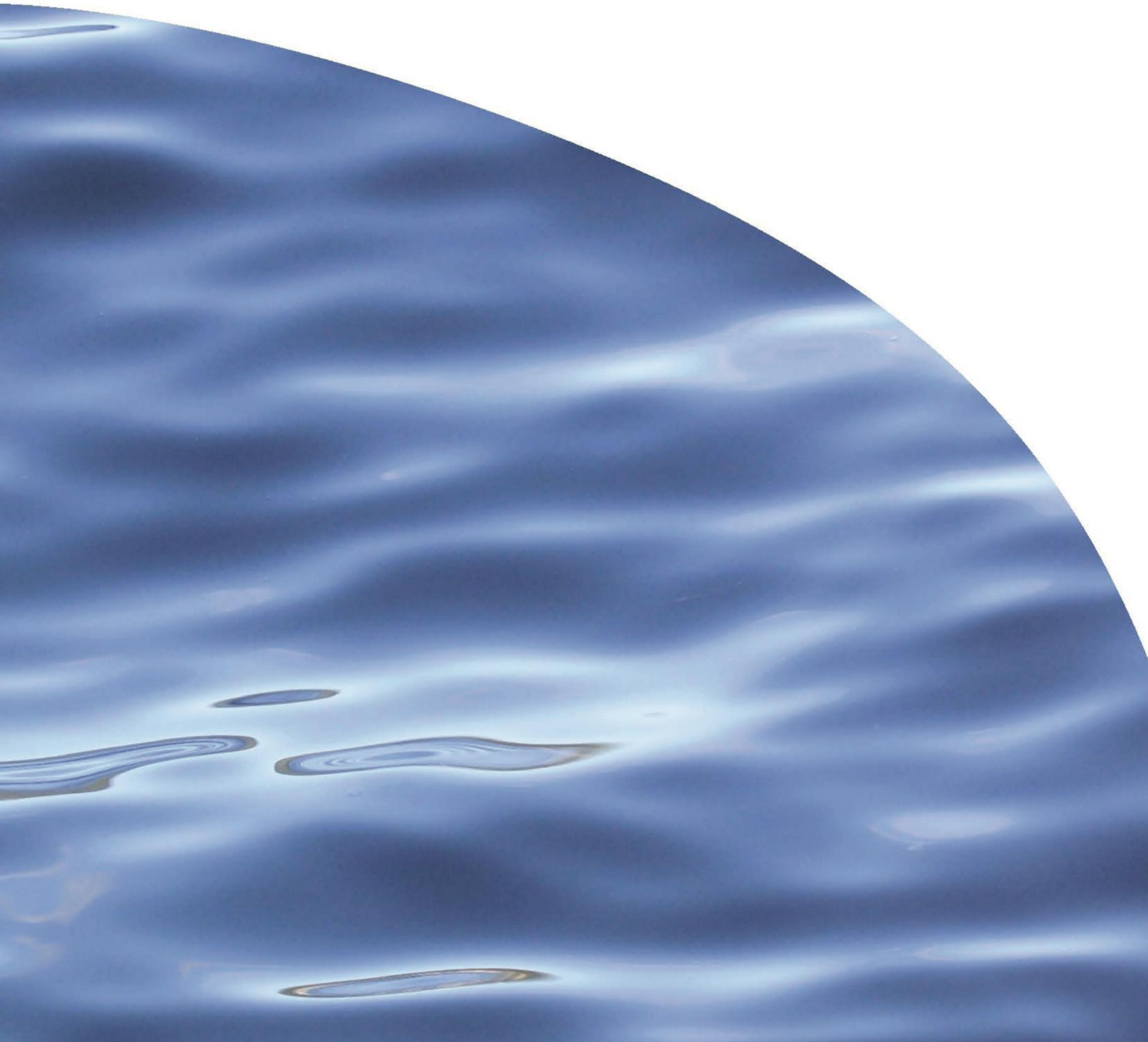
REPORT NO. 2910

ASSESSMENT OF EFFECTS ON MARINE MAMMALS FROM PROPOSED DEEPENING AND REALIGNMENT OF THE WHANGAREI HARBOUR ENTRANCE AND APPROACHES



ASSESSMENT OF EFFECTS ON MARINE MAMMALS FROM PROPOSED DEEPENING AND REALIGNMENT OF THE WHANGAREI HARBOUR ENTRANCE AND APPROACHES

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Prepared for Chancery Green on behalf of the New Zealand Refining Company Limited (trading as 'Refining NZ')

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EXECUTIVE SUMMARY

Refining NZ (RNZ) is proposing to utilise more heavily-laden tankers to transport crude oil to its refinery in Whangarei Harbour, which would ultimately result in fewer crude oil shipping movements compared to current numbers. To accommodate heavier vessels, Whangarei's inner harbour, harbour entrance and various locations along the shipping channel would need to be dredged, some areas re-aligned and navigational aids modified accordingly. As part of the resource consent application process, RNZ contracted the Cawthron Institute to investigate possible environmental effects of the proposal on local and regional marine mammal species. This report outlines and assesses the potential effects of dredging, disposal and pile-driving activities on the relevant marine mammals.

Out of the 29 marine mammal species that have been sighted or stranded within Whangarei and Bream Bay waters, only four species regularly or seasonally frequent these coastal waters. These species are bottlenose dolphin, orca, Bryde's whale and common dolphin. Several other species, that visit the area less frequently, are also considered in this report because various life history dynamics (e.g. low population numbers) or species-specific sensitivities (e.g. acoustically sensitive) make them potentially vulnerable to effects of dredging. Tangata Whenua also hold most of these species in high regard, as their name for the harbour, Whangarei te rerenga parāoa, means 'the gathering place of whales'.

The direct effects of dredging and pile-driving activities that are most relevant to marine mammal species in the Whangarei region are: vessel strike, increased underwater sound production and possibly the risk of entanglement. While these effects have the greatest potential consequences (i.e. injury or death of a marine mammal), the actual likelihood of them occurring in this case is low, and overall the effects are deemed *de minimis* with proposed mitigation actions.

Indirect effects of dredging and disposal activities on marine mammals may result from physical changes to the habitat itself that adversely affect the health of the local ecosystem and/or impinge on important prey resources. Given the location and habitats associated with the dredging proposal, the review of possible indirect effects to the ecosystem focused on: quality of spoil; and ecological effects on the benthos and associated fish assemblages, including the effects of any resulting turbidity plumes. Overall, any indirect effects of project activities are not expected to be detrimental for local or visiting marine mammals in the region, and any such effects will be temporary.

Several avoidance/remediation/mitigation and monitoring measures are recommended, including an informative (rather than an impact) monitoring plan. Recommended measures involve a combination of visual sightings (both opportunistic and from the project vessels themselves) with simultaneous passive underwater acoustic monitoring collected within the proposal area before, during and after dredging and disposal activities. Such a programme will report on the actual effects of dredging and pile-driving on New Zealand marine mammals while also assessing the effectiveness of the mitigation measures employed.

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1. SCOPE OF WORK

1.1. Description of proposal

Refining NZ (RNZ) operates New Zealand's only oil refinery based at Marsden Point at the entrance to Whangarei Harbour. In order to improve competitiveness by reducing freight costs, the company is investigating options to deepen and realign the entrance channel to Whangarei Harbour so that more heavily-laden tankers (which require deeper drafts) can access its jetty, resulting in fewer ship movements. To accommodate heavier vessels, the inner harbour, harbour entrance and various locations along the shipping channel would need to be dredged and some areas realigned. Inner harbour dredging is likely to involve creation or deepening of 'jetty pockets' to allow for berthing of vessels with deeper drafts. The proposal will also include disposal of dredge spoil in the coastal marine area, as well as periodic maintenance dredging (every 2–20 years depending on location) to address subsequent sedimentation in the proposal area. It will also include the relocation of some existing navigation aids and installation of five new navigation aids.

1.2. Scope of assessment

This report constitutes the second of a two-phase assessment. The first (Phase 1) report (Clement & Elvines 2015) consisted of a desktop review of the marine mammal populations utilising Whangarei Harbour and the wider Bream Bay ecosystem; and a literature review of the potential effects currently associated with dredging/disposal activities and marine mammals. The Phase 1 report, along with additional information from other consultancy reports, forms the basis of the final Phase 2 assessment. This Phase 2 report is a comprehensive assessment of effects of the proposed activities on local and visiting marine mammals, with recommended avoidance, remediation and mitigation options, and is intended to support the final resource consent application. It specifically includes:

- a summary description of the existing environment in terms of those marine mammal species most susceptible to any effects of the proposed activities
- categorisation of any impacts in the context of the actual project area and environment, based on the findings of other relevant reports (e.g. underwater noise, ecology, hydrodynamics)
- categorisation of the overall risk of any resulting effects in terms of scale, duration/persistence, likelihood and possible consequences
- recommendations for avoidance, remediation and mitigation options based on the final risk assessment of effects.

2. DESCRIPTION OF EXISTING ENVIRONMENT

2.1. General site description

Whangarei Heads is also known as 'Whangarei te rerenga parāoa', which means 'Whangarei, the gathering place of whales'. While this reference is also thought to be a metaphor for the gathering place of chiefs[1], the significance of whale migrations past this region is supported by the number of whaling stations found north near Whangamumu and along the entire eastern coastline of the North Island during the late 1800s and early 1900s (Dawbin 1956).

Out of the more than 50 species of cetaceans (whales, dolphins and porpoises) and pinnipeds (seal and sea lions) known to live or migrate through New Zealand waters, at least 27 cetacean and two pinniped species have been sighted or stranded along the north-eastern coastline of the North Island. When considering potential implications of coastal developments on marine mammals, the importance of Whangarei waters needs to be considered in the context of the species' regional and New Zealand-wide distributions, given that most species regularly range for hundreds to thousands of kilometres. Hence, Figure 1 highlights the various marine mammal species found to frequent north-eastern coastal regions between the Bay of Islands to the north and the entrance to the Hauraki Gulf and Great Barrier Island to the south.

2.2. Species of concern

The marine mammals most likely to be affected by the proposed project include those species that frequent the Whangarei Harbour and Bream Bay regions year-round or on a semi-regular basis, including bottlenose dolphins (*Tursiops truncatus*), orca (*Orcinus orca*), Bryde's whale (*Balaenoptera edeni)* and common dolphins (*Delphinus delphis*; Clement & Elvines 2015). Although infrequent visitors, other species of concern include those that are more vulnerable to anthropogenic (human-made) impacts due to various life-history dynamics (e.g. southern right whales due to low population numbers) or species-specific sensitivities (e.g. pilot whales due to underwater noise sensitivities). Given the reference to whales in their name for the harbour, Tangata Whenua o Whangarei Te Rerenga Paraoa are also concerned about the continued presence of several marine mammals in the region. Table 1 summarises those marine mammal species considered further in terms of any dredging/disposal effects associated with this proposal.

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[1] A history of Ngati Wai – First of Four Instalments by Morore Piripi (http://teaohou.natlib.govt.nz/journals/teaohou/image/Mao37TeA/Mao37TeA018.html).

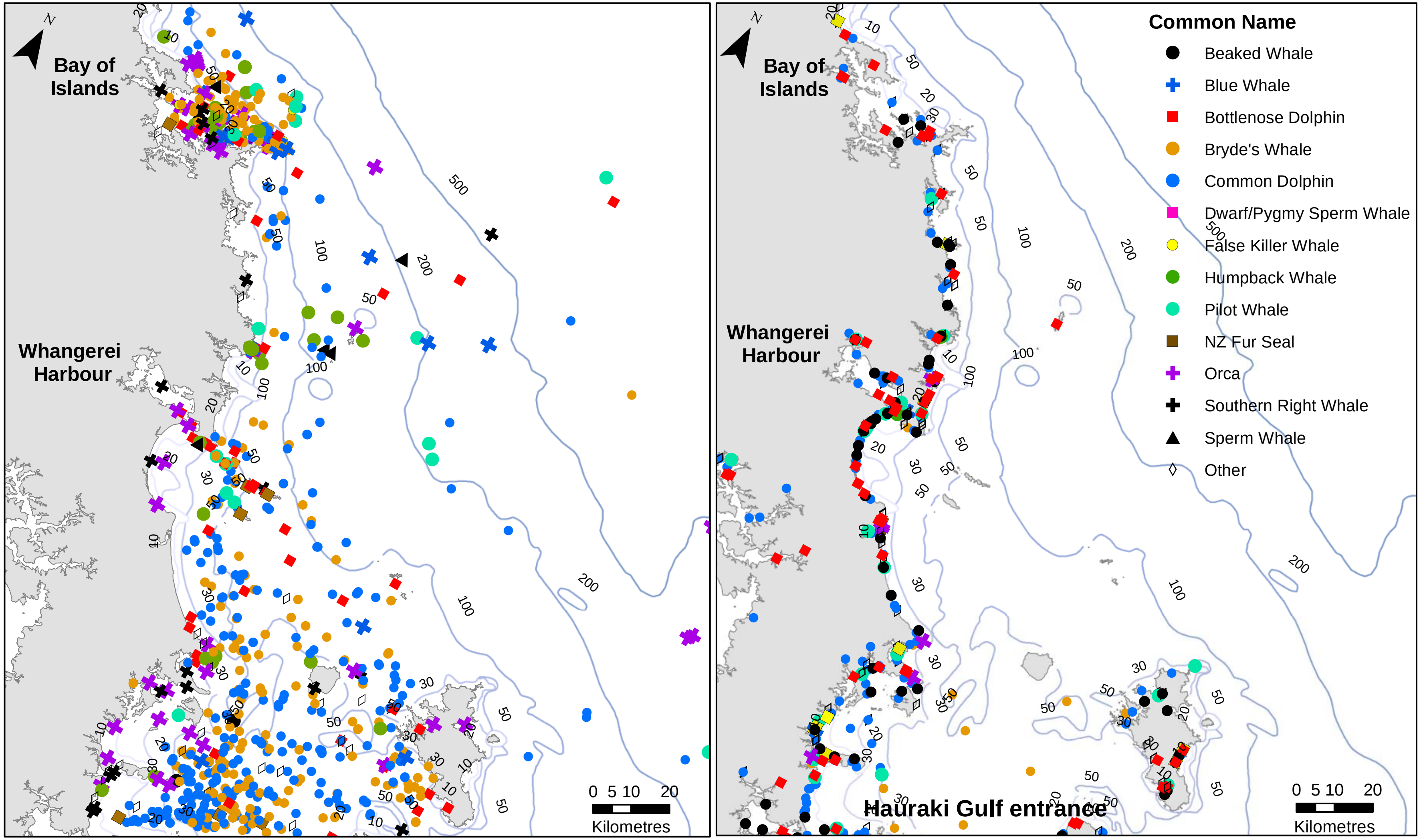

Figure 1. Opportunistic sightings (left) and strandings (right) of marine mammals prevalent in north-eastern coastal waters between the Bay of Islands to the north and Whangaparaoa and Great Barrier Island to the south (Department of Conservation's sighting and stranding database).

Table 1. Marine mammal species potentially affected by the proposal and areas of concern (modified from Clement & Elvines 2015).

Species	Resident or semi-resident	Conservation concern	Acoustic concern	Tangata whenua concern
Bottlenose dolphin	✓	NE	MF	✓
Orca	✓	NC	MF	✓
Bryde's whale	✓	NC	LF	✓
Common dolphin	✓		MF	✓
NZ fur seal			OP	✓
Pilot whale			MF/AS	✓
Beaked whale			MF/AS	✓
Southern right whale		NV	LF	✓
Humpback whale			LF	✓
Sperm whale			MF	✓
Pygmy sperm whale			HF/AS	✓

The definitions used in the table are:

- NC – Nationally Critical, NE- Nationally Endangered, NV – Nationally Vulnerable (Baker et al. 2016)
- LF – Low-Frequency cetacean hearing group; 7 Hz-35 kHz, all baleen whales
- MF - Mid-Frequency cetaceans – 150 Hz-160 kHz, all toothed cetaceans except those listed in high-frequency category
- HF - High-Frequency cetaceans - 275 Hz-160 kHz (i.e. *Kogia*, cephalorhynchid (Hector's dolphin) (NOAA 2016)
- AS – species thought to be more Acoustically Sensitive to underwater noise than other species (Clement & Elvines 2015, Appendix 1)
- OP – acoustic sensitivity (60 Hz to 39 kHz) consistent with the generalised Otariid Pinniped group for sea lions and fur seals underwater (NOAA 2016).

This north-eastern coastline represents some of the largest groupings of common dolphins and beaked whale species around the North Island, while potentially supporting isolated sub-populations of bottlenose dolphins, orca and Bryde's whale (Clement & Elvines 2015). However, based on the available species data, and in reference to Section 6(c) of the Resource Management Act (RMA) [2], Policy 11 of the New Zealand Coastal Policy Statement (NZCPS), and Method 9.2.5.2 of Northland's Regional Coastal Policy (RCP)[3], Whangarei Harbour and nearby Bream Bay waters are not considered ecologically significant in terms of feeding, resting or breeding habitats for any particular species relative to other regions along the north-eastern coastline. Instead, Whangarei Harbour and Bream Bay coastal waters represent a small fraction of similar habitats available to support these species that utilise the larger north-eastern coastal region (Clement & Elvines 2015). While several whale species have their regular migration routes through this region, the Harbour and Bream Bay are not considered as ecologically important migration corridors as most animals generally pass by the area further offshore.

[2] Section 6(c) - the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna.

[3] Appendix 9 - The Council has used the following criteria to determine those areas of important conservation value identified in the Plan as Marine 1 Management Areas. 5 – Marine Mammals and Birds Area including or near any: (a) marine mammal breeding or haul-out site.

3. ASSESSMENT OF ACTUAL AND POTENTIAL EFFECTS

The purpose of the Phase 1 report was to review and determine which effects of dredging and / or disposal on marine mammals needed to be considered further in the context of this proposal. These effects, including any associated with pile driving, are outlined in this section and discussed in further detail below.

3.1. Direct effects

Most consequential interactions between marine mammals and coastal development usually result from a direct overlap between the spatial location of anthropogenic activity and important habitats of the species (i.e. feeding or nursing grounds). The act of disturbing and / or removing bottom substrate in itself is not expected to directly affect any marine mammals known to frequent Whangarei waters. Instead, the associated increase in vessel activity, resulting production of underwater sound, and physical activities within the general harbour entrance region are the more likely factors by which marine mammals will be affected.

3.1.1. Vessel strikes

A recent worldwide review of dredging effects suggests that the risk of collision between dredge vessels and marine mammals will be minimal if the activity avoids critical habitats and seasons when the species of concern may be more ‘distracted’ while feeding or resting (Todd et al. 2015). Particular species (i.e. baleen whales) and certain age groups (i.e. calves and juveniles) are noted as being more susceptible to vessel strike than others. In this case, the species considered most vulnerable to any potential vessel collisions include Bryde’s, humpback and southern right whales and to a lesser extent, bottlenose dolphins and orca given their current endangered species status rather than proneness for vessel strike.

The likelihood of vessel strike also depends on a number of operational factors including vessel type, speed, and location (Van Waerebeek et al. 2007). The greatest increase in both the risk of a collision and the likelihood that it will result in severe injury or death occurs at speeds over 11 knots (Vanderlaan & Taggart 2007; Gende et al. 2011). This might explain why dredge vessels, which generally have maximum transit speeds of only 12–16 knots (Brunn et al. 2005), have been involved in only one out of the 134 worldwide collision cases (in which the vessel type was known) reported between 1975 and 2002 (Jensen & Silber 2004).

The proposed capital dredging of the Whangarei Harbour entrance will involve the removal of up to 3,700,000 m^3 of dredge spoil to the proposed disposal site(s) in Bream Bay. Sediment volumes for maintenance dredging are likely to be ~3.4% (per annum) of the capital disposal volume. Depending on the type of dredge vessel used,

this removal will involve several thousand return trips (relatively fewer trips will be associated with larger vessels) between the various locations over an approximate six-month period of capital dredging. Significantly reduced time scales and vessel movements will be associated with maintenance dredging (Tonkin & Taylor 2016).

Despite an overall increase in vessel traffic during dredging[4], the likelihood of a vessel strike (injury or mortality) associated with the proposal is assessed as *low* for migrating baleen whales, odontocete and pinniped species and the significance of the effect is considered *de minimis* with proposed mitigation actions (Table 2, see Section 3.3 for details). This conclusion is based on local species information (Clement & Elvines 2015) and relevant factors as summarised below:

Spatial and temporal factors

- Relatively temporary increase in capital dredge vessel traffic (approximately six months) within a fairly localised area compared to the rest of Whangarei Harbour and the wider Bream Bay system (i.e. ~3–7 km distance between proposed channel and disposal sites).
- Low probability of the dredge vessel encountering a migrating whale as currently only 1–3 individual whales are sighted within Whangarei Harbour and Bream Bay each year; the majority passing by Hen (Taranga) and Chicken Islands in deeper, more offshore waters (e.g. further than 5 to 10 nm) (Clement & Elvines 2015).
- Most whales occur in the area for a limited period each year; mainly in the winter months and some spring months, and most only remain for a day up to a week (the exception being Bryde's whales).
- Most odontocete and pinniped species known to frequent Whangarei waters are in regular contact with all types and speeds of commercial and recreational vessels throughout their entire distributional range.

Known collision factors

- Low probability of the dredge vessel striking an individual animal given the vessel will be stationary (cutter-suction dredges and back-hoe dredges) or slow moving (trailer-suction hopper dredges) while dredging. When travelling to the disposal site, the normal operating speed of the dredge vessel (15 knots or less, depending on dredge vessel used; Tonkin & Taylor Ltd 2016) should be slow enough for the animals to manoeuvre out of the path of the vessel.
- Most dolphin species have a general attraction to boats and safely approach and/or bowride with numerous vessels. Fur seals often respond neutrally to boats when in the water (although they may bowride occasionally).
- Whangarei Harbour and Bream Bay are not considered unique or important feeding, resting or nursery habitats for any residential or visiting species, hence

[4] While harbour traffic will temporarily increase during the capital dredging project, it will decrease over the long-term as the same, but more heavily-laden, tankers will result in fewer overall ship movements (Navigatus 2016; section 4.5, pg. 12).

individuals are less likely to be 'distracted' by such activities, and are thus less vulnerable to collision risk.

3.1.2. Underwater noise

The proposed capital and maintenance dredging activities, as well as the relocation and placement of navigation aids, will introduce a source of vessel traffic and mechanical activities that will generally increase the amount of anthropogenic underwater sound produced in the area (e.g. CEDA 2011; WODA 2013). Materially increasing underwater noise can affect marine mammals because they rely heavily on underwater sounds for communication, orientation, predator avoidance and foraging. Additional underwater noise may adversely affect marine mammals through changes in behaviour, masking of important noise signals, temporary auditory shifts (TTS; temporary threshold shift), or permanent injury (PTS; permanent threshold shift) (Todd et al 2015; Clement & Elvines 2015, Madsen et al. 2006).

