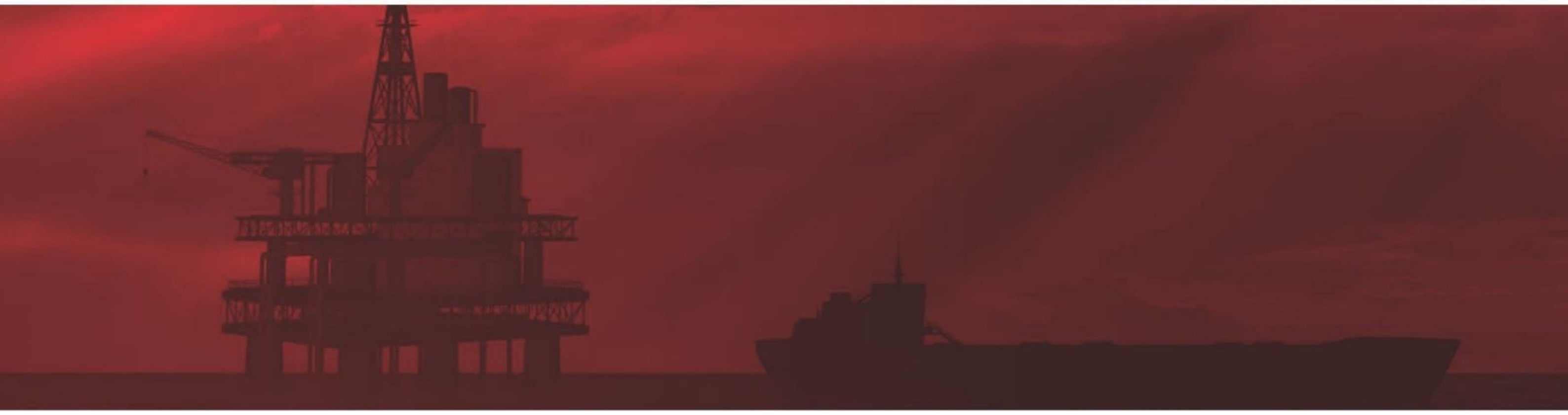
Sustainable Seas National Science Challenge

Decommissioning of Offshore Structures in the Taranaki Bight and Potential Effects on Marine Fauna



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Author: S. Jervis

Table of Contents

1 Introduction

There are currently six active offshore oil installations operating in New Zealand, five in the Exclusive Economic Zone in the South Taranaki Bight and one in coastal waters in the North Taranaki Bight. The first platform to be developed was Māui A, which started production in 1979 and operates in 110 metres of water. The other installations that service the area were built later, and operate in water ranging in depth from 50 to 120 metres.

Sone of the Taranaki offshore oil and gas fields are now approaching the end of their economic life. While new technologies are being used to extend the life of the fields, at some point continued production will become economically unviable and the structures will be rendered obsolete.

The question of what to do with disused marine structures is being asked around the globe as increasing numbers reach obsolescence. Options vary widely from full or partial removal, to re-use as artificial reefs, to repurposing e.g. as wind/wave power generators or permanently based marine research stations. However all proposals require one of the following to occur - that the installation be subjected to: retrofitting for an alternative purpose (left to stand); total removal; partial removal; or to separate and submerge the upper potions of the installation and allow it to degrade over time. There may be positive and/or negative environmental impacts for each option. Here, we provide an overview of the number and variety of marine mammals that inhabit the offshore waters where current oil and gas activities are located, based on data collected by the Department of Conservation (DOC), and which may be affected by decisions regarding the future of the existing oil and gas structures.

2 Marine Mammals Inhabiting the Taranaki Bight

The species variety and frequency of recorded marine mammal sightings within the northern and southern Taranaki Bight on the west coast of the North Island of New Zealand are presented in the map of Marine Mammal Sightings, Appendix 1. Based on data collected for over 100 years, the map illustrates the variety of marine mammal species sighted in the Taranaki region and recorded by the Department of Conservation (DOC). Twenty species of cetacean and two pinniped species were noted over the recorded period.

Data were not collected as part of a targeted survey, but rather by casual observation or as a legal requirement for marine seismic testing in the area. Accordingly, there are some questions as to the veracity of the data, in particular identification to subspecies level and sampling bias due to temporal and spatial inconsistencies.

