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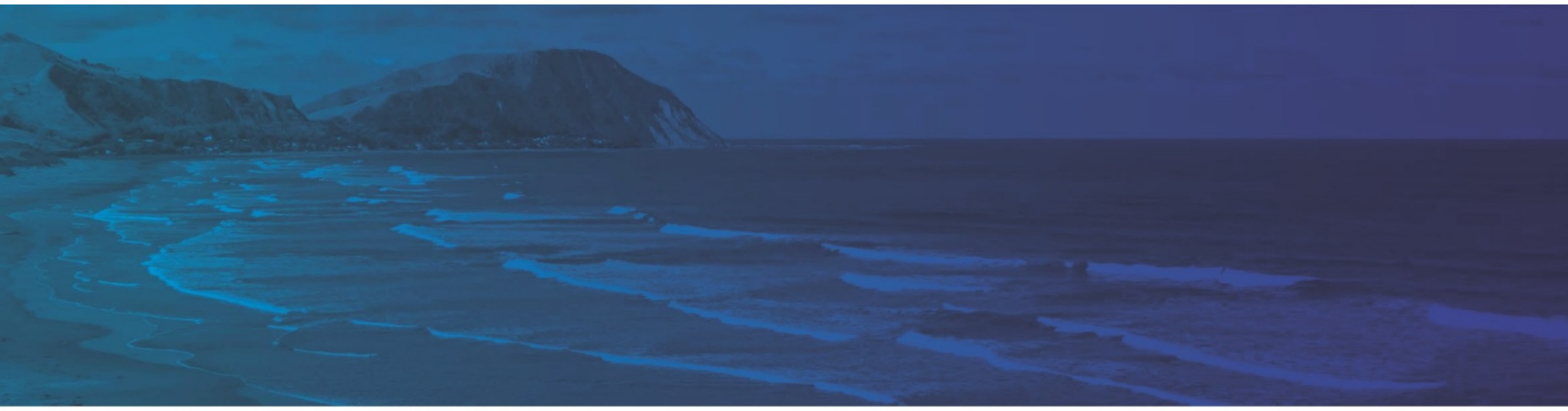

March 2018

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Executive Summary

There are a number of offshore oil and gas installations in New Zealand that are approaching the end of their economic field-life and there is an interest in understanding local perspectives of decommissioning and how that may align with international practice. This study investigates the regulatory, economic, environmental, and social considerations of future decommissioning practises in New Zealand. This summary report is intended to provide a brief overview of each component of the study and how collectively the results presented here link together to address the overarching research aim of "Re-use of offshore infrastructure and platforms: Assessing value to communities, industry and the environment".

Presented in this report are summaries of the following key studies:

A regulatory review of New Zealand's current legislation and regulatory frameworks related to offshore decommissioning, accompanied by a comparison of selected international jurisdictions;

The local Cost verse Benefit analysis of decommissioning options used globally and how that could be applied in the New Zealand context;

An analysis of benthic community composition around existing offshore oil and gas structures, including consideration of whether the structures themselves have an effect on the composition;

A review of marine mammal sightings in the Taranaki Bight with an explanation of migratory, resident or transient behavioural patterns; and

An investigation of social considerations towards decommissioning obtained through media analysis and a range of social engagements.

Our research programme comprised several stand-along investigations that together contribute to understanding any potential environmental or social benefits relating to the re-use of offshore oil and gas structures in New Zealand, or whether associated risks or costs may outweigh those benefits.

The funding for this research project was provided through an innovation grant from the Sustainable Seas National Science Challenge, with the aim of increasing the value of New Zealand's marine resource estate through scientific research. The project was completed through the collaborative efforts of Elemental Group, ERM New Zealand Limited, and Victoria University of Wellington.

We would like to acknowledge Beach Energy, Anadarko OMV, Shell, Tamarind, and New Zealand Oil and Gas, all of whom supported this project through provision of their environmental monitoring databases and information regarding their operations.

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The Research Focus Area

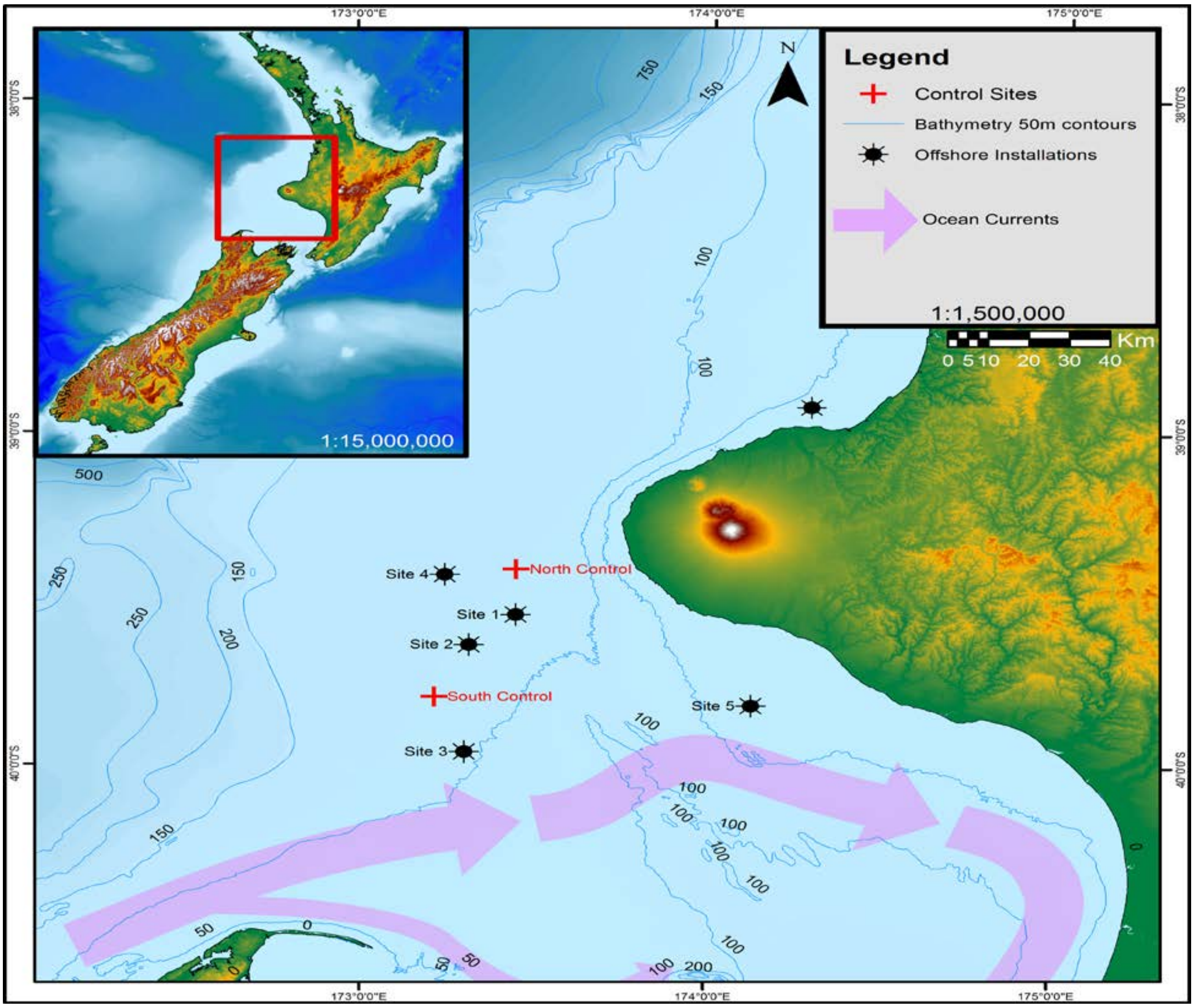

Figure 1 Map of the Research Focus Area

Figure 1 outlines the research focus area, providing the context for our wider research programme. The South Taranaki Bight, located centrally on the map, is home to four of New Zealand's currently producing offshore oil and gas fields and was the focus for our benthic analysis and marine mammal mapping study. The cost benefit analysis and discussions with communities also included a fifth producing field in the North Taranaki Bight. The black stars represent the six offshore oil and gas installations currently in operation (noting site 1 and 2 are both located within the same producing field).

The installations range in age from 38 to 8 years old, and some are approaching the end of their economic field life. The offshore installations consist of four normally unmanned wellhead platforms, one manned platform and two Floating Production Storage and Offloading vessels (FPSOs).

1. Literature Review - New Zealand Environmental and Regulatory Frameworks in a Global Context

1.1 Literature Review - Introduction and Aims

The literature review contains an analysis of selected international jurisdictions associated with offshore decommissioning and relates these to existing and proposed regulatory frameworks in New Zealand. In particular, the review examines the regulatory regimes in the United States (Gulf of Mexico states and California), the North Sea, and Australia. The underlying aim of this component of the research was to assess the frameworks by which offshore assets could legally be decommissioned either fully or partly *in-situ*, including conversion into artificial reefs.

In reviewing the legal framework in the United States, the review focused on the *Rigs to Reef* approach where legal frameworks exist and are applied to undertake such activities. The review also examined the Commonwealth jurisdictions of Australia and the United Kingdom, where legislation can be considered comparable due to the similarities in Commonwealth law. These jurisdictions conversely do not provide the same sort of regulatory regime for a *Rigs to Reef* approach to that of the United States. However, the review explores gaps in the legal frameworks, which have been previously applied in the North Sea to allow case-by-case exemptions to standard decommissioning practises, noting the preference for a 'clean sea bed' approach. These comparisons may provide useful analogues for New Zealand, where decommissioning is untested in regulatory and environmental frameworks.

When considering the legal components for decommissioning offshore installations and infrastructure, environmental parameters should be taken into consideration, understanding that the Gulf of Mexico may in some cases provide a more favourable marine environment for the conversion of a platform to artificial reef than the deep cold waters off the coast of the United Kingdom. The review briefly considered the various ecological conditions present in each of the studied legal jurisdictions with the intention of providing some context to the stated decommissioning policies discussed in the research.