Dredge noise

Generally, the noises produced from dredging activities are continuous, broad-band sounds at frequencies mostly below 1 kHz (Todd et al. 2015). Underwater noise reviews by CEDA (2011) and WODA (2013) found that trailer-suction hopper dredges (TSHD), cutter-suction dredges (CSD) and back-hoe dredges (BHD), [the main types of dredges considered for this proposal], produce mostly low frequency, omni-directional sounds between 100-500 Hz (Figure 2). Their bandwidths can fluctuate as low as 20 Hz and as high as 20 kHz. Dredge-related sound levels will be dependent on the specific vessel selected to undertake the proposed works (Pine & Styles 2016). However, sound levels generated from dredgers similar to that considered for this proposal generally range between 164 and 185 dB *re*1 µPa rms @ 1 m [5] (Pine & Styles 2016). These are generally lower sound levels than a powerful ship which is between 180-190 dB *re*1 µPa rms @ 1 m (OSPAR 2009; Todd et al. 2015). The exact sound ranges of dredges are also dependent more on the sediment extraction process and the types of sediment being extracted, with coarser gravel causing greater sound levels (WODA 2013 and references therein). Sediments being removed for the proposal are predominantly sand and shell fragments (MSL 2016).

[5] The term 'dB *re*1 µPa rms @ 1 m' represents the sound pressure level that has been back calculated to a standardised distance of one metre distance from the source, and termed source level. RMS = root mean square or mean squared pressure and rms levels are often used for the assessment of continuous noise sources. The averaged square pressure is measured across some defined time window that encompasses the signal.

Table 2. Summary of potential effects on marine mammal species from the dredging of Whangarei Harbour entrance and associated disposal within Bream Bay with mitigation measures.

Potential environmental effects	Spatial scale of effect on marine mammals	Persistence / duration of effect for marine mammals	Consequences for marine mammals	Likelihood of effect	Avoidance Factors / Mitigation Options (see Section 3.3 and Table 4 for more details)	Significance Level of Residual Effect
Marine mammal / vessel strike due to increased vessel activity	**Medium to Large** Limited to vessel movements between the harbour entrance and disposal site (~3-7km)	**Short to Moderate** Whales are only present in area for a day to weeks; approximately 6 months for local dolphins and pinnipeds (during capital dredging), and < 6 months periodically every 2–20 years (for maintenance dredging).	**Population Level:** Death or injury of endangered or threatened species **Individual Level** Death or injury of non-threatened species	**Low**	• Very low probability of whale encounter • Often stationary and relatively slow speeds of dredging vessels • Adoption of boating behaviour guidelines • Liaison with DOC about possible whale presence in area while dredging	***De Minimis***
Behavioural and / or physical responses to underwater sound from: • **Dredging / disposal activities**	**Small to Large** Dependent on sounds produced; behavioural / masking responses predicted at large distances (several kms), potential TTS within close proximity (< 10 m)	**Short to Moderate** Whales are only present in area for a day to weeks; approximately 6 months for local dolphins and pinnipeds (during capital dredging), and < 6 months periodically every 2–20 years (for maintenance dredging).	**Individual to Regional Level:** Individuals may avoid or approach dredging activities; individuals subject to potential TTS; possible acoustic masking between conspecifics (regional).	**Low -** TTS, masking **to** **Moderate -** behavioural	• Very low probability of whale presence • BPO (best practicable option) used in dredge vessel selection • Regular maintenance and proper up-keep of all dredging equipment and the vessel • Designated marine mammal observer and precautionary safety zone (50 m) for cessation of active dredging while any marine mammals present within zone (daylight hours only)	**Nil –** TTS (daylight) **to** ***De Minimis* –** TTS (overnight), behavioural, masking
• **Pile driving for navigational aids**	**Small to Large** Behavioural / masking responses predicted at large distances (several kms), potential hearing injury/impairment with close proximity	**Short** Estimated 2 days	**Individual to Regional Level**: Individual avoidance or hearing injury/impairment (TTS/PTS), possible acoustic masking between conspecifics (regional)	**Low –** PTS, TTS **to** **High** - masking, behavioural	• BPO used in pile and pile-driving technique selection • Regular maintenance and up-keep of equipment • Ramping up and/or soft starts • Safety zone enforced by marine mammal observer	**Nil –** TTS / PTS **to** ***De Minimis* –**, behavioural, masking
Marine mammal entanglement in operational gear and / or debris	**Small to Medium** Limited to immediate waters around operating dredge vessels	**Short to Moderate** Mainly while dredge vessel is operating; approximately 6 months (during capital dredging), and < 6 months periodically every 2–20 years (during maintenance dredging).	**Population Level:** Death or injury of endangered or threatened species **Individual Level** Death or injury of pinniped or dolphin	**Low**	• Avoid use of loose rope and other lines • Compliance with NZ Maritime Rules Part 180	***De Minimis***
Contaminant effects on marine mammals from dredge sediments and / or spoil	**Medium to Large** Limited to immediate waters and habitats adjacent to dredge and disposal sites (< 1–3 km)	**Short to Persistent** Dependent on type and level of contamination in sediments	**Individual Level** Limited potential for any individual to consume more than few prey species exposed to dredging sediments	**Not Applicable to Low**	• Tested sediments have low to less than trace levels of contaminants and a low silt content (i.e. relatively lower potential for contaminant accumulation), with limited bioavailability and solubility • Continue to test sediments to ensure no contamination (i.e. prior to maintenance dredging)	**Nil to *De Minimis***
Marine mammal habitat and / or prey disturbance from loss of benthic habitat and increased turbidity from dredging and spoil disposal	**Medium to Large** Limited to immediate waters and habitats adjacent to dredge and disposal sites (< 1–3 km)	**Short to Persistent** Re-colonisation of benthos will begin during ongoing activities, and recovery within disposal site only after disturbance has ceased (e.g. 6-24 months). 99% of any given turbidity plume expected to settle out within less than a day.	**Individual Level** Possible avoidance of disturbed area, some individuals may approach disposal site(s) for foraging	**Not Applicable to Low**	• No unique feeding habitats in the proposed areas, and areas represent only a small portion of similar available habitat • Use of green valve disposal and monitoring thresholds to ensure turbidity limits	**Nil to *De Minimis***

Ranking of terms used in table:
- Spatial scale of effect: Small (tens of metres), Medium (hundreds of metres), Large (> 1 km)
- Duration of effect: Short (days to weeks), Moderate (weeks to months), Persistent (years or more)
- Consequence: Individual, Regional, Population
- Likelihood of effect: Not Applicable (NA), Low (< 25%), Moderate (25–75%), High (> 75%)
- Significance of effect: Nil (no effects at all), De Minimis (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 mitigated)

Understanding ambient underwater sound levels is important in assessing the potential scale and impact of additional underwater noises as these background noises, along with the physical environment, will influence the propagation and detection of any introduced sounds. In a study undertaken by Pine and Styles (2015; Appendix 1), the ambient background sound levels for the Whangarei Harbour region varied but were generally less than 119 ± 0.08 dB_{rms} re 1 µPa (based on no shipping in the area) and considered comparable to other nearshore habitats around New Zealand. The harbour was also similar to other New Zealand harbours in that lower frequencies (below 1 kHz) tended to dominate due to high vessel activity.

Marine mammal hearing

The lower frequency vocalisation ranges of southern right whales suggest their best hearing capabilities are at least between 50 Hz and 2 kHz (Parks & Tyack 2005) and 20 Hz to 12 kHz for humpbacks (McCauley & Cato 2003), while the generalised hearing range of most baleen whales is thought to be between 7 Hz and 35 kHz (NOAA 2016). These frequency ranges overlap with most anthropogenic underwater noise, including dredging activities as discussed above, meaning baleen whales are the species most susceptible to any noise effects from dredging (e.g. Clark et al. 2009).

Odontocetes (e.g. orca, bottlenose and common dolphins) generally communicate over a wider frequency range than baleen whales. They also have the capability to echolocate (produce biological sonar) for navigation and hunting. While most dolphins' functional hearing ranges are estimated to be quite large (mid-frequency hearing groups 150 Hz–160 kHz; NOAA 2016), and they can likely detect low-frequency sounds, their sensitivity significantly decreases at frequencies below 1–2 kHz (Au 2000; Southall et al. 2007). Pinnipeds' hearing ranges are thought to vary more widely (otariid pinnipeds e.g. NZ fur seal; 60 Hz–39 kHz; NOAA 2016), including some ultrasonic frequencies, and are quite sensitive to frequencies below 1 kHz (based on overseas research on Atlantic grey and harbour seals; Thomsen et al. 2009).

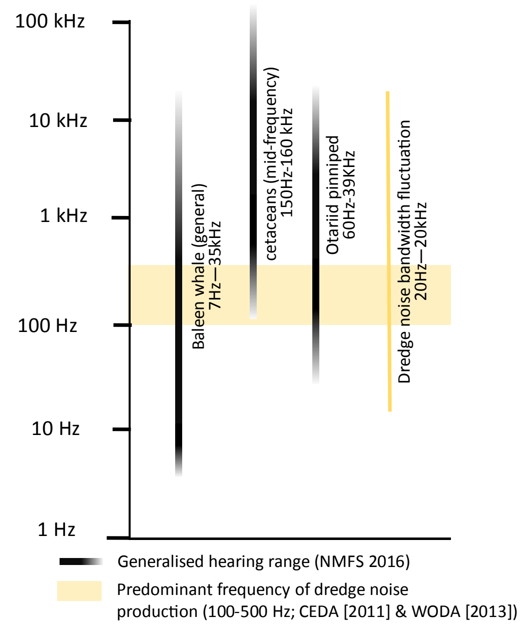

Figure 2. Schematic summary of overlap in frequency of marine mammal communication/hearing, dredge noise production.

Potential underwater noise effects

As evidenced by the spatial modelling results of Pine and Styles (2016) and local species information, the likelihood of any migrating baleen whales, odontocetes and fur seals being able to hear and behaviourally respond to underwater noise produced by dredging activity in the proposal areas is *low* to *moderate* (Table 2). This is dependent on the location of the animal in relation to the harbour, the dredge's location in the harbour entrance, and the size of the dredge vessel. A TSHD dredging in the outer channel location is expected to generate the largest spatial extent of noise, which is estimated to extend throughout the vicinity of Bream Bay (Figure 3), compared to other dredge types (CSD, BHD) and dredge locations (mid- and inner channel; Pine & Styles 2016).

The precautionary modelled scenarios in Pine and Styles (2016) estimate the potential onset for behavioural responses (e.g. changes in swimming direction, speed, surface intervals, respiration rates, vocalisation behaviours) in baleen whales to dredging noises may occur as far away as 18.5 km when using a medium-sized TSHD in the outer channel (Figure 3 and Table 3), and are based on NOAA's 120 dB re 1 µPa rms threshold[6] (Appendix 2). This radius is significantly less for mid-

[6] The 120 dB threshold has been used as a general guideline for assessing the possible spatial extent in which various marine mammals may detect and / or react behavioural to capital dredging sounds in the Whangarei and Bream Bay region. We have applied this particular threshold in the absence of any more up-to-date threshold information but acknowledge that this threshold, and its site- and species-specific approach in this proposal, is not necessarily the most appropriate threshold or approach for other such applications. See Appendix 2 for more details.

frequency cetaceans (i.e. orca, bottlenose, common dolphins) and otariid pinnipeds (i.e. fur seals). Any short-term auditory masking of particular communication signals for orca, bottlenose dolphin and NZ fur seal would be limited to 7.6, 4.7, and 14.7 km radius (respectively) from the dredge location when in the outer channel (Table 3) as a worst-case scenario.

The potential for the onset of temporary threshold shifts (TTS) are estimated to occur only when an animal is within 1–10 m of the TSHD during dredging operations, and only within 1 m for other dredge types (Pines & Styles 2016). No permanent hearing injuries (PTS) are predicted for any marine mammals regardless of dredge type or location, based on the estimated sound exposure levels being below the PTS thresholds. Noise generated from spoil disposal will be significantly lower than dredge noise, and will have a short duration (several minutes).

Table 3. Auditory masking and behavioural impact ranges for the three modelled species in Pine and Styles (2016), using both the small- and medium-sized trailing suction hopper dredge (TSHD) in the various channel locations. OP = Otariid Pinniped group, LF = Low Frequency group, MF = Mid-Frequency group (includes all other cetaceans considered for this proposal except pygmy sperm whale).

	Masking range (km)*		Behavioural response range (km)†	
Small TSHD	**Inner/mid-channel**	**Outer-channel**	**Inner/mid-channel**	**Outer-channel**
Orca	1.0	3.4	-	-
Bottlenose dolphin	1.1	3.3	-	-
Fur seal**	2.3	13.3		
LF (includes baleen whales)	-	-	2.2	17.8
MF (orca, bottlenose & common dolphin)	-	-	0.7	1.2
OP (i.e. fur seal)			1.1	5.2
Medium TSHD				
Orca	3.5	7.6	-	-
Bottlenose dolphin	3.2	4.7	-	-
Fur seal*	3.7	14.7	-	-
LF (i.e. baleen whales)	-	-	5.1	18.5
MF (e.g. orca, bottlenose & common dolphin)	-	-	1.1	1.8
OP (i.e. fur seal)			1.9	6.2

* Where available, these were based on the relevant species audiogram data (Pine & Styles 2016).

† Based on NOAA interim sound threshold guideline of 120 dB for behavioural disturbance, using hearing frequency for generalised group rather than individual species (see details in Appendix 2).

** Masking range based on northern fur seal audiogram data in the absence of NZ fur seal audiogram.

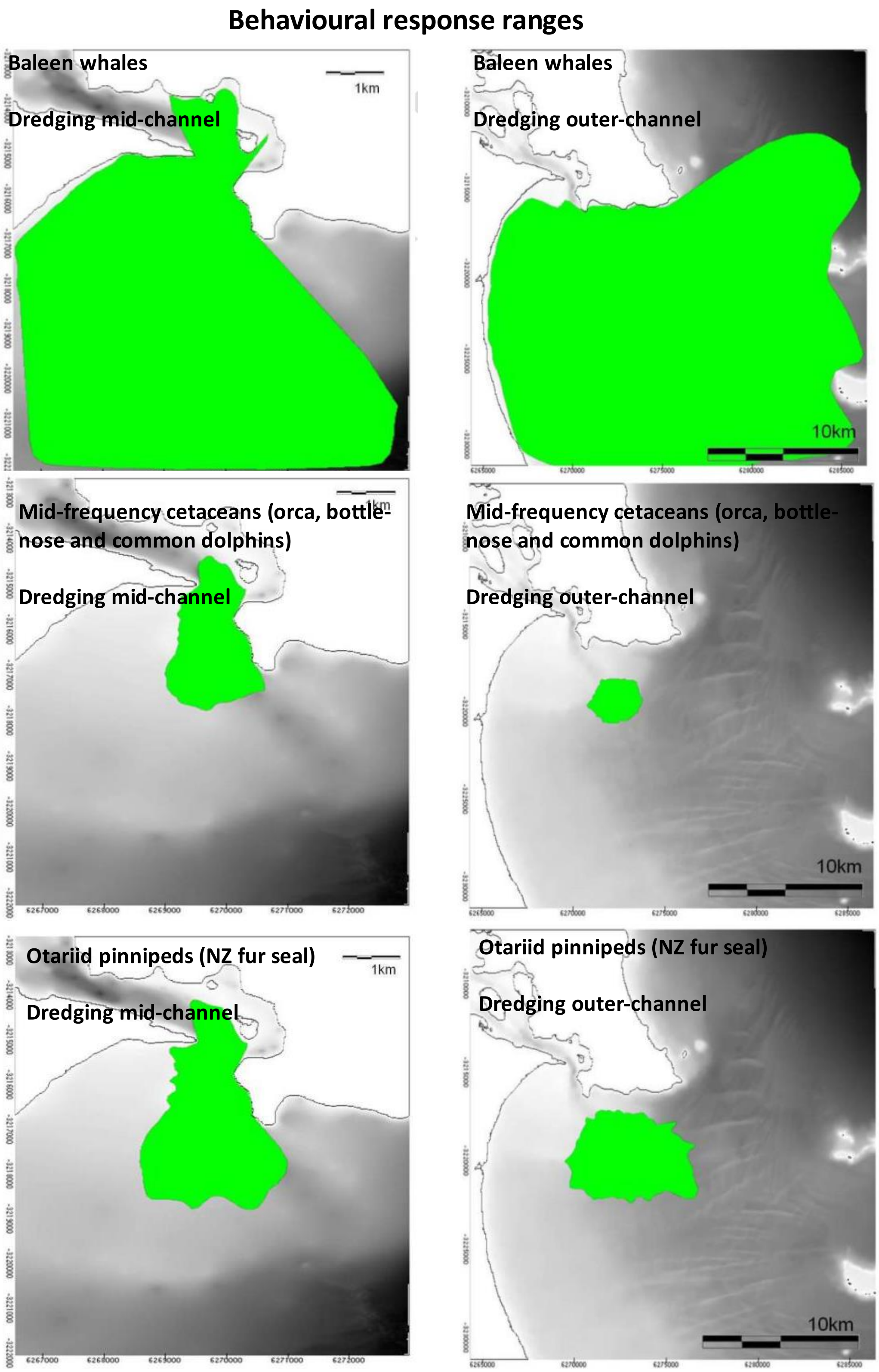

Figure 3. Expected behavioural response range for marine mammal groups during dredging using the medium-sized trailing suction hopper dredge at both the mid- and outer-channel locations. Note the change in map extent between dredge locations. Figures from Pine and Styles (2016).

Based on these modelled results and our Phase 1 review, any effects from additional underwater noise generated from the dredging proposal will likely be transitory and non-injurious. The overall levels and character of dredging noise will be generally comparable to existing vessel movements currently travelling to and from the harbour. Effects will be predominantly limited to the momentary masking of some noise signals (for example, members of the same species may find it more difficult to communicate across particular frequencies / levels while in proximity of the operating dredge); and a range of potential behavioural responses (for example, avoidance by mothers with calves but equally possible, attraction of lone males to areas in proximity of the operating dredge) depending on the species and individual animal (Pine & Styles 2016). The likelihood of any TTS effects occurring is considered *low* and any hearing injury effects (PTS) are *not applicable* based on modelling results. Therefore, with the recommended mitigation actions, the significance of any acoustic effects are considered to be *nil* to *de minimis* for both local and visiting species (Table 2; see Section 3.3 for more details). The most relevant factors contributing to this assessment are summarised below:

Spatial and temporal factors

- Relatively temporary increase in underwater noise from capital (approximately 6 months) and maintenance dredging activities based on proposed dredge schedule.
- Mainly lower-frequency noise generated by proposed dredge vessels and activities propagate farther underwater and may be detected several kilometres away (e.g. Figure 3); similar to the majority of commercial vessels currently entering and leaving the harbour.
- Only 1-3 migrating whales are sighted within the wider Bream Bay area each year, the majority pass by Hen (Taranga) and Chicken Islands in deeper, more offshore waters (e.g. further than 5 to 10 nm; Clement & Elvines 2015).
- Most whales occur in the area for a limited period each year; restricted mainly to winter months and some spring months when most only remain for a day or up to a week (the exception being Bryde's whales).
- Most odontocete and pinniped species known to frequent Whangarei waters are regularly exposed to similar types and levels of underwater noise from commercial and recreational vessels throughout their entire distributional range.
- Marine mammals may travel past the vessel while dredging is underway in order to enter or leave the harbour. However, no individuals are expected to approach and remain in close enough proximity to the vessel (i.e. 1–10 m) long enough for more than minor adverse effects to occur.

Known acoustic factors

- Dredge sound levels are not expected to exceed any permanent injury threshold criteria (Pine & Styles 2016, Appendix 2).

- Extremely close proximity to the dredge vessel sufficient for the onset of TTS to occur combined with visiting marine mammals' short-term visits to the area (i.e. dolphins—hours to days; and whales—days to weeks) ensure that the likelihood of exposure effects will be *low* to *not applicable* with mitigation (for more details see Section 3.3),
- Relevant environmental factors (i.e. shallow depths, relatively soft sediments; Coffey 2017; Pine & Styles 2016) may help dampen some underwater noise production in the lower, and some higher, frequency ranges.
- Limited overlap between the lower frequency sounds produced by dredge activities, and the functional hearing frequency ranges and sensitivities of odontocetes and pinnipeds.
- Whangarei Harbour and Bream Bay are not considered unique or particularly important feeding, resting or nursery habitats for any residential or visiting species.

Pile driving noise

Pile driving has been identified as one of the 'noisiest' of all construction sounds. It produces a very high source level as broadband impulses and has a high potential to disrupt marine mammal behaviour up to many kilometres away (Madsen et al. 2006). In close proximity, these impulses could induce acute stress and hearing impairment (i.e. permanent auditory threshold shift-PTS).

Bailey et al. (2010) measured actual pile-driving sounds off northeast Scotland at various distances ranging from 100 m to 80 km away from the source to determine potential impacts on marine mammals in the vicinity. The authors found any possible hearing impairments or injuries (TTS or PTS) were only possible within 100 m or less from the source and depended on exposure duration. Within 2 km of the source, peak sound energy was recorded between 100 Hz to 2 kHz, which decreased with increasing distance. The authors suggested, in this case, noise levels would more likely affect low- to mid-frequency marine mammals (e.g. baleen whales, orca, bottlenose and common dolphins).

To date, no known published studies have focused on the reactions of baleen whales to pile-driving activities and very few have observed cetaceans other than harbour porpoises. Based on their *in situ* measurements, Bailey et al. (2010) predicted that pile-driving sounds have the potential to elicit disturbance behaviours in minke whales and bottlenose dolphins as far as 40 and 50 km from the source, respectively.

The effect of pile driving on pinnipeds is less straightforward, with reported reactions of overseas pinnipeds ranging from little to no response in 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, the authors noted that changes in haul-out numbers were short term

as the general abundance of seals showed no decrease over the whole construction period.

High-frequency cetaceans (*e.g.* pygmy sperm whales) will detect pile-driving sounds at similar distances to low- and mid-frequency cetaceans. However, as greater energy was generally found in the lower frequencies, Bailey et al. (2010) predicted strong avoidance behaviours occurring only within 20 km or less of the source for these species. For example, Tougaard et al. (2003) noted that harbour porpoises (a high frequency cetacean) in Danish waters showed strong negative responses to pile driving up to 15 km away with all porpoises leaving the area when the driving began, but later returning once the activity finished.

