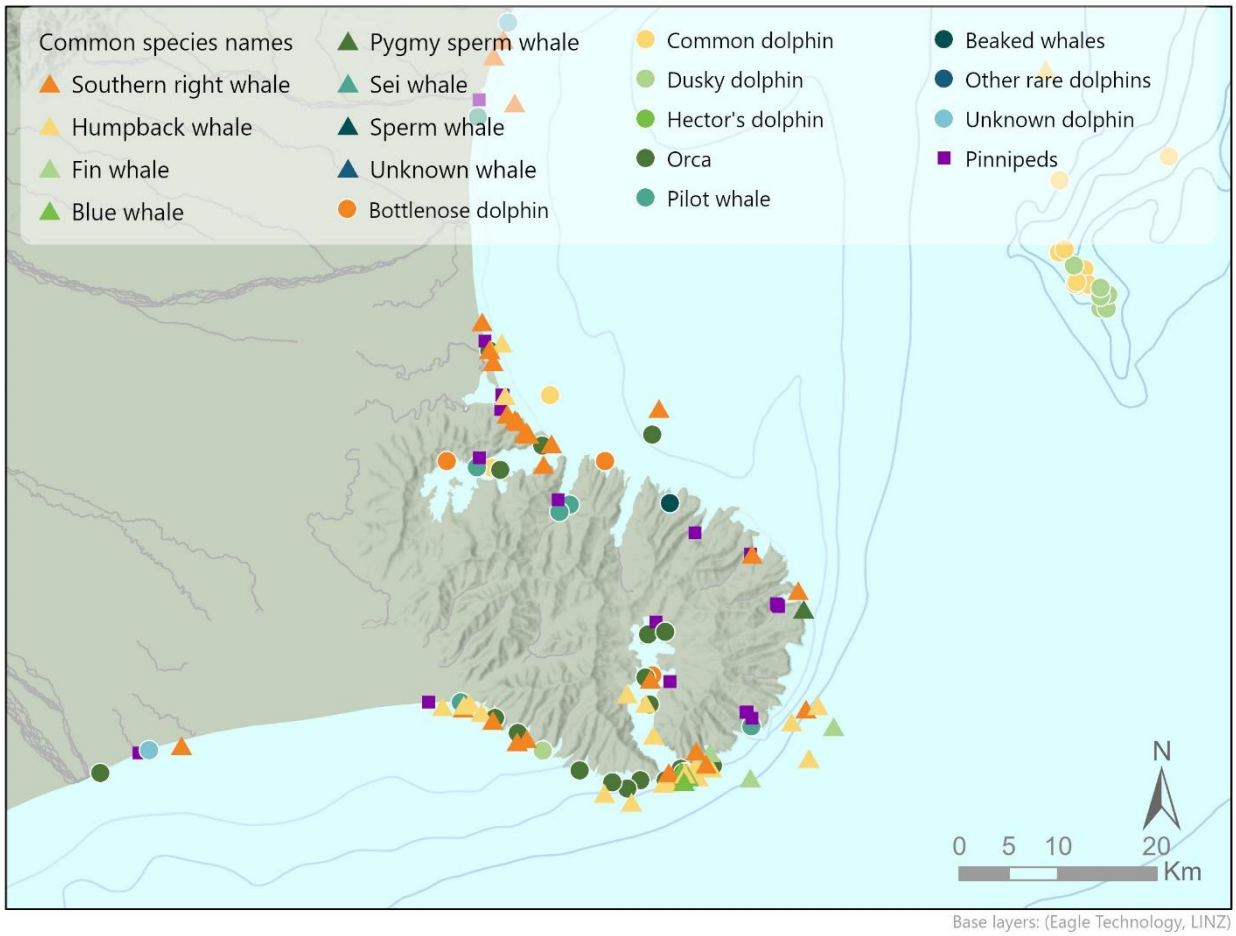


Figure 2. Distribution map of marine mammal sightings (except Hector's dolphin / upokohue) around Banks Peninsula as recorded in the Department of Conservation marine mammal database 1948–2023. Mysticetes (baleen whales) are represented by triangles, odontocetes (dolphins, toothed whales) by circles and pinnipeds (seals) by squares. Given the large number of Hector's dolphin / upokohue sightings around Banks Peninsula, these data have not been included on the map. Base map source: Land Information New Zealand.

Table 2 further summarises the current information for these main species, drawing on both published and unpublished literature. With this information, those species with multiple sightings and stranding reports were divided into three general categories describing their known distribution patterns across the wider coastal region, as follows:

1. Residents: species that occur year-round or for a regular time period, usually associated with breeding and feeding activities in the area (e.g. Hector's dolphin / upokohue).
2. Migrants: species that occur seasonally in the area as part of their migration paths, remaining in the area temporarily (e.g. southern right whale / tohorā).
3. Visitors: species that may occur in the area intermittently, including seasonal, frequent, infrequent and rare visitors (e.g. orca / maki).

Overall, the marine mammals most likely to be affected by the proposed wharf redevelopment are those species that frequent Akaroa Harbour and inshore waters of Banks Peninsula year-round or on a semi-regular and / or seasonal basis (Table 1, Table 2). These include Hector's dolphin / upokohue, the New Zealand fur seal / kekeno and, to a lesser degree, the southern right whale / tohorā and humpback whale / paikea. The potential risks of the proposed construction activities to these more relevant marine mammals were assessed based on species' life history dynamics (e.g. species-specific sensitivities, conservation status, lifespan, main prey sources, etc.), as surmised from Aotearoa New Zealand and international data sources and discussed further in Section 4.

Of the four species, Hector's dolphin / upokohue is the only one to regularly frequent the harbour waters and the vicinity of the proposed work. They are listed as Nationally Vulnerable in the New Zealand Threat Classification System (NZTCS) and Endangered in the International Union for Conservation (IUCN) Red List of Threatened Species due to their genetically distinct regional sub-populations around the South Island, as well as their small home ranges and low total abundance (Baker et al. 2019). Hector's dolphins / upokohue are therefore considered to be the critical species in terms of potential effects from the proposal.

A summary of Hector's dolphins / upokohue in relation to the Banks Peninsula is given below, while occurrences in the area of the other species are discussed in more detail in both Lyttelton Port's Channel Deepening Project assessment report (Clement 2016) and Te Awaparahi Bay Reclamation Project report (Sneddon et al. 2017).

Table 2. The residency patterns of the most common and / or frequently reported marine mammal species at Banks Peninsula Species conservation threat status is listed following the New Zealand Threat Classification System (NZTCS; Baker et al. 2019) and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (version 3.1).