1.2 Literature Review - Key Findings

The key findings of the literature review centred on the recent and upcoming changes to offshore decommissioning legislation and requirements under the Exclusive Economic Zone (EEZ) Act and changes implemented through the Resource Legislation Amendment Act, 2017. The review discusses the requirements for Decommissioning Plans, Safety Cases and marine consenting. New Zealand's regulatory regime consists of overlapping jurisdictions of each agency concerned with the management of offshore natural resources. Figure 2 represents the overlapping legislative frameworks for New Zealand.

Figure 2 New Zealand's Legislative Frameworks applicable to Offshore Decommissioning

The review considered the various End-of-Life (EoL) options for the re-use of offshore infrastructure and compared the current practices identified in each of the international jurisdictions analysed. Figure 3 depicts the decommissioning scenarios possible in New Zealand, given its physical and legal context.

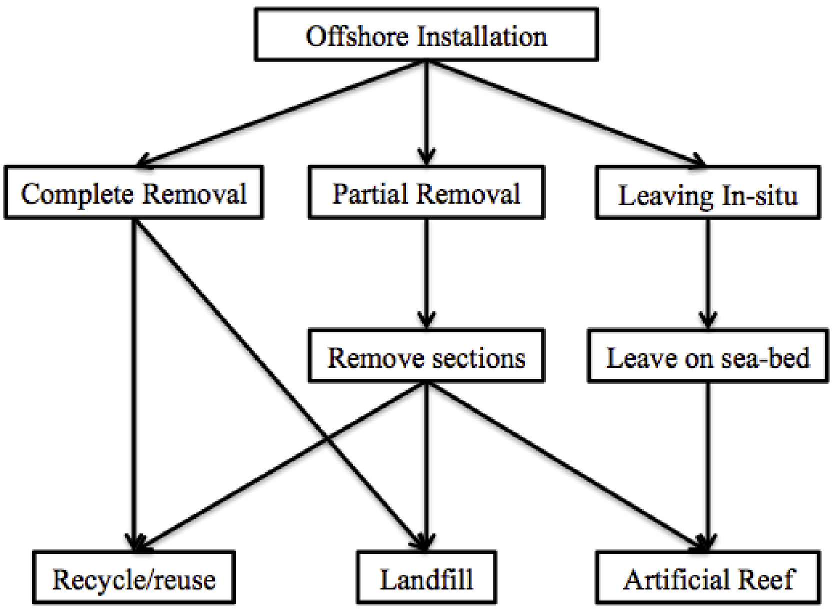

Figure 3 Offshore Decommissioning Options

Each of the three primary options (Complete Removal, Partial Removal and Leaving *In-situ*), where analysed in the literature review, comparing the international jurisdictions to the New Zealand context. The review found that, in general, the states within the Gulf of Mexico (Alabama, Florida, Louisiana, Mississippi and Texas) had reasonable success in demonstrating the important ecological benefits arising from *in situ* decommissioning, with over 420 converted installations to date. Although California has yet to convert any obsolete installations, the literature suggests that there are potential benefits to fisheries and marine ecosystem conservation. Conversely, in the North Sea the benefits of *in situ* decommissioning are more ambiguous, and appear to deliver no or little marine enhancement. In Australia, there needs to be more research into *in-situ* decommissioning to determine the long-term benefits to or impacts on the marine environment.

The review concluded that, from a social prospective, the Gulf of Mexico has entrenched financial incentives that provide a benefit to wider marine users, equating to a degree of 'social license to operate'. California has some financial spreading of benefits to marine conservation, which also contributes to a 'social license to operate'. The general population in California has historically viewed *in-situ* decommissioning with less optimism than their Gulf of Mexico counterparts. Australia's regulatory mechanism provides for public consultation to occur, although the degree to which consultation occurs may be limited to 'relevant persons', which has the potential to limit or impact the overall perceived social benefit.

Decommissioning scenarios in New Zealand will be subject to stringent national and international regulation. Recent changes to the current legislation and the forthcoming regulations highlight the Crown's intent to establish a robust national framework, with guidance to allow the decommissioning process to follow global best practices. The first offshore installation to be decommissioned will set an interesting precedent for future activities and will present a clearer picture of where the social perceptions lie.

2. Benthic Community Analysis of Offshore Installations in New Zealand's South Taranaki Bight

2.1 Benthic Analysis - Introduction and Aims

The aim of the this component of the research was to assess what effects, if any, offshore installations have on benthic communities in the Taranaki Bight, to help evaluate the environmental risks and benefits associated with different options for decommissioning in the future. To assess the influence of structures, data analysis was performed on environmental monitoring data provided by each of the oil and gas operators with assets in the area. The data consisted of species counts identified from sediment samples collected over five years at various transects and distances around five offshore installations, and from two control sites outside of the expected area of influence for production-related activities. The original purpose of the benthic sampling was as part of compliance monitoring to assess potential effects from offshore discharges or drilling activities at each of the sites.

From a statistical point of view, the challenges associated with analysing the data consisted of many more response variables (i.e. count of species) than observations, and high correlation between different species counts, non-normality, and zero-inflation. Therefore, the data did not meet the assumptions that traditional multivariate methods typically rely on. To address these limitations, a non-parametric alternative technique called permutational analysis of variance (PERMANOVA) was used.

The following diversity indices were calculated from the standardised benthic abundance data collated from previous offshore monitoring surveys undertaken by operators over a number of years through monitoring programmes, and that included ROV survey and benthic grab sampling techniques:

- Total Abundance: Count of all organisms within a sample
- Number of taxa (S): Count of total number of different taxa identified within a sample
- Shannon-Wiener Diversity (H)

$$H' = -SUM\ [(p_i) \times \log_e (p_i)]$$

p_i = Number of individuals of taxa / total number of samples

Sampling effort was variable across year, offshore installation, axis, and distance, so the number of samples was included with the diversity indices. The benthic abundance data were square-root transformed and the Bray-Curtis similarity measure was calculated prior to performing multivariate analysis. The difference in benthic community composition was then investigated using PERMANOVA, and non-metric multidimensional scaling (nMDS) was used to visually display the differences between groups.

Within the five stations (representing each of the offshore installations in the South Taranaki Bight), a nMDS plot was constructed to visually assess the difference due to year (2012, 2013, 2014, 2015, and 2016), station (MAP, MAF, MPA, MPB, and TUI), axis (Major and Minor), and distance from the structure (1, 2, 3, 4, 5, and 6). A PERMANOVA analysis was also performed to formally test such differences and their associated interaction terms. The nMDS plot was inspected in detail to confirm the PERMANOVA findings. Control site data were excluded from this analysis.

For the five stations and two controls, a nMDS plot was constructed to visually assess the difference due to year (2012, 2013, 2014, 2015, and 2016) and station (MAP, MAF, MPA, MPB, TUI, NCC, and SCC). A PERMANOVA analysis was performed to formally test differences and the associated interaction terms. The nMDS plot was again further inspected to confirm the PERMANOVA findings. Lastly, SIMPER (similarity percentages) analysis was performed to determine which taxa were contributing most to any significant differences detected between various groups. This analysis used the statistical programming software R (R Core Team, 2017) and various functions in the R package vegan (Jari Oksanen et al., 2017).

2.2 Benthic Analysis - Key Findings and Results

The distance gradient effect predicted that any effect due to the presence of offshore installations would be greater closer to the installation than further away. Of the offshore installations studied, the ones exhibiting a convincing distance effect were the Māui Platform Alpha (MPA) and Māui Platform Bravo (MPB) platforms, the two oldest installations, which were first operational in 1979 and 1993, respectively. However, the only significant difference detected was between samples taken at 250 m and the intermediate distances of 500 m, 1000 m, 2000 m and 4000 m. It was noted by the study author that the differences may have been the result of in-fill drilling activities in recent years. There was no evidence of a consistent difference between samples taken at 250 m and the furthest distance of 6000 m across years; however, this may relate to lower sampling effort at 6000 m from the station. With respect to assessing distance gradient effect, sample size imbalance was inherent in the sampling methodology as there was less sampling at further distances from the installations and only on the major current axes that could influence effects of discharges from the installations. Key result figures from the benthic community analysis are shown in Figures 4 to 6.

