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NELSON NORTH WASTEWATER TREATMENT PLANT DISCHARGE: ASSESSMENT OF EFFECTS ON MARINE MAMMALS

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Prepared for Nelson City Council

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EXECUTIVE SUMMARY

Nelson City Council (NCC) owns and operates the Nelson North Wastewater Treatment Plant (NWWTP), which lies next to the northwest corner of the Nelson Haven at The Glen and discharges to Tasman Bay / Te Tai-o-Aorere (hereafter Tasman Bay). NCC is seeking to renew the existing coastal permit to discharge treated wastewater, which expires in December 2024. As marine mammals are susceptible to the effects of wastewater contaminants associated with coastal discharges, NCC contracted Cawthron Institute (Cawthron) to consider the potential effects on local and visiting marine mammal species.

The marine mammals most likely to be affected by the plant's discharges are those species that frequent the inner Tasman Bay water throughout the year or on a semi-regular basis. These species include New Zealand fur seal / kekeno, bottlenose dolphin / terehu, dusky dolphin, orca / maki and Hector's dolphin. Several other species have life-history dynamics that may make them vulnerable to effects of contaminants. However, there is no evidence that any species have home ranges or foraging habitats restricted solely to nearshore waters along the Boulder Bank, or in proximity to the discharge area. Based on this knowledge, the nearshore waters immediately around the outfall are not considered ecologically more significant in terms of feeding, resting or breeding habitats for any species relative to other regions along the top of the South Island.

The long lifespans and occurrences in nearshore coastal waters of some marine mammals make them susceptible to the long-lasting accumulation of contaminants in their thick blubber layers, due to the persistent, fat-soluble nature of several chemicals. Moreover, marine mammals occupy a high trophic position in the food chain, making them potentially vulnerable to high concentrations of chemicals from lower-order prey. The extent of any effects from wastewater contaminants on marine mammals is determined by the type and amount of contaminants present, the frequency and duration of exposure, the individual's or species' susceptibility to the contaminant, and the animal's health when exposed.

Predicting the possible impacts of marine discharges on New Zealand marine mammal species from a single source is complex. Given the present state of knowledge, this must be based mainly on the quality and type of discharges and the expected exposure risk of each species. The overall adverse effect from the NWWTP discharge is expected to be low for those marine mammal species with the highest potential sensitivities and risk of exposure. Exposure to any discharge contaminants would most likely occur via the food chain (through prey species). However, the species known to occur in Tasman Bay are generalist feeders, potentially ranging and foraging along the coastline (and beyond). Since no marine mammals reside along the Boulder Bank and larger Tasman Bay region year-round, the likelihood of an individual animal foraging on prey, or swimming through waters exposed to the discharge, would be very low. Based on the recent monitoring of the discharge and receiving environment, and the available information on the dispersion and dilution of the wastewater in the bay, any potential effects on marine mammals from the renewal proposal are considered negligible and no further mitigation is warranted.

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GLOSSARY

Bioaccumulation	Process by which an organism absorbs and stores a chemical substance (natural or anthropogenic) in its tissues at a higher rate than the substance is broken down or excreted from its body.
Biomagnification	Process by which a chemical is passed up the food chain to higher trophic levels, such that in predators it exceeds the concentration to be expected where equilibrium prevails between an organism and its environment.
Contaminant	As defined in the Resource Management Act 1991, ‘any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat— (a) when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water; or (b) when discharged onto or into land or into air, changes or is likely to change the physical, chemical, or biological condition of the land or air onto or into which it is discharged’.
Echolocation	Physiological process used by marine mammals and other animals for locating distant or invisible objects by means of sound waves reflected back to the emitter.
Emerging organic contaminants (EOCs)	Natural or manufactured chemicals in household and personal care products, pharmaceuticals and agrichemicals; their use and discharge are largely unregulated.
Endocrine disrupting chemicals (EDCs)	Chemicals that can interfere with the normal functions of the endocrine system.
Tangata whenua	As defined in the Resource Management Act 1991, ‘in relation to a particular area, means the iwi, or hapu, that holds mana whenua over that area’.
Wastewater	Flow of used water discharged from homes, businesses, industries, commercial activities and institutions that is directed to treatment plants by a network of pipes. Wastewater can be categorised according to its source. The term ‘domestic wastewater’ refers to flows discharged principally from residential sources; industrial / trade wastewater is flow generated and discharged from manufacturing and commercial activities.

LIST OF ABBREVIATIONS

DDT	Dichlorodiphenyltrichloroethane
DOC	Department of Conservation
EDCs	Endocrine disrupting chemicals
EOCs	Emerging organic contaminants
NCC	Nelson City Council
NWWTP	Nelson North Wastewater Treatment Plant
NZCPS	New Zealand Coastal Policy Statement
OCPs	Organochlorine pesticides
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PPCPs	Pharmaceutical and personal care products
RMA	Resource Management Act 1991

1. INTRODUCTION

1.1. Background

Nelson City Council (NCC) currently holds several resource consents associated with the operation of the Nelson North Wastewater Treatment Plant (NWWTP), including a coastal permit (SAR 05-61-01-06) that authorises the discharge of treated wastewater to Tasman Bay / Te Tai-o-Aorere (hereafter Tasman Bay). This coastal permit was granted in 2004 for a duration of 20 years and expires in December 2024.

The NWWTP lies on the seaward, northwest corner of an area of low-lying land in the upper parts of Nelson Haven between Glen Road and what is now Boulder Bank Drive (Figure 1). The plant has been operational since 1979 and receives domestic wastewater and a small contribution of trade wastewater from the western part of Nelson City, which has a population of approximately 28,200 people. The treatment process consists of removal of gross solids through the inlet works (screening), pre-treatment of influent flows to reduce biochemical oxygen demand and total suspended solids, oxidation pond-based treatment through maturation ponds and final polishing through a wetland system prior to discharge into Tasman Bay. The outfall consists of a cement pipe approximately 350 m long, which emerges from the seabed at its offshore end as an 18 m-long multiport diffuser in water depth of 11 m (Barter & Forrest 1998).

Discharges of wastewater to the coastal marine environment have the potential to affect marine mammals through respiratory, dermal and oral contact with contaminants present in the discharge. Contaminant categories of particular concern are those with high bioaccumulation and biomagnification potentials. Given these concerns, NCC has contracted Cawthron Institute (Cawthron) to consider the potential effects of renewing the coastal permit on local and visiting marine mammal species.

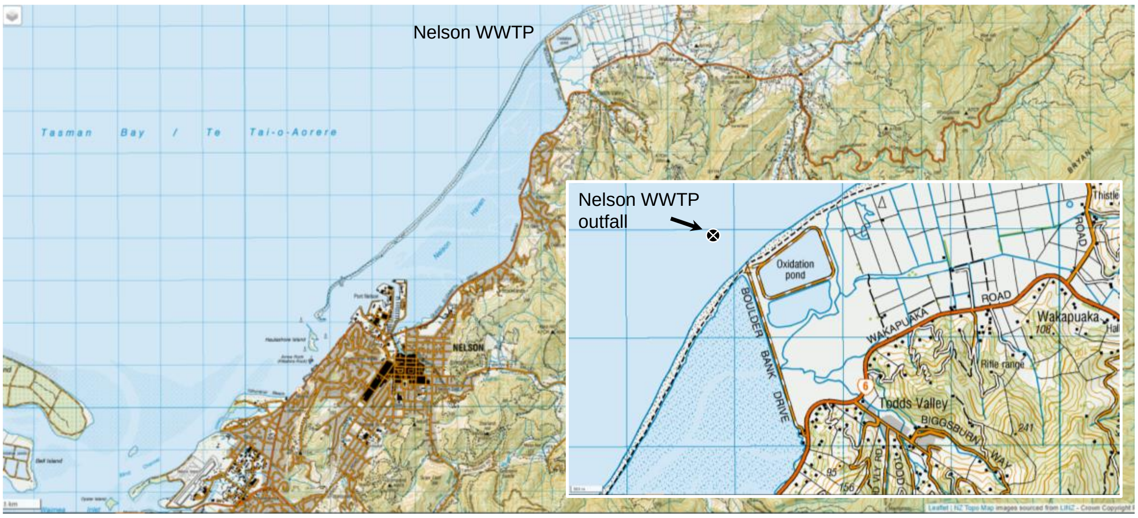


Figure 1. Location of Nelson North Wastewater Treatment Plant discharge point in Tasman Bay. (Credit: NZ TopoMap©)

1.2. Scope of this report

In this report, we present:

- a summary description of the existing environment in terms of marine mammal species identified as being the most susceptible to any effects of the discharge in its immediate area of influence, as well as the wider Tasman Bay and Golden Bay / Mohua (hereafter Golden Bay)
- a review of the literature on the potential effects of wastewater discharges with relevance to marine mammals and any relevant guidelines
- categorisation of the overall effects in terms of scale, duration / persistence, likelihood and possible consequences based on the findings of published literature (e.g. water quality, hydrodynamics, ecology)
- recommendations for avoidance, remediation and mitigation options based on the final assessment of effects, if necessary.

The potential effects of the NWWTP discharge on the ecological values of the receiving environment are presented in a companion report (Morrisey & Campos 2023). Detailed information on the dispersive characteristics of the wastewater is also presented in a separate study (MetOcean Solutions 2022). Detailed characterisations of the wastewater discharge concerning microplastics and emerging organic contaminants have been undertaken (Northcott et al. 2022; Masterton et al. 2023), and therefore the present assessment should be read in conjunction with those reports.

2. GENERAL APPROACH FOR EFFECTS ASSESSMENT

When considering the potential effects of wastewater discharges on local marine mammals, the appropriate scale of consideration is not just the immediate area of the discharge but also the spatial scales relevant to the marine mammal species. While the effects of the NWWTP discharges on the seabed and water column can be detected several kilometres from the discharge point, home ranges for most marine mammals can vary between hundreds to thousands of kilometres. As a result, the importance of the Tasman Bay coastal marine area needs to be considered in the context of species' regional and New Zealand-wide distributions.