2.1 Data Selection

Data were obtained from a spreadsheet curated by the Department of Conservation: the *Marine Mammal Sightings Spreadsheet (National) 1.1.1900 – 12.12.2016.* They were selected to fit within a grid encompassing the North and South Taranaki Bight, which corresponds approximately to the distance from Raglan to Levin, and out to sea far enough to include current and potential extractive activity, as well as to accommodate recorded sightings.

This area also encompasses the main range of the high profile Māui dolphin, although there have been sightings further north in the past. Latitude and longitudes are as follows:

NW corner	-37.801406	172.08160
NE corner	-37.801406	175.28618
SW corner	-40.622245	172.08160
SE corner	-40.622245	175.28618

Sightings were validated by DOC staff, or were provided by trained Marine Mammal Observers aboard seismic vessels operating within the area. Initially, there were 1534 individual records of raw data with the earliest entry being 1 January 1900, the last entry 12 December 2016, however several steps were taken to ensure that the data used were as accurate as possible.

Firstly, data with unknown, unclear or impossible dates e.g. 1.1.1900 (recorded as being sourced from a seismic vessel), 0.0.97, and 01.01.1111 were removed. Latitude and longitude that were obviously incorrect i.e. marine animals placed well inland, were also removed.

If only the month and year were provided, entries were assigned the 15th of the month.

Obvious duplicates were removed if they fulfilled the following criteria:

- sightings occurred on the same day, at the same latitude and longitude, were the same species, the same pod number and from the same source
- sightings had the same data/story (based on notes recorded alongside the sighting), with the same or similar (to 2 decimal places) latitude and longitude, the same pod number, but from differing sources – in which case the larger estimate, or that from a likely more authoritative voice was retained (e.g. DOC ranger over member of the public)

2.2 Data Quality

The data has been gathered unsystematically from a variety of sources over a long time period (earliest entry is in 1900). Entries are sporadic, with notable increases in reporting frequency coinciding with periods of seismic activity. Sources vary and include members of the public, fishing/pleasure vessels, seismic vessels and DOC staff observations. The lack of standardised observer effort resulted in a strong temporal and spatial bias that impacted the quality of the data. Seasonal variations in particular were insufficiently accommodated.

The length of time the observer spent gathering data was not recorded. This is an important detail, as behaviour can make it difficult to determine the numbers of individuals. For example, if feeding, some whales may not be sighted at the surface for up to twenty minutes. This may be reflected in the data via multiple recordings at the same position, with different pod number estimates. Key data quality issues are described in the following sections.

2.2.1 Duplicate sightings and variable pod size estimates

Seismic Vessels actively watch for marine mammals, and report sighting several times a day. As mentioned, obvious repeat sightings were removed based on the criteria described above. However if the sighting had potential to be a different animal or group of animals - such as those with different latitudes/longitudes, or different pod sizes - data were not removed (see Table 1).

Sighting Number	Source	Date	Platform	Vernacular name	Location	Latitude Decimal	Longitude	Min #	# of adults	# of Calves	Other Information
3065	MMD	2/03/2013	Seismic survey vessel	Blue Whale	Not recorded	-40.0945	172.9972	1	1	0	Not required
3064	MMD	2/03/2013	Seismic survey vessel	Blue Whale	Not recorded	-40.1292	172.9844	2	2	0	Not required
3062	MMD	2/03/2013	Seismic survey vessel	Blue Whale	Not recorded	-40.0869	173.0552	2	1	1	Request at 15:04 with shut down at 15:05
3059	MMD	2/03/2013	Seismic survey vessel	Blue Whale	Not recorded	-39.9602	173.0569	4	4	0	Vessel neared animals. Shut down when one appeared right in front. SD 17:07

Table 1: Examples of multiple sighting entries

2.2.2 Species identification

Without expert knowledge, it can be difficult to distinguish between many similarly shaped cetaceans whilst at sea. Although there are some limited physical differences between Hector's dolphins (*Cephalorhynchus hectori*) and Māui dolphins (*Cephalorhynchus hectori Māui*), genetic testing is considered the most reliable way to determine the sub-species as behaviour and appearance in the water is so similar. The data contained reports of both Māui and Hector's dolphin sightings in overlapping areas. Three sightings did not differentiate but were listed as 'Māui or Hector's dolphin'.