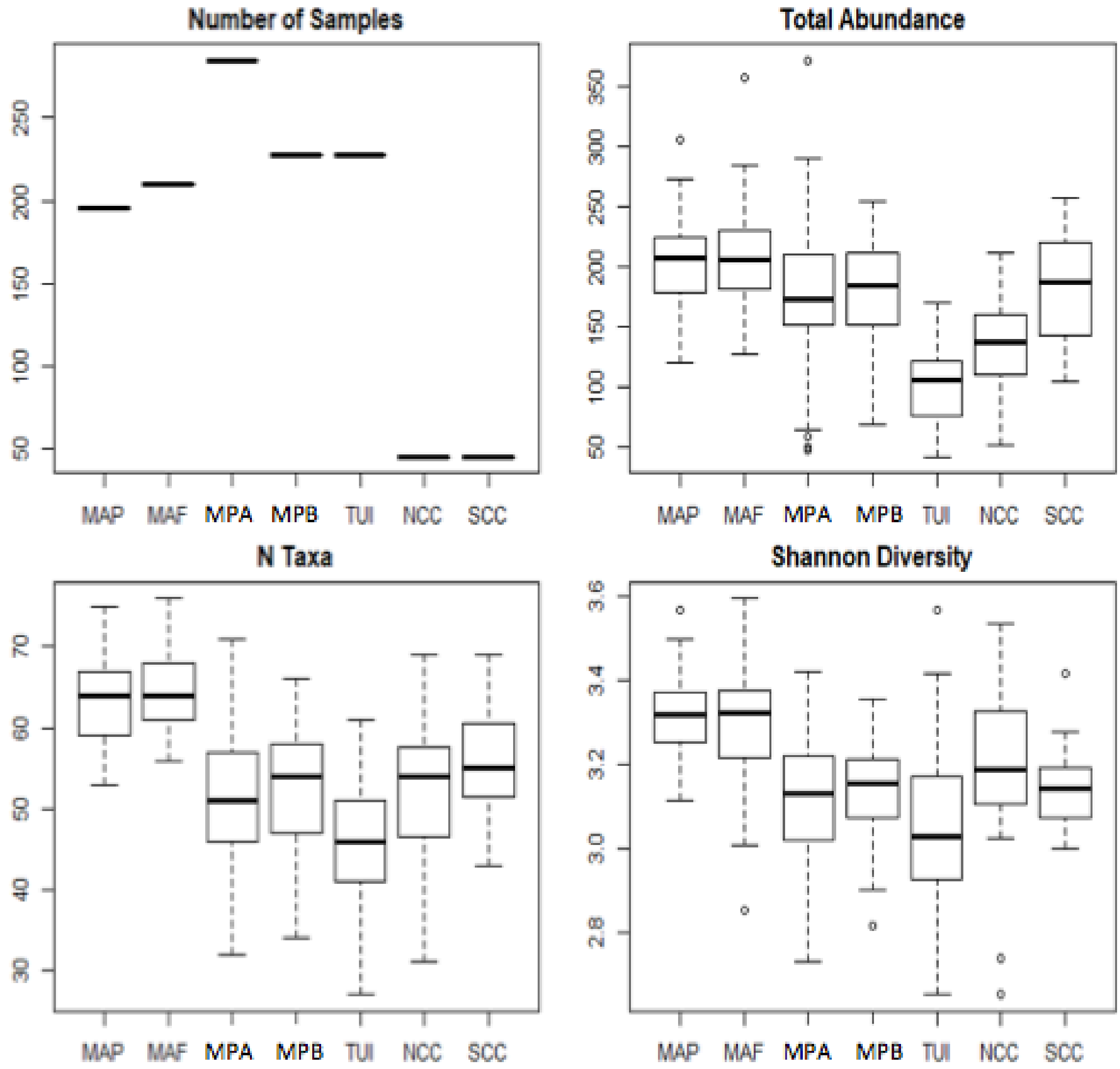

Figure 4 Sampling effort and univariate indices of infaunal communities, by site

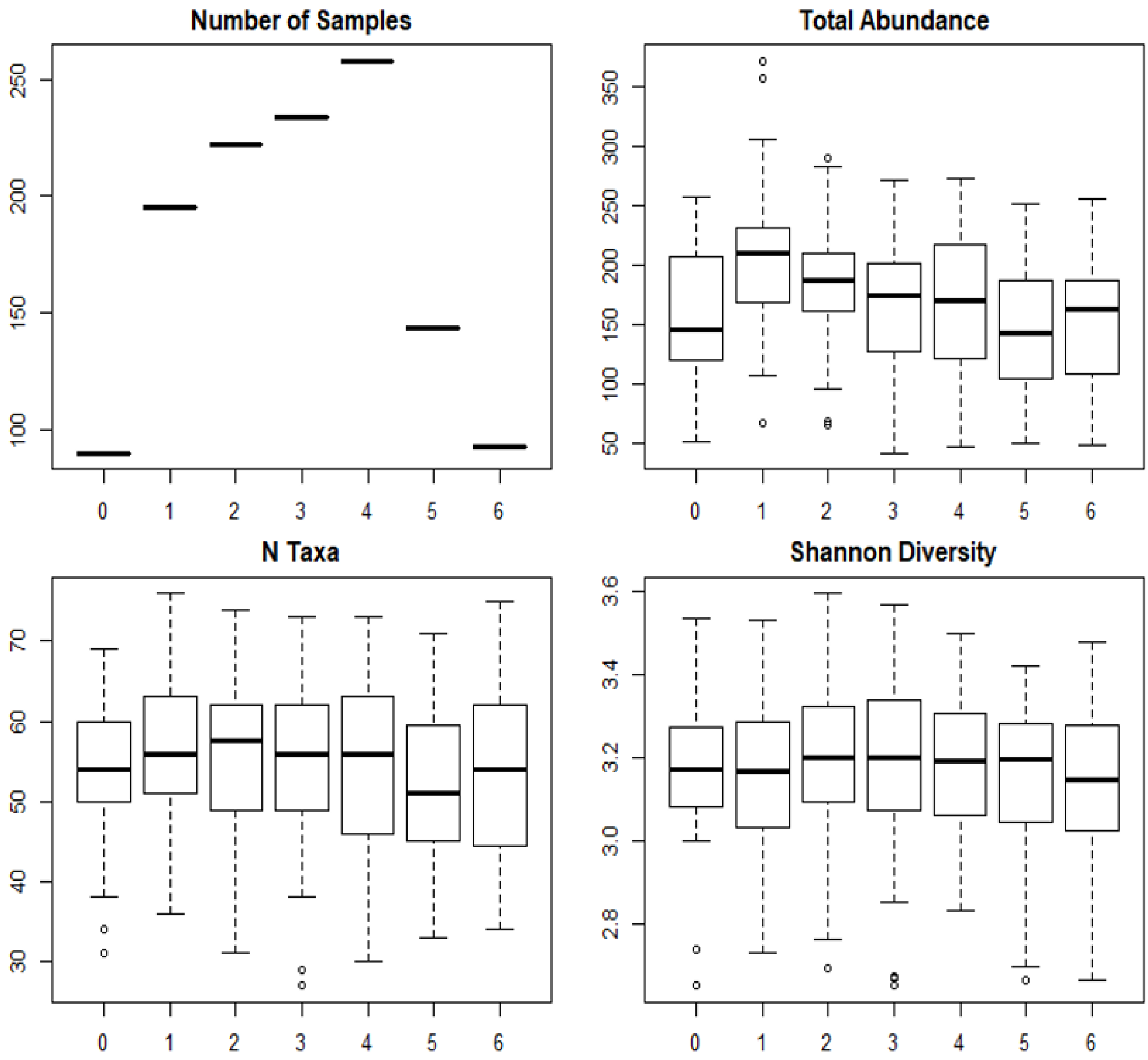

Figure 5 Sampling effort and univariate indices of infaunal communities, by distance from offshore infrastructure (Distance = 0 refers to the two control sites. Distance 1: 250 m (except Tui: 300 m); Distance 2: 500 m; Distance 3: 1000 m; Distance 4: 2000 m (except Tui: 2250 m), Distance 5: 4000 m, Distance 6: 6000 m)

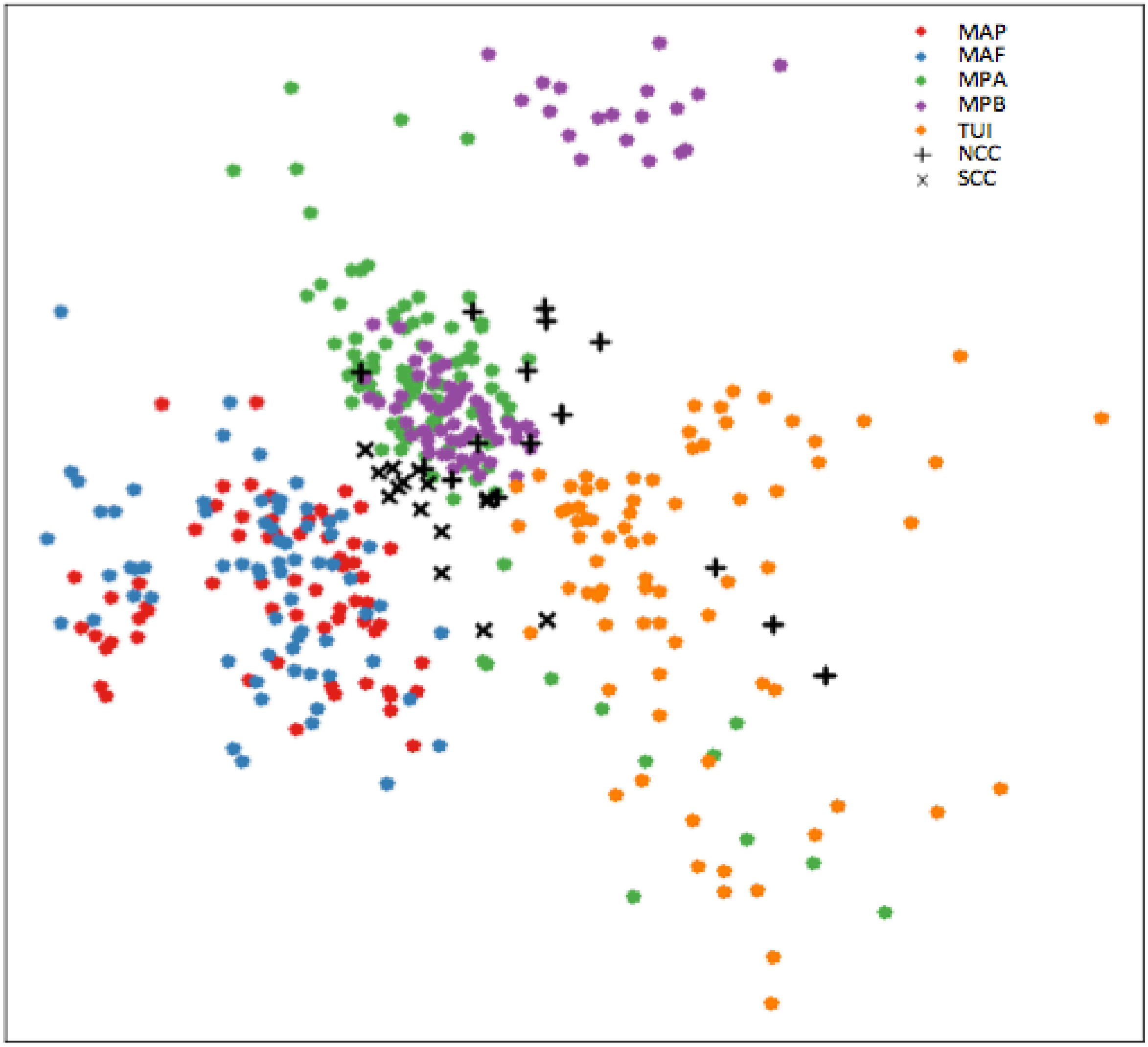

Figure 6 nMDS results coloured by station, displaying dispersal of North and South controls in the midst of stations (Stress = 0.1955807)

The PERMANOVA results confirmed that the seven sites, even the two controls, are statistically different from each other in terms of surrounding benthic communities. When all seven sites are taken together and visualised in the nMDS plot, the stations are slightly more similar to the control station that they are geographically nearest to.