The proposed pile-driving activities will be of very short duration (approximately 4 hours per pile, or up to 2 days in total) and will involve the driving of steel tube piles at two different locations within Calliope Bay, just past the harbour entrance (RHDHV 2016; see figure E3 or appendix A drawing PA1028-MA-1121). It will likely involve either vibro hammer (continuous noise production) or traditional hammer (impulsive noise) piling techniques (summarised in RHDHV 2016). Bottom substrates at these locations are predominantly soft-sediments and within relatively shallow depths (~10 m), which means fewer impacts (or shorter duration vibro-hammer bursts) will be needed to drive the pile to the required sediment depth. In addition, soft sediments help attenuate (absorb or dampen) some of the lower frequency sounds and thus reduce the distance at which they can be detected (e.g. Gerstein & Blue 2006).

Underwater noise propagation modelling undertaken for similar coastal pile-driving activities in New Zealand suggest pile-driving noise may be detectable and with potential behavioural responses (e.g. avoidance / abandonment of the area) occurring at a scale of several kilometres (pers. comm. M Pine, Styles Acoustic Group). However, the distance within which PTS and TTS could occur are likely to be relatively small (e.g. < 300 m from work area; DPTI 2012). While pile-driving activities do have the potential to cause injury within a small radius, it is unlikely that PTS would be caused by a single impact nor would an individual animal remain within close enough proximity of the source for an extended period for any cumulative exposure to occur.

In this case, effects from piling noise are more likely to involve temporary acoustic masking or behavioural responses of marine mammals in the immediate vicinity (several kilometres) of the pile-driving works, which may see animals moving to other regions of the proposal area (e.g. up into the inner harbour or other areas of the wider Bream Bay area) while piling is underway. The likelihood of TTS or PTS as a result of pile driving is considered *low* due to the short duration, expected small spatial envelope for the onset of any physical hearing effects and an extremely short exposure time to any individual marine mammal; and with the recommended mitigation actions, the effects will be *nil* to *de minimis*. The relevant factors

contributing to this conclusion are very similar to those listed above for dredging effects. Any additional factors specific to pile driving are summarised below:

Spatial and temporal factors

- Any underwater noise produced from the proposed pile driving will be extremely short-term (~4 hrs and up to 2 days) and localised mainly to the surrounding harbour entrance area and some nearby Bream Bay areas.

Known acoustic factors

- A small estimated spatial zone for the onset of TTS or PTS to occur,(e.g., < 300 m; DPTI 2012) will be confined mainly to Calliope Bay and ensures that the likelihood of exposure effects will be *low to not applicable* with mitigation (for more details see Section 3.3).
- The semi-confined nature of the pile-driving locations means the spatial area for any behavioural responses will be relatively small (several kilometres) and unlikely to affect most odontocetes or any whales migrating offshore.
- All pile driving will occur in shallow (~10 m) and soft sediment areas, which has natural attenuation properties that will help dampen some noise production.

3.1.3. Possible entanglement in operational debris

The major hazard associated with marine debris from coastal development projects to marine mammals is the possibility of entanglement (Laist et al. 1999). Whales, dolphins and pinnipeds are often attracted to floating debris, with a potential risk of becoming entangled in floating lines and netting (e.g. Suisted & Neale 2004; Groom & Coughran 2012). Loose, thin lines pose the greatest entanglement risk (e.g. lines used to tie up boats, floats and other equipment) and especially lost ropes and lines.

However, the only ropes required as part of this proposal are to secure the barge to the BHD or CSD during dredging of the inner- or mid-channel. Thus, the nature of dredge operating activities and equipment involved means the likelihood of entanglement in marine debris from dredging and disposal is *low* (Table 2). Any subsequent effects to marine mammals are expected to be *de minimis* in well-maintained coastal development projects with proper waste management programmes in place (e.g. secure onboard storage of lines, ropes, and waste) in order to comply with the NZ Maritime Rules Part 180.

3.2. Indirect effects

Coastal dredging and the associated spoil disposal within any established ecosystem will result in some change to that system (e.g. loss of habitat; Todd et al. 2015). It is unlikely that the actual changes themselves will affect marine mammals directly; rather, concern relates to possible indirect flow-on effects that these changes might

have on the ecosystem as a whole and, more specifically, on the health of prey resources of marine mammals. As such, potential indirect effects from this proposal that may affect marine mammals include bioaccumulation of contaminants that may be associated with dredge spoil, loss or disturbance of prey species due to habitat loss, benthic disturbance or turbidity plumes.

3.2.1. Quality of dredge spoil

The level of exposure to contaminants for any local marine mammals will depend on the chemical characteristics of the dredge spoil and the subsequent uptake by relevant prey resources (e.g. plankton, fish, rays, cephalopods), as well as the feeding habits and ranges of the marine mammal species (e.g. Jones 1998; Evans 2003). Whangarei Harbour and Bream Bay, relative to other regions along the north-eastern coastline, are not currently considered unique or important feeding habitats for local or visiting marine mammals (see Section 2.2). In fact, most local species, such as bottlenose dolphins, common dolphins and fur seals, are generalist feeders that will opportunistically forage throughout the entire proposal area as well as more offshore waters, and along most north-eastern coastal regions (see Clement & Elvines 2015). While orca are considered more specialist feeders, they regularly forage for rays among estuarine mud and sand flats areas from the Bay of Islands to Auckland Harbour (Visser 1999). Some migrating species (i.e. humpback whales), may not even feed while passing through New Zealand waters during parts of their migration (Dawbin 1956).

Todd et al. (2015) noted that risks are greatest to marine mammals only when dredging *contaminated* sediments (i.e. not all sediments have heavy contaminant loads), and concluded that in even those cases, exposure was still spatially restricted. Sediment sampling associated with the capital dredge spoil has not identified any contaminants that represent a risk for the ecology of Whangarei Harbour or the specified spoil ground (Coffey 2017). Therefore, the likelihood for bioaccumulation and biomagnification effects on local marine mammal species from the resuspension and dispersal of any contaminants in dredge sediments is *not applicable* to *low* and the overall effect assessed as *nil to de minimis*. This conclusion is supported by the following factors:

- low contaminant levels in sampled sediments (Coffey 2017)
- generalist diet and roving nature of local marine mammal individuals is expected to limit contact with any prey species exposed to dredged sediments
- rapid settlement of dredged sediments resulting in limited spatial exposure to individual prey species (99% of the plume expected to settle within 14 hrs; MSL 2016)
- insolubility of some contaminants while others are not expected to be bioavailable (i.e. bound in mineral forms with very limited solubility).

3.2.2. Effects on habitat and prey species

Benthic disturbance and loss

Capital and maintenance dredging of the entrance channel is expected to cause immediate loss of the existing benthic biota and alteration of the habitat within the immediate region of the activity (Coffey 2016). However, Coffey (2016) concluded that this habitat loss is unlikely to affect the bay ecosystem to more than a moderate degree as it constitutes only a small proportion[7] of similar and available benthic habitat in the harbour and bay as a whole. Once capital dredging and channel construction is finished, it is likely that a temporary colonisation of some benthic species, along with the re-establishment of soft sediments in the channel itself, will occur between periodic maintenance dredging (Coffey 2017).

Coffey (2016) also concluded that while smothering of benthic communities within the disposal site will initially take place, it will involve an incremental build-up of the deposited layer over time. Benthic recovery will continue at any single location as soon as a single depositional event[8] takes place and will not be interrupted until another deposition happens in that same location. Benthic survival and recovery around the spoil grounds will be dictated by the adopted dump release pattern and rate of spoil deposition, rather than the nominal thickness of the final deposition layer. The benthic communities within the spoil grounds are expected to effectively recover between 6–24 months after spoil disposal ceases (Coffey 2017).

Based on the above ecological effects, Coffey (2016) suggested that most finfish are expected to temporarily leave the immediate vicinity due to the physical disturbance and subsequent loss of existing food sources. However, some fish species, including known prey species of orca (e.g. various ray species) and bottlenose and common dolphins (e.g. mullet; *Aldrichetta forsteri*) are likely to be attracted to and / or forage in the disturbance area (Coffey 2016). As a result, any associated benthic changes at these project sites are expected to affect only individual fish, and not any particular species as a whole.

Coffey's (2016) conclusion that the ecological effects of dredging activities will be limited in their spatial extent, displacing (or even attracting) a small portion of individual fish temporarily from disturbance sites means that any short or long-term flow-on effects to local marine mammals will be *nil* to *de minimis*.

This conclusion is based on the following factors:

[7] For the capital dredging, the total 'disturbance' area is 4.37 km^2. Maintenance dredging disturbance area will be less than this.

[8] Within each dredging event (i.e. capital dredging event or maintenance dredging event), disposal events will occur on the order of several hours. Each dredge cycle will typically have a single disposal 'phase'. Maintenance dredging events are likely to occur at a frequency ranging from 2 – 20 years.

- a relatively small percent of benthic habitat loss within the Harbour entrance and Bay, which is expected to periodically recover after capital dredging and between maintenance dredging
- benthic smothering effects are predicted to be confined to a limited region around the spoil disposal site, and affected fauna expected to fully recover
- only temporary and localised avoidance of capital and/or disposal sites by individual prey fish with no effect on species recruitment
- general lack of evidence that dredging and disposal sites serve as unique and / or rare habitat for any marine mammal species in terms of feeding activities
- home ranges of local species are large and overlap with similar types of habitats in other parts of the Bay and along other north-eastern coastline regions.

Turbidity plumes

Increased turbidity/turbidity plumes are generated from the re-suspension of sediments at the dredging site and any marine location where dredged spoil is later deposited. High turbidity levels and movements of any sediment plumes created by dredging and / or disposal activities can be of concern to some fauna within or adjacent to work sites (e.g. Coffey 2017). However, marine mammals are known to inhabit fairly turbid environments worldwide and especially within New Zealand's nearshore environments (Clement & Elvines 2015). While they have very good vision, it does not appear to be the sense marine mammals rely upon most for foraging. Instead, odontocetes mainly depend on echolocation systems for underwater navigation and searching for food, hence, elevated turbidity does not directly affect these species' general movements or ability to find prey. Even baleen whales, which do not have the ability to echolocate, regularly forage in dark, benthic environments stirring up sediments to find prey. Gibbs and Childerhouse (2000 and references therein) noted that turbidity, along with similar environmental factors, is unlikely to have any direct effects on humpback migration routes. Turbidity plumes are thus more likely to only indirectly affect marine mammals via their prey resources.

Hydrodynamic modelling by MSL (2016) has demonstrated that plumes associated with the actual dredging (draghead and overflow) will generally settle onto the seabed in a relatively short timeframe, due to the sandy nature of the sediments. Due to this rapid settlement, modelled total suspended sediment (TSS) concentrations greater than 12 mg/L were spatially constrained to within a 1.2 km radius around the dredging footprint. During spoil disposal, TSS concentrations are not likely to exceed 10 mg/L above ambient levels greater than 3 km from the disposal location as 99% of the spoil sediment is likely to settle onto the seabed within 14 hours of disposal. As a precautionary monitoring measure, Coffey (2017; table 8) has proposed real-time turbidity plume monitoring near several management area boundaries to ensure actual turbidity levels from an project dredging and disposal plumes do not exceed acceptable threshold levels.

As discussed earlier in this section, any effects of increased turbidity from dredging activities will be limited in their spatial extent and displace only a small portion of the fish population (i.e. individual fish) temporarily from sites of the proposed activity or areas affected by the plume. Overall, any indirect effects of turbidity plumes from dredging activities are not expected to have any detrimental or long-term flow-on effects to local marine mammals in the region, and therefore will be *nil* to *de minimis*.

This conclusion is based on the following factors:

- resulting turbidity plumes from dredging or disposal activities are expected to settle out relatively quickly and are not expected to adversely affect nearby habitats
- short term displacement of only individual prey as a result of the small spatial scale of disturbance
- it is unlikely that whales would be affected by, or intentionally avoid, any localised turbidity plumes as they regularly migrate through highly turbid coastal waters around New Zealand each year.

3.3. Recommended avoidance, remediation and mitigation measures

Sections of Policy 11 of the New Zealand Coastal Policy Statement (NZCPS) relevant to the potential effects to marine mammals from the proposal are:

> (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)
>
> (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.

Species' status under the NZTCS and IUCN systems are listed in Clement and Elvines (2015), and were considered when assessing the consequence of potential effects on the relevant species (i.e. bottlenose dolphins, orca, Bryde's and southern right whales). Any potential adverse effects to threatened marine mammals species

from the proposal, in relation to 11(a) of the NZCPS[9], have been assessed as *de minimis* if the recommended mitigation plans are followed. In regards to 11(b) of the NZCPS[10], Whangarei Harbour and nearby Bream Bay waters are not considered to be of ecological significance in terms of feeding, resting or breeding habitats. They represent a small fraction of similar habitats available along the north-eastern coastal region (Clement & Elvines 2015 and Section 2.2). Neither the Harbour nor Bream Bay is considered an ecologically important migration corridor as most whales generally pass by the area further offshore. Finally, any associated effects of climate change on marine mammals within this region[11] will be a gradual drift in their overall distribution range to the south over several decades. The only remaining effects of this proposal at that stage will be fewer (but more heavily laden) oil tankers using the harbour entrance and occasional maintenance dredging.

Overall, any adverse effects from dredging activities on local and visiting marine mammals are assessed as *de minimis* when considering the types of effects, their spatial scales and durations, likelihood, and potential consequences (Table 2). However, given that some of the possible consequences of rare events (i.e. vessel collision or entanglement) could have population level effects (i.e. injury or death of an endangered animal), several best management practices (BMPs) are recommended as mitigation actions in relation to marine mammals and dredging in Whangarei Harbour entrance (Table 4 and Appendix 3). Importantly, BMPs are recommended even where the likelihood is assessed as *low* given the concerns that Tangata Whenua o Whangarei Te Rerenga Paraoa have about maintaining and protecting the continued presence of these species in the region.

To ensure that the most appropriate measures are in place, it is suggested that a marine wildlife management plan (MWMP; Appendix 3) is finalised in consultation with DOC before commencing operations. The plan should detail the procedures referred to in Table 4, and may also include timelines for any on-going monitoring and / or any implemented procedures that will need to be reviewed for effectiveness during operations (Appendix 4).

In regards to vessel strike, researchers have found that when given a chance, most marine mammal species will exhibit avoidance behaviours when approached by a vessel moving at speed, a vessel producing rapidly changing noises and / or when a vessel directly approaches the animal (Richardson 1995). There will be few occasions when the dredge could be operating at the same time as commercial vessels are entering or leaving the harbour, given the narrow entrance channel and shallow depths associated with this particular section of the project area (e.g. Tonkin & Taylor

[9] As well as considering the tiered protection provided for in Policy 4.4.1 of the Northland's Regional Policy Statement (NRPS).
[10] Including Objective 9.2.3 of Northland's RCP.
[11] In regards to Section 7(i) of the RMA that requires Council to have particular regard to the effects of climate change.

2016; Appendix A, section 9.6). This reduces any potential cumulative effects from multiple vessel presence (and any associated masking effects on noise) leading to possible vessel strike.The adoption and use of simple and commonsense boating behaviour guidelines around marine mammals by the dredge vessel (as proposed in the MWMP; Appendix 3), particularly around baleen whales and any calves, are expected to reduce the already *low* risk of collision to near zero (see Table 2 and Table 4 for further details). In addition, it is recommend that real-time / recent sighting information is obtained from DOC (or other project vessels), in order to anticipate and mitigate potential interactions with any whale species sighted in and near the project area.

In the case of underwater noise effects, we recommend adopting the best practicable option (BPO) in terms of Part 1 Interpretation and application, section 2(1) of the Resource Management Act 1991 (the Act), which states:

> **best practicable option**, in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to -
>
> a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and
> b) the financial implications, and the effects on the environment, of that option when compared with other options; and
> c) the current state of technical knowledge and the likelihood that the option can be successfully applied.

For this proposal, the most effective options for minimising underwater noise in the first instance would be the selection of the smallest practical dredge vessel[12] and the least acoustically invasive pile-driving technique[13] practically suited for the conditions, as well as ensuring both the dredge and pile driver are regularly maintained to a high standard. However, as per (b) above, the BPO must also consider financial and other environmental implications, such as the use of a smaller dredge vessel will likely lengthen the overall duration of the project (and potentially other effects). Using the BPO at all times will ensure noise emissions are minimised to the lowest practicable level, thereby minimising any subsequent underwater noise effects to marine mammals.

[12]Also see comment in Pine and Styles 2016: "The use of smaller dredgers may reduce the broadband noise levels however, smaller dredgers will likely have a different source spectra that for some marine mammals, might contain more acoustic energy in certain frequencies that they are more sensitive to. In this case, smaller and older dredgers may have impact zones commensurate with the larger TSHDs and CSD modelled in this report. After the commencement of dredging, in-field measurements of the actual plant should be undertaken and compared to the modelled impact zones presented in [Pine & Styles 2016], and mitigation strategies or monitoring could be updated accordingly."

[13] Although the proposal suggest using either traditional or vibro-driving techniques, additional considerations for pile-driving techniques and pile types are listed in the underwater noise management section (1.3.3) of the MWMP.

It is recommended that the actual noise levels produced from dredging activities be confirmed by measuring the associated underwater noises of these activities as soon as practical once the project has begun (see MWMP; Appendix 3 - 1.3.1). Using these measurements, spatial acoustic modelling should be completed or confirmed to understand the scale of any actual TTS effects before any further dredging activities take place.

In this case, acoustic modelling suggests that the chance of any auditory effects on marine mammal hearing (i.e. TTS) is extremely small based on how close an animal must approach (i.e. 1–10 m) an operating dredge vessel, and that the degree of any TTS effects is also dependent on how long the animal remains within close proximity to the dredge vessel. As discussed in Section 3.1.2, the likelihood of this overlap occurring is extremely *low* for this proposal. As such, intensive 24-hour monitoring is not warranted in terms of expense or practicality. Instead, and as an additional precaution only, we recommend the establishment of a precautionary safety zone (enforced by a marine-mammal observer) around an active dredge vessel during daylight hours, which would be sufficient to reduce this effect to effectively zero (*nil*) for a large portion of the project. If a marine mammal is sighted within or entering the precautionary zone, active sediment extraction (which generates the highest noise levels) would temporarily cease until the animal has exited the zone. Cessation of sediment extraction in this case refers to (for example): lifting the draghead from seafloor and ramping down the suction pump (TSHD); or cessation of on-going removal (BHD) or cutting (CSD) of the seabed.

Although no guidelines exist for pile driving within New Zealand, the government of South Australia has developed *Underwater Piling Noise Guidelines* (DPTI 2012) that provide excellent context and guidance on appropriate mitigation measures for the potential effects of pile driving activities on marine mammals. As mitigation actions for pile-driving noise we recommend the standard operational procedures and noise exposure thresholds from the DPTI guidelines (Appendix 3 - 1.3.2) are followed. These include, but are not limited to, soft-starts and a safety / shut-down zone around the work area to further minimise any risk of hearing impairment or injury to marine mammals from the proposed modifications to navigation aids. The key mitigation considerations are briefly described below:

- The **preferred method** of pile driving for this proposal is vibro-driving, due to the lower level of sound produced using this technique compared to impact-driving.
- **Soft-start / ramp-up** procedures in which the pile drive slowly increases the energy of the emitted sound giving any animals in the area time to move a safe distance away (Richardson et al. 1995).
- **Marine mammal observer and safety zone**. This involves a dedicated observer scanning a defined radius of the water's surface and coastal shoreline around the construction area for the presence of fur seals, dolphins or whales prior to commencement of pile-driving activities. If present, ramp-up procedures should

only commence once they have moved out of the zone. The size of the zone will be dependent on the technique used for pile driving, with vibro-driving having a smaller safety zone (100 m) than impact driving (300 m; DPTI 2012).

Table 4. Proposed mitigation goals and practices to mitigate or minimise the risk of any adverse effects of dredging activities on marine mammals in Whangarei Harbour and Bream Bay.

Potential effects	Mitigation goal	Best Management Practice	Reporting and monitoring (see Section 3.4, Appendix 3 and Appendix 4 for more detail)
Marine mammal / vessel strike due to increased vessel activity	1. Minimise the risk of dredge vessel collisions with any marine mammal and aim for zero injury/mortality.	1a. Adoption of best boating guidelines for marine mammals, including speed limits, to reduce any chances of mortality from vessel strikes (see Appendix 3). 1b. Liaise with the Department of Conservation (DOC) over the project period for real-time/recent sighting information, in order to anticipate and mitigate potential interactions with any whale species sighted in and near the project area.	• Record all vessel strike incidents or near incidents regardless of outcome (e.g. injury or mortality). • In case of a fatal marine mammal incident, carcass(es) recovered (if possible) and given to DOC, and further steps taken in consultation with DOC to reduce the risk of future incidences. Tangata Whenua notified.
Increase in underwater sound from dredging / disposal or pile-driving activities	2. Minimise the avoidance (attraction) or potential for injury of marine mammals due to dredging or pile-driving activities.	Dredging 2a. Use BPO to minimise underwater noise effects. 2b. Regular maintenance and proper up-keep of all dredging equipment and the vessel (e.g. lubrication and repair of winches, generators). 2b. Establish a designated observer on the dredge vessel and maintain a watch for marine mammals during any dredging and disposal activities over daylight hours. 2c. Establish a designated 'precautionary' safety zone (50 m) that marine mammal observers can enforce temporary cessation of active dredge operations when marine mammals are present (over daylight hours only), until any marine mammal leaves the zone. Pile driving 2d. Adoption of standard operating procedures, including the establishment of safety and observation zones, enforced by a dedicated marine mammal observer. 2e. Choose plant/techniques on the basis of minimisation of underwater noise levels (e.g. vibro-driving preferred over impact-driving).	• Measure actual underwater noise levels from dredging, and adjust modelling results and monitoring zones based on these data, if necessary (Appendix 4). • Record and report the type and frequency of any marine mammal sighted (or acoustically recorded) before, during or after transiting to or from the dredging/disposal site and pile-driving activities. Include behavioural data if possible. • Project sightings from 2b and 2d should be reported to DOC for input to database. • Passive acoustic monitoring of marine mammals' presence near dredging activities (see Section 3.4)

Potential effects	Mitigation goal	Best Management Practice	Reporting and monitoring (see Section 3.4, Appendix 3 and Appendix 4 for more detail)
Marine mammal entangle-ment in operational gear and / or debris	3. Minimise entanglement and aim for zero injury/mortality	3a. Avoid loose rope and other lines (keep them taut). 3b. Ensure that all dredging, support vessels and other project activities have waste management plans in place before the commencement of works.	• Record all entanglement incidents or near incidents regardless of outcome (e.g. injury or mortality). • In case of a fatal marine mammal incident, carcass(es) recovered and given to DOC, and further steps taken in consultation with DOC to reduce the risk of future incidences. Tangata Whenua notified.
Contaminant effects on marine mammals from maintenance dredging activities	4. Minimise or lower the risk of exposure to any contaminated sediments	4a. Test spoil sediments before maintenance dredging (sediment testing has already been undertaken for this proposal for capital dredge spoil).	