Common name	Scientific name	NZTCS classification	IUCN Red List category	Residency category in Banks Peninsula	Patterns of occurrence
RESIDENTS					
Hector's dolphin / upokohue	*Cephalorhynchus hectori hectori*	Nationally Vulnerable	Endangered	Year-round resident	Resident of Banks Peninsula, with high site fidelity. Animals occur in most of the bays around the peninsula, including Akaroa Harbour. Tendency for density to decrease from outer to inner harbour and change seasonally, but animals can be found year-round in the vicinity of Akaroa Wharf.
New Zealand fur seal / kekeno	*Arctocephalus forsteri*	Not Threatened	Least Concern	Year-round resident	Several documented breeding colonies and haul-outs around Banks Peninsula. Animals seen within Akaroa Harbour year-round.
MIGRANTS					
Humpback whale / paikea	*Megaptera novaeangliae*	Migrant	Endangered (Oceania population only)	Seasonal migrant	South–north migration path along east coast of the South Island and off Banks Peninsula May–August, with a peak in June. Migrating animals travel in relatively close proximity to the peninsula, occasionally entering the harbour.
Southern right whale / tohorā	*Eubalaena australis*	At Risk: Recovering	Least Concern	Seasonal migrant	Occasional visitor to inshore waters around Banks Peninsula in winter and spring. Animals mostly found at the Akaroa Harbour entrance and within bays around the peninsula.
Antarctic and pygmy blue whales	*Balaenoptera musculus*	Data Deficient	Endangered	Frequent migrant	Numerous acoustic detections along the east coast of the South Island, but it is unclear how much time animals spend near Banks Peninsula. Occurs year-round in other areas of Aotearoa New Zealand (e.g. South Taranaki Bight).
VISITORS					
Leopard seal / popoiangore	*Hydrurga leptonyx*	At Risk: Naturally Uncommon	Least Concern	Frequent visitor	Increasing frequency of sightings on mainland Aotearoa New Zealand, with occurrences lasting for a few days or weeks. Animals likely coming from the Antarctic population, with no evidence of a breeding population in Aotearoa New Zealand.
Orca / maki	*Orcinus orca*	Nationally Critical	Least Concern	Frequent visitor	Animals are regularly seen in Akaroa Harbour seasonally, with sightings as far as the inner bays over the warmer months of summer and autumn.

Hector's dolphin / upokohue

Banks Peninsula is the location of Aotearoa New Zealand's first marine mammal sanctuary, the Banks Peninsula Marine Mammal Sanctuary (BPMMS). The BPMMS, including Akaroa Harbour, was created in 1988 after being identified as a hotspot for the endemic and endangered Hector's dolphin / upokohue on the east coast of the South Island. The original purpose of the BPMMS was to protect this species from bycatch in set-nets (Marine Mammals Protection [Banks Peninsula Sanctuary] Notice 1988[1]). Covering an area of approximately 14,310 km^2, the sanctuary was extended to 20 nautical miles offshore and from the Waitaki River (near Oamaru) in the south to the Jed River near Kaikōura in the north following the species' threat review in 2020. Restrictions within the sanctuary include bans on seismic surveying and seabed mining,[2] while fishery restrictions are now managed by Fisheries New Zealand.

In addition, most of the continental shelf along the east coast of the South Island (out to the 200 m depth contour) has been designated as an Important Marine Mammal Area (IMMA) by the IUCN's Marine Mammal Protected Areas Task Force (IUCN-MMPATF 2024). IMMAs are not marine protected areas with any legal or regulatory status. Instead, an international community of scientists have assessed areas for marine mammal species worldwide that have the potential to be delineated and managed to promote the conservation of marine mammals and their habitats. The Coast and Shelf Waters of Eastern Te Waipounamu IMMA is one of nine IMMAs in Aotearoa New Zealand waters.

Hector's dolphins / upokohue are found around Banks Peninsula waters year-round, with individuals having relatively small home ranges (less than 50 km) and showing high site fidelity (Clement 2005; Rayment et al. 2009; Brough et al. 2019). The species' movement patterns within Akaroa Harbour itself suggest a decrease in relative density from the outer to the inner harbour, and from warmer to colder months (Dawson et al. 2013; Brough et al. 2019; Carome et al. 2022). In the middle harbour region, where the existing Akaroa Wharf is located, the species is present throughout the year, with slightly fewer occurrences over winter relative to summer (Dawson et al. 2013).

1 Available at https://www.legislation.govt.nz/regulation/public/1988/0333/13.0/whole.html

2 Latest amendments available at https://www.legislation.govt.nz/regulation/public/2020/0271/latest/whole.html#LMS410877

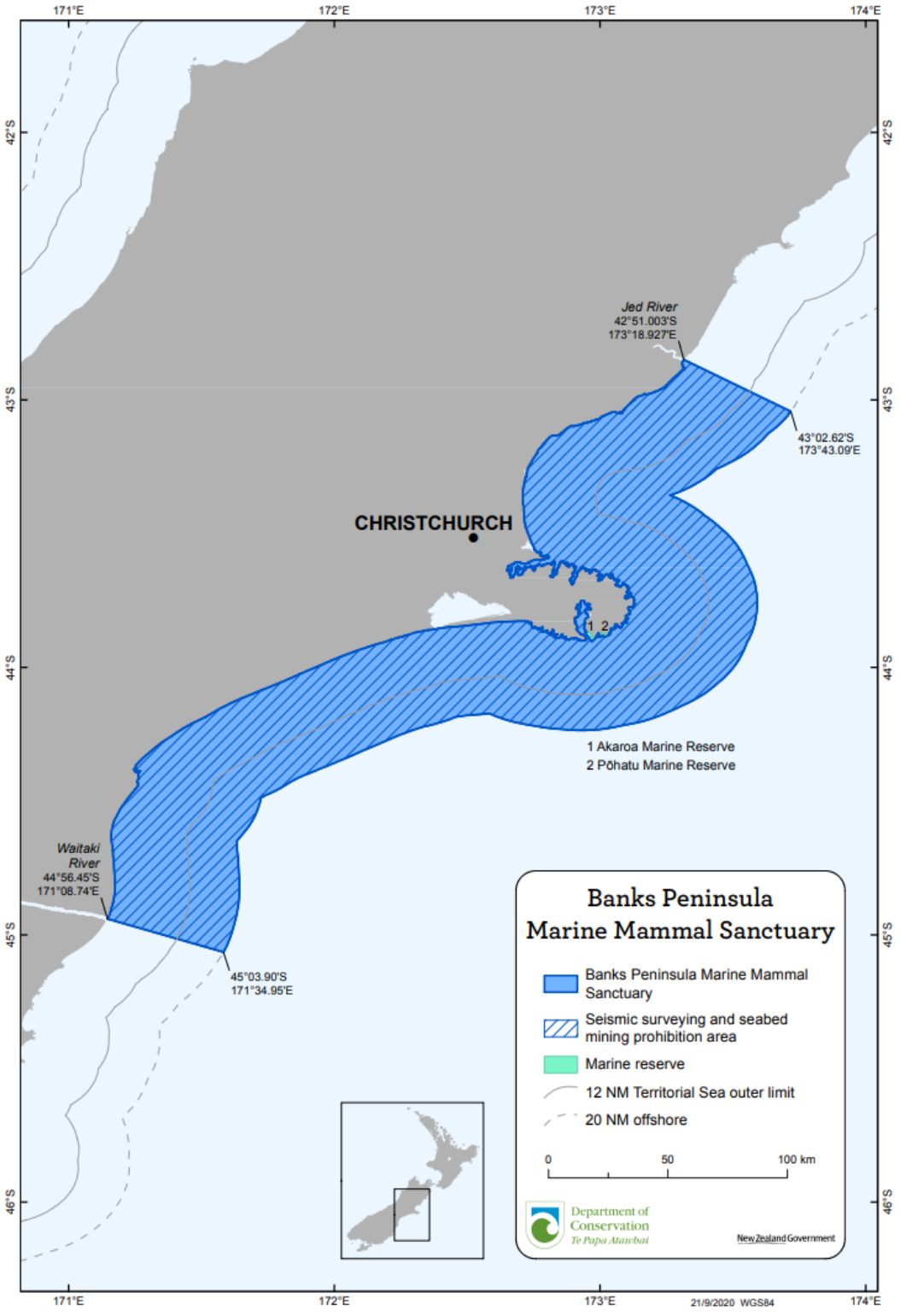


Figure 3. Banks Peninsula Marine Mammal Sanctuary boundaries. Source: Department of Conservation (2020).[3]