The same confusion potentially exists between several other species with similar physiology: Sei whales (Bala*enoptera borealis*) and Bryde's whales (*Balaenoptera brydei)* are anatomically similar and their distinguishing features (existence of rostral ridges on a Bryde's whale, and throat pleats that end mid-body on a Sei whale) are often obscured by water. The differences between Pygmy Blue (*Balaenoptera musculus brevicauda)* and Blue whales (*Balaenoptera musculus)* include the head to the body ratio, the length of baleen plates, and size when fully mature – all challenging to ascertain in a brief in situ encounter. It can be difficult to differentiate between Long-finned Pilot whales (*Globicephala melas)* and Short-finned Pilot whales (*Globicephala macrorhynchus)*; between False Killer whales (*Pseudorca crassidens)* and other blackfish due to similar physical appearance and behaviour. The single report of a Short-fin Pilot whale (Seismic vessel) was more likely a Long-finned whale, as the former typically reside in tropical waters.

All sightings appear to be from lower elevations, either by observers on the beach, or from vessels within the study area. The height of a seismic vessel provides a better viewing platform than being at sea level, however it remains a challenge to ascertain species specific anatomical details of marine mammals whilst at sea. Distance from the mammal -not noted in the data- is also pertinent as the lack of any comparative feature other than the vessel, makes estimating the size (often one of the species specific features) of an animal difficult.

There was a single sighting of a Shepherd's Beaked whale (*Tasmacetus shepherdii)* in 2014, by a private vessel. However until recently, the presence of Shepherd's beaked whales in NZ waters was known only from carcasses found on beaches. The first confirmed sighting was made by an Otago University research expedition on 8 July, 2016 (Rayment, Dr. W., University of Otago).

Of the total sightings mapped, 22% were recorded as unknown baleen whale, unknown cetacean or unknown large mammal. In one case, the encounter was described as an unknown baleen whale, identified by a sound described as a whistle – however only toothed whales are able to whistle and click.

2.2.3 Sampling bias: inconsistent temporal and spatial data acquisition

The primary source of data is from seismic vessels that follow specific survey designs that relate directly to the subterranean geology -reporting cetacean sightings is not the key focus of these surveys. Differing requirements mean that not all of the Taranaki Bight is surveyed, and those areas that are surveyed may not be for equal time or intensity. Correspondingly, sightings are most dense where survey vessels have been active and scant where they are not. Public sightings are significantly higher from shore.

Data was not equally acquired over time. There were four recorded sightings in 1970, one sighting in 1974 and three sightings 1976. Nothing is recorded for the period 1971-3, or for 1975. 2004 saw an increase in the data recorded (29 sightings). Sightings increased gradually between 1999 and 2011 (67 sightings), peaked in 2013 (352 sightings), and decreased again in the last two years (96 sightings in 2014, and 136 sightings in 2015). Increased sightings are primarily due to reporting from seismic vessels in the study area.

Seasonal variation in reporting is principally due to the seasonality of seismic surveying. Seismic vessels typically work the Boreal summer as winter ice is an obstacle, and make their way south for the Austral summer - which coincides with a better weather window for marine seismic surveying (Dr. A. Macpherson, Seismic Project Manager, pers. comm. 2017). Accordingly, 65% of the sightings occur in the summer months (January – December), with a further 19% occurring in autumn (March – May). Only 16% of sightings occur during the winter-spring months (June – November).

Blue whales, Māui/Hector's Dolphins and Common Dolphins were the most frequently sighted species. Sightings for all species occurred in each month of the year.