3.4. Recommended monitoring

Given the generally *low* likelihood and *de minimis* effect levels in this case, informative, rather than impact monitoring, is recommended for capital dredging as systematic marine mammal surveys to assess cause-effect relationships are not warranted or practical for this proposal[14]. Our recommendations are considered a more realistic monitoring option (scientifically and economically) because the programme will be focused on simple and answerable questions related to specific effects of the dredging, such as recording actual behavioural responses of local and visiting marine mammals. In this regard, monitoring is not intended to statistically assess the impact of dredging on local marine mammal populations in relation to pre-determined indicators or thresholds. Instead, the monitoring programme has been designed to help validate any potential assumptions of the AEE (e.g. underwater noise levels of dredge vessels given the lack of New Zealand data available) and further fine-tune mitigation options.

[14] There are inherent problems associated with implementing comprehensive monitoring programmes for marine mammals around cause-effect relationships. This is due to their mobility and flexible behaviour, highly variable population dynamics, and low sample sizes, with the manifestation of impacts from dredging likely to be very small relative to other stressors (and consequently lost in the 'noise' of background variability). As such, even with an established baseline dataset (such as exists for orca) and a high level of long-term effort, it would be highly unlikely that any statistically-valid conclusion could be reached in terms of a dredging effect on the population.

Informative monitoring questions should include:

- What are marine mammal behavioural reactions to the presence of dredge vessels during active versus non-active operations? For example, if present before dredging start-up, do animals immediately leave at start up?
- What are marine mammal behavioural reactions to spoil disposal? For example, if they are present before disposal, do animals immediately leave once disposal begins? If so, what is the mean time it takes them to return (if at all)?
- Are marine mammals visiting/passing through the dredging or spoil area in between dredging/disposals?
- What are the actual noise levels and frequencies produced from dredging and disposal activities within the Harbour entrance and at the disposal sites?
- How many delayed starts or shutdowns occurred due to marine mammal presence (and what species were these) during a single daylight period during pile driving?

Industry and DOC can use the information gained through the proposed capital dredge monitoring plan to further understand any actual effects of dredging activities on marine mammals and, if necessary, help reduce the risk of similar incidences with any future maintenance dredging.

3.4.1. Capital dredging

Pre- and post-dredging and disposal monitoring

Recommended monitoring involves the collection of opportunistic visual sightings and passive underwater acoustic monitoring before, and after capital dredging has ceased over a relatively short time period (approximately one month for each, depending on time of year). These data sources together will confirm which species are present in the proposal areas prior to the start of any dredging activities and assess marine mammals continued presence in the area once dredging has ceased. The recommended monitoring protocol is also described in Appendix 4.

Collection of sighting data

Any sightings collected before capital dredging will confirm which species may be currently using habitats in the vicinity of the project as discussed in the Phase 1 assessment. Post-dredge sightings (and acoustic monitoring) will mainly be used to assess the continued presence of any marine mammals within the project area after capital dredging activities have stopped. Opportunistic sightings have already been recorded by vessels collecting preliminary information for the project in the vicinity of the proposal and other nearby regions (i.e. benthic sampling in channel and proposed spoil disposal areas; Appendix 5). For instance, opportunistic sightings gathered by other consultants and the general public since March 2015 have helped reaffirm the limited presence of baleen whales in the Harbour region, as predicted based on the earlier Phase 1 literature and DOC national databases review.

Similar sources would be sufficient to collect opportunistic sightings on species' presence in the proposal areas for at least a month before and after any capital dredging activity. Any regular (non-project) users of the Whangarei Harbour entrance (e.g. tug boats) could also be encouraged to record and report opportunistic marine mammal sightings. Sighting data gained through the project should be exchanged with DOC for collation to the national database.

Passive acoustic monitoring

Passive acoustic recorders (i.e. moored underwater acoustic recorders) automatically listen and record any underwater sound at frequencies likely to be from marine mammal vocalisations. These recordings (also known as detections) are downloaded at a later date and used to assess whether marine mammals may have been present in a particular area. Pine and Styles (2015; Appendix 1) recorded marine mammal clicks and whistles (characteristic of dolphins) at four passive acoustic moorings over a single ~10-day period while undertaking preliminary ambient sound recordings around the Whangarei Harbour entrance. Although acoustic recorders are limited in range (usually within a few hundred metres of the device), and cannot assess if marine mammals are truly absent (versus present but not vocalising or echo-locating), the advantage of using passive acoustic moorings is that they can 'listen' for the presence of any marine mammals both day and night and when sea conditions are not favourable for visual sightings, thus helping to supplement and confirm sighting data. We recommend placing a limited number of passive acoustic moorings (~4) near the Harbour entrance, disposal area and near the 120 dB underwater noise boundary to record marine mammal detections over the same time period that opportunistic sighting data are collected (for one month before capital dredging, and for one month after).

3.4.2. Monitoring during dredging and disposal

The recommended monitoring during dredging and disposal activities also includes collecting general information on species presence within the project vicinity while assessing specific questions related to the actual versus potential responses of local and visiting marine mammals to dredging and disposal activities. This includes a marine mammal observer on board the dredge vessel and passive underwater acoustic monitoring for both marine mammal presence in the project area and dredge noise.

Marine mammal observer

A designated marine mammal observer should maintain a watch on the dredge vessel whenever dredging or disposal activities are underway (including transiting) over daylight hours only (Appendix 3). The observer does not need to be a qualified marine mammal observer (e.g. an existing crew member can be inducted and designated to fill the role of the observer).

The primary objective would be to enforce a precautionary safety zone of 50 m around dredging operations to avoid any TTS effects. The presence of any marine mammal within the zone would result in cessation of active dredging (i.e. cease suction, cutting or digging—depending on the dredge type being used at the time), until the animal leaves the pre-determined zone. An additional advantage of such observation is that it will allow for the effectiveness of any mitigation measures (e.g. boating behaviour guidelines) put in place to be reported and amended, if necessary, while dredging operations are underway.

While the observer is primarily recommended for implementing mitigation measures (i.e. shut-down of sediment extraction when marine mammals are in the vicinity), there will also be information-gathering benefits. The secondary objective would therefore be for the observer to record opportunistic sightings and observation data (e.g. behavioural information) on marine mammals in the general area, with an emphasis on those nearest to the dredging and disposal sites.

In addition, a central contact point should be established (e.g. with DOC and other project staff) to obtain up-to-date regional sighting information, so the observer onboard the dredge vessel can anticipate the presence of any marine mammals previously sighted in or near the area.

Passive underwater acoustic monitoring

Given the use of onboard observers, passive acoustic monitoring is necessary to assess whether marine mammals are passing through project areas when the dredge vessel is absent (i.e. transiting to/from spoil disposal site or during rough weather). This monitoring is not intended to assess species frequency or intensity of use but rather simply determine whether any marine mammals are present within project areas during different cycles and noise levels of the capital dredging project. Hence, only two separate monitoring periods of approximately 14 days each are necessary within the estimated six-month project duration to sufficiently detect the potential presence of marine mammals across several dredging cycles.

Measuring underwater noise produced from dredging works.

Actual dredging noise levels should be monitored periodically throughout different work phases. The monitoring periods should represent variation in dredging noise, for example noise associated with dredging different sediment types and different parts of the dredging cycle; and transiting vs. extraction vs. disposal.

Both datasets should be used to validate some of the assumptions made in this assessment. Of particular interest are marine mammal observations near the operating dredge vessel (i.e. out to 300 m), as these could provide some context around the underwater noise effects when coupled with actual acoustic data taken from the dredging operation (for example, ‘when starting to dredge sediment and the noise levels were approximately ‘x’ dB, the animals approached/avoided the vessel’).

Sighting data (from the observer, acoustic monitoring or that reported from other vessels or the public) would ideally be reviewed with the predicted TTS, auditory masking or behavioural spatial ranges (as determined in Pine and Styles 2016) to refine the assumptions of the acoustic modelling and any associated effects (as outlined in this report) prior to maintenance dredging.

3.4.3. Maintenance dredging

The consideration of possible monitoring options for capital dredging and spoil disposal also applies to any ongoing maintenance dredging, but more so in relation to operational practices in proximity to sighted marine mammals. The assumed smaller-scale aspects of maintenance dredging and disposal, along with smaller dredge vessel size, will likely require less extensive monitoring than that proposed for the capital dredging. At a minimum, best management practices should still be adopted (i.e. as part of the Marine Wildlife Management Plan). A designated marine mammal observer should also maintain a watch on the dredge vessel whenever dredging or disposal activities are underway (including transiting) over daylight hours only. The purpose of this observer would be to record opportunistic sightings and observation data (e.g. behavioural information) on marine mammals in the general area, with an emphasis on those nearest to the dredging and disposal sites; and secondarily, to avoid vessel strike / marine mammal interactions. As with capital dredging activities, a central contact point should be established (e.g. with DOC and other project staff) to obtain up-to-date regional sighting information, so the observer onboard the dredge vessel can anticipate the presence of any marine mammals previously sighted in or near the area.

The information compiled via direct observation and passive acoustic monitoring during the capital dredging project can be used to inform aspects of any program for maintenance dredging; especially regarding marine mammal response to dredging and spoil disposal operations and seasonal use of the area by individual species. Any additional monitoring practices, if required, will be determined after analysis of the capital dredging project data.

3.4.4. Pile driving

The recommended monitoring during pile-driving activities includes a marine mammal observer on board the pile-driving vessel (i.e. additional to the observer on-board the dredge vessel) and / or a separate support vessel in order to monitor for marine mammal presence within the observation zone and safety zone, if the size of these zones is not able to be surveyed effectively from a fixed platform.

Marine mammal observer

A designated marine mammal observer should maintain a watch on the pile-driving vessel whenever pile driving is underway (constrained to daylight hours; see Appendix 3 for more details). The observer does not need to be a qualified marine mammal

observer (e.g. an existing crew member can be inducted and designated to fill the role of the observer).

The primary objective would be to enforce a safety zone around pile-driving activities to reduce the risk of any TTS/PTS. The presence of any marine mammal within the zone would result in cessation of pile driving until the animal leaves the pre-determined zone. The size of the zone would be determined as part of the underwater noise management plan (Appendix 3, Section 1.3). In addition, the observer onboard the pile-driving vessel should be kept up to date with regional sighting information (as exchanged with DOC, Section 3.4.2), so they can anticipate the presence of any marine mammals previously sighted in or near the area.

4. PRE-SUBMISSION CONSULTATION

Consultation has been undertaken with the general public (via open days) and with all relevant stakeholders (at least attempted in some cases) throughout the writing of the Phase 1 report (Clement & Elvines 2015) and this Phase 2 marine mammal report . Specific concerns are highlighted and discussed further in this section.

4.1. Issues raised in the Tangata Whenua O Whangarei Te Rerenga Paraoa draft cultural effects assessment

The cultural assessment highlights that tangata whenua are concerned that some of the potential effects on marine mammals from the RNZ capital dredging proposal are considered ‘low probability’ but ‘high impact’. In fact, the cultural assessment cites a statement from this report that refers to “some of the possible consequences of rare events (i.e. vessel collision or entanglement) could have population level effects” (see Section 3.3, p. 23). This means that effects with a very low or rare likelihood of occurring could have a severe consequence if they were to occur. In the case of marine mammals, the extreme example of this would be a death of an endangered female, as loss of her breeding potential could have serious repercussions on the future reproductive capabilities for the population as a whole. Tangata whenua feel that the existence of these rare events is an unacceptable adverse effect. Their conclusion is that such events cannot be mitigated and instead, must be avoided.

This report specifically addressed these concerns in detail, and concluded that implementing the appropriate mitigation actions could lower the overall chances of these rare events occurring to as near to zero as possible while increasing the animal’s chances of survival in the extremely unlikely event that one did occur. I discuss these report findings further below using the mitigation of vessel strikes as an example.

4.1.1. Vessel strikes

It is important to emphasise that any vessel that is on the water in areas that marine mammals reside or travel has the exact same chance of striking an animal, regardless of type (commercial or recreational). This is due to the fact that marine mammals spend the majority of their time underwater and are usually only visible as they are surfacing. Their surfacing intervals, and subsequent reaction to a nearby vessel once surfaced, are at times completely random and often unpredictable. The only difference between a small recreational boat striking a marine mammal and a container ship is the potential outcome to the animal.

Most reported incidences of vessel strikes have been with mysticete (baleen) whales (see Section 3.1.1). Whale occurrences in Bream Bay (and Whangarei Harbour) are

seasonal with sightings restricted mainly to winter months, and individuals remain in the greater region for only a few days. As the proposed timeline for the capital dredging project is approximately six months, there is the possibility that the dredging will occur completely outside the whale migration period, overlap partially or occur throughout the entire migration period. However, it is important to note here that while vessel traffic will temporarily increase over the course of the capital dredging project, it will decrease over the longer term as fewer, but more heavily laden, oil tankers will be used in the future.

In order to place the likelihood of a vessel strike occurring in the context of this proposal, I have estimated a possible 'worst-case' scenario. I estimated the maximum number of whales that could occur in the larger coastal region[15] in one year at 5 individuals, based on the DOC sighting and stranding database. Out of the 112 reported sightings of baleen whales [16] in this same area, only 22 of these animals (or 19%) have passed through inshore waters between Bream Bay and Hen and Chicken Islands (to just north of Bream Head and Mangawhai Heads to the south). Based on these previous data, only 1 of 5 whales would be predicted to occur in Bream Bay waters near the proposal area.

The proposal area over which the vessel will be working is approximately 10 km^2 (including all channel areas and disposal sites; Tonkin & Taylor 2016), around 2% of the total Bream Bay area[17]. The average distance between the channel and disposal sites in which the dredge vessel must travel is between 3 and 7 km. This distance equates to around 60 to 90 mins of vessel transiting for each complete dredge cycle, or 12–13 hrs of transiting over a 24 hr period of uninterrupted dredging in perfect conditions.

Finally, I assumed that this hypothetical animal remained in this same Bream Bay area for up to three days[18]. Without any mitigation, the overall chances of this whale being struck by the dredge vessel are dependent on this one animal wandering through the specific transiting area (< 2% of Bream Bay) within a three-day period at the same time the dredge vessel is traveling to or from the disposal site (i.e. a potential collision window of 39 hrs out of an estimated 1800 hrs of transit time over a conservative five months for project completion). In other words, the likelihood of a whale being struck by the dredge vessel in this worst-case example is extremely low, but as pointed out in this report, can never be presumed to be zero.

[15] The coastal and more offshore waters between Tukukaka to the north and Omaha Bay and Great Barrier Island to the south.

[16] Note that several of these sightings will be re-sightings of the same animal on the same day and / or over different days as they travelled up the coast.

[17] Defined as ~432 km^2 from a line just north of Bream Head to the Hen and Chicken Islands to the east, to Mangawhai Head to the south and Bream Bay coastline to the west.

[18] Whales have only been resighted in the same location off this region over 1-2 days, but in other locations around NZ can occur up to a few weeks.

As discussed in this assessment, the likelihood of a vessel strike and the risk that it will result in serious injury or death increases above speeds of 10–14 knots (see references in Section 3.1.1). As demonstrated above, for approximately half of the dredging cycle, the dredge vessel will be of little concern to nearby whales as it will be relatively stationary while dredging (i.e. 1–3 knots) and disposing of dredged sediment. When travelling to the disposal site, the normal operating speed of a dredging vessel is estimated to be around 7.5 knots with a loaded hopper and up to 15 knots empty, depending on TSHD used (Tonkin & Taylor 2016). The generally slower speeds of dredge vessels likely explain why they have been involved in only one out of the 134 worldwide collisions with whales (in which the vessel type was known) reported between 1975 and 2002.

To further reduce the likelihood of a strike and avoid any risk of a mortality, we have recommended several mitigation actions (see Table 4 and Appendices 3-4). These actions include the adoption of best boating behaviour guidelines around marine mammals by the dredge vessel as part of a Marine Wildlife Management Plan, which importantly includes vessel speed limits. In addition, it is recommend that real-time / recent sighting information is obtained from DOC (or other project vessels) throughout the duration of the project, in order to anticipate and mitigate potential interactions with any whale species sighted in and near the project area. Finally, as part of the proposed informative monitoring programme, a designated marine mammal observer will also be maintaining a watch for marine mammals on the dredge vessel whenever dredging or disposal activities are underway (including transiting) over daylight hours.

Together, these mitigations actions will ensure that all available information is being used to help locate, further reduce and avoid any interactions between the dredge vessel and any visiting marine mammals (e.g. vessel collision, entanglement or otherwise) that may occur within the proposal area during the course of this project.

4.2. Issues raised by Forest & Bird

At a meeting in Wellington on 29 June 2017, Forest & Bird's marine representative raised several points of concern in relation to the capital dredging proposal and more specifically, the resulting oil tanker traffic once the project was completed. The main issues are outlined and discussed further below.

4.2.1. Underwater noise issues

Forest & Bird's main concern is that this report and the underwater noise assessment (Pine & Styles 2016) have used NOAA's previously recommended behavioural noise threshold of 120 dB, developed in 1998, for assessing the spatial extent of any behavioural effects. Unlike NOAA's recent recommendations for TTS and PTS thresholds (2016), there is currently no agreed-upon behavioural noise threshold for marine mammals in the United States or worldwide. This is due to the fact that

understanding behavioural responses to varying noise levels is complex and complicated by differences in species, age groups, current behavioural state and even individual tolerances.

Forest & Bird is worried that use of 120 dB threshold for behavioural reactions, without further explanation, will set an unwarranted precedent for future resource consents of a similar nature (e.g. marine construction). As a result it was suggested, and we have agreed, that further explanation around the use of this threshold and our approach as being specific only to this application was included (see footnote 6 p.12 and further discussion in Appendix 2). We have also included spatial figures for the 120 dB threshold for behavioural reactions as single, un-weighted models in Appendix 2 (Figure A2.1), as requested by Forest & Bird to be used in combination with proposed acoustic monitoring to determine the efficacy of the 120 dB behavioural threshold in this particular case (see below for more detail).

4.2.2. Lack of proposed marine mammal surveys

Forest & Bird were curious why there was no systematic marine mammal surveys of the proposal area and nearby waters undertaken or recommended as part of the monitoring programme in this report. Given the general lack of information available on marine mammals in New Zealand and no current government initiatives to fund research, they feel that this is one of the only ways to gain more knowledge.

We discussed the lack of any resident species in the proposal area and the amount of data that could be realistically gathered over the course of this project, in particular, the 6 months while capital dredging was occurring. Through the discussion, it was pointed out that in a case such as this, several months or even years of surveys only accumulate a small sample size, too small for statistical testing to see whether there are any significant behavioural effects on marine mammals. As a result, such surveys would be collecting ‘data for data’s sake’ and not necessarily providing any useful data for mammal experts or answering any useful questions in context of the proposal. Instead, we have carefully framed the monitoring to actually get some useable data on marine mammal reactions to dredging and disposal; and the representative agreed that they were happy with that part of the monitoring programme.

Forest & Bird noted an interest in finding out more about some of the offshore species (particularly beaked whales), as Northland in general seems to be a high density region for these species. They noted that beaked whales can be extremely sensitive to underwater noise and overseas research has found that impulsive sound levels (i.e. military sonar and seismic surveys) as low as 80 dB can have behavioural effects on these species.

Our Phase 1 report (Clement & Elvines 2015) identified the presence of beaked whales as possible offshore residents of the Northland region and suggested the theory that they may move inshore during summer and autumn months as evident by increase in strandings during that time, as well as noting their increased acoustic sensitivity. At the meeting, we all agreed that there is no evidence that beaked whales would venture into waters as shallow as the proposal areas, but they still remain a potential species of interest.

It was suggested, and we agreed, that one of the passive acoustic recorders for monitoring could be placed along the 120 dB sound contour during the capital dredging work to monitor any evidence of offshore species presence and possibly their acoustic reactions to the various dredging cycles and noises levels (see Appendix 2). These results would be correlative, not causative but still useful from the perspective of trying to understanding underwater noise effects of dredging on such species and may provide some empirical evidence in terms of the 120 dB threshold for behavioural reactions. However, the actual placement of a recorder will be dependent on practicality (e.g. exposure to commercial fishing, distance offshore) and local environmental conditions (e.g. depth and currents).

4.2.3. Resulting shipping issues

Forest & Bird are concerned that the heavier oil tankers used once the capital dredging was completed would sit deeper in water and therefore, more underwater noise would be generated from the greater surface area of ship underwater. The speeds of the tankers in the channel and harbour were also queried, noting that there is a preference for 10 knots or less based on research for the avoidance of ship strike.

In response, it was noted that the current oil tankers will only be adding 10% more cargo and this will result in it sitting only 3 m deeper than currently. Jon Styles (Styles Group, acoustic and vibration consultants) noted that underwater noise comes primarily from the propeller and engine, not hull and that the extra draft would only increase the noise levels by a very small amount. Navigatus' (2016; section 4.7) risk assessment and the RHDHV (2016; section 2.2.5) report confirm that the tankers will do less than 10 knots, typically 6-8 knots in the channel, slowing as they near the berth.

4.2.4. Other issues

It was noted that it might be possible for some marine mammals to swim into the harbour while the dredge was transiting or disposing of dredge sediment, and then be 'trapped' in the harbor by the dredge noise once it started working in channel again. As discussed in Section 4.1, the THSD dredging cycle was estimated to be approximately 110–180 minutes and the transfer and disposal would be approximately half of that length (RHDHV 2016). Hence, if animals did enter the harbour and were not willing to pass by a working dredge, they would not be trapped for long. The

proposed passive acoustic monitoring stations located near the Harbour entrance will be able to provide actual data into whether this issue is occurring and information on any subsequent responses.

Note, there is the possibility of both the THSD (in the channel) and BHD (at the jetty) barges working at the same time during daylight hours. In this case, the break in active dredging is likely to be shorter but still adequate for any animals to exit the Harbour within a few hours of entering.

5. CONCLUSIONS

The purpose of this report is to describe the existing environment in terms of the local and visiting marine mammals that utilise and / or are influenced by the Whangarei Harbour and associated Bream Bay ecosystem. In particular, information on the various species was reviewed for any life-history dynamics that make them more vulnerable to dredging and disposal activities or where proposal sites may overlap with any ecologically significant feeding, resting or breeding habitats (which include prey resources). This, in turn, enabled the potential effects associated with the capital and maintenance dredging and disposal components on marine mammals to be assessed.