[3] Available at https://www.doc.govt.nz/globalassets/documents/conservation/marine-and-coastal/marine-protected-areas/mms-banks-peninsula-map.pdf

4. Assessment of effects

As described in Section 2, the proposed project will involve activities that will generally disturb the marine environment and increase the amount of noise (both airborne and underwater) produced within French Bay and regions within the middle harbour. Recent studies into the effects of underwater noise associated with demolition and construction activities have demonstrated that the overlap between the distribution of marine mammals and underwater noise propagation is spatially larger and the effects wider ranging than previously thought. Anthropogenic underwater noise is now recognised as a concern by several industries and regulatory agencies around the world (e.g. OSPAR Commission 2009; DPTI 2012; ACCOBAMS 2013; WODA 2013; NMFS 2018).

In this assessment, the following nomenclature is used to categorise potential effects or responses of marine mammals to underwater noise:

1. Permanent threshold shift (PTS): alteration of hearing function caused by physical damage and leading to irreversible hearing loss. The damage can be due to acute or chronic impacts.
2. Temporary threshold shift (TTS): non-permanent alteration of hearing function causing temporary hearing loss, in which the longer the exposure time, the longer this temporary effect lasts.
3. Behavioural responses: either displacement or attraction to the noise source, including changes in swimming direction, surfacing or diving patterns, click rates, etc.

The following sections describe the potential effects the proposed wharf redevelopment may actually or potentially have on marine mammals. These effects are based on available studies (predominantly overseas) of construction activities and marine mammals, while relying on a wider range of research on marine mammals near coastal development, along with information from other assessment reports. For the current project, the main activities that have potential to impact marine mammals are the demolition of the current wharf structure and the installation of new piles in the construction phase. Other identified issues include adverse effects on habitat / prey and the operational loss of gear, potentially leading to entanglement.

4.1 Pile-driving activities

Background

Among underwater noise sources, pile driving has been identified as one of the 'noisiest' of all construction sounds (e.g. Madsen et al. 2006) because it generates a very high source level as broadband impulses (i.e. sound pulses across a range of frequencies) and has a high potential to disrupt marine mammal hearing and behaviour up to many kilometres away. As a result, pile-driving activities can adversely affect marine mammals, as they rely heavily on underwater sounds for communication, orientation, predator avoidance and foraging (Nowacek et al. 2007).

In close proximity, these impulses could induce acute stress and cause hearing impairment (i.e. PTS or TTS, e.g. Tougaard et al. 2003, 2005; Madsen et al. 2006; Brandt et al. 2016; Dähne et al. 2017). In humans, the onset of a TTS is often described as the muffled effect your hearing might have after a loud concert; the longer the exposure time, the longer this temporary effect lasts. A PTS results in physical damage to hearing function and irreversible hearing loss. PTS can occur suddenly through trauma (i.e. intense impulses) or develop gradually over time from a less intense but persistent noise source.

Overseas behavioural disturbance studies from underwater noise show that marine mammal responses tend to be highly variable between species and among individual animals, as well as being context specific (e.g. they display different reactions when feeding or communicating), making them less predictable. The duration of exposure may also be an important factor (Southall et al. 2007, 2019, 2021). Behavioural responses can vary from low-level changes in swimming direction / speed, breathing or vocalisation rates, to more moderate-level responses (e.g. extensive changes in swimming or cessation of vocalisations), to complete abandonment or avoidance of impacted waters (Southall et al. 2007, 2019, 2021). Acoustic disturbance can also involve the 'masking' of certain communication or echolocation signals. For instance, members of the same species may find it more difficult to communicate with one another across particular frequencies or at certain sound levels while near an anthropogenic noise source.

The only studies in Aotearoa New Zealand that have focused on pile-driving noise levels and their associated effects are on Hector's dolphins / upokohue in Lyttelton Harbour / Whakaraupō (hereafter Lyttelton Harbour) (e.g. Leunissen 2017; Clement et al. 2022, 2025). As expected, pile-driving noise was detectable above Lyttelton Harbour's already noisy background levels (i.e. ambient noise) across areas greater than 16.3 km^2 (Leunissen and Dawson 2017). However, *in situ* noise verification and both visual and underwater acoustic detections confirmed that the establishment of a designated shut-down zone (based on TTS levels) was an effective measure for protecting Hector's dolphin / upokohue from injurious pile-driving noise levels (Clement et al. 2022). Behaviourally, as sound exposure levels from impact pile driving increased, declines in dolphin detections varied spatially, with immediate declines occurring at sites less than 1 km from the source. Clement et al. (2025) also confirmed that local animals returned to the area once piling activity finished, but full recovery to pre-piling levels was not immediate and could take several days. Based on these results, additional measures were recommended for future infrastructure developments to avoid short- and longer-term impacts on Hector's dolphin / upokohue use of the harbour (Clement et al. 2022, 2025).

The effect of pile driving on pinnipeds is less straightforward, with reported reactions in overseas species ranging from little to no response from ringed seals (*Phoca hispida*; Blackwell et al. 2004), to significantly fewer harbour seals (*Phoca vitulina*) observed in haul-out areas located 10 km from pile-driving activities (Edrén et al. 2004). However, changes in haul-out numbers of harbour seals were short term, as the general abundance of seals showed no decrease over the whole construction period. As pinnipeds also spend significant amounts of time out of the water and hauled out on shore, in-air sound levels also need to be considered, although the in-air hearing of both otariids (e.g. New Zealand fur seal / kekeno) and phocids (e.g. leopard seal / popoiangore) is substantially less sensitive than their underwater hearing (e.g. Southall et al. 2007).

Underwater noise standards

There are currently no national or standard guidelines for pile-driving activities within Aotearoa New Zealand waters. To determine the distance at which pile-driving noise levels could cause any physical impairment or injury (i.e. PTS or TTS) to local marine mammal species, most assessments in Aotearoa New Zealand have used the underwater acoustic thresholds defined by the United States National Oceanic and Atmospheric Administration's (NMFS) 'Revisions to technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing' (NMFS 2018, 2024). These thresholds are weighted, meaning that they are based on the functional hearing groups (i.e. considers the range of hearing that a species is most sensitive to) and take into consideration the frequencies over which most of the sound energy might be concentrated for a particular sound source (i.e. pile-driving strikes). These thresholds have recently been updated and the new thresholds applied by Pine (2025) in his underwater noise assessment.