To date, few studies have been undertaken on marine mammal species in the Tasman Bay area. Consequently, to inform this assessment we collated species information and sighting data from previous and ongoing research across both Tasman and Golden Bay coastal regions (i.e. studies undertaken by Cawthron, Massey University-Albany, University of Auckland, Orca Research Trust). We also reviewed opportunistic sightings reported to Department of Conservation (DOC) (including by the public, tourism vessels, seismic surveys, etc.) and strandings (previously collated through the Museum of New Zealand Te Papa Tongarewa and now DOC).[1] A list of the collated information sources is available in Appendix 1.

It is important to note that a large majority of these reported sightings have been collected opportunistically since the 1970s rather than systematically. Consequently, the numbers of sightings in an area do not necessarily represent unique animals (i.e. the same animal may be reported by multiple members of the public or on two separate days). As effort is not considered with opportunistic data, certain areas (e.g. favourite fishing spots and tour boat tracks) are likely to be over-represented, especially during periods of more favourable conditions (e.g. summer, daylight).

To establish relative occurrence information on marine mammal presence near the NWWTP discharge and reduce uncertainty in the assessment, we undertook four month-long underwater acoustic monitoring surveys between August 2020 and June 2021. In the surveys, we deployed an underwater acoustic recorder (SoundTrap ST500) concurrently with a water quality monitoring buoy (data reported in MetOcean Solutions 2022 and Morrisey & Campos 2023) and associated mooring at the northeastern corner of the discharge mixing zone (Figure 2). A detailed description of the methods used and data analysis procedures is presented in Appendix 2.

We assessed the potential effects associated with various anthropogenic activities on marine mammal species using the collated information and data on the species' life-history dynamics (e.g. specific sensitivities, conservation listing, lifespan, main prey

[1] The Department of Conservation's seismic database, public sightings, tourism reports, fisheries observers etc., and Cawthron's opportunistic marine mammal database.

sources) summarised from New Zealand and international data sources.[2] Collectively, we used this information to determine what is currently known about any relevant species' occurrence, behaviour and distribution within the area of interest and to evaluate those species most likely to be affected by the wastewater discharge.

2.1. Description of existing environment

Of the more than 50 species of cetaceans (whales, dolphins, porpoises) and pinnipeds (seals and sea lions) known to live or migrate through New Zealand waters, at least 22 cetacean and two pinniped species have been sighted or stranded within Tasman and Golden Bays. Figure 2 and Table 1 highlight the various marine mammal species recorded since 1978 in Tasman Bay, from Separation Point / Te Matau (hereafter Separation Point) in the west to Rangitoto ki te Tonga / D'Urville Island (hereafter D'Urville Island) in the east.

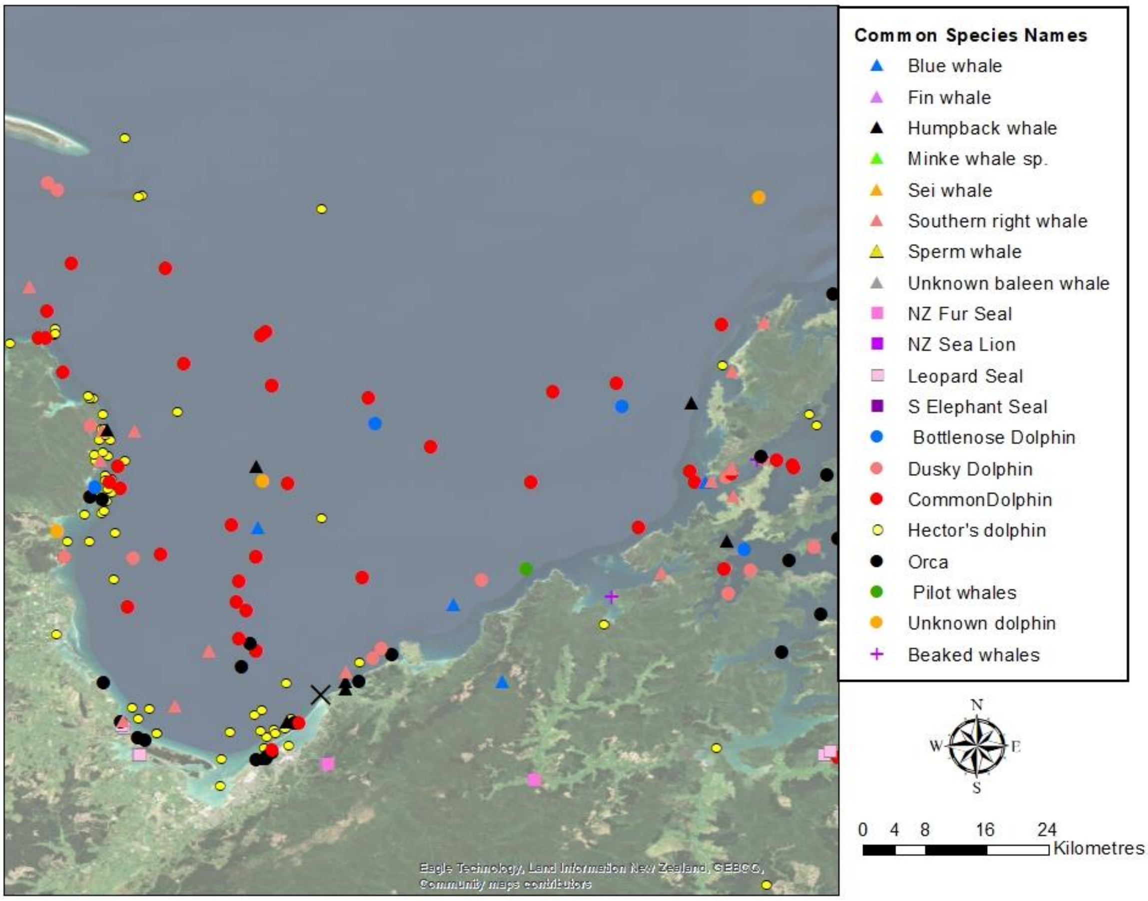


Figure 2. The distribution of Department of Conservation reported sightings (1978–2021) in Tasman Bay. The black (X) represents the location of the underwater acoustic recorder just off the discharge site.

[2] 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).

Table 1. The residency patterns of marine mammal species known to frequent Tasman Bay and Golden Bay waters. Species conservation threat status is listed for both the New Zealand system (NZTCS; Baker et al. 2019) and international IUCN system (ver. 3.1).

Common name	Species name	NZ Threat Classification System	IUCN Red Listing	Residency category in Tasman Bay	Patterns of seasonality (relative to proposal area)
RESIDENTS					
NZ fur seal / kekeno	*Arctocephalus forsteri*	Not Threatened	Least Concern	Seasonal to Year-Round Resident	Present year-round, with multiple haul-out sites and breeding colonies in western Tasman Bay and regular sightings off the Boulder Bank and breakwaters, particularly when pups leave rookeries in winter / spring. More susceptible to human effects in breeding colonies. Feed mainly over continental shelf waters.
Hector's dolphin	*Cephalorhynchus hectori hectori*	Nationally Vulnerable	Endangered	Year-round Resident	Small, local population inhabits Golden Bay and nearby Abel Tasman National Park waters year-round, with occasional sightings reported between Motueka and Nelson each year. Greatest densities of this species occur during the summer and autumn seasons. Generalist / benthic feeders on smaller-sized fish.
MIGRANTS					
Southern right whale / tohorā	*Eubalaena australis*	At Risk – Recovering	Least Concern	Seasonal Migrant	Frequent the inshore, shallow regions of Tasman Bay during seasonal migration periods of winter and spring. Once present, they can remain in the region for several days to weeks. Most often seen in Tasman region between August and September.
Humpback whale	*Megaptera novaeangliae*	Migrant	Endangered	Seasonal Migrant	Pass by Tasman Bay on both north and south migrations, but more prevalent and closer to shore on northern migration (mainly June to August).
VISITORS					
Bottlenose dolphin / terehu	*Tursiops truncatus*	Nationally Endangered	Data Deficient	Seasonal to Year-Round Visitor	Small resident population across the top of the South Island and larger Cook Strait coastal region. Animals regularly travel to and from western and eastern areas of the Marlborough Sounds and into Tasman / Golden Bays. Generalist feeders.
Dusky dolphin	*Lagenorhynchus obscurus*	Not Threatened	Data Deficient	Seasonal to Year-Round Visitor	Seasonal movements from Kaikōura through the Marlborough Sounds, Tasman / Golden Bays to the West Coast over the colder months of winter and back in spring.
Orca (killer whale) / maki	*Orcinus orca*	Nationally Critical	Data Deficient	Seasonal to Year-Round Visitor	Two of three NZ sub-populations of orca travel between / or around the South Island. Can be encountered any time of year but occur in Tasman Bay more in spring to autumn months. Feed on stingrays and a variety of fish and marine mammals.
Common dolphin / aihe	*Delphinus delphis* (including *D. capensis*)	Not Threatened	Least Concern	Seasonal to Year-Round Visitor	Most commonly seen cetacean in South Taranaki Bight / Cook Strait area; regularly seen in mid-waters of Tasman and Golden Bays, sighted year-round, generally more common in inshore regions over warmer months. Feed on schooling or more pelagic fish species.
Pilot whales	*Globicephala melas, G. macrohynchus*	Not Threatened to Data Deficient	Data Deficient	Offshore Seasonal Visitor	Known to migrate through Cook Strait, with a chance of at least one or two groups venturing into Tasman Bay each year. More common over summer. Forages off shelf waters. Known for frequent and mass strandings off Farewell Spit in Golden Bay.

2.2. Species of interest

Based on the available data and published research, the main species of interest in regard to discharge activities are New Zealand fur seal / kekeno (*Arctocephalus forsteri*), bottlenose dolphin / terehu (*Tursiops truncatus*) and dusky dolphin[3] (*Lagenorhynchus obscurus*), in addition to orca / maki (*Orcinus orca*) and Hector's dolphin (*Cephalorhynchus hectori hectori*) (Table 1). A short summary of these species is given below, and Appendix 3 has further species information.

New Zealand fur seal is the only pinniped species known to occur regularly within Tasman Bay waters year-round. Haul-out sites along rocky shore regions are used throughout the year, when seals come ashore to rest or moult (Goldsworthy & Gales 2008). Individuals are frequently observed resting along the Boulder Bank (Figure 3) and Haulashore Island's breakwaters adjacent to The Cut, and occasionally travel up the tidal channels of the Haven and the Maitai River. This species easily and repeatedly covers large distances, with individuals rarely remaining at one location year-round.