After accounting for year and site effects, there is no evidence that major ocean current flow has an effect on benthic community structure, suggesting that discharges from the existing structures are not influencing benthic communities. Around older infrastructures, there was slight evidence that sample locations in close proximity to the infrastructure have a different benthic community structure compared with sample locations further away, but no evidence that these differences represent a negative effect.

3. Decommissioning of Offshore Structures in the Taranaki Bight and Potential Effects on Marine Mammals

3.1 Marine Mammal Mapping – Introduction and Aims

The purpose of this component of the study was to correlate the recorded sightings of marine mammals within our research focus area and then assess the known species' migratory, resident or transient behavioural patterns to better understand how these marine fauna may interact with the current level of oil and gas associated activities within the Taranaki Bight.

The dataset used in the study was provided by the Department of Conservation (the *Marine Mammal Sightings Spreadsheet (National) 1.1.1900 – 12.12.2016*), and included records of sightings of live animals as well as stranding records. The sightings data are noted as dating back to 1900.

The 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. Data from the records 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 so as to include current oil and gas 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 of the research focus area were:

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

3.2 Marine Mammal Mapping - Key Findings and Results

Figures 7 and 8 illustrate the variety of marine mammal species sighted in the Taranaki region. The map contains sightings of twenty species of cetacean and two pinniped species over the recorded period. Initially, there were 1534 individual records of raw data with the earliest entry being 1 January 1900 and the last entry being 12 December 2016, but several steps were taken to ensure that the data used were as accurate as possible (e.g. to remove obviously duplicated entries) and to exclude entries that made no sense or where the location could not be refined (e.g. sightings of a whale on the top of Mount Taranaki).

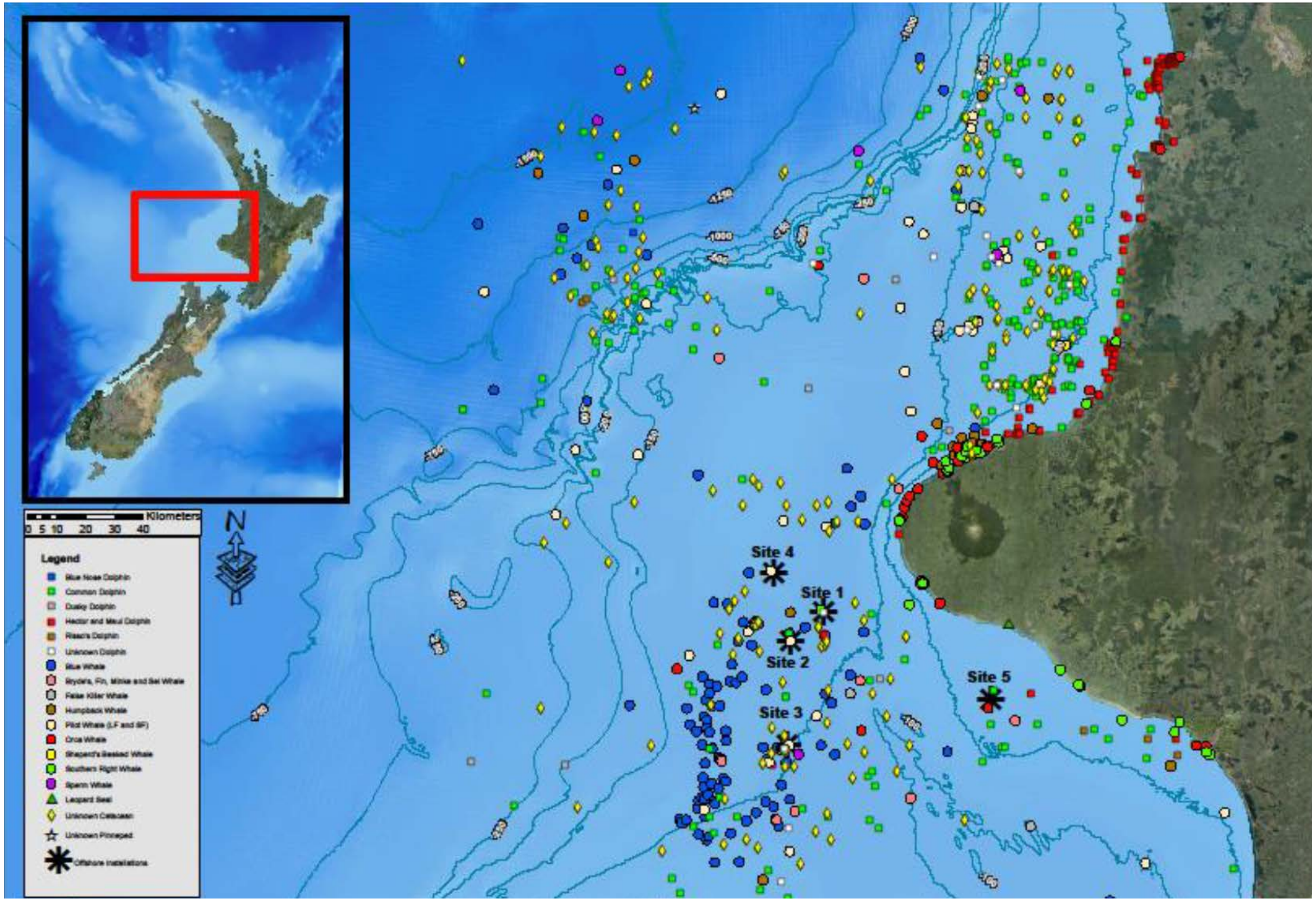

Figure 7 Map of the recorded marine mammal sightings 1900-2016

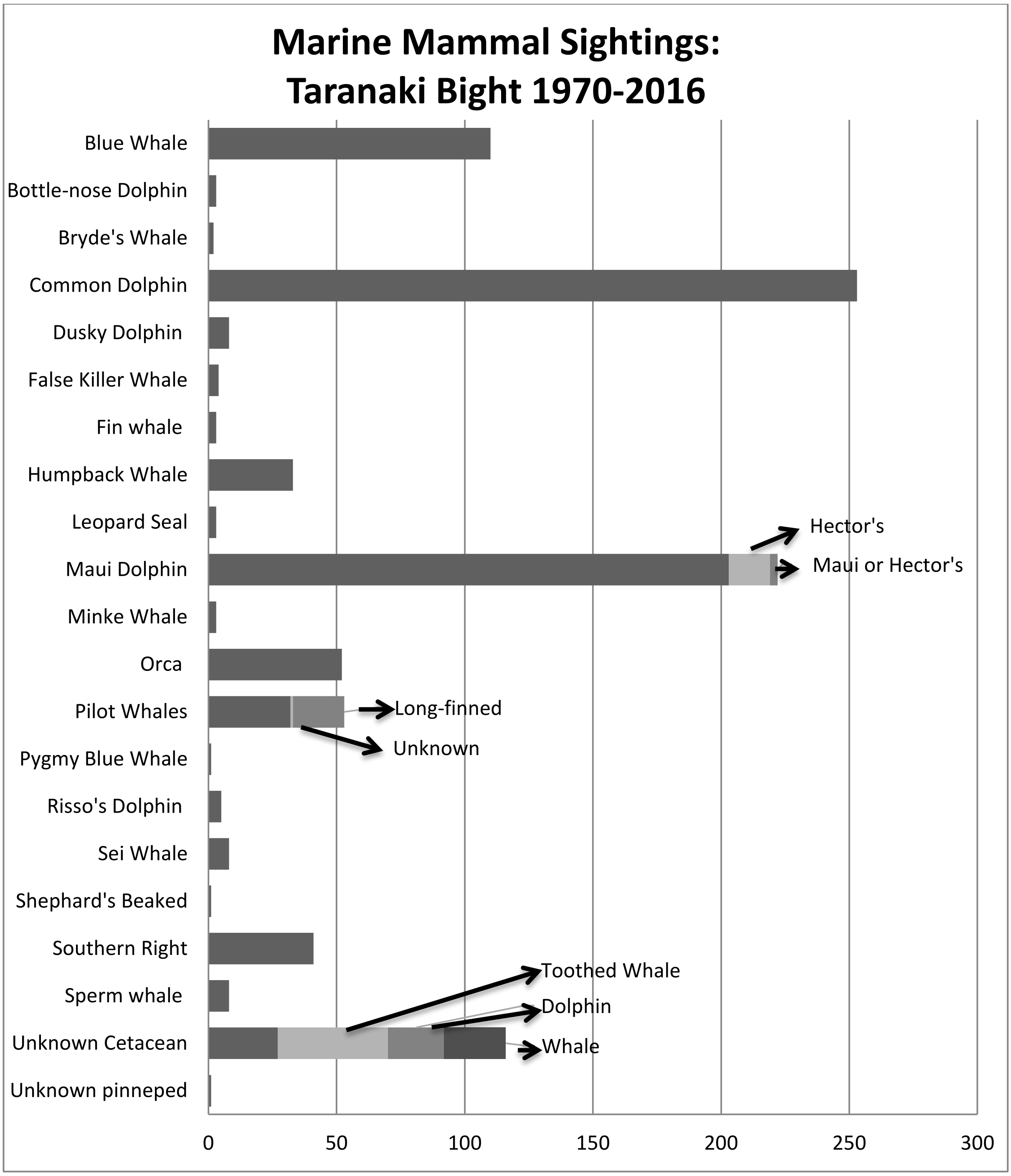

Figure 8 Marine mammal sightings by species within the Taranaki Bight 1970 - 2016.

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

Two of nine pinniped species known to inhabit New Zealand waters were sighted: three Leopard seals (*Hydrurga leptonyx*), and one occurrence of an unknown pinniped. The absence of 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.

Southern Right Whales 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. They are found along the West Coast of New Zealand during winter and spring. As data were primarily sourced during summer and autumn, results may underestimate the prevalence of this species.

Cetaceans may have migratory, resident or transient behavioural patterns. Species such as Bryde's whales do all three - individuals that are permanent residents within an area, others that migrate seasonally, and some that behave in a transient manner (Behrens & Jervis 2009). Without identifying individual animals, it is impossible to know which occur in this area and how that affects the frequency of sightings.