Figure 1 Number of sightings by date, 1970 to 4 July 2016

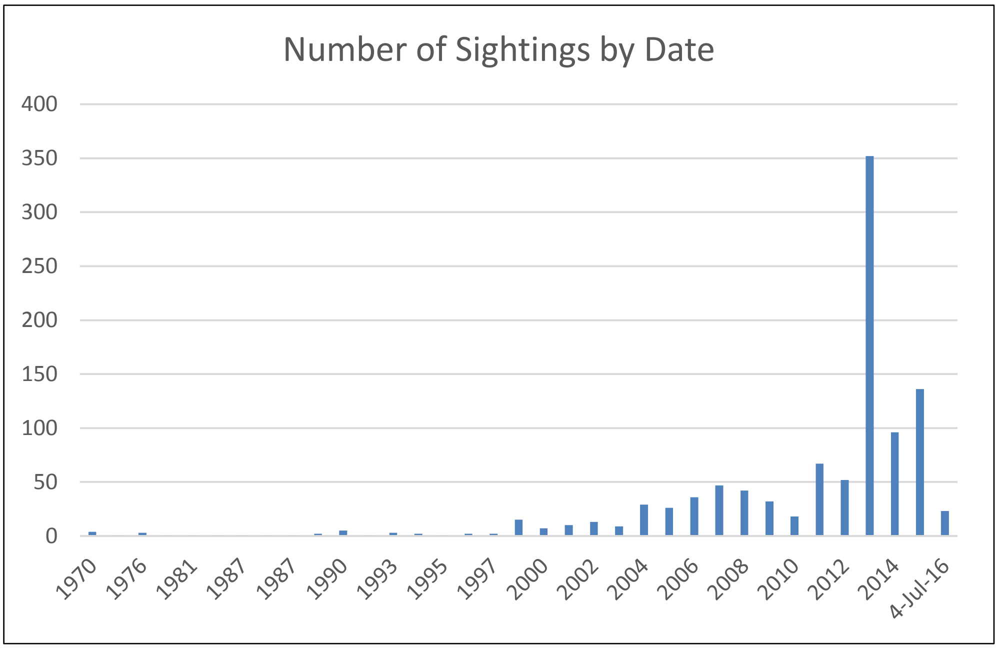


Figure 2 Sightings by season

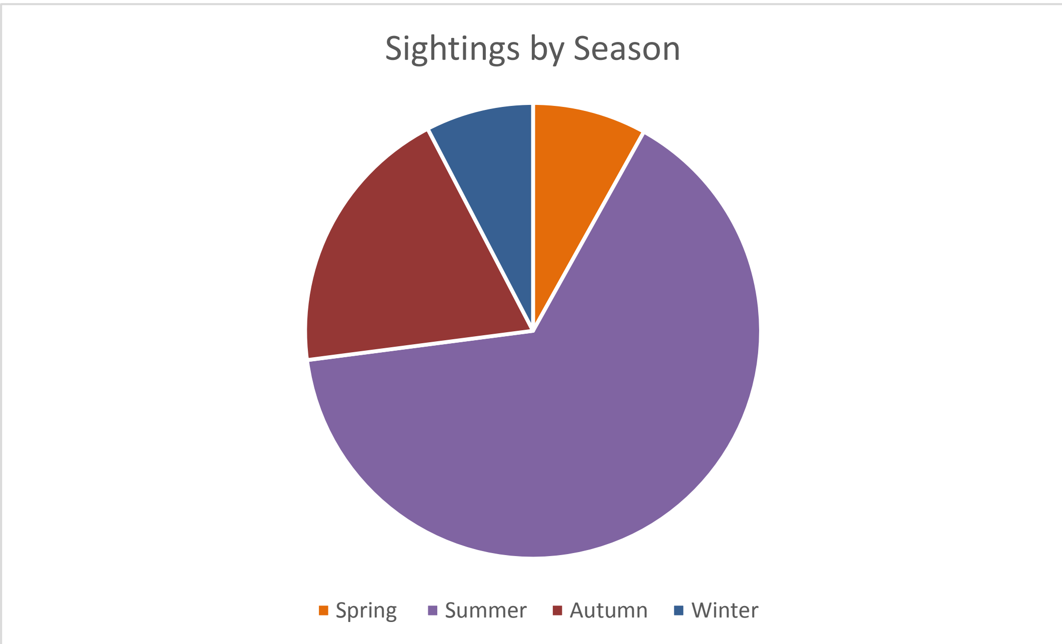
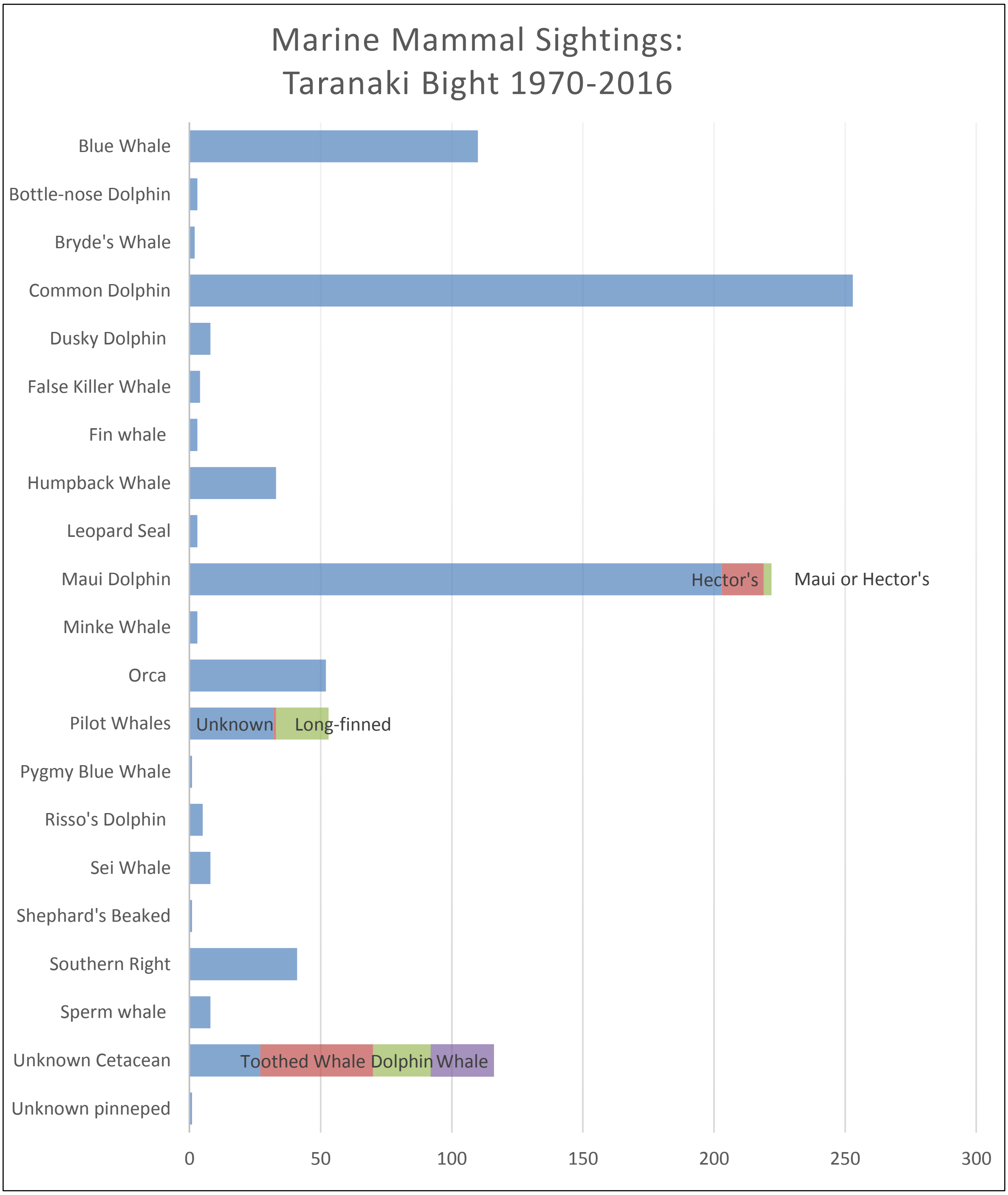


Figure 3 Marine mammal sightings by species within the Taranaki Bight 1970 – 2016. Species recorded as Māui, Hector's and Māui or Hectors; unknown Pilot whale, Long or Short-finned pilot whale; and unknown cetacean, toothed whale, unknown dolphin or unknown whales have been compiled in the same bar.



3 Discussion

Forty-one of the world's 80 known cetacea are found in New Zealand waters. New Zealand marine mammals include baleen and toothed whales, the latter of which comprise beaked whales, dolphins, and porpoise (Suisted & Neale, 2004). Of these 41 cetacean species, 51% were sighted within the surveyed area. This number may be higher if cryptic species, such as beaked whales, were accurately surveyed. However due to their low abundance and elusive behaviour they are poorly studied and rarely seen.

Two of nine pinniped species known to inhabit NZ waters were recorded as sightings by DOC: three Leopard seals (*Hydrurga leptonyx*) and one occurrence of an unknown pinniped. The absence of any records of New Zealand Fur Seals (*Arctocephalus forsteri*) is notable as the Sugarloaf Islands in New Plymouth are considered an important breeding colony and haul out area for this recovering species.