Based on what is known about the marine mammals that occur in Banks Peninsula (see Section 3), the focal groups for this assessment are categorised into NMFS's updated functional hearing groups as listed in Table 3.

Table 3. Summary of the generalised functional hearing ranges defining the different marine mammal hearing sensitivity groups used by the USA National Oceanic and Atmospheric Administration agency.
Source: NMFS (2024).

Hearing group	Generalised hearing range
Very high-frequency cetaceans (VHF) e.g. Hector's dolphin / upokohue	200 Hz to 165 kHz
High-frequency cetaceans (HF) e.g. toothed dolphins and whales, beaked whales	150 Hz to 160 kHz
Low-frequency cetaceans (LF) e.g. baleen whales (e.g. humpback whale / Paikea, southern right whale / tohorā)	7 Hz to 36 kHz
Phocid carnivores in water (PCW) e.g. true seals, leopard seals / popoiangore	40 Hz to 90 kHz
Otariid and other marine carnivores in water (OCW) e.g. New Zealand sea lion / whakahao, New Zealand fur seal / kekeno	60 Hz to 68 kHz

It is expected that Hector's dolphin / upokohue will be the main species present in the harbour on any given day. However, the five categories listed above represent all of the possible marine mammal functional hearing groups. Therefore, noise impacts that may affect any species that are not listed or directly addressed in this report are still considered under these standards.

Proposed piling works

The demolition and rebuild of the Akaroa Wharf will involve temporary activities that will potentially disturb the marine environment and increase the amount of noise (both airborne and underwater) produced within Akaroa Harbour. The sources of underwater noise from this proposal are related to the demolition of the current wharf structure and the installation of new piles. Several options of pile-driving methods have been proposed, including vibro-hammer (continuous noise production), traditional hydraulic impact hammer (impulsive noise) and boring (excavation) from both barge and wharf-based platforms.

The deconstruction of the current wharf is expected to take up to 2–3 months, the piling and deck construction of the new wharf is estimated to take 5–6 months and all other elements are expected to take 3–4 months. At this point, no specific timeline of pile-driving activities is available. However, it is assumed that the two rigs will not undertake any piling simultaneously, no concurrent vibro- and hydraulic hammering will take place over the course of the day, and pile driving will take place only during daylight hours.

Potential physical effects

Pine (2025) developed an underwater noise propagation model to estimate the potential noise levels generated by the proposed construction works based on ambient noise levels measured *in situ* in Akaroa Harbour (Pine 2023). This propagation model incorporated data on local bathymetry, water temperature (both summer and winter), tidal flow and sediment type, all of which affect how noise travels through water. Within this framework, acoustic models were then built for the largest proposed steel piles (i.e. 710 mm) at the location with the greatest potential impact on marine life (i.e. the western offshore end of the new wharf) in order to predict the 'worst-case' distance ranges of piling-generated noise. The approaches used by Pine (2025) are appropriate and similar to approaches adopted for the other Akaroa Wharf redevelopments, as well as for several marine development projects undertaken around Aotearoa New Zealand that involve pile-driving activities.[4]

Subject to *in situ* validation of the project's actual piling noise levels, the coloured distance contours, displayed in Figure 5, represent the predicted worst-case sound levels from impact driving methods in which cumulative PTS (PTS_{cum}) and TTS (TTS_{cum}) were estimated for the largest proposed piles[5] (Table 4). Given the distance estimates in Table 4, impact pile-driving activities could cause the onset of TTS in Hector's dolphins / upokohue when animals are within the middle harbour region near French Bay (e.g. 1.593 km from the construction site; Figure 5, right image). PTS effects are possible if an animal comes within the vicinity of the construction site (i.e. 16–209 m, depending on the species).

4 Refining New Zealand Ltd, Deepening and Alignment project; Lyttelton Port Company Ltd, Capital Dredging and Cruise Berth Development projects; Port Marlborough Ltd, Waitohi Ferry Precinct Redevelopment project.

5 These modelling scenarios assume similar impact driving rates to recently completed piling work in Lyttelton Harbour; an average of 2,400 strikes on 760 mm piles over a 24-hour period with a BSP HH16-1.2 Hammer with 106 kJ capacity (M. Pine, pers. comm., 25 November 2024).

Table 4. Estimated unmitigated distance ranges of impact pile-driving[6] generated noise over winter temperatures for potential hearing effects (TTS, PTS), behavioural impacts[7] and listening space reduction (i.e. masking) of the five functional hearing groups in Pine (2023). Distances equate to the maximum distance estimated from sound propagation models developed for the piling source by Pine (2025). VHF = very high-frequency group, HF = high-frequency group, LF = low-frequency group, PCW = phocid pinniped group in water, OCW = otariid pinniped group in water.

Threshold criteria		**VHF (Hector's dolphin / upokohue)**	**HF (orca / maki, other delphinids)**	**LF (baleen whales)**	**PCW (leopard seal / popoiangore)**	**OCW (New Zealand fur seal / kekeno)**
		Max. distance (m) *	Max. distance (m) *	Max. distance (m) *	Max. distance (m) *	Max. distance (m) **
PTS (permanent threshold shift)		209	15	112	85	16
TTS (temporary threshold shift)		1,593	91	329	307	175
140 dB Low behavioural threshold		502			5,000#	
160 dB Moderate behavioural threshold		80			1,478	
Listening space reduction (LSR) (masking) #		**VHF (Hector's dolphin / upokohue)**	**HF (orca / maki, other delphinids)**	**LF (baleen whales)**	**PCW (leopard seal / popoiangore)**	**OCW (New Zealand fur seal / kekeno)**
		Max. distance (m) *	Max. distance (m) *	Max. distance (m) *	Max. distance (m) *	Max. distance (m) **
Percentage reduction	**0%**	5,000 #	5,000 #	5,000 #	5,000 #	5,000 #
	25%	5,000 #	5,000 #	5,000 #	5,000 #	5,000 #
	50%	1,336	1,101	5,000 #	4,164	1,985
	75%	208	138	1,377	754	162