A small resident population of **Hector's dolphins** is found within Golden Bay and nearby Abel Tasman National Park waters year-round (Figure 2). While the vast majority of their visits to Motueka and Nelson waters occur in the warmer months, individual animals are sighted throughout the year in the Nelson region. Acoustic monitoring recorded Hector's dolphin high-frequency clicks at the discharge site only in late winter (Table 2). Hector's dolphins are listed in New Zealand as a Nationally Vulnerable species due to their regional distribution, small home ranges and fairly low total abundance (Baker et al. 2019). Despite their extremely low occurrence in the discharge area, their conservation status means that any potential impacts warrant consideration due to the potential consequences for the wider population (Table 1).

Seasonal and more occasional visitors to Tasman Bay, and particularly along the Boulder Bank, include **orca**, **dusky** and **bottlenose dolphins**, and **common dolphins / aihe** (*Delphinus delphis*). These species tend to visit Tasman Bay periodically, in the case of bottlenose dolphins, or during particular seasons (i.e. orca, dusky dolphins) for 1–2 days at a time. The underwater acoustic monitoring confirmed visits by mid-frequency dolphin species (e.g. bottlenose, dusky and common dolphins) in the discharge area throughout the year. With the exception of late winter / early spring, these visits were relatively infrequent (i.e. less than 10% of sampling time; Table 2). When present, these species tend to travel along the Boulder Bank, and the Haven in the case of orca, sweeping up and down the shoreline searching for prey.

While no visits from **southern right whales / tohorā** (*Eubalaena australis*) were recorded, acoustic results indicated that other whale species (possibly humpback

[3] Māori name not currently known.

whales (*Megaptera novaeangliae*) and sei whales (*Balaenoptera borealis*)) were present in Tasman Bay (see Figure A2.4). Other species that mainly remain within deeper, offshore waters include **common dolphins**, **pilot whales** (*Globicephala melas*), **humpback whales** and other baleen whales.

It is important to note that as baleen whale calls are in the low-frequency ranges, they can be heard over very large distances (greater than 20 km from recorders). Hence, these results likely suggest whales were located somewhere within Tasman Bay or near its entrance, rather than in the discharge area itself. Acoustic records over early spring and early winter are likely from humpbacks passing through Cook Strait on migration (Gibbs et al. 2017), while whale calls in summer and autumn match those of sei whales, which are potentially travelling to or from feeding grounds in the South Taranaki Bight on their way south to Antarctica (e.g. Hutching 2006).

Figure 3. Left: bottlenose dolphins / terehu swimming off the Boulder Bank near the wastewater treatment plant discharge. Top right: Hector’s dolphin swimming off the Boulder Bank lighthouse. Bottom right: New Zealand fur seal / kekeno on the Boulder Bank just northeast of Glenduan. Photo credits: Cawthron.

Table 2. Summary of the total number of marine mammal vocalisation events detected by the SoundTrap deployed near the Nelson North Wastewater Treatment Plant discharge during the four survey periods between August 2020 and June 2021.

Species	Deployment	1a	1b	2	3	4
	Recording start	1 Aug 2020	9 Sep 2020	8 Dec 2020	1 Mar 2021	1 Jun 2021
	Recording end	8 Aug 2020	22 Sep 2020	8 Jan 2021	31 Mar 2021	30 Jun 2021
	No. days recording	7	13	31	30	29
Dolphins (other than Hector's)	No. of minutes detected	164	77	41	37	12
	No. of events[1]	4	4	4	3	1
	No. of days with detections	3	3	3	2	1
	Percentage of days with ≥ 1 detections	43%	23%	10%	7%	3%
	Events per day	0.57	0.31	0.13	0.10	0.03
Hector's dolphin	No. of minutes detected	57	0	0	0	0
	No. of events*	1	0	0	0	0
	No. of days with detections	1	0	0	0	0
	Percentage of days with ≥1 detections	14%	0	0	0	0
	Events per day	0.14	0	0	0	0
Southern right whale	No. of minutes detected	0	0	0	0	0
	No. of events*	0	0	0	0	0
	No. of days with detections	0	0	0	0	0
	Percentage of days with ≥ 1 detections	0	0	0	0	0
	Events per day	0	0	0	0	0
Other whales	No. of minutes detected	0	1	2	2	2
	No. of events[1]	0	1	2	2	2
	No. of days with detections	0	1	2	1	2
	Percentage of days with ≥ 1 detections	0	8%	6%	3%	7%
	Events per day	0	0.08	0.06	0.07	0.07

* A single detection event is defined as the time between the first and last confirmed vocalisation (either echolocation clicks or whistles) after no vocalisations were detected for more than 30 minutes following the last detection.

2.3. Species summary

It is important to note that, with regards Policy 11(a)[4] of the New Zealand Coastal Policy Statement (NZCPS), several of the species discussed are considered threatened or endangered within New Zealand waters: orca are classified as Nationally Critical, bottlenose dolphin are Nationally Endangered and Hector's dolphin are Nationally Vulnerable (Baker et al. 2019). However, based on the available data, and with regards Section 6(c) of the Resource Management Act 1991 (RMA) and Policy 11(b) of the NZCPS,[5] there is no evidence to indicate that any of these species have home ranges restricted solely to Tasman Bay waters. Nor can the habitat around the discharge be considered ecologically more important in terms of feeding, resting or breeding habitats for any particular species relative to other regions around Tasman Bay or the western top of the South Island region. In this regard, the discharge area represents a small fraction of similar habitats used by some marine mammal species frequenting the larger Tasman and Golden Bay ecosystems.

[4] Policy 11(a) – avoid adverse effects of activities on: (i) indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System (NZTCS) lists; (ii) taxa that are listed by the International Union for Conservation of Nature and Natural Resources (IUCN).

[5] Section 6(c) – the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna. Policy 11(b) – avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on: (ii) habitats in the coastal environment that are important during the vulnerable life stages of indigenous species; (iv) habitats, including areas and routes, important to migratory species.

3. POTENTIAL EFFECTS OF WASTEWATER CONTAMINANTS ON MARINE MAMMALS

Marine mammals are often referred to as 'marine sentinel organisms' or barometers for current ocean health issues (e.g. Bonde et al. 2004; Jessup et al. 2004; Wells et al. 2004; Bossart 2011). With long lifespans, high-trophic-level diets and coastal residency, marine mammals are vulnerable to the bioaccumulation of anthropogenic contaminants. Measurable amounts of chemical pollutants have now been found in virtually every species of marine mammal tested worldwide (Kraus & Rolland 2007).

The lipophilic (fat-soluble) and persistent nature of some chemicals makes marine mammals particularly vulnerable to bioaccumulation within their thick blubber layers (a lipid-rich, collagen fibre-laced tissue), in addition to biomagnification due to their generally higher trophic level in the food chain (Woodley et al. 1991; Weisbrod et al. 2000). Trace elements (e.g. trace or toxic metals) are also known to accumulate in the protein-rich tissues of marine mammals, such as the liver and muscle. Once contaminants are retained within an animal, they are not easily eliminated except during pregnancy and lactation, during which some contaminants can be passed to the offspring (Tanabe et al. 1994).

A comprehensive review of pollutant concentrations across southern hemisphere marine mammals found that coastal-living species in higher trophic levels (fish-eating) and with smaller bodies tend to have greater concentrations of most pollutants (Evans 2003). As a result, local marine mammals are often considered when assessing the potential effects of various discharges and / or contaminants on marine ecosystem health (Bonde et al. 2004). Key factors that influence the severity of potential effects from discharge contaminants on marine mammals include:

- types of contaminants
- pathways of exposure
- baseline health and susceptibility.

3.1. Types of contaminants

The focus on contaminants of concern for marine mammals has shifted over the decades from trace metals to legacy pollutants,[6] many of which are known for their endocrine disrupting potential. Endocrine disrupting chemicals (EDCs), known to affect reproductive and / or immune functions, include synthetic organic chemicals used in past industry and agriculture (e.g. organochlorine pesticides – OCPs) and those currently used for plasticisers and detergents (e.g. alkylphenols; Fossi & Marsili 2003).

[6] Legacy pollutants are generally persistent contaminants that have been left in the environment by sources that are no longer discharging them. As they are very hard to break down and often are not soluble in water, they remain long after the source disappears.

The best-studied organochlorine endocrine disruptors are organochlorine pesticides (e.g. DDT) and polychlorinated biphenyls (PCBs – dioxins and furans) used previously as coolants and lubricants for electrical equipment.

Wastewater discharges with elevated concentrations of fats, oils and greases are also a major concern for marine wildlife. However, the chemicals of concern for marine mammals are not the aromatics present in oils, despite their toxicity. The high volatility of aromatics means they are found in large concentrations only immediately after a spill of untreated wastewater during treatment malfunction / infrastructure breakdown and generally disperse quickly. Instead, the less volatile polycyclic aromatic hydrocarbons (PAHs) are of greater concern for marine mammals because they are more persistent and have a wide range of adverse effects, including endocrine disruption (Godard-Codding & Collier 2018).

More recently, emerging organic contaminants (EOCs) have become a global focus of concern as little is known about their fate or effects on the environment. These chemicals are found in pharmaceuticals and personal care products (PPCPs), such as soaps and detergents, and ultimately end up in wastewater systems. More information on both EDCs and EOCs can be found in Northcott et al. (2022) and Appendix 4.

3.2. Pathways of exposure

The three main routes of contaminant exposure in cetaceans, as in most animals, are respiratory, dermal and oral (Godard-Codding & Collier 2018). Contaminants within the water column can be absorbed or actively taken up by organisms via the gills, skin, buccal cavity and gastrointestinal tract, through lesions and lacerations in the skin or, in the case of marine mammals, aspirated into the lungs while the animal is at the surface. Some chemical and biological contaminants can concentrate in sea-surface microlayers (appearing as slicks) and / or bind to floating debris that can be directly ingested by coastal marine mammal species (Kraus & Rolland 2007). Due to the aggregating effect of coastal currents and frontal zones, baleen whales may swim through, and feed directly on, some contaminants. For other species that feed on fish, exposure to chemical contaminants may occur via the food chain or indirectly via the skin if they are in proximity to areas influenced by high levels of industry or agriculture (Damstra et al. 2002). Alternatively, exposure during critical periods of development for marine mammals can occur via maternal transfer to their young, either via the placenta during gestation or when young are suckling (Tanabe 2002; Fossi & Marsili 2003).