Many cetaceans may have migratory, resident or transient behavioural patterns. Species such as Bryde's whales comprise all three - individuals that are permanent residents within an area, others that migrate seasonally, and some that behave in a transient manner (Behrens, S. [Jervis] 2009). Without identifying individual animals, it is not known which behavioural patterns occur in this area and how that may affect the frequency of sightings.

Southern Right Whales (*Eubalaena australis*) whales are found along the West Coast of New Zealand during winter and spring. They follow a regular migratory pattern where they hunt and feed during the summer months in colder southern waters, and migrate to northern tropical waters during the winter months to give birth. Data for this region was primarily sourced during summer and autumn, so the results may underestimate the prevalence of this species in the area.

Blue whales typically follow regular migratory patterns between the cooler feeding grounds of the South, and the warmer breeding grounds in the North. There are fewer studies on Pygmy Blue whale movements, however it is thought that their migration is more elastic and responsive to changes in prey availability (Double *et al*., 2014). Recent studies suggests that the Taranaki Bight appears to be an important whale feeding ground for both subspecies (Blue and Pygmy Blue) with a currently indeterminate seasonal pattern (Torres, 2013, Torres et. al. 2017). 'Blue' whale sightings occurred in all months of the year.

In general the sightings were consistent with the preferred habitat of the species – for example Māui or Hector's dolphins were most often sighted near the coastline whilst most of the Blue whale sightings occurred in deeper water. However the absence of sightings does not necessarily translate to the absence of cetaceans. A purpose-specific study incorporating systematic aerial and acoustic surveying would yield a comprehensive data set that reflected seasonal variation. As this has not been the case, data presented here are likely not an accurate measure of marine mammal distribution or occurrence but rather indicative of the diversity of species that frequent the area.

Even though the data has substantial potential for inaccuracy, the resulting map clearly demonstrates that a wide variety of marine mammals inhabit or frequent the Taranaki Bight year round.

3.1 Potential Ecosystem Effects from Offshore Oil and Gas Structures and Impacts on Marine Mammals

Marine ecosystems are innately linked - compromise at one level of the system often impacts another. The various stages of installation planning and development, construction, production and decommissioning each affect marine systems in different ways (Marine Mammal Commission, 2012). At the planning stage, the geophysical surveys used to determine platform sightings and for ongoing monitoring and guidance of extractive activity are a significant source of low-frequency sound, also used by baleen whales to communicate – this overlap may obscure or confuse whale communications. These activities are typically of short duration from a few weeks to months depending on the activity.

The anchoring of a structure during construction can alter or degrade a portion of the sea bed and deposit debris into the water column. Debris plumes from pile driving and some forms of drilling, although spatially limited, can affect both motile species and, as it resettles, the benthos (Thomsen & Bitsch Schack 2013; Gordon et al., 2003).

Activities that compromise sea floor habitat have the potential to interrupt links between the productivity of the benthos and marine mammal food supply (trophic cascade), however this is greatly dependent on the extent of sea floor damage incurred and the productivity of the benthos. (Newer drilling practises greatly reduce the release of debris by employing a 'closed' system (Dr. A. Macpherson, Seismic Project Manager, pers. comm. 2017)). Increased marine and/or air activity between the structure and the shore during construction and production can cause marine mammals to move away from the area.

The potential for impacts on marine mammals by decommissioning or modification to offshore structures in offshore waters around Taranaki will be determined by a) the severity of the interruption (frequency, intensity and duration), b) possible impacts of the food web, and c) the importance of that area for feeding, reproducing or migrating.

Removal of the top structure only, and either toppling part of or leaving the total supports of redundant offshore platforms to natural processes as a decommissioning option has gained much support globally. This is principally because of the substantial savings over the cost of removal for corporate owners. However it is less invasive than complete removal, and there is the potential for the remaining structure to develop as an artificial reef, enhancing the biological productivity of the area (Jackson & Callahan, 2014, Macreadie *et al*., 2011).

In the Gulf of Mexico, a 'rigs to reefs' programme has been implemented for a number of decommissioned platforms, where large parts of submerged offshore structures are left to form artificial reefs. Large offshore structures are also known to act as artificial reefs during their production lifetime. The in-situ reefing approach is technically not lawful in the North Sea (another major oil producing region); however exemptions are secured (OSPAR Convention). Submerged structures not only become important food sources for fish aggregations, but are known to provide some protection from heavy exploitation, as they become exclusion zones for trawler fishing. Reports of an increase in biomass due to the protection of artificial reefs is supported by a strong positive correlation between oil platforms and commercial hook and line fishing, which has been consistently observed in the Gulf of Mexico (Jackson & Callahan 2014).