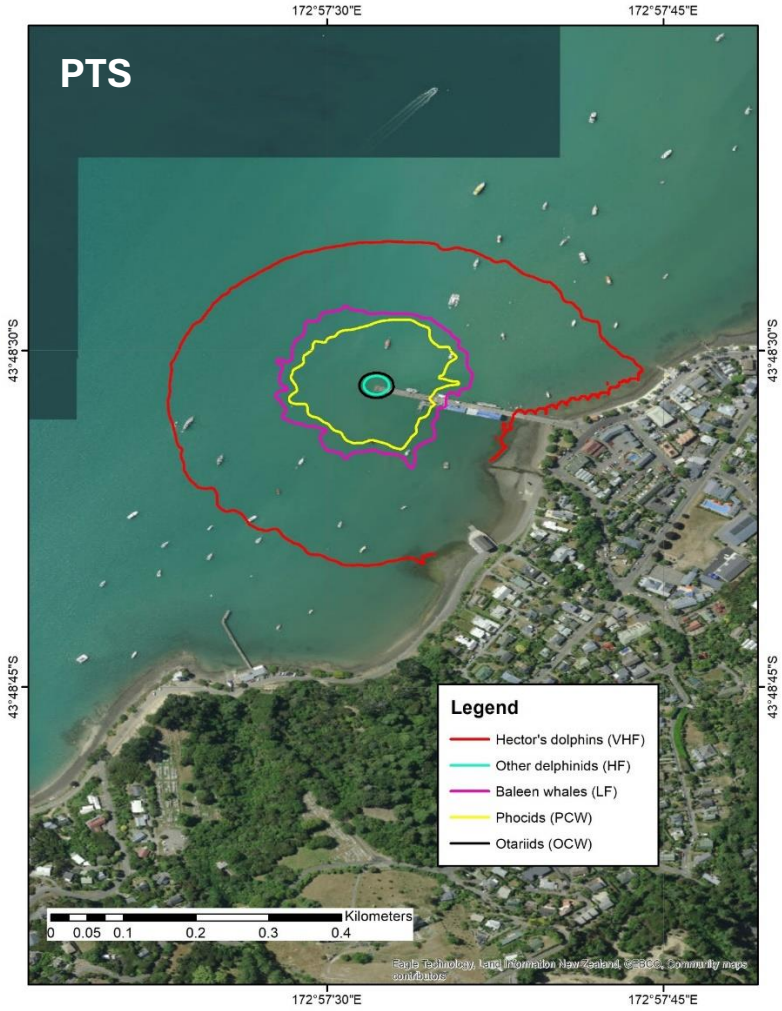
* Where available, these distances were based on the relevant species audiogram data (Pine 2025). Masking results for whales were calculated based on fin whale audiograms.

** Range based on northern fur seal audiogram in the absence of New Zealand fur seal / kekeno audiogram.

\# LSR > 30% across harbour opposite French Bay (5,000 m away).

6 Vibro-piling methods are not included, as noise levels were assessed by Pine (2025) to be lower than impact driving based on the expected durations of piling as per the proposed schedule.

7 The probability of a behavioural response occurring at varying distances from a piling source could not be calculated through the dose-response method. See Pine (2025) for more details.



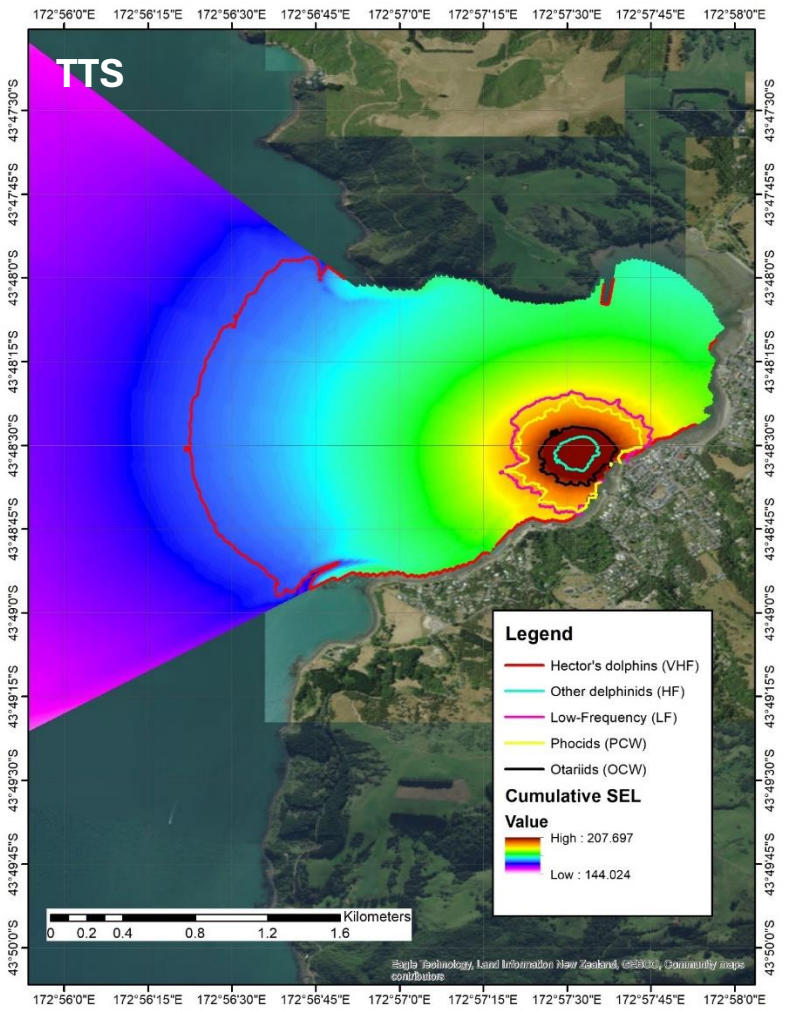


Figure 5. The predicted spatial ranges for the onset of permanent threshold shift (PTS; left image) and temporary threshold shift (TTS; right image) hearing effects on marine mammals from percussive impact piling methods at the western edge of the proposed Akaroa Wharf area. Images reproduced with permission from Pine (2025).

Potential displacement or behavioural effects

Appropriate sound-level thresholds for behavioural disturbance are currently being assessed and revised overseas (see NOAA 2016). In the interim, and based on overseas studies, Pine (2025) used the two-tiered approach of Southall et al. (2007, 2021). This approach notes that lower behavioural responses to impulse noise can occur at sound levels as low as 140 dB_{rms} re 1 µPa, with more moderate responses at sound levels of 160 dB_{rms} re 1 µPa for all species. Based on these two-tiered unweighted thresholds, the distance ranges for potential low- and moderate-level behavioural effects were conservatively estimated for all hearing groups (Table 4).

However, as Pine (2025) notes, actual behavioural effects depend on the species, location and temporal aspects. Recent underwater acoustic monitoring work within Lyttelton Harbour found a response gradient from Hector's dolphins / upokohue in which acoustic detections of dolphins decreased as piling noise increased up to distances of 1.75 km from the port (Clement et al. 2025). Hence, due to the importance of Akaroa Harbour to Hector's dolphin / upokohue, we would expect individuals to demonstrate both low and moderate behavioural responses at much lower sound levels (and hence greater distances) than noted in Table 4

Behavioural responses are also expected to be contextual and dependent on the situation. While these behavioural thresholds are much lower than the noise levels generated by most commercial and recreational vessels (i.e. OSPAR Commission 2009; Todd et al. 2015), animals are expected to respond more adversely to intermittent and unexpected noise than more consistent or regular intervals of noise such as that generated by ships. By way of analogy, a fire alarm will startle people nearby when it goes off unexpectedly. However, if a person approaches an alarm that has been sounding prior to their arrival, their response is more modest, and they may even approach or pass by the building as they habituate to the noise of the alarm. This is why management measures such as a 'soft start' or 'ramping up' are used by piling operators to avoid sudden or unexpected full-force piling noise.