Bioaccumulation is a process by which an organism absorbs and stores a chemical substance (natural or anthropogenic) in its tissues at a higher rate than the substance is broken down or excreted from its body. High chemical stability and resistance to metabolic degradation means that a range of substances can remain active within the environment through several generations. Sediments, plants and / or plankton can absorb varying amounts of chemical contaminants once these are released into the marine ecosystem. Some contaminants tend to adsorb to fine-grained particles (e.g. silt and clay) due to their larger surface areas and organic matter content. Organisms such as seaweed and plankton can accumulate toxins in their tissues and, due to their persistence, these stored toxins usually remain in the organism until it dies or is eaten, when the chemicals are passed on to the consumer. This build-up of pollutants within lower-trophic organisms is later passed on in greater and greater concentrations through the trophic levels, a process known as biomagnification.

Due to biomagnification, continued exposure (and thus storage of a particular substance within the tissues of an organism) can occur even when environmental concentrations of the same substance are low or no longer exist. In addition, fat-soluble substances can be released when the fat is broken down for energy. Such toxins can circulate in the bloodstream of an animal and affect certain tissues and / or disrupt the normal functions of hormones.

The constant processes of bioaccumulation and biomagnification taking place within marine mammals means that any testing for potential exposure to a contaminant (via skin scrapes or biopsies of blubber) cannot be easily linked to a single source and / or response from the animal.

3.2.1. Level of exposure

Currently, there are no national or international guidelines for monitoring contaminant exposure in marine mammals in relation to wastewater discharges. Existing best practice for assessing exposure risk in the case of a discharge is based mainly on the quality of the wastewater or the sediments and water column conditions near the discharge point. The quality of the wastewater depends largely on the original source of the wastewater (e.g. domestic, industrial), the level of treatment (e.g. primary, secondary, tertiary), final concentrations and persistence of wastewater contaminants.

The level of exposure of marine mammals to contaminants also depends on the amount of wastewater dilution and / or dispersion in the receiving environment. There are several specific life-history characteristics that potentially increase the degree to which a species might be exposed to a discharge. These include a preference for shallower inshore waters near urban areas, year-round residency within a restricted home range near the discharge, or a carnivorous diet based mainly on prey species that are regularly exposed to a discharge.

Understanding the concentration of a contaminant being discharged into the environment can help with evaluating the likelihood that a species will encounter the contaminant within their habitat at concentrations of potential concern. However, even with a sound knowledge of wastewater quality, predicting the possible exposure of a marine mammal to chemical and biological contaminants, and the animal's subsequent response, is confounded by many still unknown factors. There is rarely a clear relationship between contaminant concentration and its likely effect(s) on marine mammals (e.g. AMSA 2015). The response of any given species to the contaminant(s) varies with prey preference and subsequent uptake, home range, sensitivity to contaminants, health, immunological status of individual animals and other environmental conditions, some of which can cause synergies between contaminants (e.g. Jones 1998; La Patra 2003). Hence, exposure concentration is used as a broadscale indicator of the likelihood of lethal effects (French-McCay 2009).

3.3. Baseline health and susceptibility to contaminants

Natural resistance is normally effective enough to protect healthy marine mammals from infectious disease or contaminants. But when the physiological integrity of an individual is compromised by exposure to chronic pollution, particularly during more sensitive life stages (e.g. foetal or egg development), this may lead to immune suppression. Such a condition may lead to outbreaks of disease from pathogens already present in the environment or to pathogens already held by a host under a normal, non-stressed situation (Rice & Arkoosh 2002).

A comprehensive review of pollutant concentrations in southern hemisphere marine mammals found that the species that tended to accumulate the greatest concentrations of pollutants were mainly smaller ones that inhabited coastal regions and were in higher trophic levels (fish-eating animals) (Evans 2003). Species that are present year-round tend to be more susceptible to both chronic (small amounts over several different periods) and acute (one large event) exposure than species with seasonal movement patterns. Species that are in the area to feed or breed are also more susceptible to contaminants than those that just travel through a region.

4. ASSESSMENT OF EFFECTS

Predicting the actual / potential effects of wastewater discharges on marine mammals is complex. As discussed in the previous section, this must be based mainly on the quality and type of wastewater and the expected exposure risks to individual species.

4.1. Discharge quality

An environmental monitoring programme was undertaken during the period August 2020 to December 2021 to obtain additional data to support the coastal permit renewal application for NWWTP. In this monitoring programme, samples of wastewater, fresh water, seawater and groundwater were taken from points in the wastewater treatment process and discharge-receiving environment and tested for a range of physical, chemical and microbiological parameters (Campos & Morrisey 2022). These results are not represented in detail here; instead, they are summarised below.

Campos and Morrisey's (2022) results indicated that the quality of the discharge from NWWTP is typical of that in other New Zealand WWTPs with well-performing oxidation ponds and wetland systems. Concentrations of faecal coliforms and trace metals (cadmium, chromium, copper, lead, mercury, nickel, zinc) and other toxic substances (cyanide, phenols) were generally below the discharge permit limits, with many results at or just above the limits of detection of the testing methods. Concentrations of volatile and semi-volatile organic compounds and oil and grease in the wastewater were also at or just over the limits of detection of the testing methods, except for a single, relatively high, result for oil and grease detected at the wetland outlet (Campos & Morrisey 2022). Overall, the concentrations of trace metals in the receiving environment after reasonable mixing (i.e. at or beyond the mixing zone) of the wastewater are consistent with meeting the ANZG (2018) water quality guidelines for the protection of aquatic life (95% protection level). Furthermore, several decades of wastewater disposal monitoring undertaken by Cawthron has found few discernible effects from the discharge on the seabed, and effects on water quality have been highly localised – i.e. within the confines of the discharge mixing zone (Barter & Forrest 1998; Sneddon 2018; Morrisey 2021). The effects are minimised through a subtidal diffuser discharge that promotes rapid mixing and dilution of the wastewater and a tidally driven wastewater dispersion, which prevents effects in nearshore waters.

Several EOCs – including bisphenol A and estrone, which are recognised endocrine disrupters – and the pharmaceuticals carbamazepine, diclofenac and ibuprofen were recently found in wastewater samples from the NWWTP at concentrations two orders of magnitude higher than their 'predicted no-effect concentration' values (Northcott et al. 2022). However, the high dilution available and the dispersive characteristics of the discharge-receiving environment are considered sufficient to dilute the concentrations of the EOCs below their predicted no-effect concentration values at and beyond the mixing zone.

Mean concentrations of microplastics in the NWWTP discharge were also found to exceed those reported for other treatment plants. These represent a potential risk of chemical toxicity throughout the marine food web and may eventually reach marine mammals through bioaccumulation (Masterton et al. 2023). However, there is insufficient evidence linking microplastic concentrations typically detected in coastal environments and those reported to affect marine mammals, and there is also a lack of baseline data on the fate and transport of microplastics in the discharge-receiving environment.

4.2. Marine mammal exposure

The marine mammal species with the highest potential exposure are bottlenose or dusky dolphins, fur seals, orca and, to a much lesser extent, Hector's dolphins (Table 1). However, even for individuals of these species, the overall exposure risk from the NWWTP discharge is expected to be low. The most probable pathway for exposure to discharged contaminants is expected to occur via the food chain (through prey species). Those marine mammal species known to regularly travel along and visit the Boulder Bank tend to be generalist feeders that potentially range and forage throughout the entire Tasman Bay coastlines and beyond.

Other visiting species, such as whales, often do not often feed while migrating, and more offshore species feed mainly on deeper-water prey such as squid. The absence of any year-round resident marine mammals that regularly and consistently forage within the Boulder Bank or discharge region means that the chance of an individual animal ingesting prey or swimming through waters exposed to the discharge would be very low (Table 3).

Hence, the continuation of existing discharge activities is not expected to result in significant habitat loss for any marine mammals frequenting this region, nor result in any significant long-term or indirect effects on marine mammal species. This conclusion is based on the following:

- There is no population of marine mammal species that resides year-round along the Boulder Bank, discharge mixing zone and / or Tasman Bay. Instead, resident species such as the New Zealand fur seal, Hector's dolphin and bottlenose dolphin regularly move between Tasman / Golden Bays and / or the Marlborough Sounds, occasionally passing through the discharge area.
- There is no evidence that the habitats or waters potentially affected by the discharge serve as important, unique and / or rare habitat for any marine mammal species in terms of feeding, breeding and / or migratory activities.

- Seasonal trends in occurrence indicate that both dusky dolphins and orca are more likely to visit these inshore areas over winter / spring and spring to autumn months, respectively, rather than year-round.
- Very few (one to two individuals) of the whales migrating past this region each winter (mainly June to September) would venture close to the vicinity of the Boulder Bank / discharge region, and most do not feed while migrating.
- The generalist diet and roving nature of these marine mammal species indicates that contact between individual animals and prey species exposed to the discharge is expected to be very limited.
- There are generally low concentrations of chemical and microbiological contaminants found in NWWTP wastewater or the receiving environment, including seawater and sediments near the outfall diffuser.

Table 3. Summary of effects on marine mammal species from the Nelson North Wastewater Treatment Plant discharge into Tasman Bay nearshore waters.

Potential environmental effects	Spatial scale of effect on marine mammals	Persistence / duration of effect on marine mammals	Consequences for marine mammals	Likelihood of effect	Avoidance / mitigating factors	Significance level of residual effect
Direct chemical contaminant exposure	**Medium to Large:** Limited mainly to the mixing zone and habitats associated with worst-case scenario exposure (< 1 km)	**Short to Persistent:** Dependent on types of contaminants	**Individual level:** Limited potential for any individual to be directly exposed	**NA to Low**	• Pre-treatment prior to discharge • Contaminant concentrations well below guideline levels • No resident population of marine mammals in regular contact with discharge waters	**Nil to Negligible**
Indirect contaminant exposure via prey species	**Medium to Large:** Limited mainly to the mixing zone and habitats associated with worst-case scenario exposure (< 1 km)	**Short to Persistent:** Dependent on types of contaminants	**Individual level:** Limited potential for any individual to consume prey items exposed to discharge waters	**NA to Low**	• Qualitative surveys of benthic invertebrate communities that inhabit the outfall indicate that any effects on these communities are low to very low due to low contaminant concentrations and good dispersion and dilution of the wastewater • Negligible bioaccumulation and bioavailability of contaminants of greatest concern • Generalist diet and extensive home ranges limit contact with exposed prey	**Nil to Negligible**

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)
- Consequences: 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 others), 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)

5. SUMMARY OF EFFECTS

This report reviews and assesses NCC's proposal to renew its current coastal permit for the discharge of treated wastewater from the NWWTP into Tasman Bay and the potential of the discharge to adversely affect local and visiting marine mammals. Marine mammals are vulnerable to the bioaccumulation of anthropogenic contaminants due to their long lifespans, high-trophic-level diets and coastal residency. As a result, local marine mammals are often considered when assessing the potential effects of contaminant discharges on marine ecosystem health globally, as well as locally by tangata whenua.