The marine mammals most likely to be affected by the proposed project include those species that frequent the Whangarei Harbour and Bream Bay regions year-round or on a semi-regular basis. These species are bottlenose dolphins, orca, Bryde's whales, and common dolphins. Other species including NZ fur seals, pilot whales, beaked whales, southern right whales, humpback whales, sperm whales and pygmy sperm whales were considered in this assessment because of their records of occurrence in the area and their known vulnerabilities to particular anthropogenic impacts (i.e. vessel collision); species-specific sensitivities (i.e. underwater noise); and / or special concern to local iwi Tangata Whenua o Whangarei Te Rerenga Paraoa.

The coastal waters of Whangarei Harbour and Bream Bay are not considered significant habitats for any marine mammal species. Instead, these waters represent only a small fraction of similar habitats available to these marine mammals throughout the larger north-eastern region.

Based on the direct and indirect potential effects highlighted in this report, the overall effects of the capital and maintenance dredging and the disposal and pile-driving components on marine mammal species within Whangarei waters are assessed as *de minimis* when considered with the recommended avoidance / mitigation actions. This conclusion is based in part on information from other consultancy reports including the expected levels of underwater noise due to dredging (Pine & Styles 2016) and pile-driving activities, concentrations of contaminants in dredging materials and expected effects on local benthos and fish communities (Coffey 2017), and modelled and predicted turbidity plume dynamics (MSL 2016).

Informative monitoring is recommended and based around a combination of recording visual sightings of marine mammals (both opportunistic and from dedicated observers on the project vessels) with simultaneous passive underwater acoustic monitoring. Given the *low* likelihood and *de minimis* effects of the proposal, the recommended monitoring plan for capital dredging and pile driving is based on collection of information to improve understanding of how marine mammals respond to these activities, rather than testing of specific predictions of effect (Section 3.4.1,

Appendix 4). Such a programme will serve the dual purpose of collecting important data on the actual effects of dredging and pile driving on New Zealand marine mammals while assessing the effectiveness of any mitigation measures put in place. These measures can then be amended, if necessary, while operations are underway, for later maintenance dredging projects.

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7. APPENDICES

Appendix 1. Short-term passive underwater acoustic survey of Whangarei Harbour entrance and Marsden Point: preliminary investigation by Pine and Styles 2015.

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Prepared for: **Chancery Green on behalf of Refining New Zealand**

Date: **13th November 2015**

Title: **Short-term Passive Underwater Acoustic Survey of Whangarei Harbour Entrance and Marsden Point: Preliminary Investigation**

Prepared by:

Matt Pine, BSc. PhD. MASNZ

Jon Styles, BAS. MASNZ.

Reviewed by:

Jamie Exeter, MASNZ.

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Executive Summary

Styles Group has been engaged by Refining New Zealand (RNZ) to undertake a passive acoustic survey of the ambient underwater soundscape within and around Calliope Bay at the entrance to Whangarei Harbour as part of an investigative phase 1 study. This survey addressed three separate objectives: the first was to establish the temporal and spatial variability of background sound levels over the two week study period; the second was to determine the received sound pressure levels from several vessels, particularly a suezmax vessel, entering and departing the Marsden Point Oil Refinery; and the third was to confirm the presence of marine mammals over the study period.

Up to eight passive acoustic loggers were deployed within Calliope Bay and Bream Bay at four separate survey sites (Lort Point, Mair Bank, Busby Head and Bream Bay). Ambient sound levels varied within each survey site with spectral analyses revealing variances up to 47 dB for frequencies below 10 kHz. Measured sound levels were highest within the Lort Point survey site (average 119 ± 0.08 dB$_{rms}$ re 1 µPa) and decreased with increasing distance from the Marsden Point industrial area (averages of 113 ± 0.07 dB$_{rms}$ re 1 µPa, 108 ±, 0.46 dB$_{rms}$ re 1 µPa, and 105 ± 0.10 dB$_{rms}$ re 1 µPa from within the Mair Bank, Busby Head and Bream Bay survey sites, respectively). Between survey sites, the ambient soundscape was largely characterised by frequencies below 2 kHz. Unique within the Lort Point survey site (within the boundary of a Marine 1 (Protection) Management Area) was a consistent low frequency signal (~103 - 121 dB$_{rms}$ re 1 µPa between 0.1 and 1 kHz) of various harmonics. This low frequency signal did not demonstrate any biological characteristics and appeared typical of an already existing mechanical source. In the absence of any operating vessels, the broadband sound levels within the Whangarei Harbour entrance were comparable with many other nearshore environments around New Zealand and the soundscape within Calliope Bay was spectrally similar to other busy harbours where vessels are common (as spectral analyses reveal peaks in spectral density below 1 kHz).

Received broadband sound levels from vessels showed considerable variation depending on the type of vessel as well as being a function of speed and distance. The highest broadband (0.05 - 70 kHz) received level measured from any vessel was 150 dB$_{rms}$ re 1 µPa (Torea, IMO 9274082); a considerable increase from the lowest measured level of 128 dB$_{rms}$ re 1 µPa (Anatoki, IMO 8864153). There was no apparent relationship between the tonnage of a vessel and the received broadband sound levels as the largest suezmax vessel (Jag Lagshita, IMO 9208057) had a received broadband level of 135 dB$_{rms}$ re 1 µPa; a phenomenon previously measured by Styles Group at other locations.

Dolphins (species unidentified) were detected within all survey sites, with most detections occurring outside Calliope Bay. No whales were detected during the survey period. In total, dolphins were detected on 13 separate occasions between all four survey sites and vocalisations were mostly detectable for approximately 30 minutes a time. The longest duration

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for which vocalisations were detected during a single occurrence was 1.5 hours. These data provide evidence that dolphins do frequent this area, however care should be taken when inferring any conclusions regarding their abundance or habitat use because the data is limited in sample size and methodology.

The data from this survey shows the ambient sound levels within and around Calliope Bay are comparable with other nearshore environments around New Zealand, however average and median levels were lower compared to very busy harbours such as the Waitemata Harbour and inner Hauraki Gulf.

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Introduction

Styles Group has been engaged by Refining New Zealand (RNZ) to undertake a passive acoustic survey of the ambient underwater soundscape within and around Calliope Bay at the entrance to Whangarei Harbour to accompany an application to deepen the channel at Whangarei Heads to allow suezmax vessels to operate at a higher capacity than at present, as well as ease the navigational difficulty during the channel approach. Currently, these large ships carry cargo to and from the oil refinery but are under-loaded so as to successfully navigate the channel between Whangarei Heads and Marsden Point.

The overall aim of the survey was to investigate the ambient underwater soundscape and achieve the three following objectives:

1. To establish background sound levels;
2. To determine the received levels from several vessels, particularly oil tankers, entering and departing the Marsden Point Oil Refinery;
3. To confirm any presence of marine mammals over the survey period.

This report will outline the survey methodology and results for each of the above three objectives. Potential impacts on marine life from undersea dredging or any acoustic modelling of undersea dredging noise have not been undertaken as part of this report.

Materials and Methods

Survey Sites

In order to establish background underwater sound levels within the Whangarei Harbour entrance, Styles Group was asked to design a suitable survey methodology. It was identified that potential underwater noise arising from the proposed dredging activity may propagate into four separate Marine 1 (Protected) Management Area zones in accordance with NRC Map C13 (Figure 1). Thus, eight calibrated SoundTrap (ST) acoustic loggers were deployed to assess the current background sound levels within Calliope Bay and Bream Bay; including within the Marine 1 (Protected) Management Area Lort Point and next to Mair Bank. The four survey sites (each with two individual acoustic loggers) were (1) Lort Point (S 35° 49.856' E 174° 30.223'); (2) Mair Bank (S 35° 51.091' E 174° 31.125'); (3) Busby Head (S 35° 52.449' E 174° 32.757'); and (4) Bream Bay (S 35° 53.147' E 174° 31.326'). A map showing the location of each survey site is provided in Figure 2. The location of each site was selected based on field-accessibility, depth, currents and the purpose of that particular ST logger in the scheme of the overall survey.

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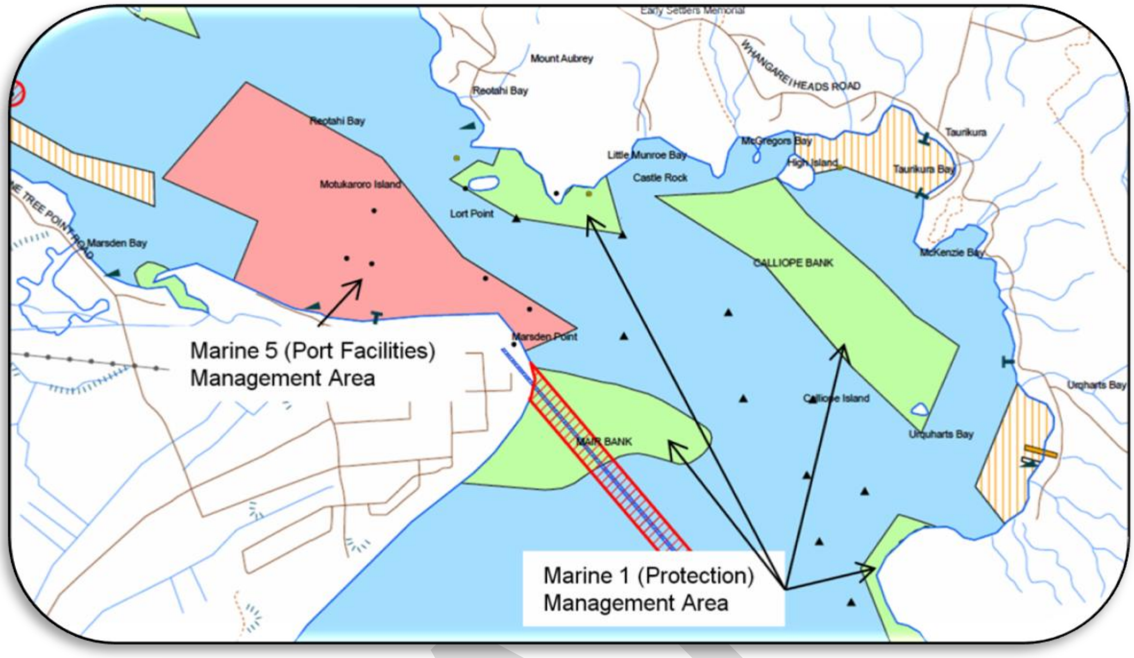

Figure 1: NRC C13 Map. Arrows show main Marine Management Areas.

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Figure 2: GPS location of each survey site where SoundTrap loggers were deployed.

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Underwater Recording Systems

Ambient sound recordings were made using SoundTrap (ST) 201 (288 kHz sampling rate), 202 (288 kHz sampling rate), and 202HF (576 kHz sampling rate) laboratory grade underwater acoustic loggers secured between 1 m and 2 m off the seabed and at a depth between 6 m and 20 m at MLWS. See Appendix A for a schematic diagram of the deployment apparatus. Two loggers were deployed at each survey site and set on alternating duty cycles to conserve memory and battery life during the survey. Acoustic data were obtained between the 26th March and 6th of April 2015.

Calibration

The hydrophone component of the ST acoustic logger was calibrated by the manufacturer and field-calibration checks before and after deployment were undertaken using a calibrated pistonphone (GRASS Type 42AA, SPL 114 dB re 20 µPa, nominal frequency 250 kHz), a calibrated (using a Brüel & Kjaer Type 4231 Sound Calibrator) sound level meter (Brüel & Kjaer 2250 Type 1 SLM with a Brüel & Kjaer 1/2 inch Condenser Microphone Type 4189) and specialist acoustic software. Electronic calibration of the recorder component was done at the

start of each recording event by comparing a set of automated tones of known frequency and voltage amplitude to the full scale response level provided by the manufacturer and verified using the pistonphone. The calibrated range of the hydrophones was 20 Hz to 144 kHz (ST 201, 202 recorders) or up to 200 kHz (ST202HF recorders) before sensitivity begins to decrease. The distances at which an animal would need to be before being detected is highly variable and depends on the vocalisation amplitude and frequency. Consequently, we are unable to identify a scientifically defined range for which marine mammals may be detected.

Data analysis

Each sound recording was examined for extraneous noise contamination from wind, waves, or precipitation to ensure accurate calculation of ambient pressure levels, as well as received levels from commercial vessels. Recordings which did contain considerable contamination were not analysed.

A descriptive statistical analysis was undertaken on 1200 thirty-minute recordings made between the 26th March and 6th April over the four survey sites. Power spectra, third-octave band levels, the spectral probability density (SPD) and broadband sound pressure level (SPL) for each survey site over the deployment period were calculated. Note the 1200 recordings were made up of systematically selected 30min recordings which did not contain extraneous noise contamination (from weather). Selection was based on every hour or half-hour period depending on the degree of contamination, if any.

Ship arrival and departure times at the oil refinery during the survey period were provided by North Tugz Limited and were used to identify passing ships in the acoustic data. Broadband received levels of each passing ship were calculated and plotted against time, along with the corresponding power spectra.

Acoustic data were analysed to determine the presence or absence of marine mammals using automated acoustic detectors and confirmed by visual inspection of the corresponding spectrogram. Vocalisations were not characterised or specifically analysed as this type of analysis was outside the survey's scope.

Survey Results and Discussion

Due to the high tidal currents within Calliope Bay, a single ST logger at Lort Point was physically compromised by mud and contained too much extraneous noise contamination to be used. The second ST logger at Lort Point that was closer to the surface was not affected. Therefore, analysis was carried out on the remaining seven acoustic loggers.

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Objective 1: Background sound levels

Broadband (50 Hz - 48 kHz) ambient SPLs measured passively over a 24 hour period (28th March 2015) are shown in Figure 3, while percentile plots of both power spectra and third-octaves over the entire survey period are given in Figure 4 and Figure 5, respectively. The 28th March 2015 was selected because the least number of ships were logged coming in or out of Marsden Point on that day and therefore provided the best opportunity to obtain a representative measure with minimal noise contamination. Simple descriptive statistics of the broadband SPLs over the survey period are provided in Table 1.

Ambient sound levels varied within each survey site with spectral analyses revealing variances up to 47 dB for frequencies below 10 kHz (due to consistent vessel activity). Consistent between survey sites was the soundscape being characterised by frequencies below 2 kHz; indicated by the power spectra (Figure 4) and third-octave (Figure 5) percentile plots. Sound levels measured from the Lort Point survey site were largely controlled by large vessels arriving and departing Marsden Point (characterised by a greater noise-floor at frequencies below 2 kHz compared to Busby Head and Bream Bay where sound levels below 200 Hz are >10 dB less). With the exception of the Lort Point survey site, in the absence of any vessels the ambient soundscape could be considered similar to other nearshore environments, such as the outer Hauraki Gulf (~109 - 118 dB re 1 µPa[1]), Rotoroa Island (~112 - 117 dB re 1 µPa[2]) or the Kaipara Harbour (~114 - 118 dB re 1 µPa, respectively (Pine et al. 2015)). However, at the Lort Point survey site only, a continuous low frequency signal (~103 - 121 dB_{rms} re 1 µPa between 0.1 and 1 kHz) of various harmonics was recorded below 1 kHz (Figure 6) on most days. Peak frequencies and SPLs of the signal did vary in time, although showed no consistent pattern (Figure 7). The source of this low frequency signal is not biological but appears mechanical. Notwithstanding this, average background sound levels (broadband) from all four survey sites were lower compared to the inner Hauraki Gulf where average sound levels measured from within the Waitemata Harbour, Rangitoto Channel and Waiheke Channel range between 116 and 127 dB re 1 µPa[3]. The gradual increases in sound energy residing in frequencies above 10 kHz were controlled by snapping shrimp, which are the most ubiquitous species within New Zealand's temperate habitats (Pine et al. 2015; Radford et al. 2008; Radford et al. 2010), such as those around Whangarei Heads and within Calliope Bay.

[1] Pine, MK. Unpublished data, August 2011. Leigh Marine Laboratory, Institute of Marine Science.
[2] Pine, MK, Styles JR. Unpublished data from passive acoustic survey, July - October 2014. Styles Group Acoustics and Vibration Consultants.
[3] Pine MK., Styles JR. Unpublished data from passive and active surveys between May 2013 and October 2014. Styles Group Acoustics and Vibration Consultants.

Survey Site	Mean ± SE (dB_{rms} re 1 µPa)	Median (dB_{rms} re 1 µPa)	Max (dB_{rms} re 1 µPa)	Min (dB_{rms} re 1 µPa)	Range (dB_{rms} re 1 µPa)
Lort Point	119 ± 0.08	117	147	111	36
Mair Bank	113 ± 0.07	111	146	108	38
Busby Head	108 ± 0.46	107	142	98	44
Bream Bay	105 ± 0.10	104	132	96	36

Table 1: Basic statistics for ambient broadband sound (50 Hz - 48 kHz) measured at each survey site between 26th March and 6th April 2015 based on 7,043 randomly selected 60-sec samples per site.

Despite the lower broadband sound levels, the soundscape within the Whangarei Harbour entrance was spectrally similar to other harbours where vessel activity is high as the root mean squared and 5th percentile spectrum was characterised by frequencies below 1 kHz, while the outermost survey site, Bream Bay, demonstrated spectra closer resembling those of soft sediment habitats.

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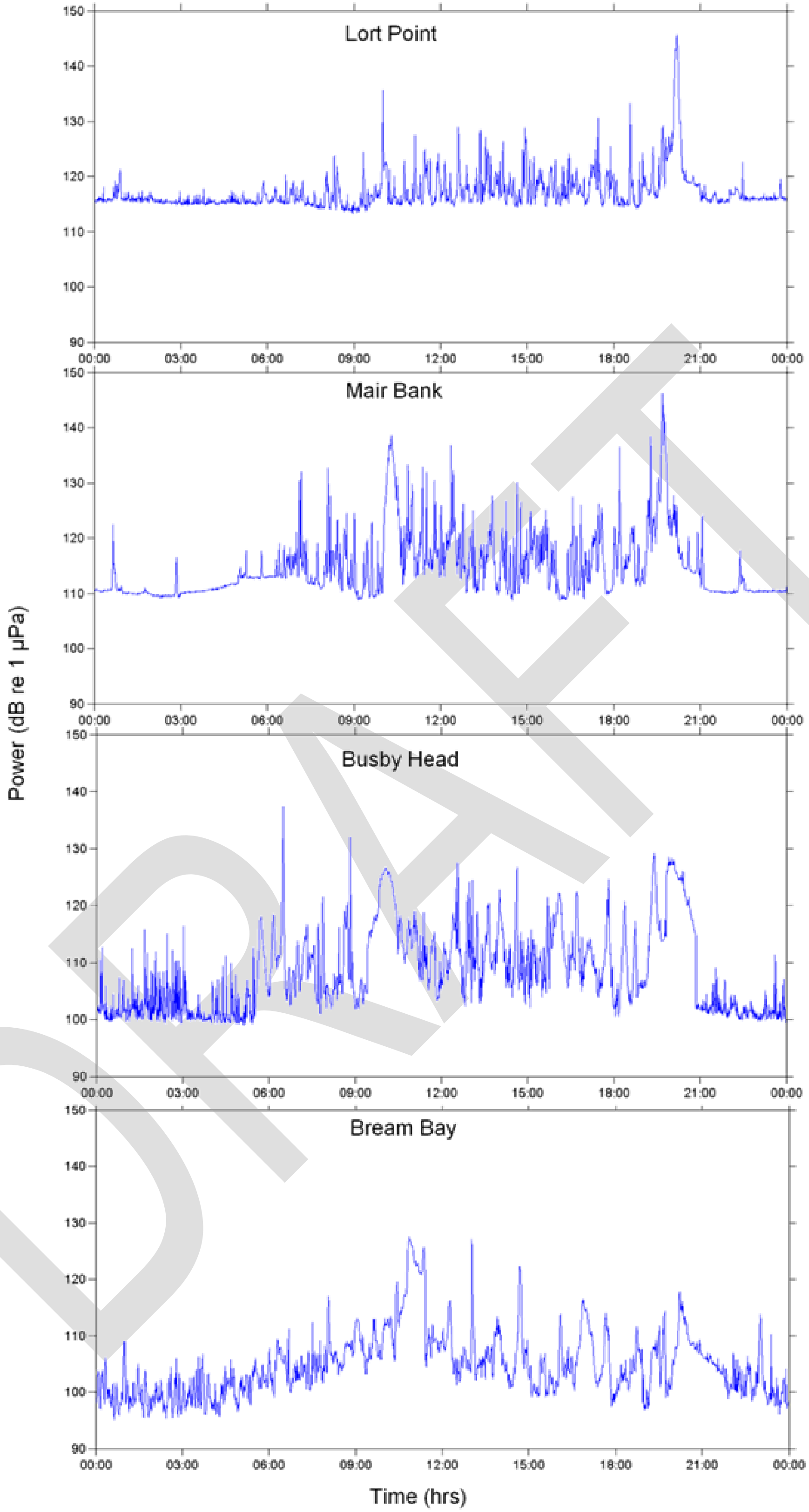

Figure 3: Broadband (50Hz - 48kHz) ambient SPLs measured over a 24 hour period (28th March 2015) at each survey site (n=2161).