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 their migration is possibly more elastic in response to changes in prey (Double *et al*., 2014). A recent study suggested that the Taranaki Bight may be an important whale feeding ground for both Blue and Pygmy Blue Whales, with a currently indeterminate seasonal pattern (Torres, 2013). 'Blue' whale sightings occurred in all months of the year. The difficulty in assessing seasonality is likely due to an inability to distinguish between Pygmy Blue and Blue Whales.

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, as observations were not systematic but were the result of human presence or activity in a particular area. A more comprehensive study that includes systematic aerial and acoustic surveying would provide a more comprehensive data set incorporating seasonal variation. As a result, 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.

4. Cost Benefit Analysis of Decommissioning Scenarios

4.1 Cost Benefit Analysis – Introduction and Aims

The purpose of the Cost Benefit Analysis (CBA) was to address the financial aspects of 'value' as it relates to the offshore decommissioning options displayed in Figure 3. The CBA assessed New Zealand's five offshore fields currently in production that will likely reach their commercial EoL (End of Life) within this generation's lifetime.

The monetary costs of removing offshore structures or sufficiently modifying structures to allow them to remain in place can be relatively easily accessed through engineering estimates. However, many of the benefits or potential negative outcomes of any course of action are more difficult to estimate in pure economic terms.

Where a cost or benefit can be assessed in economic terms, the study used standard discounted cash flow techniques with discount rates reflecting the long-term and sovereign level nature of the decisions; for example, lower than typical commercial rates. The economic values of the perceived benefits and/or negative impacts over time are derived from peer-reviewed research references. Where the cost or benefit of an action (or inaction) cannot be reasonably assessed in economic terms, then its impact has been ranked against the economic impacts using a relative scale. That cost or benefit was then carried through the CBA as if it had its relative economic impact.

The methodology for the CBA applied the New Zealand Treasury recommended approach to:

1. Define the status quo and the options;
2. Identify who benefits and who loses;
3. Identify and value the costs and benefits;
4. Discount and compare the costs and benefits; and
5. Document the results.

The status quo represents existing producing assets. This study identified policy options because there is no status quo when it comes to offshore oil and gas restoration in New Zealand. The policy options (counterfactuals) were derived from information from other offshore jurisdictions applied to the New Zealand status quo (i.e. the five active fields). The parties affected are based on current understanding within the Taranaki context and are further defined by the social surveying of local groups and iwi engagement sessions held through the social engagement aspect of the research project presented below. Costing the options utilised publicly available financial data from the local oil and gas operators, UK North Sea decommissioning norms, and statements by the Crown regarding its tax and royalty liabilities. This allowed a local and international overview to be developed for the varying options, and a sense-check of the varying methods. The costs were apportioned over the relevant time periods based on published Ministry for Business Innovation and Employment (MBIE) EoL estimates, and these have been discounted as industry norms recommended by the New Zealand Treasury.

Three policy settings were investigated:

- Policy 1: total removal of all infrastructure;
- Policy 2: partial removal of topside structures so that some structures remain on the seabed; and

- Policy 3: alternate use - sale of the entire infrastructure *in situ* for repurposing.

4.2 Cost Benefit Analysis - Key Findings and Results

The decommissioning costs are derived from oil and gas company annual reports. The cost for total removal is estimated to be $2.4 billion, the cost for partial removal is estimated to be $1.77 billion, and alternate use costs are estimated as $1.37 billion.

On a discounted cashflow basis, the study identified the main beneficiaries associated with the different options. These indicative figures show the basis of the cost benefit components under the three policy settings.

The three main industry groups benefitting from or funding offshore restoration work are:

1. Oil and gas companies (funder).
2. The Crown (net funder).
3. Restoration Industry (beneficiary).

Oil and Gas operators will fund the restoration with support from the Crown in the form of tax repayments (Table 1). The net present cost to these parties is in the billions and hundreds of millions of dollars.

The decommissioning industry will be the largest beneficiary for all policy settings. This group includes the specialist international, local equipment and engineering companies that would carry out the work. The maximum value to this group has been estimated at $1.28 billion under Policy 1, and approximately 70% of decommissioning work is likely to go to overseas decommissioning contractors while the remaining 30% would be spent on local contractors.

Overall, these costs are considered in line with the correct order of magnitude for New Zealand's restoration cost. The expected timing for restoration shows a wide date range from 2019 to 2049 (30 years). The median around this activity, however, is driven by two of the fields, which are forecast to occur in 2022 and 2023, respectively, and represent $1,841 million of the total $2,416 million restoration spend (Policy 1).

When the timing of the expenditure, the tax and royalty transfers, and time value of money are accounted for in the discounted cash flow model, the net benefits and effects are calculated as shown in Table 1.

Table 1: Net Benefit for varying parties under three policy settings (NZ$ million)

Affected Party	**Policy 1** **Total removal**	**Policy 2** **Partial removal**	**Policy 3** **Alternative use**
Oil and gas companies	(934)	(680)	(529)
Crown	(432)	(315)	(245)
Restoration industry	1,280	932	725
Commercial Fishers	20	20	20

5. Exploring Understandings of Different Decommissioning Options for Offshore Oil and Gas Structures in the South Taranaki Bight of New Zealand

5.1 Exploring Understanding – Introduction and Aims

International case studies indicate that social acceptance is crucial to the successful implementation of the different decommissioning options, regardless of which option is chosen. Recognising this, the aim of this study was to examine perceptions of complete removal, partial removal, and re-use of offshore oil and gas structures in the South Taranaki Bight. This component was submitted to Victoria University of Wellington in partial fulfilment of the requirements for a Master of Science in Psychology.

Two main studies were used to explore the research objective. To investigate how offshore decommissioning is constructed in the public sphere, Study 1 examined how offshore decommissioning (and associated options) have been portrayed in New Zealand media. Informed by these findings, Study 2 used a postal survey to directly measure perceptions of and support for different decommissioning options among the Taranaki community. This study also explored what variables could predict support for different options. In addition, a focus group was conducted with interested community members (specifically, recreational marine users) to discuss their decision-making process (see Appendix 5). Since no existing research has explored public attitudes towards decommissioning options in New Zealand or the international context, these studies were mostly exploratory and guided by theories in social and environmental psychology.

5.2 Exploring Understanding - Key Findings and Results

Study 1

Driven by agenda-setting theory, Study 1 examined the prominence and portrayal of offshore decommissioning in the media. It should be noted that the focus shifted from decommissioning options to offshore decommissioning in general due to the lack of content exploring the options available. Using Newztext Newspapers (an online media archive for New Zealand newspapers), we retrieved a sample of 13 articles (after excluding duplicate articles) published between July 2004 and April 2017 (see Figure 9). These articles coincided with major events that occurred within the oil and gas industry; namely the decommissioning of the FPSO *Whaakaropai* in 2004, consent (and protests) for the continued operation of the Māui gas field in 2015, the sale of shares in the Tui field in 2016, and the national Petroleum Conference in 2017.

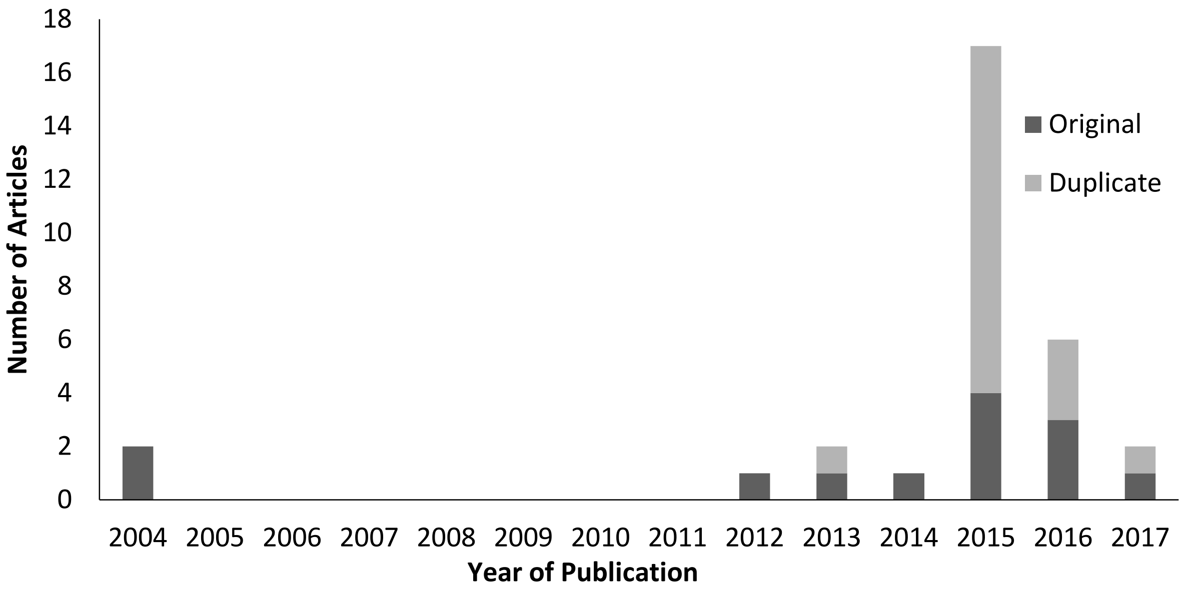

Figure 9 The spread of newspaper articles, both original (n=13) and duplicated (n=18), across time of publication

The prominence of coverage on decommissioning was calculated using descriptive statistics. Compared to the number of articles published on the oil and gas industry in Taranaki by New Zealand media (*N* = 31,657), only 0.17% (*N* = 55) mentioned the terms 'decommission' or 'decommissioning'. Moreover, compared to the number of articles published on the *offshore* oil and gas industry in Taranaki (*N* = 3,557), only 0.70% (*N* = 25) mentioned the terms 'decommission' or 'decommissioning'. This low level of coverage on decommissioning in the media indicates that there is low public awareness (if at all) of the situation among the community.

Regardless, examining how these articles portrayed decommissioning would provide insight into the current decommissioning situation in New Zealand. To do this, a thematic analysis (Braun & Clarke, 2006) was conducted to identify overarching themes and sub-themes from the articles.