Known factors that can influence the extent to which marine mammals may be affected by discharges include the types of contaminants present and potential pathways of exposure. Factors for which assessment is more challenging include the susceptibility and health of individual animals or affected species. Currently, there are no national or international guidelines for monitoring contaminant exposure in marine mammals from single-discharge sources. The processes of bioaccumulation and biomagnification mean that direct testing for such exposures cannot easily be linked back to a single source. Instead, current best practice for assessing the exposure risk from discharges is based mainly on the quality and type of discharge, combined with quantification of available dilution and supported by sediment and water quality data for the immediate vicinity of the discharge. These indicators are then considered against the likelihood of the species' exposure to discharges based on life-history dynamics such as home range and diet tendencies.

The more common species occurring within Tasman Bay, and therefore those most likely to be affected by the discharge, include bottlenose and dusky dolphins, orca and Hector's dolphin. Several other species that visit the area less frequently are also considered in this report because of their life-history dynamics (e.g. low population numbers) or because they are held in high regard culturally. However, the habitats in the proximity of the discharge are not considered to be unique and / or limited for any marine mammal species in terms of feeding, breeding and / or migrating activities. There is no species known to reside year-round within the proposal area, nor any solely reliant on foraging habitats in the area.

Based on the findings of contaminant testing and hydrodynamic modelling, no marine mammals visiting or passing through the proposal area are likely to be exposed to contaminant concentrations that exceed any ANZG thresholds. Additional mitigating factors, such as the temporary presence and generalist diet of these particular species, and the dilution and dispersion of the discharge into a high-energy marine environment, limit the exposure risk for individual marine mammals to discharge contaminants taken up from exposed prey. On these bases, the potential effects on marine mammals from the NWWTP discharge are considered negligible, and no mitigation is warranted.

6. APPENDICES

APPENDIX 1. SOURCES OF MARINE MAMMAL DATA AND INFORMATION

Only broadscale regional information is available for most of the marine mammals that use the Tasman Bay region. Multiple and finer-scale studies have been undertaken in both Golden Bay to the west and the wider Marlborough Sounds region to the east. The studies and databases used to make summaries and assessments of the marine mammal species discussed in this report are listed below:

- DOC opportunistic database and stranding record database
- National Aquatic Biodiversity Information System (NABIS)
- Scientific research through University of Auckland:
    - R Constantine – various studies on humpback and southern right whales around New Zealand
    - K Halliday – MSc thesis on several species in Admiralty Bay, Marlborough
    - E Carroll – various studies on southern right whales.
- Scientific research through Massey University at Albany:
    - K Stockin – various studies on common dolphins around New Zealand
    - C Cross – PhD thesis on tourism in Queen Charlotte Sound / Tōtaranui (hereafter Queen Charlotte Sound), Marlborough.
- Orca Research Trust – various Visser publications
- 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.
- Handley S, Sagar P. 2011. Seabird, marine mammal and surface-fish surveys of Tasman and Golden Bay, Nelson. Part A: aerial surveys. Prepared for Friends of the Nelson Haven and Tasman Bay Incorporated and AWE New Zealand Pty, Ltd. NIWA Client Report No. NEL2011-018. 39 p.
- MacKenzie DI, Clement DM. 2016. Abundance and distribution of WCSI Hector's dolphin. New Zealand Aquatic Environment and Biodiversity Report No. 168. 67 p. + supplemental material
- Stephenson F, Goetz K, Sharp BR, Mouton TL, Beets FL, Roberts J, MacDiarmid AB, Constantine R, Lundquist CJ. 2020. Modelling the spatial distribution of cetaceans in New Zealand waters. Diversity and Distributions 26: 495–516
- Taylor RH, Barton KJ, Wilson PR, Thomas BW, Karl BJ. 1995. Population status and breeding of New Zealand fur seals (*Arctocephalus forsteri*) in the Nelson–northern Marlborough region, 1991–94. New Zealand Journal of Marine and Freshwater Research 29: 223–234

- Webb BF. 1973. Dolphin sightings, Tasman Bay to Cook Strait, New Zealand, September 1968–June1969. NZ Journal of Marine & Freshwater Research 7(4): 399–405.

APPENDIX 2. UNDERWATER ACOUSTIC MONITORING OF MARINE MAMMALS

Simon Childerhouse (Cawthron Institute), Matt Pine (Styles Group)

A2.1. Introduction

As part of the assessment of environmental effects of the proposed activity, Cawthron Institute (Cawthron) was contracted by Nelson City Council (NCC) to undertake baseline underwater acoustic monitoring for the presence of marine mammals within the discharge area. The specific aims of the project were to:

- collate acoustic occurrence data on relevant species over four 1-month seasonal time periods near the discharge zone / area
- confirm which cetaceans visit this area throughout the year
- inform the relative temporal use by cetacean species within the general discharge area and wider Tasman Bay area (in the case of whales)
- use this information to help predict any potential exposure risks to marine mammals.

The acoustic monitoring project was a collaborative project between Cawthron, Styles Acoustic Group and Stantec.

A2.2. Methods

A2.2.1. Mooring set-up

The mooring comprised an Ocean Instruments NZ Ltd SoundTrap ST500 HF (Ocean Instruments, Auckland, New Zealand) acoustic recorder. This recorder was positioned within a metal frame and was attached to a sub-surface float to help it remain vertical and approximately 5 m off the bottom. The mooring itself was attached to the bottom with a Danforth anchor and / or attached to the acoustic Doppler current profiler mooring block when deployed for the same time period. A diagrammatic representation of the stand-alone mooring configuration is shown in Figure A2.1.

This deployment system was left in place for the full 12-month period, with the recorders being placed out for intervals of approximately 1 month every 3 months in order to sub-sample all four seasons. SoundTraps were set up to record at 288 kHz with a duty cycling of 1 minute's recording every 2 minutes (i.e. 1 minute on, 1 minute off). This allowed for the SoundTraps to have extended recording time. SoundTraps were set up with 9D-sized batteries with three 256 GB SD memory cards in addition to the 256 GB internal memory, bringing the total memory up to 1TB.

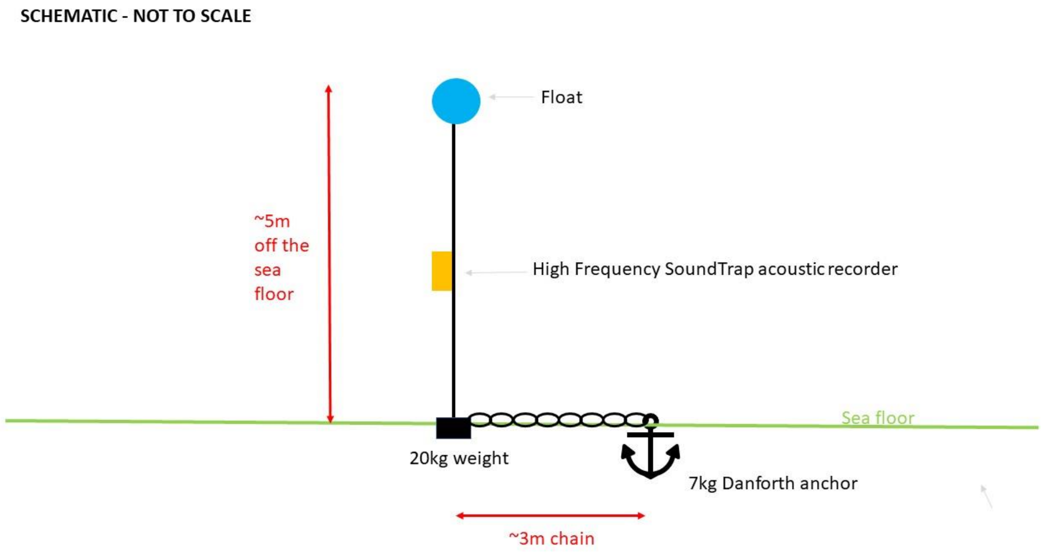


Figure A2.1. Diagrammatic representation of the mooring and SoundTrap acoustic recording unit.

It is important to note that as only a single recorder was used, the actual location of any animal recorded by the instruments cannot be calculated. Most dolphin species vocalisations (i.e. whistles or clicks) can be detected within a 300–500 m radius of the recorder. However, whale vocalisations are within the lower-frequency ranges and can travel much further than mid- or high-frequency sounds (e.g. dolphin vocalisations). As a result, whale vocalisations may be detected by the recorder from animals at distances as great as 20 km away in the case of blue whales.

A2.3. Data analysis

A2.3.1. Acoustic analysis procedure for the ambient sound levels

The waveform audio file format (WAV) files collected by the acoustic recorders were uploaded to the analysis software's file directory and restructured into 1-minute time-bins. The acoustic analysis software used for estimating ambient sound levels was PAMScan (Ocean Acoustics Ltd / Styles Group, Auckland). The results are provided for the four deployment periods.