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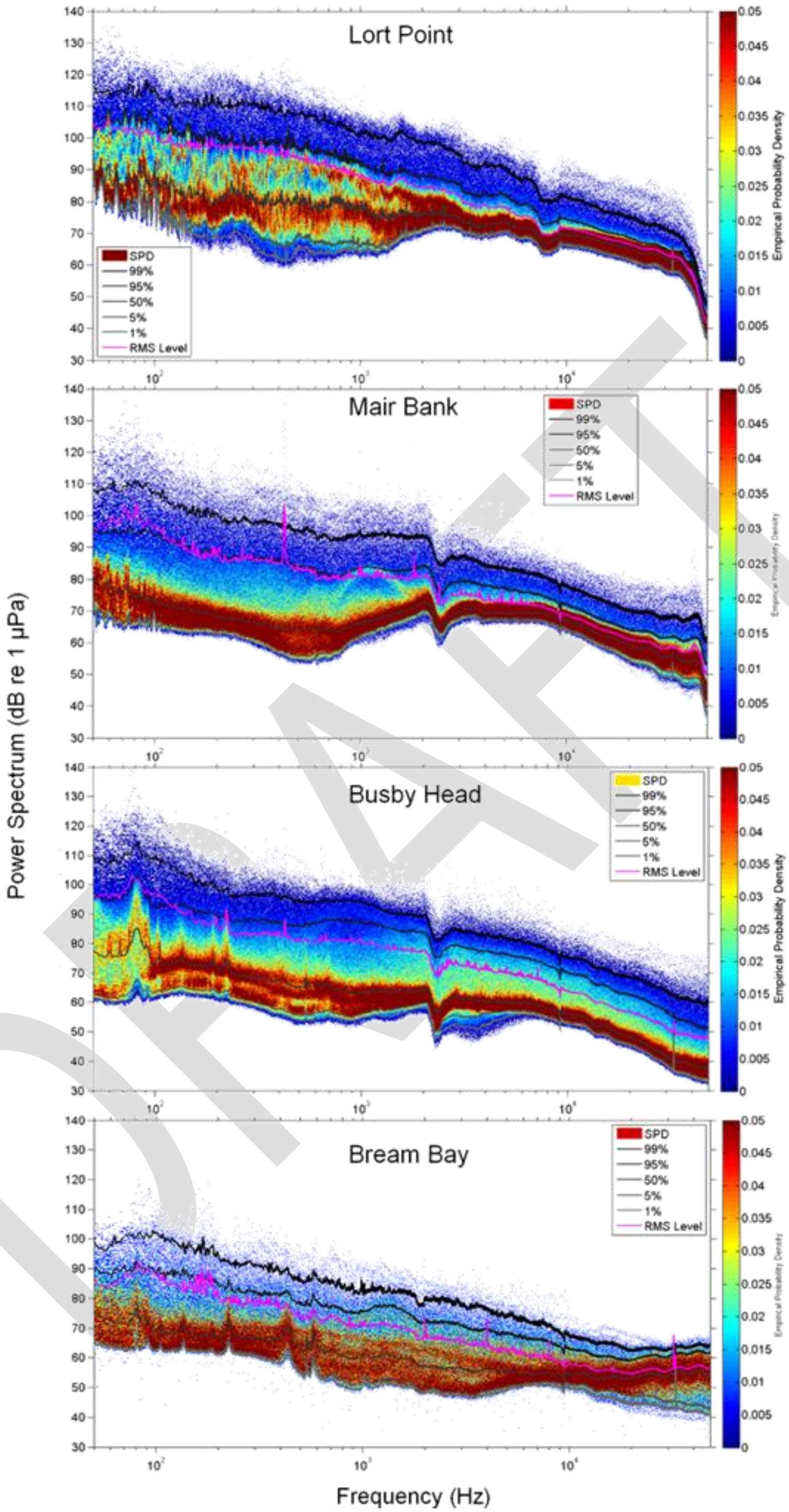

Figure 4: Power spectra plots showing RMS spectrum, percentiles and SPD measured over the survey period.

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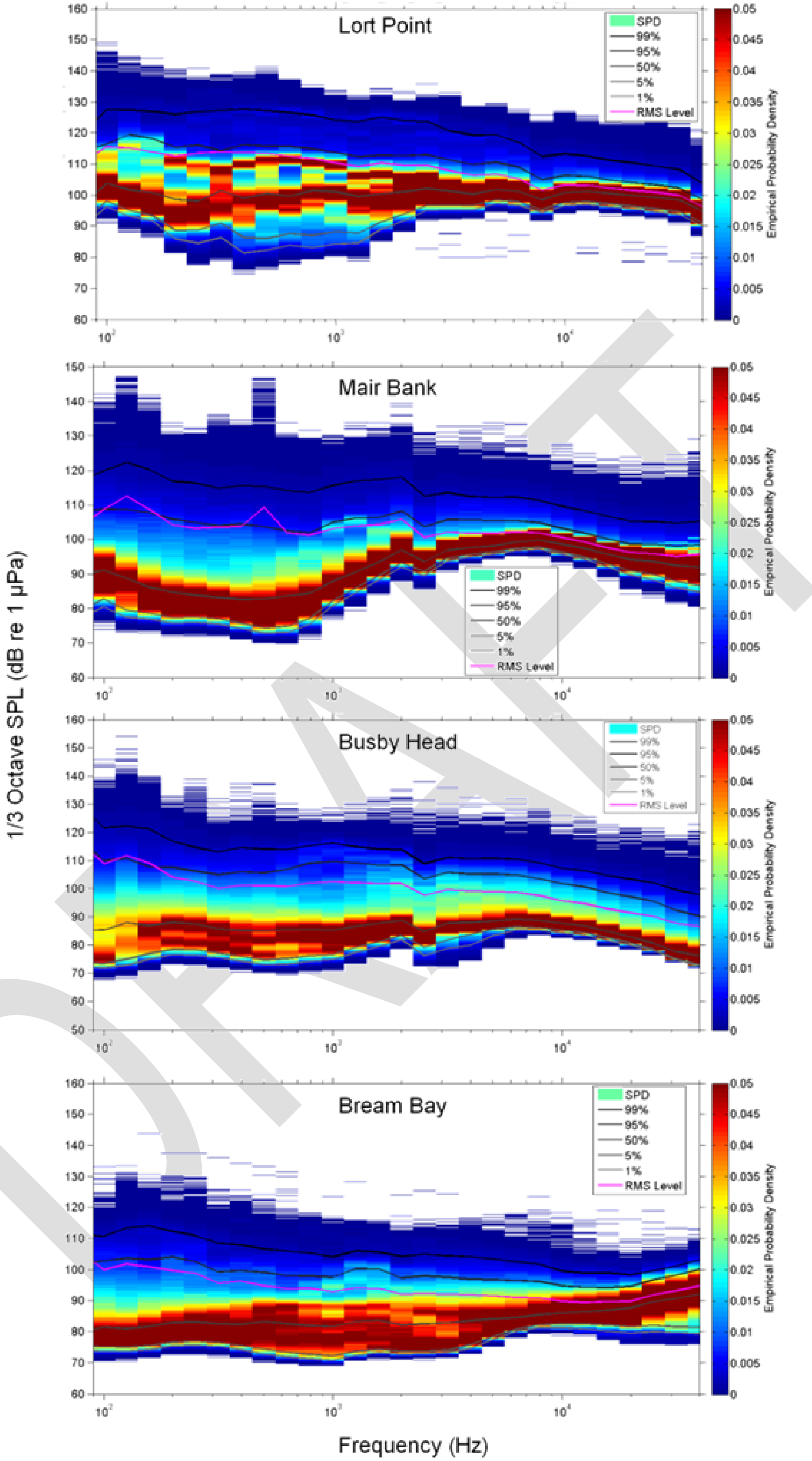

Figure 5: Third octave band plots showing RMS spectrum, percentiles and SPD measured over the survey period.

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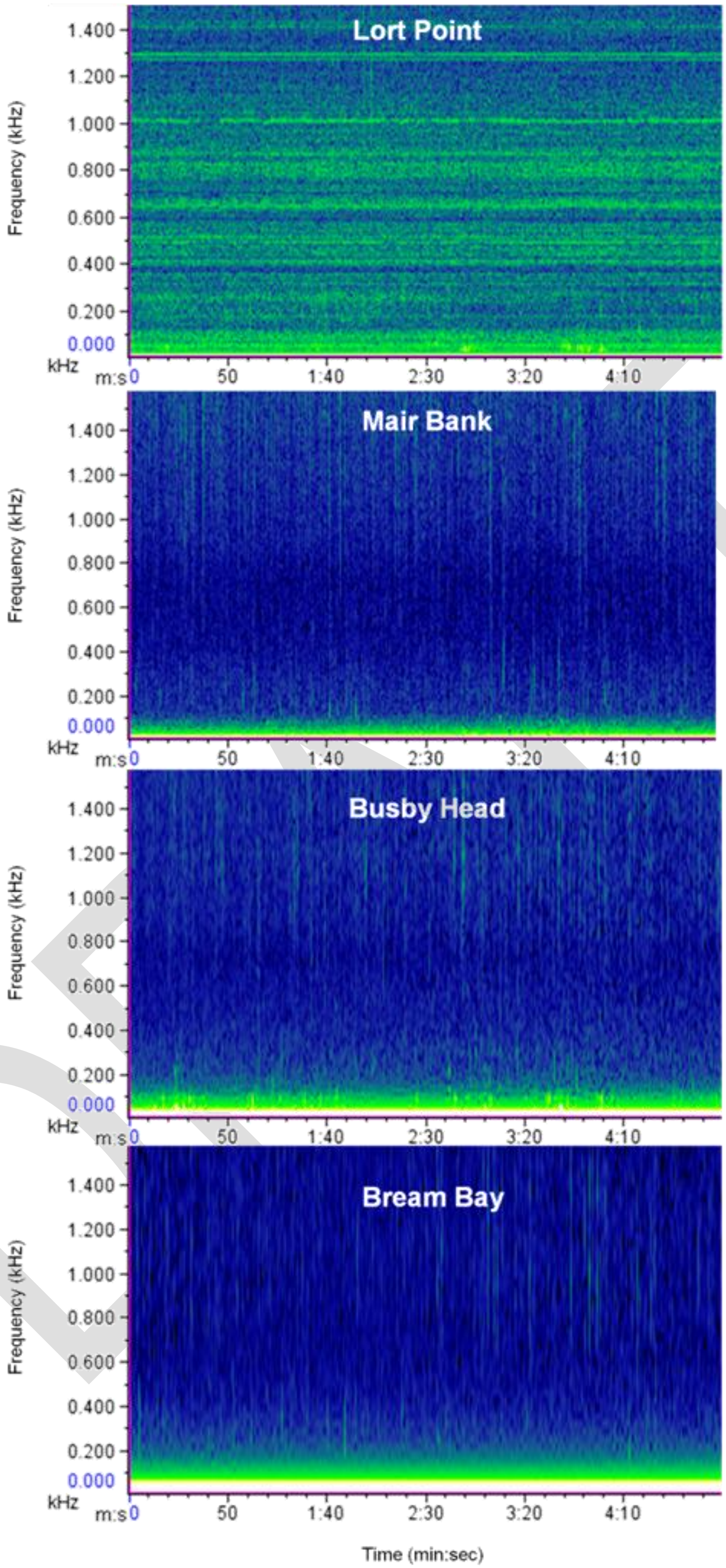

Figure 6: Acoustic spectrograms showing the low frequency signal composed of several harmonics within the Lort Point site only. Spectrograms based on five minute sample at 01:00hrs 26th March 2015.

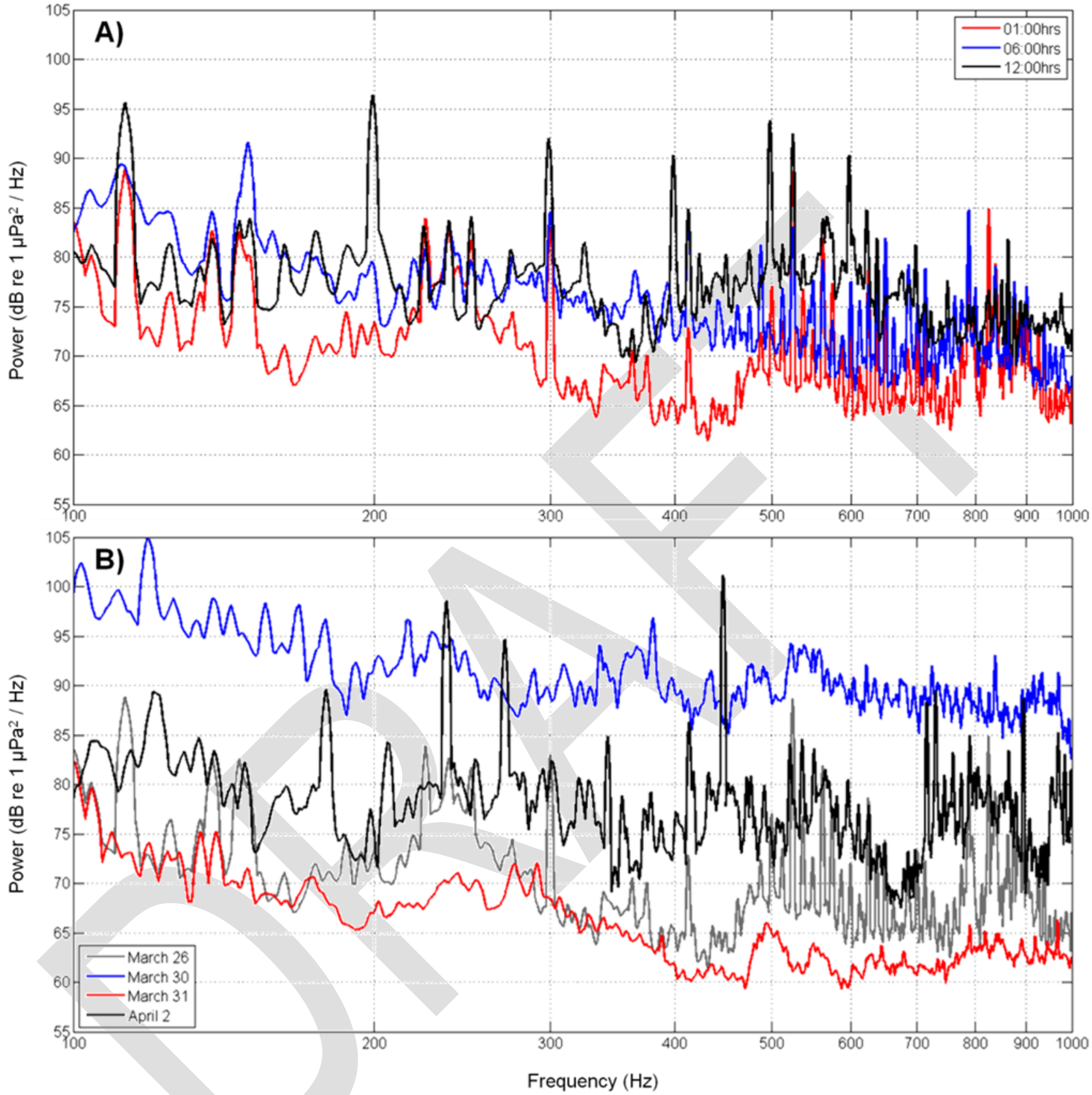

Figure 7: Power spectra plots of continuous low frequency signals within the Lort Point survey site: (A) 26th March 2015 at 01:00hrs, 06:00hrs and 12:00hrs; and (B) plots showing temporal variability in peak frequencies and SPL below 1 kHz between the 26th March and 2nd April. Samples were taken between 01:00hrs and 02:30hrs where no vessel noise (commercial and recreational) was present. Power spectra was calculated using a randomly selected 10min recording. The continuous low frequency harmonics suggest source is mechanical.

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Objective 2: Vessel noise

A total of 15 identifiable vessels were recorded both arriving and departing Marsden Point. Of those 15 vessels, five were oil tankers (four out of the five were smaller coastal product vessels). Details of all 15 vessels, including the received SPLs are given in Table 2. Broadband SPL plots of each oil tanker passing through the Mair Bank or Lort Point survey site (identified in Table 2) and the corresponding spectral plots are provided in Figure 8.

Vessel Name	IMO Number	Type	Speed (km h^{-1})	Distance (m)	Received SPL (dB_{rms} re 1 µPa)	Survey Site
Awanuia	9458042	Bunker Tanker (Coastal)	17	257	143	Mair Bank
Maritime Victory	9550292	Log	17	287	141	Mair Bank
Ningpo	9134658	Veneer	NA*	NA*	136	Mair Bank
Pacific Princess	7806271	Fishing	NA*	NA*	142	Mair Bank
Amsel	9076387	Log	15	300	141	Mair Bank
Jag Lagshita	9208057	Suezmax	12	277	135	Mair Bank
Kakariki	9158305	Coastal Tanker	19	248	137	Mair Bank
Anatoki	8864153	Cement	20	314	143	Mair Bank
Yangtze Grace	9584231	Log	19	293	142	Mair Bank
Matsumae	9401336	Triboard	17	270	136	Mair Bank
Baltic Hare	9397236	Log	18	249	143	Mair Bank
Southern Trader 3	9167459	Cement	23	286	141	Mair Bank
Torea	9274082	Coastal Tanker	22	313	150	Mair Bank
High Endurance	9272929	Small Tanker	10	508	133	Lort Point
Maritime Fidelity	9528861	Log	16	284	143	Mair Bank

*Data unavailable.

Table 2: Details of each commercial vessel arriving/departing the oil refinery and the received broadband SPLs (50 Hz - 70 kHz).

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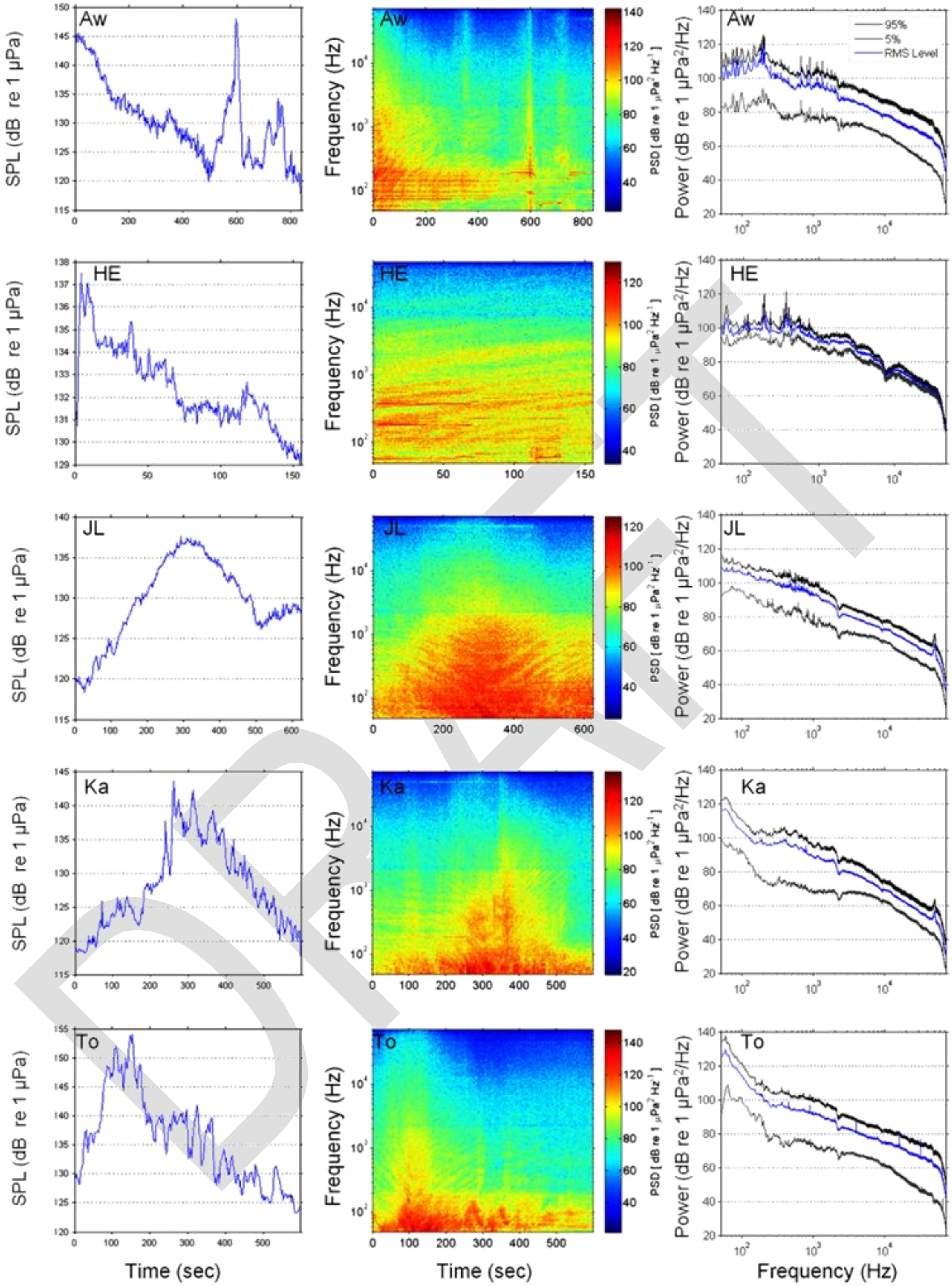

Figure 8: Broadband SPLs (left column) and corresponding acoustic spectra for five oil tankers arriving or departing the Marsden Point oil refinery (Aw=Awanuia; HE=High Endurance; JL=Jag Lagshita; Ka=Kakariki; To=Torea).

The broadband SPL of the larger suezmax tanker is not the highest, with many of the smaller coastal tankers showing greater received SPLs. It is important to note, however, that this difference may be caused from reduced speed, differing distances or engine configurations and the relationship between vessel speed and received SPLs are plotted in Figure 9.

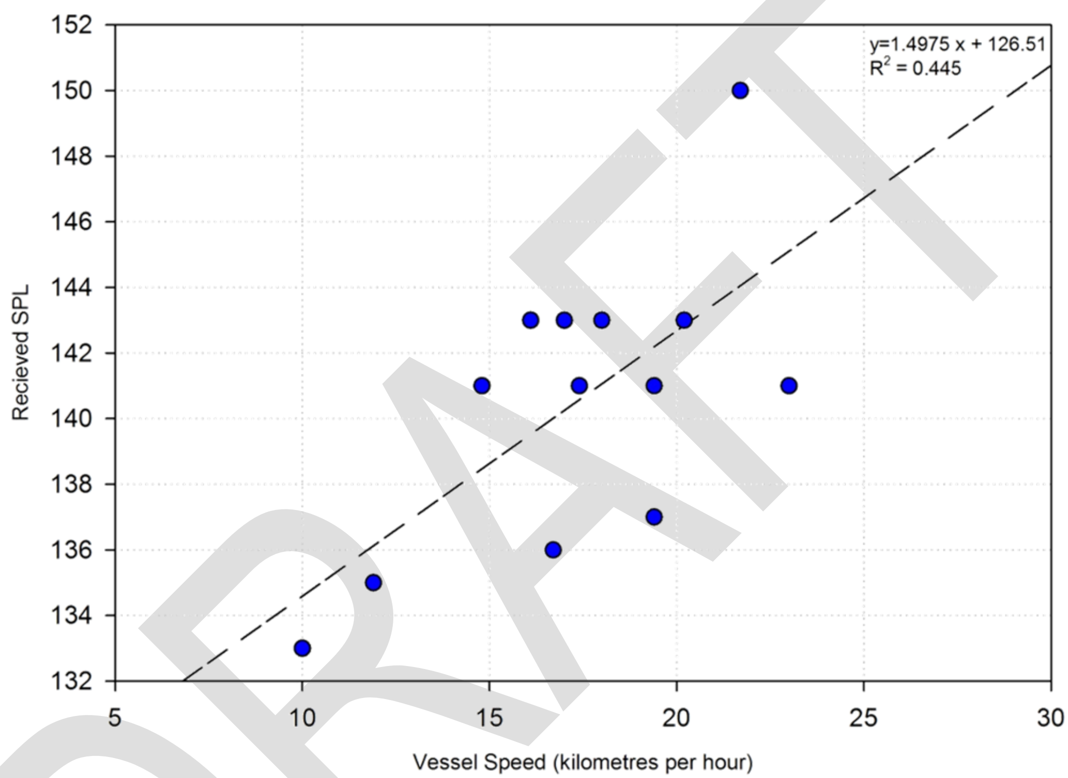

Figure 9: Relationship between received SPL (dB re 1 µPa) and vessel speed (km h^{-1}). Dotted line represents the regression line showing a statistically significant positive relationship (y = 1.4975x + 126.51; R^2 = 0.445; Regression ANOVA $F_{1,12}$ = 8.833, P = 0.013). ANOVA was performed after confirming the data met the assumptions for normality and homogeneity. Note these are based on received SPLs and have not been controlled for distances or spectral variability between vessels' acoustic outputs.