Pine (2025) also calculated distances from piling activity where the associated noise levels might interfere with an animal's ability to clearly hear some natural acoustic signals – also known as acoustic masking (e.g. members of the same species trying to communicate across particular frequencies / levels while in the proximity of the operating pile driver). The estimated reductions in an animal's listening space (e.g. the volume of ocean around an individual) or when acoustic masking might occur as it approaches a pile-driving source are listed in Table 4. For all dolphins, a 50% reduction in their listening space would occur around the entrance to French Bay (approximately 1,300 m), while a similar reduction for a leopard seal / popoiangore or baleen whale would occur almost across the width of the harbour from French Bay (approximately 4–5 km; Table 4).

Summary

Overall, the predictive sound modelling of Pine (2025) suggests that for most species (with the exception of Hector's dolphin / upokohue), pile-driving noise without any mitigation measures has a low to moderate likelihood of causing TTS impairment (or even PTS) when an animal is in the proximity of the piling source (i.e. less than 350 m; Table 4). However, the likelihood for TTS, PTS and behavioural effects is moderate to high for Hector's dolphins / upokohue when near French Bay or middle harbour regions because of the greater propagation of unmitigated high-frequency soundwaves and the

dolphins' year-round presence within the harbour, albeit with some seasonal variation. The relevant factors that underlie this assessment are listed below and discussed further in Section 5.

Spatial and temporal factors

- Underwater noise produced from the proposed pile-driving activities will occur, potentially intermittently, over the course of 6 months or more.
- Until confirmed, it has been assumed that the pile-driving system will use both vibro-hammering and traditional impact hammering, and that this will limit the number and amount of piling within any one day.
- The proposed piling activity will be restricted to weekdays and daylight hours only.
- Previous visual and current underwater acoustic monitoring confirms that Hector's dolphins / upokohue would likely be present in the vicinity of construction, with some seasonal variation in their densities.
- Akaroa Harbour is considered ecologically important habitat for the Nationally Vulnerable Hector's dolphin / upokohue.

Known acoustic factors

- Shut-down zone management can avoid any PTS_{cum} and most TTS_{cum} effects by ceasing all piling activity if and when species enter the designated marine mammal observation zone (MMOZ). The exception is the effect of TTS_{cum} on Hector's dolphins / upokohue.
- Previous research suggests that piling activity should be limited or reduced over the warmer months (summer) and that construction over two concurrent seasons should be avoided if possible (i.e. back-to-back summers, when calves are born and harbour densities are greater).
- Management options, such as soft starts and ramping-up procedures, will help reduce more moderate behavioural responses by avoiding sudden or unexpected full-force piling noise.
- The semi-enclosed nature of the bay entrance limits hearing effects to mainly middle harbour waters. Hence, underwater noise effects are unlikely to apply to other visiting dolphins, pinnipeds or migrating whales outside the harbour entrance or around Banks Peninsula.
- Different sources of underwater noise are not necessarily additive or cumulative. The 'loudest' noise (i.e. pile driving) will mask other noises generated nearby by other construction activities. However, the marine mammal management plan (MMMP) and / or proposed consent conditions will need to ensure that two or more similar pile drivers do not operate at the same time (on the same or different wharves), as under such an operational scenario it is possible that PTS and TTS thresholds will be reached over a shorter exposure period (less than 24 hours).

4.2 Operational loss and possible entanglements

Potentially harmful operational by-products of coastal development can include such items as lost ropes, support buoys, bags and plastics (Weeber and Gibbs 1998). These items are often collectively known as marine debris (Laist et al. 1999). As most marine materials are now manufactured from a

range of plastics, they often tend to float and persist rather than degrade quickly, as is generally the case with materials made from natural fibres.

The major hazard to marine mammals from marine debris originating from coastal development projects is the possibility of entanglement (Laist et al. 1999) and / or ingestion. Whales, dolphins and pinnipeds are often attracted to floating debris and therefore face the potential risk of becoming entangled in floating lines and netting (e.g. Suisted and Neale 2004; Groom and Coughran 2012). However, the nature of the proposed wharf re-establishment activities and the equipment involved means that the likelihood of entanglement in marine ropes and lines is less of a concern than floating debris such as plastics. Any effects on marine mammals are expected to be 'Nil' to 'Negligible' in well-maintained coastal development projects that have proper waste management programmes in place (e.g. secure storage of lines, ropes and waste). Regardless, a clear requirement within the construction management plan should ensure that all waste and materials are accounted for, with any accidental release of material being rapidly collected.

4.3 Ecological effects of habitat and prey species

The potential ecological effects from any loss of existing intertidal, subtidal and benthic biota, and loss or alteration of the habitats within the immediate region of the proposed activities, are discussed in detail in the ecological and underwater noise assessments (Pine 2025; Sneddon and Morrisey 2025). The possible effects of artificial lighting on marine mammals have been studied more in marine farms (Cornelisen and Quarterman 2010; Cornelisen 2011), with the results suggesting that mostly nearby schooling baitfish are attracted as the lighting footprint is usually confined. It is anticipated that the combined effects of any resulting loss or disturbance (including turbidity) to the habitats and / or wharf lighting effects associated with the wharf demolition and rebuild will be 'Not applicable' to 'Low'.

The limited effect (both spatially and temporally) the proposed construction activities are expected to have on local habitats and associated fish species means there are unlikely to be any long-term flow-on impacts on local marine mammals (see Table 5). This conclusion is based on the following factors:

- The spatial and temporal scales of disturbance to the seabed during demolition and construction are expected to be very small, and communities of animals and plants are expected to recolonise disturbed areas rapidly (within months).
- Indirect effects (from propagation of turbidity plumes) are likely to extend no more than hundreds of metres from the site and are expected to be of negligible severity / magnitude relative to naturally occurring resuspension events.
- Any construction or design lighting effects will be minimised through the use of only the minimum level of lighting on the wharf necessary for health and safety reasons.
- Although noise from pile driving may disturb fish (up to 70 m from source), most will be able to avoid the area and will return once construction is complete.
- Home ranges of local marine mammal species (including the Hector's dolphin / upokohue) are large and overlap with similar types of habitats in other parts of the harbour and along most other coastal bay regions.

Table 5. Summary of potential effects on relevant marine mammal species from the proposed Akaroa Wharf rebuild project. Abbreviations: PTS = permanent auditory threshold shift, TTS = temporary auditory threshold shift, MMMP = marine mammal management plan, BPO = best practical option, MMOZ = marine mammal observation zone.