A2.3.2. Automated detectors for dolphins

The data used to determine the presence of dolphins were from the SoundTrap recorder's click detector and were processed in PAMGuard.[7] The primary vocalisations from dolphins used to detect their presence are echolocation clicks, while whistles are secondary (see Figure A2.2 for examples). Echolocation clicks are the most reliable

[7] Open-source software for passive acoustic monitoring of marine mammals (https://www.PAMGuard.org).

vocalisations for this purpose because dolphins rely heavily on their biosonar for sensing their environment and these clicks are more easily distinguishable from other ambient noise. If a whistle is detected but no clicks are detected, the whistle must be manually checked. A second detector in PAMScan was trained on the spectrograms as images rather than the energy-based detectors in the SoundTrap recorder, and so provides an additional level of certainty in detecting dolphin presence from both clicks and whistles. These PAMScan click detectors have been trained on thousands of detections from around New Zealand and overseas, and verification of detections is very quick, since each detection event is saved with a corresponding audio and image file. PamGuard was also run on WAV files as it is trained on dolphin's whistles, providing an additional layer of reliability. However, because dolphins do not always vocalise using clicks and whistles, the two detectors were run concurrently on the two forms of datasets (e.g. click detector data and the WAV files). A single vocalisation was defined as one distinct unit of dolphin click-train, burst-pulse or whistle.

Individual clicks were detected throughout the dataset; however, for a detection to be flagged by the classifier, the clicks had to be from a train source. In other words, the inter-click intervals and amplitudes had to match the predetermined threshold requirements to be considered as a click-train source. While some species use unique frequencies or vocalisations (e.g. whistle inflections) that can differentiate them from other species, others do not. For example, several dolphin species generate echolocation clicks within the same mid-frequency range. In order to differentiate between these species, a more detailed analysis is required to discern between the acoustic signals of any associated whistle structures recorded. This process requires large amounts of acoustic data that cover the full vocal repertoire of each species for software training. The same process is needed to identify individual dolphins within the same species. For instance, bottlenose dolphins are known to have individually unique signature whistles, but these signatures need to be first recorded and identified, and then later matched to any new detections – assuming the animal makes these whistles whenever it vocalises, which is unlikely. For the purposes of this project, detection events were classified as either mid-frequency species (e.g. bottlenose, common or dusky dolphins[8]) or high-frequency species (e.g. Hector's / Māui dolphins; Figure A2.2). Hector's dolphin is one of the few species that can be easily distinguished from other dolphin species due to its use of high-frequency sounds rather than the very broadband clicks used by other dolphin species (Figure A2.2).

[8] It is difficult to distinguish between these species due to the similarity of their vocalisations, and so they have been combined for further consideration.

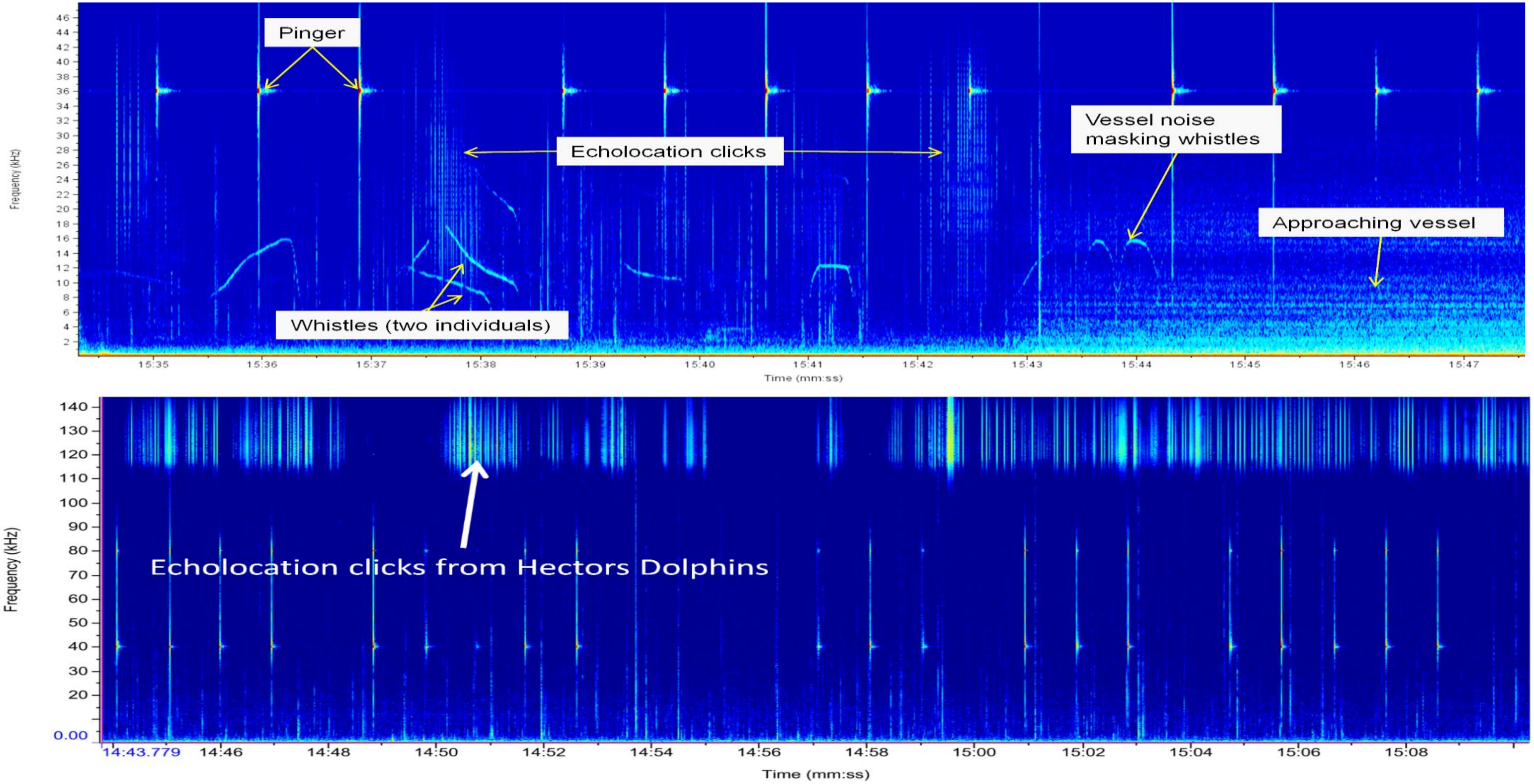


Figure A2.2. Spectrograms showing an example of detected dolphin whistles, echolocation clicks and approaching vessel noise (top panel), and echolocation clicks from Hector's dolphins (bottom panel). Hector's dolphins are narrow-band high-frequency species, meaning their echolocation clicks are predominately above 100 kHz and have significant differences in their durations from those of bottlenose / dusky dolphins, meaning their classification is highly reliable.

After confirming good agreement between detections in PAMGuard and PAMScan and manual verification with the SoundTrap's click detector, the click detector was relied on for all further data analysis. However, every detection made in PAMGuard from the SoundTrap's click detector was manually verified by assessing a combination of analysis outputs, including: the waveform, fast Fourier transform, Wigner plot, power spectral densities and, in some cases, the actual audio of every click within a click-train. Following a confirmed true positive, the start time, end time and duration of that detection event were logged, as well as minimum inter-click interval. A single detection event was defined as the time between the first and last confirmed vocalisation (either echolocation click or whistle) after no vocalisations were detected for more than 30 minutes following the last detection.

A2.3.3. Marine mammal detectors for whales

A specific detector for southern right whales was run as well as a composite detector for other low-frequency whale vocalisations similar to Hendricks et al. (2018). This composite detector can identify calls from baleen whales, such as blue, sei, minke, fin and / or humpback, but it can be difficult to distinguish between these species, so they have been combined for reporting purposes. The detector was based on an adaptive entropy band detector that processed the data through batch-processing. However, some input parameters such as the number of bands and filter bandwidths were adapted based on this survey's location and the deployment method. As a single recorder was used, triangulating the location of a calling whale was not possible. Low-frequency calls can be detected within close proximity to the recorder and as far as 20 km away in the case of blue whales.

A2.4. Results

A2.4.1. Deployments

The recorders were deployed over four separate 1-month-long seasonal sampling periods, starting in August 2020 and finishing in June 2021. All detection results of each deployment period are provided in Table 2 in Section 2.2 of this report. A short summary of the four deployment periods is provided below.

Deployment 1

The first deployment of acoustic recorders took place on 1 August to 22 September 2020 (51 days); results are shown in Table 2. The recorder was recovered successfully. However, a fault with one of the SD cards meant that a large chunk of the acoustic data was not retrievable. Hence, the deployment period has been broken into two distinct blocks of reliable recordings: (a) 1–8 August 2020 and (b) 9–22 September 2020.

Only dolphins were detected during the first part of this monitoring period (August). Hector's dolphins were recorded for 57 minutes, confirming that they are occasionally present in the area. The other dolphin clicks were likely to be either bottlenose, dusky or common dolphins, which are difficult to distinguish as their vocalisations are very similar. No southern right whales or any other whale species were detected in the first half of the sampling period but at least one other whale passed through the wider Tasman area during the second half of this sampling period (i.e. September).

Deployment 2

The second deployment of acoustic recorders took place on 8 December 2020 to 8 January 2021 (31 days) and was successfully completed; results are shown in Table 2. Either bottlenose, dusky or common dolphins were recorded, with a total of 41 minutes of detections over 3 days. There were also 2 minutes of vocalisations of whale species (possibly sei whales) across three different days. No Hector's dolphins were detected.

Deployment 3

The third deployment of acoustic recorders took place on 1 March to 31 March 2021 (30 days) and was successfully completed; results are shown in Table 2. There were 37 minutes of detections of dolphins, likely to be either bottlenose, dusky or common dolphins. No southern right whales or Hector's dolphins were detected. Two minutes of baleen whale vocalisations were detected over the same day.

Deployment 4

The fourth and final deployment of acoustic recorders took place from 1 June to 30 June 2021 (29 days) and was successfully completed; results are shown in Table 2. There were only 3 days totalling 12 minutes of non-Hector's dolphin detections, and 2 minutes of baleen whale vocalisations over this sampling period.

A2.4.2. Dolphin detections

These results confirm that several species of dolphin do visit the Boulder Bank region and discharge area throughout the year (Figure A2.3), albeit rarely and occasionally (e.g. Hector's dolphins < 1% of days and other dolphins < 15% of days on average, respectively). Greater detections rates of other dolphins were recorded over the late-winter and early-spring months (30% of days) relative to other sampling periods (Table 2, Figure A2.3). Hector's dolphin detections were recorded only during this same period.

Dolphin species tended to pass through this region mainly between late afternoon (1700 h) and into late morning (0700 h). No unexpected species vocalisations were noted from preliminary sampling of all datasets.