Objective 3: Marine mammal detection

Marine mammals were identified on several occasions during the survey. In total, marine mammals were detected 13 separate times between all four survey sites. Both echolocation clicks and whistles were detected and a typical example is shown in Figure 10. On most occasions, vocalisations were detectable for approximately 30 minutes at a time, with the longest occurrence lasting was approximately 1.5 hours.

Recorded whistles were consistently between 6 kHz and 20 kHz and clicks were broadband between 20 kHz and 100 kHz (characteristic of some dolphins). Due to the limited number of samples, identification of species was not possible. Whales and narrow-band high frequency cetaceans were not detected during the survey. The highest number of dolphin detections were within the Busby Head (6 separate detections) and Bream Bay (5 separate detections) survey site, followed by Mair Bank (2 separate detections) and Lort Point (1 detection). On one occasion, a group of dolphins were clearly detected during the passing of the ship Anatoki (IMO 8864153), at Mair Bank, as shown in Figure 11.

It is important to note that this survey does not serve as an accurate estimate of abundance or diversity, or the degree of affinity to a particular habitat or area. Dolphins vary their vocalisations depending on their behaviour and they are only detectable when they vocalise in proximity to the hydrophone, at sufficient levels to be detected over the background noise floor. Notwithstanding that, however, the results from this survey show that dolphins do frequent the general area. It is therefore our opinion that a noise management plan including passive acoustic monitoring may be required. This is, however, a matter that will be revisited in the future during the Phase 2 work.

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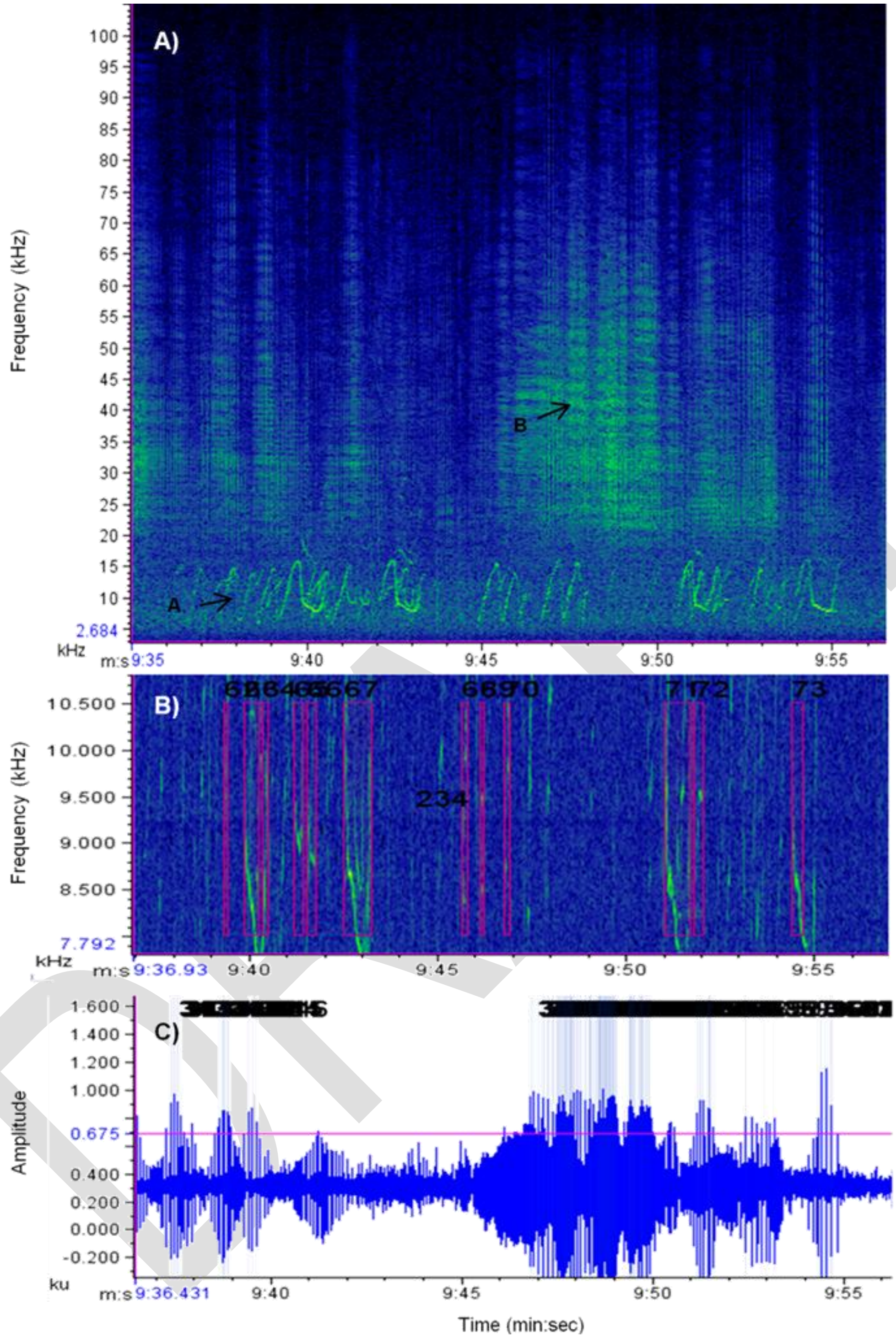

Figure 10: Acoustic spectrograms and waveform of dolphin vocalisations: (A) Echolocation clicks (shown by the arrow labelled B) and whistles (shown by arrow labelled A); (B) magnified section of whistles showing the auto-detection; and (C) waveform of vocalisations showing the amplitude auto-detection.

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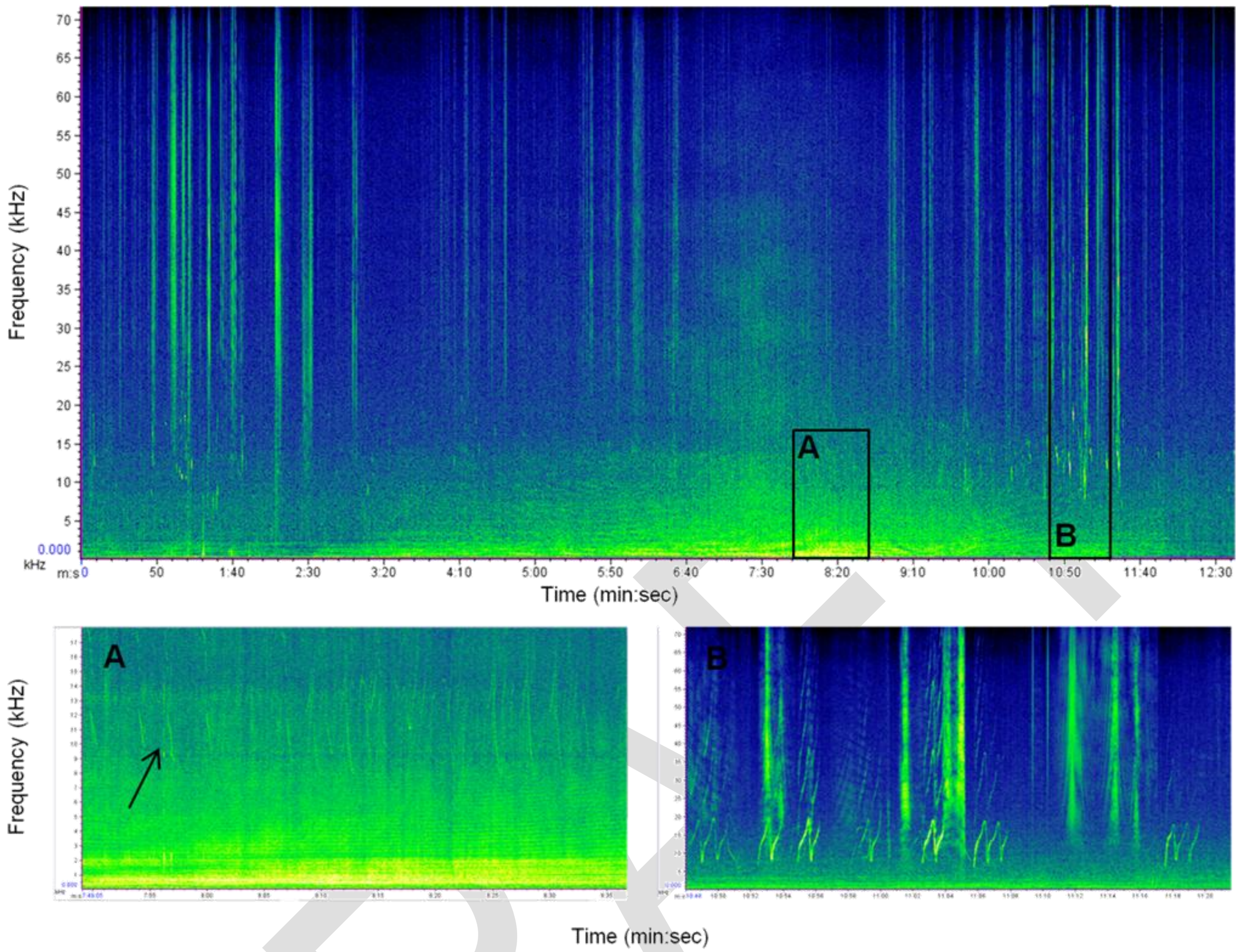

Figure 11: Acoustic spectrogram of the Anatoki (IMO 8864153) and dolphins at Mair Bank. The smaller windows labelled A and B are magnified sections corresponding to the boxes in the main spectrogram. The arrow identifies dolphin whistles over the top of the passing vessel noise.

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Conclusion

Styles Group has been engaged by RNZ to undertake a passive acoustic survey of the ambient underwater soundscape within and around Calliope Bay at the entrance to Whangarei Harbour to accompany an application to deepen the channel at Whangarei Heads to allow suezmax vessels to operate at a higher capacity than at present. Currently, these large ships carry cargo to and from the oil refinery but are under-loaded so to successfully navigate the channel between Whangarei Heads and Marsden Point.

Background sound levels varied considerably between survey sites. The highest background sound levels were measured from Lort Point (average 119 ± 0.08 dB_{rms} re 1 µPa) followed by

Mair Bank (113 ± 0.07 dB_{rms} re 1 µPa), Bubsy Head (108 ± 0.46 dB_{rms} re 1 µPa) and Bream Bay (105 ± 0.10 dB_{rms} re 1 µPa). When compared to other New Zealand harbours, for example the Waitemata Harbour and around the inner Hauraki Gulf, the broadband background sound levels measured within the Whangarei Harbour entrance were lower. However, in the absence of any operating vessels, the ambient soundscape within the Whangarei Harbour entrance was comparable with many other nearshore environments around the New Zealand coastline, for example the outer Hauraki Gulf and Kaipara Harbour. Spectrally, the soundscape within the Whangarei Harbour entrance was similar to other harbours where vessel activity is high as the root mean squared and 5th percentile spectrum was characterised by frequencies below 1 kHz, while the outermost survey site, Bream Bay, demonstrated spectra closer resembling those of soft sediment habitats.

Received noise levels from vessels also varied considerably and ranged from 128 dB_{rms} re 1 µPa (Anatoki, IMO 8864153) to 150 dB_{rms} re 1 µPa (Torea, IMO 9274082). The received SPLs from the larger suezmax tanker was less than many of the smaller coastal tankers. However, the lower SPL from the suezmax may be because of her lower speed and differing distances from the receiving hydrophone.

Dolphins were detected at all survey sites, with most detections occurring outside Calliope Bay (Busby Head and Bream Bay). However, dolphins were detected within Calliope Bay on three separate occasions; once being detected as far as Lort Point. While these findings clearly show evidence that dolphins do frequent the general area, much care should taken when inferring any conclusions regarding their abundance or habitat use because the data is limited in sample size.

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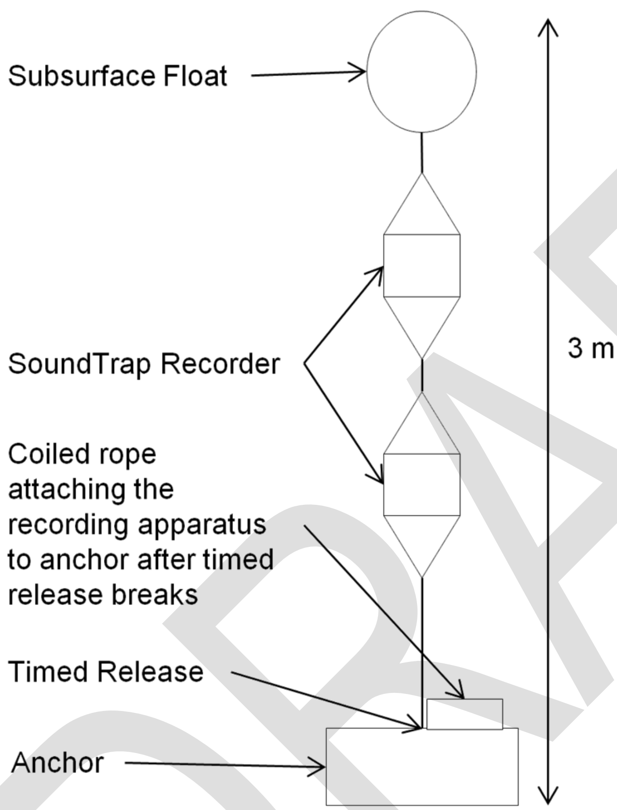
Appendix A

Schematic diagram of the SoundTrap acoustic logger apparatus and photograph of the apparatus being lowered during deployment.



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Appendix 2. Theoretical zones of auditory influence and sound threshold criteria.

Theoretical 'zones of auditory influence', originally proposed by Richardson et al. (1995), are mainly based around the distance between the source and receiver, and the idea that underwater sound intensity, and its potential impact, decreases with increasing distance. These zones include detection, behavioural responses, auditory masking and possible auditory injury (also see Pine and Styles 2016 and, in particular, figure 10).

Southall et al. (2007) used a number of studies that examined the potential onset of temporary auditory threshold shifts (TTS; in humans this is often described as the muffled effect your hearing might have after a loud concert) and more permanent threshold shifts (PTS) in captive marine mammals, and extrapolated these to set some initial thresholds for assessing potential auditory damage. More recently, the USA National Oceanic and Atmospheric Administration (NOAA) has researched, and suggested functional hearing specific sound thresholds for, the sound levels likely to cause injury (NOAA 2016), or behavioural responses (NOAA 2011). These threshold criteria are summarised in Table A2.1.

The sound levels at which significant behavioural disturbance for marine mammals can occur are still under discussion (NOAA 2016). Interim sound threshold guidelines (previously known as Level B harassment) are defined in the context of the Marine Mammal Protection Act (MMPA), Endangered Species Act (ESA) and other United States statutes (NOAA 2011; also see Southall et al. 2007). These behavioural disturbance thresholds range between 120 and 160 dB *re*1µPa rms (including both non-pulse and pulse noise) and are defined as having …*the potential to disturb a marine mammal or marine mammal stock in the wild by causing meaningful disruption of biologically significant activities, including, but not limited to, migration, breeding, care of young, predator avoidance or defense, and feeding.* (see Table A2.1).

In the absence of any new behavioural guidelines, this report and Pine and Styles (2016) have used the 120 dB re.1µPa rms non-pulse noise threshold. We have chosen to weight this threshold in combination with the main species functional hearing group weightings proposed by NOAA (2016) to give a better estimate as to what the animals are actually receiving. We have also modelled the unweighted spatial extent of the 120 dB re.1µPa rms threshold (Figure A2.1). If practical, we will monitor this theoretical behavioural boundary for the possible presence of offshore species (i.e. beaked whales, pilot whales) to empirically test any subsequent behavioural responses to the dredging noise at the time and determine whether this noise threshold is an effective mitigation tool for protecting these species.

It is important to emphasises that Pine and Styles (2016) have used topography and oceanographic data specific to the proposal location to model the spatial extent of capital dredging noise within Whangarei Harbour and Bream Bay waters. Hence, the

underwater noise approach and findings reported in Pine and Styles (2016) and this report are not applicable to other regions or similar dredging proposals.

Table A2.1. Proposed acoustic injury criteria for individual marine mammals exposed to 'discrete' noise events (multiple exposures within a 24-h period) from NOAA (2016) (and NOAA [2011] for behavioural threshold for non-pulse noise levels).

Mammal Group	Effect	Measurement	Threshold
Cetaceans (LF)*	PTS onset	Exposure Level†	199 dB re.1μPa²/s SEL_{cum} weighted
	TTS onset	Exposure Level	179 dB re.1μPa²/s SEL_{cum}
	Behavioural	Non-pulse noise	120 dB re.1μPa rms
Cetaceans (MF)**	PTS onset	Exposure Level†	198 dB re.1μPa²/s SEL_{cum} weighted
	TTS onset	Exposure Level	178 dB re.1μPa²/s SEL_{cum}
	Behavioural	Non-pulse noise	120 dB re.1μPa rms
Otariid pinnipeds (in water)	PTS onset	Exposure Level†	219 dB re 1μPa²/s SEL_{cum} weighted
	TTS onset	Exposure Level	199 dB re 1μPa²/s SEL_{cum}
	Behavioural	Non-pulse noise	120 dB re.1μPa rms

* Applies to low-frequency cetaceans – 7 Hz-35 kHz, all baleen whales;
**Applies to mid-frequency cetaceans – 150 Hz-160 kHz, all toothed cetaceans except those listed in high-frequency category (high-frequency cetaceans - 275 Hz-160 kHz, true porpoises, *Kogia*, river dolphins, cephalorhynchid (Hector's dolphin), *Lagenorhynchus cruciger, L. australis)*.
†Non-impulsive sounds only.

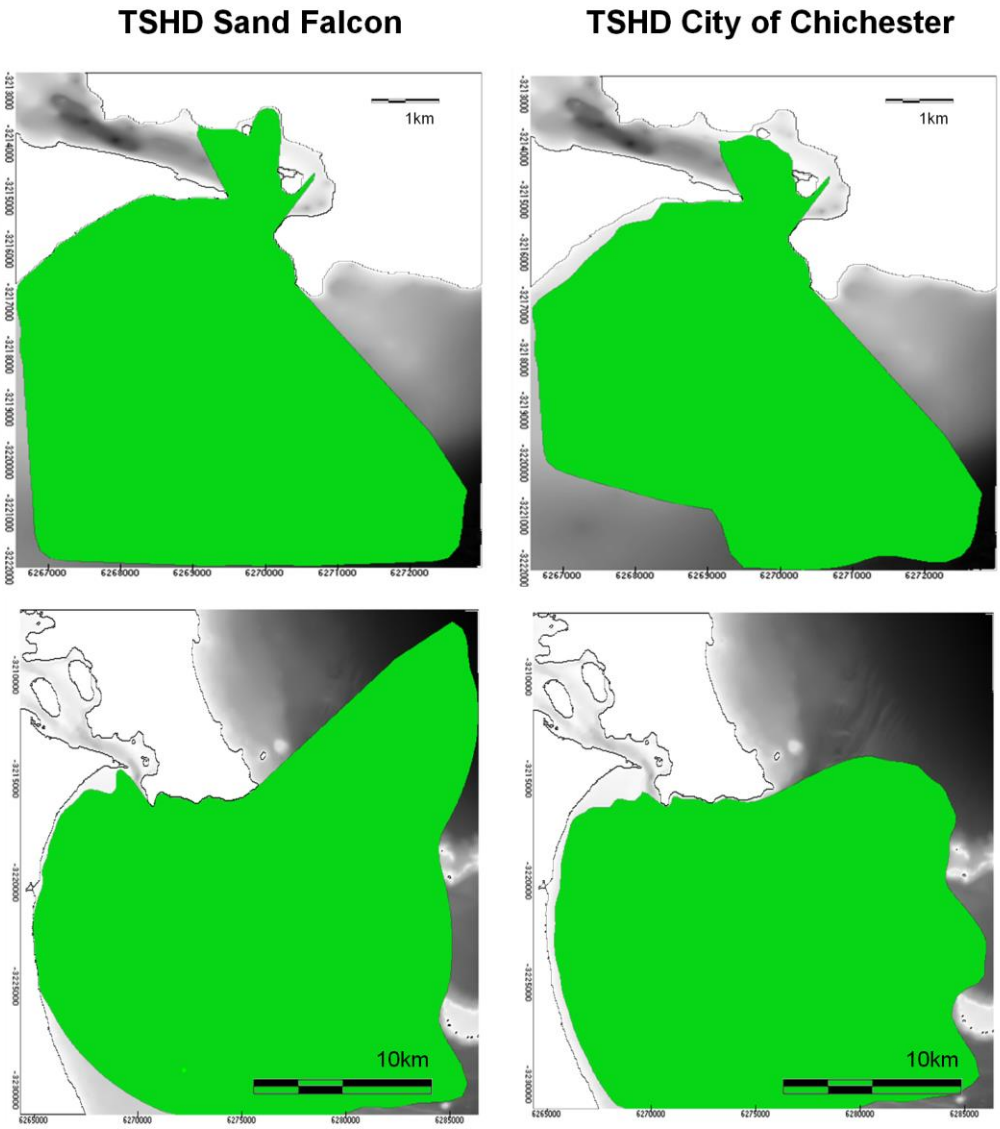

Figure A2.1. Modelled impact zone for the potential onset of behavioural responses at the 120 dB contour for unweighted noise levels for the larger TSHD Sand Falcon (left column) and smaller TSHD City of Chichester (right column) under full dredging conditions within the inner channel (top row) and outer channel (bottom row). Full dredging conditions is draghead down, pumps running and dredging vessel underway.

Appendix 3. Marine Wildlife Management Plan for the proposed capital dredging and pile driving.