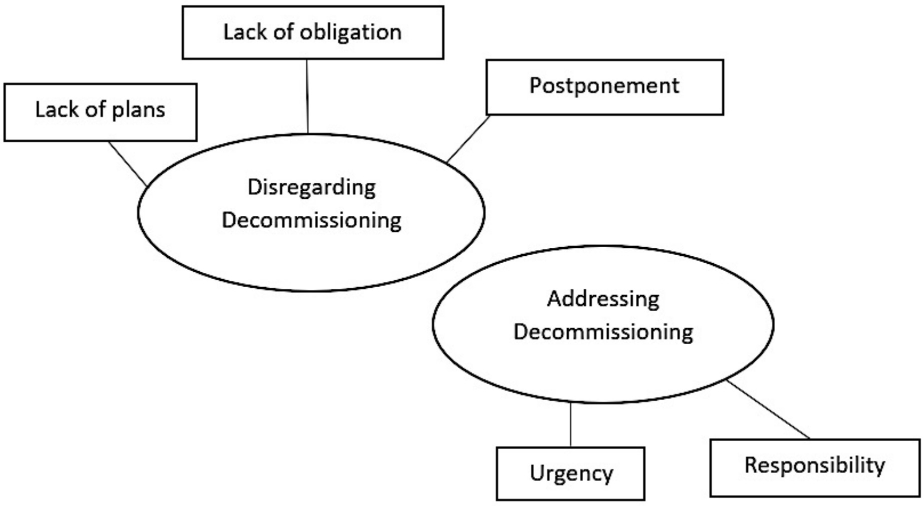

Figure 10 Thematic map of offshore decommissioning in New Zealand media, with main themes (ovals) and sub-themes (rectangles)

As seen in Figure 10, two main themes (and sub-themes) were identified: *disregarding decommissioning* and *addressing decommissioning*. These themes were gathered solely based on the articles in the sample so these themes might not provide an accurate or thorough depiction of events or the situation. Moreover, the latest article in the sample was published in April 2017 so any new developments (if they were published by the media) would not be included. Despite this, these themes portray how offshore decommissioning has been framed to the public, therefore providing insight into what readers know. To summarise the themes: under *disregarding decommissioning*, *lack of plans* refers to the lack of plans made (or at least publicised) for the decommissioning process and decommissioned structures; *lack of obligation* refers to the lack of legal obligation to develop decommissioning plans (these articles were published prior to Resource Legislation Amendment Act 2017); and *postponement* refers to extending the life of oil and gas fields to retrieve more product, thereby delaying decommissioning. Under *addressing decommissioning*, *urgency* refers to the need to decommission structures as soon as possible; and *responsibility* refers to initial plans made over who will be responsible for the decommissioning process. Together, these themes suggest that decommissioning (let alone exploration of different decommissioning options) in New Zealand has yet to be planned.

Study 2

Using a postal survey (N = 154 returned surveys), Study 2 measured how the Taranaki community currently understands different decommissioning options. The results confirmed a lack of knowledge and awareness (but high levels of interest) in the topic. Moreover, 57.3% (n = 86) of the sample preferred complete removal, 15.3% (n = 23) preferred partial removal, and 27.3% (n = 41) preferred re-use.

Respondents were also asked to rate whether they believed each option had a positive, negligible, or negative impact on a number of areas (Figure 11). Overall, the community perceive complete removal to be the most beneficial, with up to 70% of the sample believing that complete removal would have a positive impact on nine out of 13 areas. Moreover, between 40 to 55% of respondents think that partial removal would have a negligible impact on eight areas. Perceived impacts for re-use is more divided, with positive impacts perceived for employment, the local economy, and the New Zealand economy, but negative impacts for Māori values and aesthetics of the ocean view. Compared to complete and partial removal, more individuals also think that re-use would result in more negative impacts on the environment (marine life, ocean water quality, and air quality).

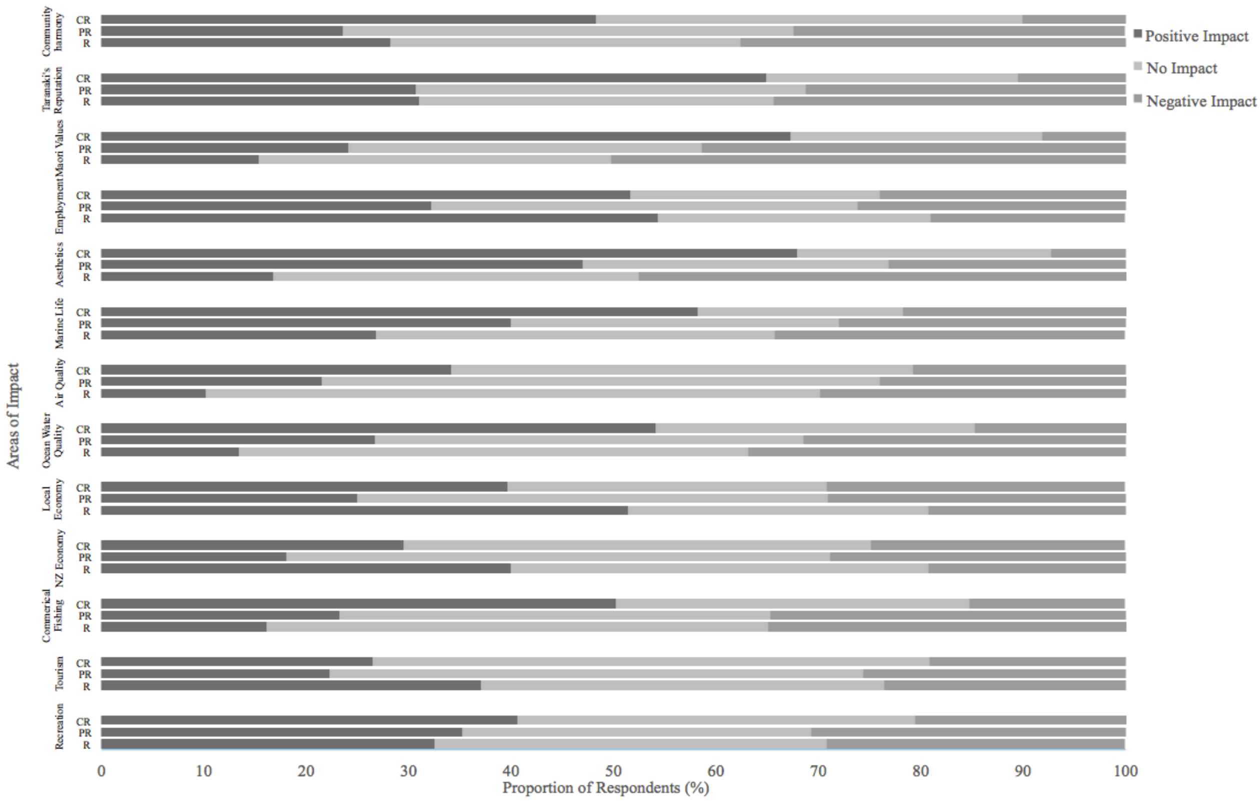

Figure 11 Perceived Impacts (Positive, None, Negative) of decommissioning options: Complete Removal (CR), Partial Removal (PR), and Re-use (R), on various areas by proportion of respondents (%)

Lastly, path analyses were carried out to investigate whether familiarity with the topic, psychological constructs, and demographic variables were significantly associated with support for different options. The results showed that: (1) lower awareness, higher levels of knowledge, and egalitarian worldviews predicted support for complete removal, (2) individualist worldviews and egalitarian worldviews predicted support for partial removal, and (3) younger age predicted support for re-use. The implications of these findings for communication and engagement is further discussed in the final Thesis.

Focus Group with Recreational Marine Users

The purpose of the focus group was to provide an opportunity for stakeholder groups (recreational marine users, commercial marine users, and general community members) to provide their input on different decommissioning options for offshore oil and gas structures. We initially emailed invitations to community clubs and/or organisations, and followed up with a phone call if there was no response. Contact was made with six recreational clubs, five commercial operators, and two community clubs, of which the majority did not respond, discontinued communication after initial contact, were not interested in meeting, or were no longer operating. As a result, only one focus group was conducted with two recreational marine users.

During this focus group, participants were provided with information about the structures and given a summary document based on the existing research conducted by our project team on the environmental, economic, and social consequences of decommissioning options. As the discussion unfolded, preferences for decommissioned structures changed. Although initially inclined towards complete removal, participants began to discuss the potential for re-use to benefit the community. However, after recognising and discussing the risks involved (i.e. lack of accessibility, safety concerns, and ongoing liability), opinions reverted back to support for complete removal as the most realistic option. Their thoughts, as well as their recommendations for future engagement and research, are further summarised in Appendix 5.

6. Iwi Engagement

As part of assessing the community component of our research project, engagement was undertaken with representatives from Ngāti Mutunga, Te Atiawa, Ngāti Maru and Ngāruahine.

The iwi representatives with whom we engaged acknowledged that any post-operational plans and associated cleanup will be unique to each structure because each has different oceanographic and environmental conditions and different engineering designs.

On land, decommissioned wells are plugged and the land restored as far as possible to its original condition. Representatives noted a similar expectation at sea, aiming to see an active restoration and a defined period of time over which restoration occurs. Whether this active restoration process involves the complete removal of all infrastructure and restoration to a clean sea bed, or whether any components of the platforms could be left in place during decommissioning, needs careful negotiation between iwi, the operators and the New Zealand government, so that core values are not compromised and Treaty Rights are recognised. This requires consideration of three specific questions during decommissioning planning:

- What are you going to do to restore the environment?
- What are you going to do to appropriately include relevant iwi or hapū in the development and application of decommissioning plans?
- How are you going to ensure core values are not compromised and Treaty Rights are respected?

Iwi representatives noted that initial promises were made to leave a clean sea bed at the end of a well life. Breaking this promise was considered worse by some than damaging the environment during the decommissioning process. However, for most people, the environmental perspective is as important as the cultural perspective because for iwi the environment sits within and is founded on a Māori cultural context.

There was general feeling that the structures could be cut off and the legs left to decompose slowly in the sea, but our engagement indicated that this was not the consensus of iwi in Taranaki. If there is no significant environmental harm from the structures then as a generality, Māori consider that removing them now may do more damage than leaving the legs, pipelines and cables. However, a core value expressed repeatedly is the need to ensure that Māori are a central party in decision-making. The analyses and communication that lead to any particular decision have to be transparent and robust. There must be evidence that all probabilities have been equally assessed, equally weighted and considered. Ideally, operators would be negotiating with mana whenua on the best options on a case-by-case basis.