A2.4.3. Whale detections

Overall, there were 7 minutes of other baleen whale detections, which together relates to less than 6% of the total time that recorders were active. This result corresponds to baleen whales being detected on six different days during the year. Vocalisations recorded in September and June were most probably humpbacks, which typically migrate through Cook Strait during this period, while sei whales were likely the source of other vocalisations detected in summer and autumn (Figure A2.4). Despite southern right whales having been sighted within Tasman Bay previously, no southern right whale vocalisations were recorded by this acoustic monitoring programme. These results confirm that while whales do migrate through Cook Strait every year, they are only seasonal and infrequent visitors (e.g. < 6% of days) into Tasman Bay waters.

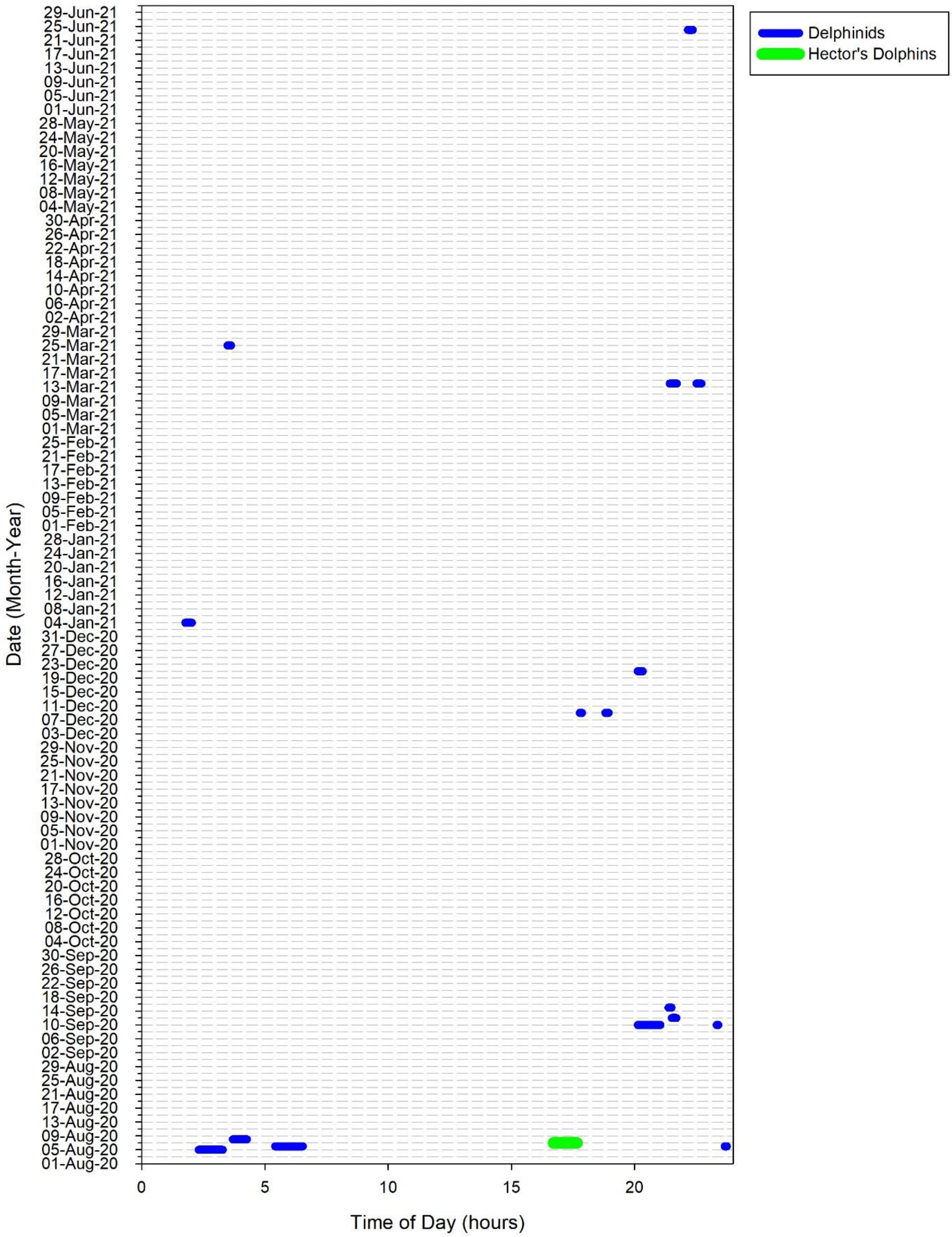


Figure A2.3 Seasonal acoustic detection of Hector's and other dolphins from the acoustic monitoring station placed near the Nelson North Wastewater Treatment Plant outfall in Tasman Bay between 1 August 2020 and 30 June 2021.

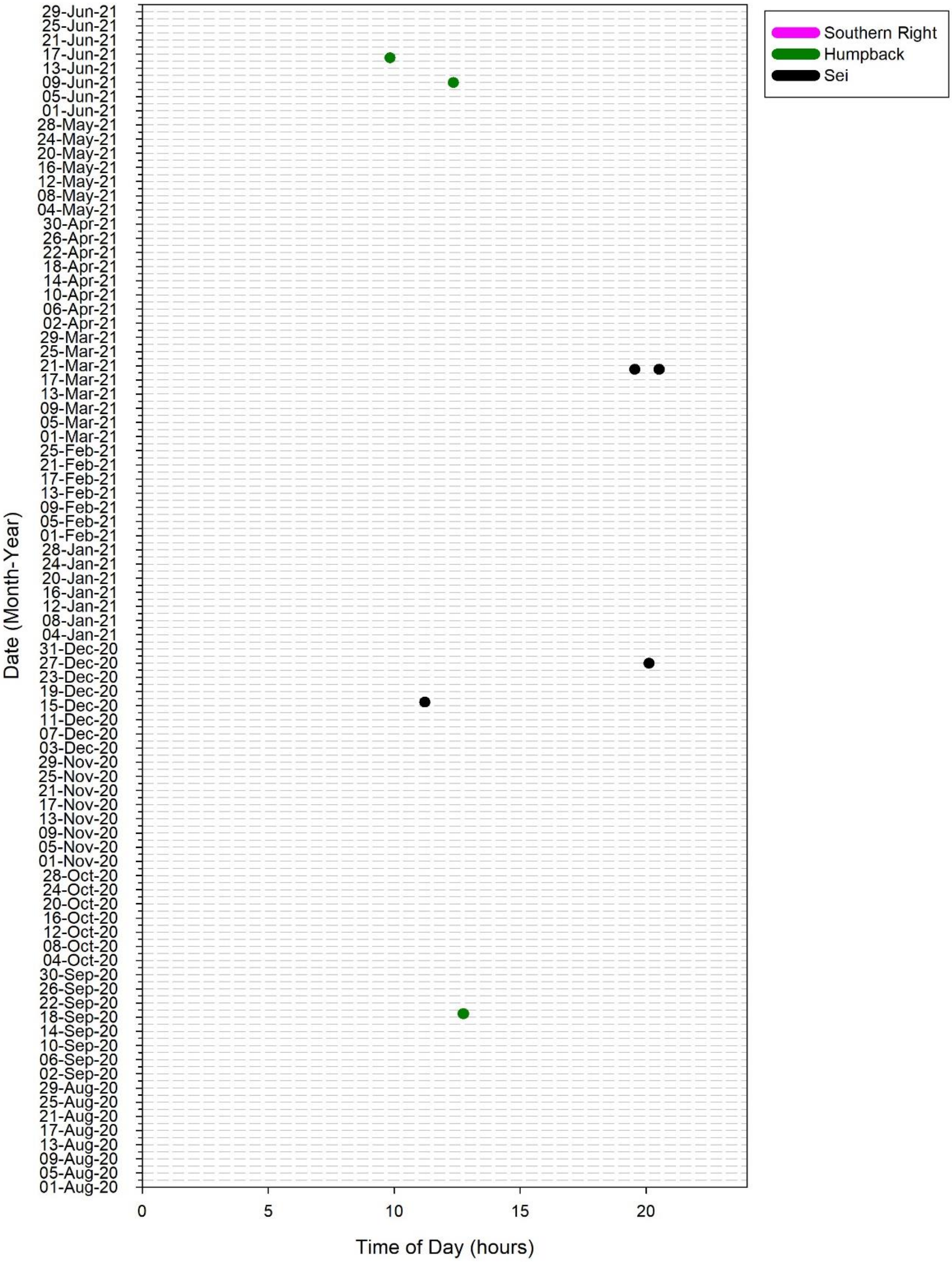


Figure A2.4 Seasonal acoustic detection of baleen whales from the acoustic monitoring station placed near the Nelson North Wastewater Treatment Plant outfall in Tasman Bay between 1 August 2020 and 30 June 2021.

APPENDIX 3. MARINE MAMMAL SPECIES SUMMARIES, MODIFIED FROM SNEDDON AND CLEMENT (2018)

The marine mammals most likely to be affected by the NWWTP discharge include those species that frequent Tasman Bay year-round or on a semi-regular basis (see Table 1). Other species of concern include those that are more vulnerable to anthropogenic impacts due to various life-history dynamics (e.g. low population numbers) or species-specific sensitivities.

New Zealand fur seals can be observed year-round across Golden and Tasman Bays and the Marlborough Sound as they move between several regional breeding rookeries and numerous haul-out sites, including the breakwaters off the northern tip of Haulashore Island in the Haven and along the Boulder Bank. The closest breeding colonies to the discharge site are more than 40 km away, off Tonga Island (along with other breeding sites in the Abel Tasman National Park area) and more than and 100 km away, off Stephens Island / Takapourewa (north of D'Urville Island). Seals are more densely clumped within the breeding colonies around summer periods, with pups generally leaving in winter / spring months. Haul-out sites along rocky shore regions are more regularly used throughout the year, when seals come ashore to rest or moult (Goldsworthy & Gales 2008). This species easily and repeatedly covers large distances, with individuals rarely remaining at any one location year-round. Fur seals are not currently considered threatened in New Zealand waters; therefore, their current conservation status is of Least Concern (Baker et al. 2019).

Orca sighted along the top of the South Island and in the Marlborough Sounds region belong to two of the three regional sub-populations as described by Visser (2000), known as either the 'North+South Island' and 'South Island only' sub-populations. As frequent transients through Marlborough Sounds and Tasman Bay waters, orca can be observed year-round but are more common during late spring and throughout summer months (Visser 2000; Slooten et al. 2002; DOC databases).