1. MARINE WILDLIFE MANAGEMENT PLAN

1.1. Best boating guidelines

The overall risk of a vessel strike between dredge vessels and marine mammals is low. In the unlikely case that a vessel should encounter a marine mammal while working, implementing the following 'best practice' boating behaviours (used worldwide) around marine mammals shall reduce any chance of collision.

1.1.1. General practice

If a whale or dolphin is sighted, but not directly in the path of the vessel:

- Keep boat speed constant and / or slow down while maintaining current direction
- Avoid any abrupt or erratic changes in direction
- Maintain or resume normal operating speeds once well way from animals.

1.1.2. Large baleen whales—such as Bryde's or southern right whales

If a whale is sighted directly in the path of the vessel:

- If the whale is far enough ahead of the vessel (e.g. > 500 m) and can be avoided, slow to 'no-wake' if necessary and maintain a straight course away from the immediate sighting area (where practicable)
- If the whale is too close to the vessel and cannot be avoided, immediately place the engine in neutral and allow the boat to drift to one side of the sighting area where practicable (do not assume the whale will move out of the way)
- Avoid any abrupt or erratic changes in direction while at speed
- Once the whale has been re-sighted away from the vessel, slowly increase speed back to normal operation levels.

If a cow / calf pair is sighted within 500 m of an underway vessel:

- Gradually slow boat while maintaining a course away from the immediate sighting area (where practicable)
- Allow the pair to pass
- Once the pair has been re-sighted away from the vessel (> 500 m), slowly increase speed back to normal operation levels
- Avoid any abrupt or erratic changes in direction while at speed.

If a whale and / or cow / calf pair approaches a stationary vessel:

- Keep the engine in neutral, and allow the animal to pass
- Maintain or resume normal operating speeds once well way from animals (> 500 m).

1.1.3. Small to medium whales and dolphins —– such as bottlenose dolphin or orca

If a dolphin(s) is sighted directly in the path of the vessel:

- Keep boat speed constant and / or slow down while maintaining a course slightly to one side of the group, do not drive through the middle of a pod
- Avoid any abrupt or erratic changes in direction
- Maintain or resume normal operating speeds once well way from animals.

If a dolphin(s) approach an underway vessel to bow-ride or ride the stern wave:

- Keep boat speed constant and / or slow down while maintaining course
- Avoid any abrupt or erratic changes in direction
- Do not drive through the middle of a pod
- Maintain or resume normal operating speeds once well way from animals (> 500 m).

1.2. Debris management guidelines

To avoid the risk of entanglement to marine mammals, all dredging, support vessels and other project activities shall have waste management plans in place prior to the commencement of works. Debris and waste management shall, at a minimum, include:

- Avoiding use of continuous looping lines.
- Slack or free-floating lines should be avoided where practicable.
- Any lines to be kept under tension.
- Proper disposal, and secure storage of plastics and other wastes, especially in higher wind conditions.

1.3. Underwater noise management

Foremost, all dredging and pile-driving equipment and vessels will be regularly maintained with proper upkeep (e.g. lubrication and repair of winches, generators) to reduce the production of underwater noise.

1.3.1. Dredging noise level measurements

Acoustic monitoring shall be undertaken at the earliest possible date once the dredge vessels has arrived to confirm that the actual noise levels associated with dredging activities are as expected for dredging (Pine & Styles 2016). This monitoring shall include, as a minimum, underwater noise measurements, taken during good weather conditions and at varying distances and bearings from the vessels, during the following operational conditions/production cycles:

- During the sediment extraction phase (for all dredge types), from when the bucket/draghead/cutterhead enters the water and sediment is being loaded into the hopper/barge
- During disposal of sediment.

Noise emissions from the loaded/unloaded transit of the dredged material can be assessed and monitored from the passive acoustic moorings and AIS data from the area during dredging. Underwater recordings of each production phase identified above should be taken from the dredge vessel itself (if possible) and a range of log distances (such as, but not limited to, 50 m, 100 m, 200 m, 500 m, 1000 m, 2000 m). Recordings should be of a duration that allows for at least three representative production cycles to be sampled in good weather over the same day. RMS parameters will be measured to compare with the behavioural criteria for ground truthing the underwater noise propagation modelling in Pine and Styles (2016).

Results will be reviewed with parameters used for acoustic modelling in Pine and Styles 2016, and if necessary, spatial modelling results adjusted for use in later maintenance dredging planning. The designated ‘precautionary’ safety zone of 50 m for avoiding TTS effects (discussed in Section 1.1.2) is highly conservative and robust enough to accommodate any final adjustments based on actual dredging sound data.

1.3.2. Standard operational procedures for pile-driving activities (from DPTI 2012)

Standard operation procedures that must be undertaken by contractors during piling activities include pre-start, soft start, normal operation, stand-by operation, and shut-down procedures. The marine mammal observer (Appendix 4, Section 1.1.3) associated with the pile-driving works will be familiar with the SOP, and will document the process.

<u>Pre-start procedure</u> – The presence of marine mammals should be visually monitored by a suitably trained crew member for at least 30 minutes before the commencement of the soft start procedure. Particular focus should be put on the shut-down zone but the observation zone [which can be up to 2 km radius depending on pile-driving type and noise propagation] should be inspected as well, for the full extent where visibility allows. Observations should be made from the piling rig or a better vantage point if possible [i.e. in the absence of a high vantage point, a large observation zone may require an additional vessel as sufficient observation platform].

<u>Soft start procedure</u> – If marine mammals have not been sighted within or are likely to enter the shut-down zone during the pre-start procedure, the soft start procedure may commence in which the piling impact energy is gradually increased over a 10 minute time period. The soft start procedure should also be used after long breaks of more than 30 minutes in piling activity. Visual observations of marine mammals within the safety zones should be maintained by trained crew throughout soft starts. The soft

start procedure may alert marine mammals to the presence of the piling rig and enable animals to move away to distances where injury is unlikely.

Normal operation procedure – If marine mammals have not been sighted within or are not likely to enter the shut down or observation zone during the soft start procedure, piling may start at full impact energy. Trained crew should continuously undertake visual observations during piling activities and shut-down periods. After long breaks in piling activity or when visual observations ceased or were hampered by poor visibility, the pre-start procedure should be used. Night-time or low visibility operations may proceed provided that no more than 3 shut-downs occurred during the preceding 24 hour period.

Stand-by operations procedure – If a marine mammal is sighted within the observation zone during the soft start or normal operation procedures, the operator of the piling rig should be placed on stand-by to shut-down the piling rig. The trained crew member should continuously monitor the marine mammal in sight.

Shut-down procedure – If a marine mammal is sighted within or about to enter the shut-down zone, the piling activity should be stopped immediately. If a shut-down procedure occurred and marine mammals have been observed to move outside the shut-down zone, or 30 minutes have lapsed since the last marine mammal sighting, then piling activities should recommence using the soft start procedure. If marine mammals are detected in the shut-down zone during poor visibility, operations should stop until visibility improves.

In addition, it is recommended that a record is be kept of all sightings (as per the sighting data form in the marine mammal monitoring plan), delayed start-up or enforced shut-downs due to presence of marine mammals.

Zone sizes

The size of the safety zone and observation zone will be based on the chosen driving technique, noise exposure thresholds and subsequent safety zone distances as provided by the Australia DPTI guidelines and listed in the following table.

Species	Noise exposure threshold	Observation zone	Shutdown zone	Zone of behavioural response
Impact piling	**SEL in db(M*) re 1 μPa^{2}s for single impact**			
All species / all functional groups	≤150 db(M_{xx}) at 100 m	1 km	100 m	≤ 150 m
	≤150 db(M_{xx}) at 300 m	1.5 km	300 m	≤ 500 m
	>150 db(M_{xx}) at 300 m	2 km	1 km	≤ 3 km
Vibro-driving	**SPL in dB re 1 μPa for single impact**			
Cetaceans	≤180 db at 10 m	500 m	10 m**	≤ 5 km
	>180 db at 10 m	1 km	100 m**	≤ 10 m
Pinnipeds	≤190 db at 10 m	500 m	10 m**	≤ 5 km
	>190 db at 10 m	1 km	100 m**	≤ 10 m

*M-weightings should be used for the species functional hearing groups for impact driving noise exposure threshold. For example, for LF cetaceans, the first noise exposure threshold would be ≤150 db(M_{lf}) at 100 m.

** when no avoidance.

1.3.3. Additional measures

Given the shallow location, soft sandy sediments and extremely short-term duration of the proposed pile-driving activity, no additional or further noise minimising options are considered necessary. The following measures are listed as additional considerations when determining the BPO for pile-driving techniques, depending on the practicality and appropriateness specific to this proposal.

Considerations for the BPO for pile driving

- Suction piling (directly from DPTI [2012]) – Suction piling uses tubular piles that are driven into the seabed, or dropped a few metres into a soft seabed, after which air and water are sucked out the top of the tubular pile thereby sinking the pile into the ground. Suction piles are often used to secure offshore floating platforms, in both shallow and deep waters. Although noise levels have not been reported, they are expected to be low as the only source of noise is the pump.
- If practicable, to reduce impact noise use a non-metallic dolly for concrete and steel piles.

1.4. Department of Conservation liaison procedures

A two-way liaison with the Department of Conservation shall be established for exchange of marine mammal sighting data throughout the capital dredging project.

The Department of Conservation shall be contacted regularly [INSERT FREQUENCY; TBC in liaison with DOC] over the project period to obtain real-time/recent sighting information. Information will be shared with officers on board all project vessels, including the designated observer on-board the dredge vessel. This will allow project vessels to anticipate and mitigate potential interactions with any whale species sighted in and near the project area.

In addition, RNZ shall collate and regularly [INSERT FREQUENCY; TBC in liaison with DOC] share any opportunistic or on-board observer sighting data (Appendix 4, Section 1.1) with DOC.

1.4.1. Contact persons and contact details

Contact person (DOC): [INSERT NAME AND CONTACT DETAILS]
Contact person (RNZ): [INSERT NAME AND CONTACT DETAILS]

1.5. Incident reporting (vessel strike and entanglement)

Incidents involving the injury or mortality of a marine mammal shall be reported to the Department of Conservation's contact person as soon as is practicable but not more than six hours. In the case of a fatality, tangata whenua's representative shall also be notified within 24 hours of the incident occurring.

Incident details shall include as much information as possible relating to incident (e.g. date, time, weather conditions [visibility, sea state, etc], vessel location, speed, activity, etc). Any details of the marine mammal (e.g. species, group size) and its behaviour before, during and after the incident shall also be recorded. If practicable, video or photos could be taken. Information will be used to inform how future incidences could be avoided.

Any incident that results in marine mammal injury or fatality will be documented using the incident reporting form (Section 1.5.2 below).

1.5.1. Contact persons and contact details

Department of Conservation: [INSERT NAME AND CONTACT DETAILS]
Tangata Whenua representative: [INSERT NAME AND CONTACT DETAILS]

1.5.2. Incident reporting form

Project vessels shall record any incidents in which a marine mammal physically contacts any project gear with this plan using the incident reporting form shown below. Incident reporting forms will be shared with DOC and Tangata Whenua within 24 hours of the incident occurring. [Final form content TBC in liaison with DOC and Tangata Whenua]

INCIDENT REPORTING FORM

Date	Time	Incident Location on Vessel (description; port, bow, propeller,..)	Vessel Position Latitude (northing	Vessel Position Longitude (easting)	Vessel type, activity, and speed at time of incident and any subsequent responses*	Species ¥	No. of animals involved	Animal(s) activity before incident and after #	Description of any injury or mortality	Observer/ reporter	Additional comments (e.g. weather and sea conditions)

* TSHD, CSD, BHD; in transit, dredging, discharging spoil, etc

¥ Using a species guide such as IFAW and AHP (2005).

Feeding, resting, travelling, socialising, breaching, bowriding etc (e.g. see IFAW and AHP (2005]).

Appendix 4. Description of the recommended marine mammal monitoring for the proposed capital dredging.

1. MARINE MAMMAL MONITORING PLAN

1.1. Visual sighting data collection

The general public and other (non-project related) vessels working in vicinity of the project should be encouraged to report opportunistic marine mammal sightings to RNZ or DOC over the specified monitoring and project timeframes (Section 1.1.1 below). Project vessels shall record and report opportunistic sightings in accordance with this plan and sighting data shall be collected by the on-board observer when on watch (Section 1.1.2).

1.1.1. Opportunistic sighting data collection

Opportunistic sighting data shall be recorded in and around Whangarei Harbour and Bream Bay area for approximately[19]:

- One month before capital dredging.
  Aim - The resulting data will be used (in conjunction with passive acoustic monitoring data) to verify the predicted visitation/presence of marine mammals as described in the Phase 1 and Phase 2 reports.
- The entire ~6 month period when capital dredging is underway.
  Aim - The resulting data will be used (in conjunction with passive acoustic monitoring data) to determine use of the project area by marine mammals during active dredging operations (e.g. are marine mammals still coming into the project area even though dredging is underway?).
- One month following the completion of capital dredging.
  Aim - The resulting data will be used (in conjunction with passive acoustic monitoring data) to determine the continued presence, or return, of marine mammals in the project area following the completion of capital dredging.

1.1.2. On-board observer (dredging)

An observer will be on board the dredge vessel during daylight hours over the duration of capital dredging. The observer will be on watch whenever dredging or disposal activities are underway (including transiting). The observer has two general duties; (1) to enforce the shut-down of sediment extraction when marine mammals are within the precautionary exclusion zone (50 m; see 'shut downs') and (2) to record sighting data (Section 1.1.4), with an emphasis on marine mammals within 300 m of

[19] The necessity and timing of the collection of opportunistic sightings for maintenance dredge monitoring will be reviewed and revised, if necessary, based on capital dredge monitoring results.

the dredge vessel. The observer does not need to be a qualified marine mammal observer (e.g. an existing crew member can be inducted and designated to fill the role of the observer).

Shut-downs

If a marine mammal comes within 50 m of an active dredge vessel (i.e. undertaking sediment extraction), a 'shut-down' should be initiated. This is to further reduce the risk of TTS onset (see Section 3.1.2 of main report, Assessment of Actual and Potential Effects).

A 'shut-down' in this case refers to cessation of sediment extraction. This might involve lifting the draghead from seafloor and ramping down the suction pump (TSHD) or cessation of ongoing removal (BHD) or cutting (CSD) of the seabed[20]. Once the mammal has left the 50 m radius, operations can be resumed. Details of any shut-down event should be captured on an incident reporting form.

The on-board observer will communicate to the [INSERT CREW POSITION] when a marine mammal is within 50 m of the dredge vessel. The [INSERT CREW POSITION] will then cease sediment extraction. Once the marine mammals has left the 50 m radius, the observer will advise the [INSERT CREW POSITION] that operations can be resumed.

1.1.3. Onboard observer (pile driving)

The observer/s associated with pile-driving works has two general duties; (1) to detect and record the presence of marine mammals and (2) to ensure standard operating procedures are followed including documenting any enforcements (if necessary). Specifically, these are detailed in Appendix 3 (Section 1.3.2). The observer does not need to be a qualified marine mammal observer (e.g. an existing crew member can be inducted and designated to fill the role of the observer).

1.1.4. Sighting data form

All sighting data collected should be collated into a tabulated format as shown below, for ease of database input.

[20] TSHD: Trailer suction hopper dredge, BHD: Back-hoe dredge, CSD: cutter suction dredge.

SIGHTING FORM

Date	Time (of first sight)	Sighting duration	Location (description including minimum distance from vessel if applicable)	Position (at first sight)		Species*	No. of animals	Animal activity ¥	Vessel type and activity of vessel #	Observer/ reporter	Additional comments (e.g. weather and sea conditions)
				Latitude (northing	Longitude (easting)						

* Using a species guide such as IFAW and AHP (2005).

¥ Feeding, resting, travelling, socialising, breaching, bowriding etc (e.g. see IFAW and AHP 2005).

TSHD, CSD, BHD; in transit, dredging, discharging spoil, etc

1.2. Acoustic data collection

1.2.1. Passive acoustic monitoring for presence of marine mammals

Passive acoustic monitoring for the presence of marine mammals shall be undertaken for approximately:

- One month before capital dredging.

  Aim - The resulting data will be used (in conjunction with sighting data) to verify the predicted visitation/presence of marine mammals as described in the Phase 1 and Phase 2 reports.

- Two separate fortnightly monitoring periods while capital dredging is underway (~6 months). These timeframes will be sufficient to capture several dredging cycles.

  Aim - The resulting data will be used (in conjunction with sighting data) to determine use of the project area by marine mammals during active dredging operations (e.g. are marine mammals still coming into the project area even though dredging is underway?).

- One month following the completion of capital dredging.

  Aim - The resulting data will be used (in conjunction with sighting data) to determine the continued presence, or return, of marine mammals in the project area following the completion of capital dredging.

During each of these periods, passive acoustic moorings would be placed in at least four locations, including around the Harbour entrance to record any animals entering or leaving the Harbour, near the disposal area in Bream Bay and along the 120 dB contour (see Figure A4.1 for some general site locations).

Figure A4.1. Suggested site locations for passive acoustic monitoring moorings. Figure originally from Pine and Styles (2015).

Appendix 5. Reported occurrences of marine mammals in the Whangarei coastal region and Harbour since March 2015.

Date	Start time	Finish time	Location Description	longitude (easting)	latitude (northing)	Species	Number observed	Activites around animals	Observer_reporter	Comments
13/03/2015	9:00		off Whangerai Harbour			bottlenose dolphin	3 to 4 (multiple groups in area)	socializing, fast travel, chasing (prey?), bow and stern riding	Simon West	Bioresearches - Simon West while doing benthic sampling on project; photos confirm bottlenose and one animal with distinct 1 tooth rake patch on top of dorsal, left side and maybe some other good shots
26/03/2015	4:30	5:00	Bream Bay			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
26/03/2015	7:30	8:00	Bream Bay			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
28/03/2015	3:00	3:26	Busby Head			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
29/03/2015	14:00	14:30	Bream Bay			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
30/03/2015	4:30	5:35	Busby Head			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
30/03/2015	5:30	7:00	Mairs Bank			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
30/03/2015	7:30	8:00	Busby Head			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
30/03/2015	17:30	18:00	Bream Bay			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
30/03/2015	18:30	19:00	Bream Bay			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
31/03/2015	6:30	7:00	Busby Head			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
31/03/2015	9:30	10:00	Busby Head			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
2/04/2015	11:30	12:15	Mairs Bank			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
2/04/2015	14:00	14:30	Lort Point			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
2/04/2015	18:30	19:00	Busby Head			unknown dolphin			Styles Group data - acoustic logger	Styles Group data - acoustic logs of dolphin species in pre-assessment field work
3/08/2015	10:30	13:00	went up Whangerai Harbour (reported Tamaterau and furthest pt was Kissing Point)			bottlenose dolphin	10	fast travel swimming up harbour, maybe in response to orca outside of heads	Northern Advocate news article	Northern Advocate news article - Lindy Laird, orca also sighted in Parau Bay
3/08/2015	10:00		off Parau Bay			orca			Floppy Halliday with Whale Watch hotline	Northern Advocate news article - Lindy Laird,
15/08/2015	15:00	17:00	Smugglers Cove (Whangarei Heads near Busby Head)			Southern right whale	1	resting in shallows	Andrea Robinson and friends	Northern Advocate news article - Mike Dinsdale, watched for about 1.5 to 2 hrs in same general area, resting in shallowssame whale seen in Auckland's Mechanics Bay a few days earlier (not sure if ID confirmed or not); Ingrid Visser reported same animal in Sandy Bay (further north) on following Tuesday (18 Aug) and again off Bland Bay campground (Puriri Bay, Whangaruru Harbour) on the Friday 21 Aug 2015.
16/09/2015	14:00		entered Whangerai Harbour - Snake Bank sandbar (between McLeod's Bay and One Tree Point)			orca	3 +	feeding on eagle rays and stingrays	Northern Advocate news article	Northern Advocate news article - Lindy Laird, went on boat with Ingrid Visser; Good shot of orca in front of RNZ jetty and ship - Michael Cunningham Northern Advocate
22/11/2015	9:00		Managawhai estuary (south of Bream Bay); few hundred metres south of the Tara Creek mouth			bottlenose dolphin	6		Daren Grover-Project Jonah	Northern Advocate news article - Lindy Laird, stranded up creek with low tide, all released
9/03/2016	9:00		Ruakaka Beach	1731815	6023433.9	Gray's beaked whale	3	STRANDING	Clive Stone, Juliane Cheltham, Ingrid Visser; Marie Jordan - DOC	DOC stranding report and photos attached
21/04/2016			Bream Bay near proposed spoil grounds	35 54.954'S	174 31.740'E	bottlenose dolphin	5	5 included cow/calf pair	Alice Morrison - independent	Refining NZ benthic field work for ??
23/04/2016			Bream Bay near proposed spoil grounds	35 57.531'S	174 33.046'E	bottlenose dolphin	5	possibly same group both days	Alice Morrison - independent	Refining NZ benthic field work for ??
3/05/2016	a.m		north of RNZ jetty			bottlenose dolphin	2 to 3 (?)	chasing kahawhai and following small rubber boat	Joshua Roberts - RNZ staff	chasing and catching kahawhai on way to work in morning
19/06/2016	14:00		Prob 5 miles out off Ruakaka, middle of Bream Bay			Bryde's whale	2	traveling north to south	Steve Tyson - RNZ staff	mum with calf; sighted while sailing boat from Auckland; video at (https://youtu.be/3wplPJ9XhWI); same pair may have been seen again on 15 jUne in harbour
2/07/2016	9:00	10:00	Whangarei Harbour just west of the Port			Humpback whale	2	rolling around in shallows with lots of flippers out of water	Riaan Elliot - RNZ staff	Whale on side with fin in the air. Fin was white and serrated along one edge. Also Northern Advocate article that showed 2 whales and confirmed humpback
13/07/2016			Kerikeri- far north beach			blue whale	1	dead stranding	Northern Advocate news article	Northern Advocate news article - Mike Dinsdale, dead blue whale washed up on private kerikeri beach. No obvious causes of death
8/09/2016	7:45		Reotahi and Darch Point			Orca	3	Travelling	Steve Tyson, RNZ, via Riaan Elliot - RNZ staff	Reotahi and Darch Point. "I talked to Ingird Visser, the male with the wobbly dorsal fin is called Funky Monkey and is 18 yrs old". Caught on video at 0745am.
3/09/2016			Onerahi			Orca			Friend of Riaan Elliot - RNA	
22-24 Oct 2016			Bream Bay			Unknown dolphin	50-100	Large pod of dolphins	Staff members sailing in the coastal classic (via Riaan Elliot, RNZ)	Staff members sailing in the Coastal classic over labour weekend sighted a large pod of dolphins in Bream Bay. Pod size was somewhere between 50 and 100.