Whatever activity is decided, iwi considered that there needs to be a genuine engagement process that provides ample opportunity for collective agreement. Ideally, solutions presented in a decommissioning plan would be co-developed with relevant iwi and hapū groups. This approach is far more likely to lead to an enduring decision-making outcome that meets the needs of communities and industry. Leaving such engagement to the public consultation phase of a regulatory process (such as a marine consent) is likely to create unnecessary confrontation and opposition, which can be costly to all concerned.

7. Conclusions

To date, no offshore installations have been through the process of full decommissioning.

There is little evidence that the presence of the installations is having any measurable effect, either positive or negative, on marine ecology in the region. However it is also noted that the current monitoring studies target potential effects of operational discharges and certain areas that would be directly relevant to the physical presence of the structures themselves (e.g. fish surveys) have not been conducted.

Although there is some evidence of environmental benefits provided by *in-situ* abandonment of structures, or parts thereof, in some parts of the world it is not clear whether these benefits would apply in New Zealand. Deeper water where many of the current structures are located means there is no natural light at the seabed and this, combined with low temperatures, limits potential for enhancement of reef species. However, international studies do support the benefits provided in terms of fish habitat from offshore structures.

New regulations are being developed in New Zealand that includes requirements for extensive consultation and engagement with stakeholders and the general public during the development of decommissioning plans. However, our studies have shown that there is currently limited awareness of the requirements and implications of different decommissioning options. Additionally, analysis of media, and requests for engagement during our research have shown that there is limited public interest in the topic at this time although several iwi groups in Taranaki have indicated strong interest. Iwi groups in particular have indicated a clear desire to be part of the discussion, as equal parties to the process, when it comes to decommissioning planning for offshore structures.

Given the current lack of knowledge of offshore decommissioning amongst the Taranaki community, there is likely to be benefit in the formation of a community panel that would allow a consistent and representative voice and that individual operators could work with in developing decommissioning plans for their installations. This may give rise to a regional decommissioning strategy.

APPENDIX 1: Literature Review of New Zealand Environmental and Regulatory Framework in a Global Context

APPENDIX 2: An Analysis Of The Benthic Diversity Around Offshore Installations In The South Taranaki Bight

APPENDIX 3: Decommissioning Of Offshore Structures In The Taranaki Bight And Potential Effects On Marine Fauna

APPENDIX 4: Cost Benefit Analysis

APPENDIX 5: Focus Group with Recreational Marine Users (Summary Notes)

APPENDIX 6: Iwi Engagement Summary

National Science Challenges
"Sustainable Seas"

Literature Review

Re-use of offshore infrastructure and platforms: Assessing value to communities, industry and the environment

December 2017

Author(s): M Guthrie, K Bromfield, S Davy, S Jervis, A Lane, T Milfont

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Executive Summary

The total and partial decommissioning of offshore oil and gas installations may not have been comprehensively documented throughout the world, but particular aspects of published information provide useful analogues for New Zealand, where decommissioning is untested in regulatory and environmental frameworks. As a number of offshore operations in New Zealand are approaching the end of their economic field life, there is an interest in establishing decommissioning guidelines, taking into account international practice. This paper considers decommissioning options used globally, New Zealand's current legislation relating to the decommissioning of offshore structures, and the social and environmental implications resulting from various end-of-life options for offshore structures. This information is used in considering whether the re-use of structures in New Zealand's offshore waters could have any environmental or social benefits, or how the associated risks or costs may outweigh those benefits.

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1 Introduction

New Zealand has five operational oil and gas fields offshore from the Taranaki Region, on the North Island (Figure 1). These range in age from 38 to 8 years old, and some are approaching the end of their economic value (Table 1). Exploration activities have taken place in other regions around the country, but to date no fields beyond the Taranaki Basin have been commercially developed. New Zealand has not yet had to consider how decommissioning will be approached, although there is some anecdotal evidence that operators originally stated they would be leaving a "clean sea bed" when the facilities were initially constructed.

It is useful to compare how New Zealand installations compare to those in international examples, including in the Gulf of Mexico (GoM) and California in the United States, the North Sea, and in Australia. This will assist both the New Zealand public and New Zealand regulators when they are considering various end-of-life (EOL) options for the current structures offshore in the Taranaki Bight.

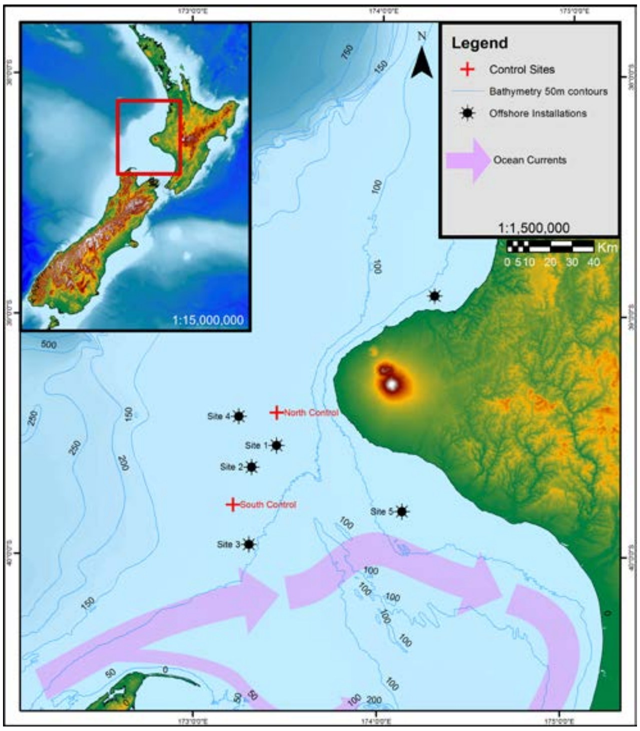

Figure: 1 Map of New Zealand's offshore installations. Adapted from Guthrie et al., (2017)

The Pohokura unmanned platform is the only producing facility located within New Zealand's 12 nautical mile territorial water limit, governed under the Resource Management Act, 1991 (the RMA). The other four actively producing fields lie within the Exclusive Economic Zone (EEZ), located from 12 to 200 nautical miles from the shore. Pohokura was designed to be removed at the end of the field life, is not scheduled for decommissioning until 2036, and we do not consider it further in this discussion. Both the Kupe and Maui fields have pipelines running to shore, which cross into the territorial sea limit administered by the RMA. Regardless, under the new legislation, the abandonment of pipelines will require a marine consent though the Environmental Protection Authority (EPA).

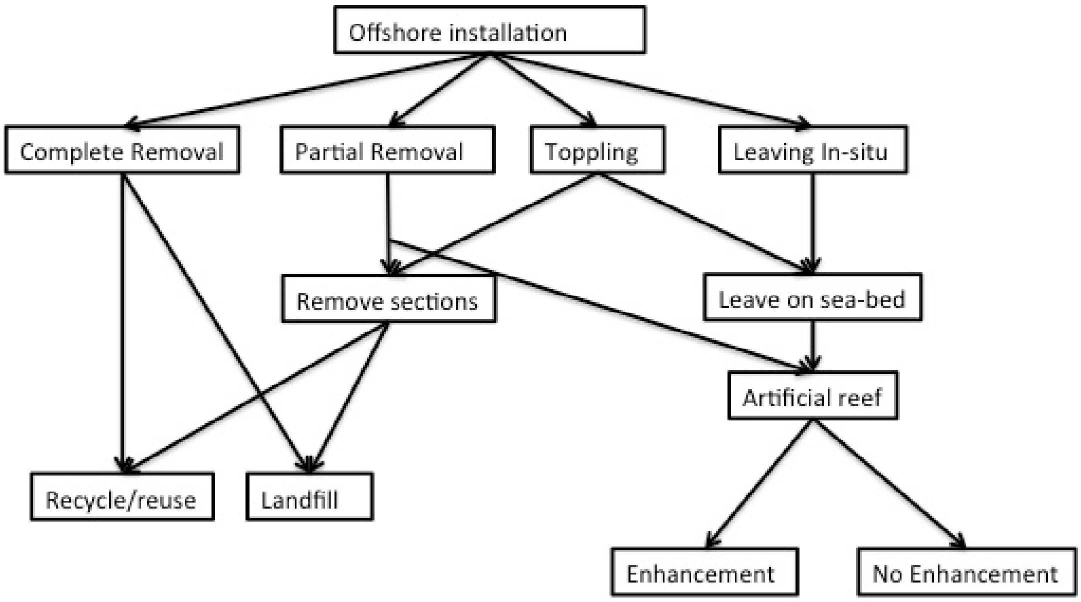

Figure: 2 Flowchart of options for decommissioning oil and gas platforms and infrastructure. Adapted from Schroeder and Love (2004) and Kakhal et al., (2009).

Schroeder and Love (2004) outlined four main strategies for decommissioning offshore structures; complete removal, partial removal, toppling and leaving *in situ*. Figure 2 depicts these options and possible outcomes. Here we consider some of those options, and provide clarity about which might be relevant to the New Zealand context.

Table 1 New Zealand producing fields in the EEZ.

Fields	**Māui**		**Tui**	**Maari**	**Kupe**
	Māui A	Māui B			
Water Depth	108 m	108 m	120 m	100 m	34 m
Discovery	1969	1969	2003	1983	1986
Production commencement	1979	1992	2007	2009	2008
Distance to Shore	35 km	50 km	55 km	80 km	30 km
Infrastructure	11,800 (t) Jacket & 9,000 (t) Topside (Manned Platform), 14 wells, Two 35 km submarine pipelines to onshore production facility	5,000 (t) Jacket & 3,300 (t) Topside. Unmanned Wellhead Platform), 12 wells, 15 km submarine pipeline to Māui A	Multiple Subsea Wellhead systems, FPSO	10,000 (t) Unmanned Wellhead Platform, FPSO	1,000 (t) Unmanned Wellhead Platform, 5 wells, subsea pipeline to shore
Permit Expiry Date	27/06/2036		24/11/2025	01/12/2027	26/06/2031

Anticipated end of field Life	2022	2023	2020	2028

1.1 Gulf of Mexico

The Gulf of Mexico (GoM) has the largest concentration of offshore installations in the world (Fujii, 2015), and the practice of converting obsolete and disused platforms into artificial reef structures is well established (Baine, 2002; Reggio & Kasprzak, 1991). In 2012, there were 2,996 platforms (BSEE, 2017a), with approximately 535 eligible for decommissioning by 2015 (BSEE, 2017a).