Potential environmental effects	Spatial scale of effect on marine mammals	Persistence / duration of effect for marine mammals	Consequences for marine mammals	Likelihood of effect	**Significance level of effect** (without proposed management approaches)	Proposed management approaches / effects analysis	**Significance level of residual effect** (with proposed management approaches)
Behavioural and / or physical responses to:							
• **General demolition / construction activities (including dredging)**	**Small to Large** - Dependent on final method / sounds produced - Behavioural responses predicted at larger distances	**Short to Moderate** - Demolition completed within 2–3 months; construction completed within 11–14 months - Various activities will produce varying levels of noise	**Individual Level** - Individuals may avoid or approach activities	**NA / Low** - TTS - Masking - Behavioural	**Nil to Negligible**	• Localised, intermittent activity of short durations (days to weeks) • Relevant environmental factors (may naturally help dampen underwater noise production) • *In situ* measurements of underwater noise levels from demolition / construction activities and adjust mitigation if necessary (MMMP)	**Nil to Negligible**
• **Pile-driving activities:**							
- **Physical injury (TTS / PTS)**	**Small to Large** - PTS and TTS vary with species, up to 1.6 km	**Short to Moderate** - Dependent on exposure, hearing damage and recovery periods; pile-driving activities intermittent over 7.5 months	**Individual to Regional Level** - Hearing impairment or injury of endangered individual (i.e. breeding female) to potential attraction of juvenile animals	**Low to High** - Species dependent	**Less than Minor to More than Minor** - PTS - TTS	• BPO used in method selection (MMMP) • Regular maintenance and upkeep of piling equipment (MMMP) • Unexpected noise reduced by using ramping up and / or soft starts (MMMP) • *In situ* verification of underwater noise levels from piling activities and adjust mitigation if necessary (MMMP) • Establishment of 300 m MMOZ for cetaceans (inclusive of Hector's dolphins / upokohue) and pinnipeds from piling source based on TTS – piling activities will cease if an animal enters (MMMP) • Implementation of noise reduction measures necessary to maintain acceptable TTS levels at 300 m or less from piling source (MMOZ) • Operations restricted to weekday and daylight hours (MMMP) • Single piling rig method used at any one time	**Nil to Negligible** - PTS - TTS
- **Displacement effects (behavioural / masking)**	**Large** - Behavioural responses / masking over 1–2 km	**Short to Moderate** - Dependent on exposure and recovery periods between events; pile-driving activities intermittent over 7.5 months	**Individual to Regional Level** - Abandonment or avoidance by particular age groups (e.g. mother / calves) or individuals - Possible acoustic masking between conspecifics only within harbour waters	**Low to High** - Species dependent	**Less than Minor to More than Minor** - Behavioural - Masking		**Negligible to Less than Minor** - behavioural - masking
Marine mammal entanglement in operational gear and / or debris	**Small to Medium** - Limited to immediate waters around demolition / construction sites	**Short to Moderate** - Demolition completed within 2–3 months; construction completed within 11–14 months - Different activities have variable risk	**Individual to Population Level** - Death or injury of endangered or threatened species vs death of non-threatened dolphins or pinnipeds	**NA to Low**	**Nil to Less than Minor**	• Loose rope, lines, nets or other debris avoided (MMMP) • New Zealand Maritime Rules Part 180 complied with (MMMP) • Properly tensioned silt curtains or other sediment containment gear regularly maintained / inspected (MMMP)	**Nil to Negligible**
Marine mammal habitat loss and / or prey disturbance	**Medium to Large** - Limited to immediate waters and habitats adjacent to demolition / construction sites	**Short to Persistent** - Recolonisation of most habitats will begin after disturbance has ceased, boat scour persistent for wharf lifetime - Lighting throughout consent, night-time only	**Individual Level** - Individuals may avoid or approach activities	**NA to Low**	**Nil to Negligible**	• Previous or ongoing disturbance to nearby seabed from associated boating activities • No unique feeding habitats in the proposed areas • No known attraction effects due to current wharf lighting (prey or marine mammals)	**Nil to Negligible**

Definitions 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 level, Regional level, 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 others), Minor (noticeable but will not cause any significant adverse effects), More than Minor (noticeable and may cause adverse impact but could be mitigated), Significant (noticeable and will have serious adverse impact but could be potential for mitigation)

5. Management and monitoring

Management actions are warranted with regard to Policy 11(a) of the New Zealand Coastal Policy Statement (DOC 2010) and the occurrence of Hector's dolphins / upokohue. In particular, the distance of the unmitigated TTS threshold (1,593 m) is too large to be effectively managed using only a standard observed shut-down zone (MMOZ), as visual monitoring of Hector's dolphins / upokohue (and other dolphins) over such distances is imperfect. Hence, a combination of management and mitigation actions will be necessary and will depend, in the first instance, on their efficacy at reducing or dampening the underwater noise levels produced from pile-driving activities at Akaroa Wharf to manageable levels (Table 6). The aim is to reduce the potential adverse effects on all marine mammals to within a workable and effective MMOZ (approximately 300 m), thus avoiding any TTS and PTS effects, minimising behavioural effects and effectively managing any other residual aspects.

To ensure that the most appropriate measures are in place, I recommend that an MMMP is developed by a marine mammal expert in consultation with an underwater acoustic expert. This plan should outline in detail the procedures referred to in Table 5 and measures discussed in Section 5.1 and Table 6, as well as determine the timelines for management actions and implemented mitigation procedures, which will need to be reviewed for their effectiveness during operations. The final MMMP should be reviewed and consulted on with DOC, iwi and other stakeholders before operations commence.

5.1 Management measures

The MMMP will require the consent holder to identify and adopt accepted best practices to minimise adverse effects on the environment from underwater noise emissions. The key recommended management measures and actions are as follows:

- **Use of a sacrificial, non-metallic hammer cushion cap (or dolly)**. The noise modelling by Pine (2025) assumes that all impact piling works use a dolly cushion. This cushion is made of wood (preferred), nylon or polymer plastic and sits between the hammer and the top of the pile, where it is used to reduce wear. By dampening the impact of the hammer, appreciable reductions in both underwater noise and airborne noise are achieved with this method.
- **Verification of *in situ* noise levels**. The actual underwater noise levels produced from pile-driving activities will to be verified at the start of the project. Results will be reviewed against the same parameters used for acoustic modelling by Pine (2025), and any necessary adjustments made to mitigation actions (e.g. revised MMOZ size) prior to any further pile-driving activities taking place.
- **Reduction of noise levels generated at the source**. Several operational considerations may help reduce the source level of underwater noise produced by pile-driving activities to meet the 300 m TTS limit:
    - *Piling method*. The preferred method for minimising underwater noise would be the use of vibro-driving, whenever possible. This technique generates a continuous and generally lower level of sound compared to the intense, discrete pulses from impact driving. However, full

consideration must be given to other environmental factors such as substrate type and duration implications (i.e. 'best practical option').

- *Pile size / type*. The smallest possible pile size that meets the specific operational need should be used – generally, the smaller the pile, the lower the noise level (subject to different piling methodologies). The materials that the piles are made of, or pile type, in order of increasing noise generation are: timber, concrete and steel piles.
- *Daily / weekly limits*. Limiting pile driving to weekdays and daylight hours restricts the total strikes within a 24-hour period and allows for hearing recovery periods (e.g. overnight, weekend).
- *Modifying and / or lowering the number of strikes in a day (strike rate)*. This limits the cumulative noise generated.
- *Driving the largest piles (western piles associated with pontoons) during low tide or as close to it as possible*. This will reduce noise into the water column.