If this option were chosen for the Taranaki region it is possible that the toppled platforms would also become successfully colonised artificial reefs and support populations of local fishes. New Zealand sits on a raised continental shelf, providing relatively shallow fishing grounds across a third of the EEZ including the Taranaki Bight. Platforms within the Bight are sited in water depths that vary between 50 and 120 metres. Common schooling fishes of the Bight include Trevallly (*Caranx georgianus*), Terakihi (*Nemadactylus macropterus*) and Snapper (*Pagrus auratus*). Trevally inhabit reefs up to 100 metres in depth, Terakihi, up to 200m and Snapper, up to 400 metres (Roberts *et al*., Eds 2015), all well within the zones of the current installations. However, it is important to recognise the differences between the New Zealand and Gulf of Mexico context, particularly with respect to the far smaller number of platforms in New Zealand and a range of environmental differences between the two regions.

Some studies have found that diversity and biomass are not enriched if circumstances for colonisation are not conducive, for example the structure is positioned in turbid or deep water, as access to larval sources for recolonisation is essential for the success of reef development (Jagerroos & Krause 2016). Other potential negatives include physical damage to the benthic habitat within the 'drop zone' if the structure is toppled, deaths to marine life caused by explosive removal techniques, potential delayed effects in the recruitment of local species (also as a result of explosive removal) (Aguilar de Soto *et al.,* 2014), and the possible release of contaminants into the water as the rig corrodes (Jagerroos & Krause 2016; Macreadie *et al*., 2011).

Little is currently known about the conveyance of contaminants from disintegrating offshore infrastructure as there is a paucity of long-term studies. The relationship between contaminants such as mercury, arsenic, cadmium and chromium from submerged structures and sunken vessels, and bioaccumulation is an emerging area of study and will vary significantly depending on the nature of the structures involved.

Platform removal and topping are likely to require temporary, but significant anthropogenic sound incursion into the marine environment. Noise levels will vary depending on the techniques employed, however both explosive and non-explosive (cutter tools) methods disturb the benthic environment, discharge metals into the water and produce significant levels of sound pollution (Marine Mammal Commission, 2012).

Marine mammals use sound for communication, recognition of individuals, orientation and navigation, avoiding predators and finding prey. High levels of oceanic noise can affect marine mammals in three key ways: it may mask other sounds, contribute to hearing loss through physiological damage, and/or cause changes in behaviour. The significance of any behavioural change will vary by species, individual, the conditions in which the noise occurs, and the frequency and volume of the noise (Thomsen & Bitsch Schack, 2013: Gordon *et al*., 2003). Startle and fright responses have been observed in several species over ranges of tens or hundreds of kilometres, yet the biological significance of this, if any, is undetermined (Gordon *et al*., 2003). Noise that provokes behavioural change, such as reduced resting or interrupted hunting, may affect the important life functions of feeding, breeding and migrating. Interference at this level has the potential to contribute to more serious and longer term fluctuations, such as a decline in the rate of population growth.

Although some marine species are attracted to low levels of acoustic emissions, avoidance behaviour has been widely recorded when emissions are in the range at which negative effects, such as physiological damage or changes to life functions, may occur (McConnell & Govier, 2014). It is likely, that the animals inhabiting the Taranaki Bight will behave similarly when subjected to the noise levels of rig decommissioning - motile species will preferentially leave the area. Temporary acoustic disturbance is unlikely to provoke broad-scale exclusion from preferred habitats (Thompson *et al*., 2013), however efforts to mitigate the disturbance such as: planning for work to occur during periods of least disturbance (e.g. accounting for seasonal trends such as breeding seasons); acoustic monitoring for marine mammals; the use of marine mammal observers; 'shut downs' upon mammal sighting; and acoustic deterrents such as 'soft starts' (currently required by seismic vessels in accordance with the Marine Mammal Protection Regulations 1992) will help minimise negative consequences.

Charismatic marine mammals garner much focus when considering environmental impacts in the ocean. However it is prudent to recognise that marine ecosystems are intrinsically linked and that the effects of anthropogenic incursions, such as rig decommissioning, have consequences across trophic levels. Mitigatory protocols exist to diminish harm to some species, but not all. There will be some level of loss and damage to the system caused by the removal and/or topping processes of large man-made marine structures. However, given our current levels of knowledge, the major negative environmental impacts of decommissioning offshore structures appear to be localised, temporary and recoverable. In the longer term, the primary potential positive effect is an enriched biomass through the creation of artificial reef systems.