The North+South Island sub-population tends to forage on several different prey types, including fish, rays and sharks, and other cetaceans, while the South Island sub-population targets only cetaceans as prey (Visser 2000, 2007). Orca are the only cetacean species observed regularly and repeatedly entering the Haven when passing through the region, and in such instances are thought to be foraging for stingrays (and other prey) associated with the estuary (e.g. Visser 2000). However, the fact that these sub-populations eat other dolphin species may also explain why these species are not often observed in the area when orca are visiting. Orca are currently listed as Nationally Critical by the New Zealand Threat Classification System (Baker et al. 2019) based on low abundance.

Hector's dolphin is the only dolphin endemic to New Zealand waters. A small, fairly isolated local population of Hector's dolphin inhabits Golden Bay and nearby Abel

Tasman National Park waters year-round (MacKenzie & Clement 2016), with the occasional sighting reported between Motueka and Nelson each year (e.g. DOC and Cawthron sighting databases). Group sizes are usually small (one to three animals), and groups are usually clustered together within a general region. In other populations of Hector's dolphins around the South Island, the greatest densities occur during the summer and autumn seasons, when the dolphins are also more widespread (e.g. MacKenzie & Clement 2016).

Hector's dolphins are listed in New Zealand as a Nationally Vulnerable species due to their regional distribution, small home ranges and fairly low total abundance (Baker et al. 2019). A much larger population of this species (~600–1,000 dolphins) is associated with Clifford Bay and Te Koko-o-Kupe / Cloudy Bay (hereafter Cloudy Bay), just to the east of the Marlborough Sounds (MacKenzie & Clement 2016), with a small number of animals (~20 dolphins) regularly observed within Queen Charlotte Sound year-round (Cawthorn 1988; Clement et al. 2001). It is not known how much exchange may or may not occur between these local populations, but given their current conservation status, protecting vital genetic corridors between populations is a priority.

An open, yet semi-residential population of approximately 385 bottlenose dolphins ranges throughout the Marlborough Sounds (Merrimen et al. 2009), generally in groups of 30–40 animals (e.g. Cross 2018). These animals are thought to use the entire Marlborough Sounds region year-round, regularly and systematically moving from one end to the other (while additional animals migrate in and out of the region at the same time; Merriman et al. 2009). They are also known to periodically wander into Tasman / Golden Bays and Clifford / Cloudy Bays. The bottlenose dolphins within the Marlborough Sounds represent one of three isolated sub-populations around New Zealand's coastline. This species is currently listed as Nationally Endangered by the New Zealand Threat Classification System (Baker et al. 2019) due to the restricted ranges of the sub-populations, and the fact that the other two sub-populations have reported general population declines over the last decade.

Dusky dolphins are sighted in Tasman Bay more over the colder months of the year as they make seasonal movements between Kaikōura, the Marlborough Sounds and the west coasts of both main islands. Admiralty Bay in Marlborough Sounds is now recognised as an important wintering and feeding area for dusky dolphins migrating from Kaikōura and other regions around New Zealand (Markowitz et al. 2004; Davidson et al. 2011). Nationally, dusky dolphins are categorised as 'Not Threatened' and their population size, while considered large, is currently unknown for New Zealand (Baker et al. 2019).

Common dolphins are the most commonly seen cetacean in the South Taranaki Bight / Cook Strait area. This species tends to prefer mid- to deeper waters and is regularly seen in mid-waters of Tasman and Golden Bays throughout the year. Common dolphins may be more common in inshore regions of Tasman Bay over warmer months. Previous research from Clement and Halliday (2014) in Admiralty Bay suggests that this species is perhaps becoming more prevalent over time in these regions as waters in the Cook Strait and Marlborough Sounds continue to warm (Cawthron, unpubl. data).

Several baleen whale species migrate through Cook Strait and to South Taranaki Bight waters from early winter (May) to the late-spring months (November) each year. Most whale species begin their northern migrations in late autumn or winter; **humpback whales** travel from May to August and **southern right whales** from July to September. Southern right whales can be observed with newborn calves from August onwards (Carroll et al*.* 2014) and may remain in any one area for up to 4 weeks (Patenaude 2003). The southbound migration of humpback whales with their newborn calves begins in late September, passing by the South Island until late November / December. Less is known about the timing of **blue**, **sei**, **minke** and **fin whale** migrations past New Zealand, although most sightings of blue and minke whales in the South Taranaki Bight are observed from late winter to early summer. Of these species, only southern right whales are considered At Risk – Recovering by the New Zealand Threat Classification System (Baker et al*.* 2019), as their preference for shallow, protected bays and coastal waters (particularly for calving) overlaps with numerous anthropogenic activities in New Zealand's waters.

Potential offshore residents, migrants and visitors to South Taranaki Bight / Cook Strait and outer Tasman Bay waters include **pilot whales**, several species of **beaked whales** (including Gray's beaked whales (*Mesoplodon grayi*) and **sperm whales** (*Physeter macrocephalus*)) (DOC databases; Brabyn 1990). These species are known as deep-water species that spend the majority of their time offshore and feed on deep-water prey, such as squid. In general, these species tend to be more prevalent in Cook Strait or Tasman Bay over the warmer summer months. Pilot whales are known to migrate through Cook Strait over summer and autumn, with a high chance of at least one group stranding off Farewell Spit each year. Stranding records suggest they follow the coastline once past Tasman Bay, which implies they pass Separation Point and are not often near the proposal area.

APPENDIX 4. ADDITIONAL INFORMATION ON CONTAMINANTS

A4.1. Endocrine disrupting chemicals (EDCs)

There is ongoing concern over the potential adverse effects of environmental contaminants with endocrine and reproductive activities to cause what has been described as endocrine disruption in wildlife and humans (Colborn et al. 1996). Chemicals that can interfere with the normal functions of the endocrine system are referred to as endocrine disrupting chemicals (EDCs), and many are also known to affect reproductive function. The main mechanisms of toxicity by which EDCs disrupt the endocrine system are through mimicking steroid hormones (e.g. oestrogens, androgens) and binding to specific cellular receptors modulating (agonistic; oestrogenic or androgenic) or blocking a response (antagonistic; anti-oestrogenic or anti-androgenic; Fossi & Marsili 2003; Diamanti-Kandarakis et al. 2009). Thousands of natural and synthetic chemicals are expected to have endocrine disrupting effects. However, it is important to note that EDCs may also cause toxicity through other mechanisms (e.g. Diamanti-Kandarakis et al. 2009).

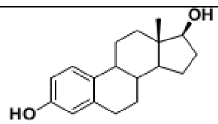
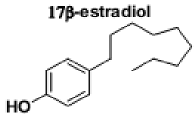
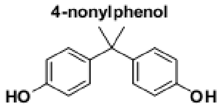
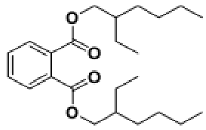
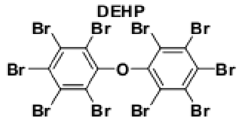
EDCs can be naturally occurring, such as hormones excreted by humans or phyto-oestrogens found in plants. They can also be manufactured chemicals, including synthetic hormones and compounds ranging from pesticides and industrial chemicals such as breakdown products of the surfactant alkylphenols, to the plasticisers bisphenol A and phthalates (Leusch et al. 2006; Table A4.1). Alkylphenols (e.g. nonylphenol and octylphenol) are breakdown products of alkylphenol polyethoxylates (APEs). APEs have been used for more than 40 years in household domestic products such as cosmetics, emulsifiers, wetting agents, detergents and dispersing agents. They are also used in many commercial sectors, including pulp and paper processing, textile manufacture, resins and synthetic coatings. Their widespread use has consequently led to the frequent detection of these compounds in wastewater discharged into the environment. In addition, nonylphenol has also been detected in both industrial and municipal wastewater as it is a degradation product of alkylphenolic compounds with oestrogenic activity (Desbrow et al. 1998; Sheahan et al. 2002).

A4.2. Pharmaceutical and personal care products (PPCPs)

An area of increasing global concern with regards emerging organic contaminants (EOCs) is the fate and environmental effects of pharmaceutically active products (PhACs; Kummerer 2009, 2010) and personal care products (Ternes et al. 2004), together termed PPCPs. This is especially pressing given the dramatic increase in the number of new products (Tremblay et al. 2011). At present, there is a general lack of baseline information on the fate and behaviour of these chemicals to assess their environmental risk, as highlighted in a review by Fent et al. (2006). Some potential issues include the rise in antibiotic-resistant bacteria, decreased decomposition rates of other contaminants due to diminished natural microbial communities (Boxall et al. 2005; Kemper 2008; Snow et al. 2008), and multi-generational effects from combinations of PPCPs (e.g. Dietrich et al. 2010).

The main sources of EOCs released into the environment have been identified as municipal wastewater discharges and agricultural wastes (US Geological Survey 2011). A wide range of PPCPs – such as antimicrobial agents, musks found in soaps, shampoos and toothpastes – enter waste systems and, ultimately, the municipal wastewater. Many of these PPCPs are not completely removed by wastewater treatment technologies (Ternes et al. 2004; Liu Z-H et al. 2009). Recent New Zealand research into the presence of PPCPs in wastewaters and environmental matrices has focused mainly on PhACs in both sewage wastewaters and / or biosolids (Gielen 2007; Stewart et al. 2009). Results varied across treatment options and environmental compartments, with some short- and long-term effects on soil microbial communities (Gielen 2007) and potentially high concentrations of PhACs entering the marine receiving environment through soil and sediments (Stewart et al. 2009).

Table A4.1 Endocrine disrupting chemicals (EDCs) of highest priority to New Zealand (Sarmah et al. 2006). EDCs are scored and ranked according to criteria such as source, potency, environmental concentrations, persistency, mobility, bioaccumulative potential and removal during treatment.

Class of EDC	Representative	EDC priority score[a]
Steroid Estrogens	 17β-estradiol	15
Alkylphenol ethoxylates and metabolites	 4-nonylphenol	14
Bisphenol A	 BPA	10
Phthalates	 DEHP	10
Brominated Flame Retardants	 BDE-209	9-11
Heavy Metals	Cd, As, Pb, Hg	7

[a] Sarmah *et al*. 2005

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