- **Reduction of underwater noise propagation**. The use of bubble curtains (i.e. single or double curtains), coffer dams, isolating sheet piles or jacket technology around the piling area are known to reduce the amount of noise that enters the water column. Bubble curtains have recently been used in Aotearoa New Zealand (e.g. CentrePort Wellington) and are most effective in areas of low current or slow tidal flow in which the bubbles can extend uninterrupted to the surface.
- **Establishment of MMOZs**. The establishment of shut-down zones around the construction area minimises the risk of hearing impairment (i.e. TTS / PTS) to marine mammals from pile-driving activities. The presence of any marine mammals within these zones would require the cessation of pile driving, with no recommencement or continuation until the animal has left the predetermined zone. Previous research has demonstrated that, for Hector's dolphins / upokohue, the ability of a single elevated marine mammal observer (MMO) to sight an animal decreases significantly after distances beyond 300 m (Dawson et al. 2004). Given the noise propagation estimates, the shape of the bay, the lack of appropriate viewing platforms and the year-round presence of the dolphins, I recommend that the final size of the MMOZ is 300 m or less from the piling source for all cetaceans and pinnipeds, pending *in situ* verification. Operational requirements include:
  - *Reduce underwater noise production* – this will contain any TTS effects to within distances of 300 m or less.
  - *Monitor the MMOZ*. This will involve at least one dedicated, experienced MMO maintaining an effective lookout station at an elevated, fixed platform near the piling site.
  - *MMO to continuously scan for the presence of marine mammals prior to, during and following any pile-driving activities (which will take place during daylight hours only)*:
    - To minimise the risk to any marine mammals already present in French Bay (i.e. overnight prior to piling starting in the morning), a pre-start scan should be undertaken by at least two MMOs first thing in the morning (and after any extended breaks in piling greater than 1 hour) for at least 30 minutes prior to the start of piling. If any animal(s) are present in or near to the MMOZ prior to the start of pile driving, operations will be suspended until the animal(s) has moved out of the MMOZ.
    - A central contact point should be established with DOC to obtain up-to-date regional sighting information for the duration of the project, particularly regarding nearby visiting baleen whales or orca sightings. With this information, the MMO can anticipate

and verify the potential presence or absence of these species and any other animals sighted in or near the project area. The MMO should also monitor news and social media for any information about marine mammals reported in the wider Banks Peninsula region.

- **Use of soft-start or ramping-up procedures**. The use of these procedures means that pile-driving energy is gradually increased to normal operating levels. They are recommended to give nearby animals (i.e. those close to or just outside the MMOZ) an opportunity to move away from the area before sound levels increase to an extent that may cause discomfort or injury (i.e. TTS). This process is also expected to help mediate some more moderate and / or low behavioural responses from nearby animals, giving them a chance to habituate to the pulses of sound over time before the noise level increases.
- **Adherence to seasonal piling**. The project should be timed so that piling work occurs over the cooler months of late autumn / winter, when fewer animals are present in the harbour. Such timing also avoids the main calving period of most marine mammals (October to March). Successive seasonal piling activity should also be avoided, particularly over two successive summer periods.
- **Avoidance of cumulative noise**. Coordinating with any other construction works that involve piling or underwater noise generation to limit simultaneous activities in French Bay is key to ensuring that the cumulative effects of PTS and TTS, and behavioural effects, are avoided.

After adopting, as necessary, a combination of these mitigation measures to achieve a TTS zone of 300 m or less, any residual effects of hearing stress or impairment are expected to be 'Nil' to 'Negligible' and behavioural effects are expected to range from 'Negligible' to 'Less than Minor' for all marine mammal species.

5.2 Monitoring recommendations

The continued presence (or absence) of the relevant marine mammal species within the harbour and / or near the construction site by MMOs can be used to confirm the effectiveness of management actions. In addition, I recommend that underwater acoustic monitoring continues at the established baseline stations (see Pine 2023) across Akaroa Harbour while pile-driving activities are underway. This monitoring can assist in verifying actual sound levels, while also determining the potential presence of any behavioural effect(s) and the sound level(s) at which these may be occurring. These results can, therefore, help determine the efficacy of implemented management actions for further monitoring throughout future wharf construction projects in Akaroa Harbour.

Table 6. Proposed management goals and practices to reduce or avoid the risk of adverse effects from construction activities on marine mammals in Akaroa Harbour. DOC = Department of Conservation, CCC = Christchurch City Council, BPO = best practical option.

Potential effects	Management goal	Best management practice	Reporting / monitoring
Physical and / or behavioural responses to underwater sound from construction activities	1. Avoid acoustic injury and minimise disturbance to marine mammals	1a. Use BPO to minimise underwater noise effects. 1b. Establish a marine mammal management plan (MMMP). 1c. Adopt soft-start / ramping-up procedures and choose plant / techniques on the basis of the BPO. 1d. Reduce underwater noise levels at the source using a combination of trialled reduction measures. 1e. Establish a designated shut-down zone (e.g. 300 m based on Hector's dolphin TTS levels), with dedicated, experienced marine mammal observer(s) maintaining a watch before, during and after any pile-driving activities (during daylight hours only). 1f. Minimise the spread of piling stages over successive seasons.	• Measure actual underwater noise levels from pile driving and other construction activities and adjust / implement any mitigation actions based on these data, if necessary. • Record and report the type and frequency of any marine mammal sightings (i.e. visual and acoustic) and interactions before, during and after pile-driving activities (including absences and effort) in a standardised format. Provide records to DOC and CCC so that these can be made publicly available (e.g. on the Internet). Include behavioural data if possible.
Marine mammal entanglement in operational gear and / or debris	2. Minimise entanglement and aim for zero mortality	2a. Avoid loose rope and / or nets (i.e. keep all ropes and nets taut). All deck lines should be tied up when not in use or under some degree of tension. 2b. Regularly maintain / inspect silt curtains or other sediment containment gear (if used) to ensure they are tensioned properly. 2c. Ensure waste management plans are in place for all support vessels and other project activities. 2d. Record all entanglement incidents or near incidents regardless of outcome (e.g. injury or mortality).	• Nothing required; self-checking with up-to-date records available. • In case of a fatal marine mammal incident, carcass(es) must be recovered and provided to DOC, and further steps should be taken in consultation with DOC to reduce the risk of future incidences. Tangata whenua must also be notified.

6. Appendices

Appendix 1. Sources of marine mammal data and information

Mainly regional information is available for most marine mammal species using the general Banks Peninsula and Canterbury coastal region. The University of Otago has undertaken multiple and finer-scale studies on Hector's dolphin / upokohue in both Akaroa and Lyttelton Harbours and inshore waters around the southern, eastern and northern side of Banks Peninsula. The studies and databases used to summarise and assess the marine mammal species discussed in this report are listed below:

- DOC opportunistic database and stranding record database.
- Marine mammal tourism data in Akaroa Harbour and the Banks Peninsula region.
- National Aquatic Biodiversity Information System (NABIS).
- Scientific research through University of Otago:
    - S Dawson and E Slooten – various studies and student projects on Hector's dolphins / upokohue in Akaroa Harbour and the Banks Peninsula region.
    - T Brough, W Carome, D Clement, E Miller, W Rayment – research on Hector's dolphin / upokohue around Banks Peninsula and within Akaroa and Lyttelton Harbours.
- Scientific research through University of Auckland:
    - R Constantine – various studies on humpback whales / paikea around Aotearoa New Zealand.
    - E Carroll – various studies on southern right whales / tohorā.
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