4 References

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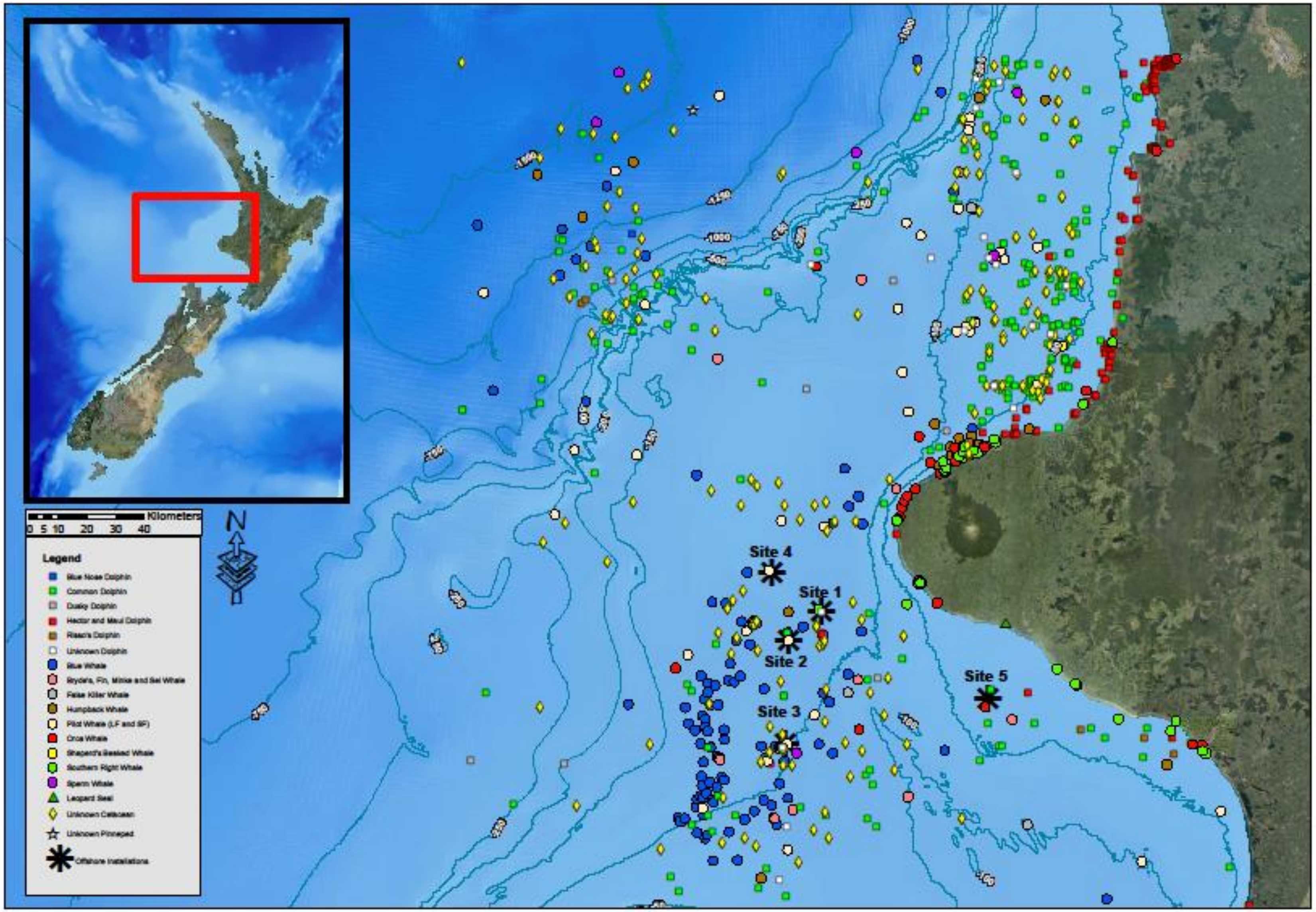
APPENDIX 1: *Map of the Department of Conservation recorded marine mammal sightings by species, Taranaki Bight 1.1.1900 – 12.12.2016*



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Group

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