The Gulf is home to the world's largest artificial reef complex, consisting of over 420 converted platforms (Table 2) (Ajemian *et al.,* 2015; Techera & Chandler, 2015). The practice of converting decommissioned rigs was a result of legislation passed by the United States Congress in 1984, establishing the National Fishing Enhancement Act. This Act led to the development of the National Artificial Reef Plan in 1985 (Schroeder & Love, 2004; Stone, 1985) by the Department of Commerce, under the auspice of the National Oceanic Atmospheric Administration (NOAA). The plan was used to guide individual States in developing their own Rigs to Reef (R2R) programmes at a State level (Ajemian *et al.,* 2015). However, the U.S Army Corps of Engineers is still responsible for the permitting of decommissioned platforms into artificial reefs under Section 10 of the Rivers and Harbours Act (1899) (NOAA, 2017a).

The R2R programme has been largely successful in terms of reducing decommissioning costs for both the owner of the structure and the taxpayer (Techera & Chandler, 2015). All five coastal states bordering the GoM (Alabama, Florida, Louisiana, Mississippi and Texas) have legislatively approved State-specific artificial reef plans (BSEE, 2017b). The State operated programmes run slightly differently due to their varied legislative requirements, however both the States of Louisiana and Texas usually require the owner of the structure to contribute approximately 50% of the savings realised through participation in the programme to an independent trust fund used to assist with State management of the programme (Dauterive, 2000; Schroeder & Love, 2004; Verbeek *et al.,* 2013). These funds are also used to support scientific research into the upkeep of both artificial and natural reef environments. Under the R2R programme, the operator relinquishes liability and responsibility for the future of the structure to the State (BSEE, 2017a).

Table 2 Rig's to Reef programmes in the United States Source: (NOAA, 2017a).

U.S States	Platforms converted into artificial reefs	Administrators of State Artificial Reef Programmes
Alabama	4	Marine Resource Division- Alabama Department of Conservation and Natural Resources
Florida	3	Florida Fish and Wildlife Conservation Commission
Louisiana	302	Louisiana Department of Wildlife and Fisheries
Mississippi	8	Mississippi Department of Marine Resources
Texas	103	Texas Parks and Wildlife Department

California	0	Department of Fish and Wildlife

While the R2R programme has largely been a successful model, its success can be attributed to both the legislative regime and the physical environment of the GoM. The GoM has a mud-dominated bottom extending to a depth of around 450 m (meters) with minimal naturally occurring hard substrate available (Jørgensen, 2009; Dennis & Bright, 1988). The naturally occurring hard substrates that do occur are interspersed by soft bottom sediments, which are unsuitable for coral larval settlement, prohibiting coral growth (Sammarco, 2013). However, in places extensive tropical reef biota has been found within the high relief-banks of hard substrates (Bright, 1977). These areas are commonly utilised by commercial fishermen, as they have been known to harbour large concentrations of Red Snapper for many years (Camber, 1955). Shipp & Bortone (2009) observed that specific locations in the GoM with artificial reef structures support the majority of the commercial red snapper catches. While analysing the specific contribution of red snapper can be complicated, Gallaway et al. (2009) estimated that between 70% and 80% of age-2 Red Snapper congregate around offshore installations. Due to the paucity of naturally occurring hard substrates in the GoM, artificial reef structures have been strategically placed with the specific purpose of increasing the availability of reef habitat (Syc & Szedlmayer 2012) and associated increased fishing resources.

Importantly, water depth and temperature play a crucial role in ensuring development of reef biota. Where a majority of offshore installations are present in the GoM, water depths typically range from 30 to 80 m (Ajemian *et al.,* 2015). Maximum surface sea temperatures (SST) during the summer months have been recorded as between 29-30°C throughout the interior regions, while temperatures ranging between 22-24°C occur in the western half and 24-26°C in the eastern half of the Gulf during the winter (Muller-Karger *et al.,* 2015). In the interior Gulf regions where depths are typically less than 100 m, the subsurface water temperatures only range from 20-22 °C during both the winter and summer months (Herring, 2010).

Given the generally calm sea conditions found in the Gulf of Mexico and a relatively high availability of capable offshore support vessels, in addition to several dedicated port facilities specialising in oil and gas activities, the logistical requirements of mobilising equipment for decommissioning are straightforward in the GoM. As a result, decommissioning is comparatively cheaper and easier than areas with less clement weather and sea conditions, such as the North Sea or New Zealand.

1.2 California

There are currently 23 oil and gas platforms in Federal waters and four platforms in State waters off the coast of California, all of which are expected to reach the end of production life and be decommissioned between 2017 and 2055. The California Marine Resource Legacy Act (2010) established the California Artificial Reef Programme. The 2016 amendments to the Act, and subsequent amendments in 2017 (Senate Bill 588), allow for the partial decommissioning of platforms. The amendments to the Act relate to Section 2 (6601) of the Fish and Game Code under the existing federal regulations which provide for partial structure removal or topping in place for the conversion to an artificial reef or other use if the structure becomes part of a state artificial reef programme. The legislation stipulates that if partial removal of a platform where to occur, then the process would need to result in a 'net benefit' to the marine environment in comparison to full removal. As with the GoM States, California law requires a portion of cost savings realised through partial removal be shared with the citizens of the State to protect and enhance their marine resources. The State Land Commission is responsible for determining the 'cost savings' that will result from partial removal versus full removal. The cost savings are then distributed to a number of funds: 85% to the California Endowment for Marine Preservation, 10% to the General Fund, 2% to the Fish and Game Preservation Fund, 2% to the Coastal Act Services Fund, and 1% to the county immediately adjacent to the decommissioning location (California Marine Resource Legacy Act, 2010). At time of writing, seven platforms had been decommissioned from 1974 to 1996 (Steinbach, 2016), but none have been converted to artificial reefs under the programme or under the amended legislation.

The 27 platforms currently found off the coast of California occur in a range of water depths; the shallowest platform, *Ester,* sits in only 11 m, while the deepest, *Harmony*, sits at 365 m. There are 14 platforms resting at depths of less than 70 m (Helvey, 2002), all situated between 1.9 and 16.9 km from the shore (Schroeder & Love, 2004). Maximum SSTs during the summer have been recorded as between 16-18°C throughout the near shore coastal regions, while temperatures ranging between 13-16°C have been recorded during the winter (NOAA, 2017b).

Claisse et al., (2014) found that oil and gas platforms off the coast of California had some of the highest rates of secondary fish production per unit area of seafloor of any marine habitat. Love & York (2005) compared fish densities along oil and gas pipelines off California, and observed an increase in fish densities of up to seven times background populations when comparing pipelines to the adjacent seafloor. Surveys undertaken on fish assemblages associated with oil and gas platforms in Southern California also indicated that platforms serve multiple uses (Love, 2006). Platforms appear to serve as nursery grounds to fish species, often with higher densities than neighbouring natural outcrops (Love *et al.,* 2003), and higher densities of sub-adult and adult fish aggregate around the bottom of platform jackets and well pipes (Love *et al.,* 2003; Love *et al.,* 1999).

1.3 North Sea

The North Sea has a number of installations occurring across multiple legal jurisdictions, with Norway and the United Kingdom (UK) currently accounting for the majority of the active offshore facilities (Jørgensen, 2012). The region hosts more than 1,350 operational offshore installations with around 500 installations located on the Norwegian continental shelf (Øen *et al.,* 2011) and 470 within UK waters (OSPAR, 2015a).

The North Sea decommissioning environment is substantially different to the GoM, as the rules around artificial reefing generally prohibit wholesale *in-situ* disposal. The 1992 Oslo Paris (OSPAR) Convention for the Protection of the Marine Environment of the North East Atlantic is a regional treaty and legal instrument that provides international guidance, intended to protect the marine environment (Ahiaga-Dagbui *et al*., 2017; Baine & Sayer, 2002; Techera & Chandler, 2015). Both the UK and Norway are Contracting Parties, including the 98/3 OSPAR Decision on the Disposal of Disused Offshore Installation (1999). The Decision states:

- *The dumping, and the leaving wholly or partly in place, of disused offshore installations within the maritime area is prohibited; and*
- *The preferable decommissioning options are reuse or recycling, or disposal of the structure on land.*

The OSPAR convention does however provide exemptions to the deep-sea disposal ban through a derogation process (Ekins *et al*., 2006; Techera & Chandler, 2015), which allows for the competent authority of the relevant Contracting Party to approve at-sea disposal of certain components of offshore structures (Øen *et al.,* 2011). For a derogation to apply, the competent authorities must be satisfied that after completing a 'Comparative Assessment' there are compelling reasons why the alternative disposal option is preferable over reuse, recycling or onshore disposal (Ahiaga-Dagbui *et al*., 2017; OSPAR, 1999; Baine & Sayer, 2002). The following components of offshore installations where derogation may apply include:

a. Steel installations weighing more than ten thousand tones in air;
b. Gravity based concrete installations;
c. Floating concrete installations;
d. Any concrete anchor-base which results, or is likely to result, in interference with other legitimate uses of the sea.

Derogations therefore technically provide for operators to undertake artificial reefing of offshore structures provided that it does not impede other users, or have a significant negative effect on the marine environment (Cripps & Aabel, 2002). Derogations recognise the potential technological and safety challenges presented when decommissioning large structures at sea (Ahiaga-Dagbui *et al*., 2017). However, due to the specific requirements for obtaining derogation, the majority of structures in the North Sea fall outside the requirements, automatically excluding them from applying. In 2014, 83% of installations in the North Sea were composed of fixed steel, with substructures weighing between 100 and 45,000 tonnes; however only 9% weighed more than 10,000 tonnes, meaning that the remaining 91% were ineligible for the derogation (ARUP, 2014; OSPAR, 2015b).

If derogation is granted for a section of the structure to remain *in-situ*, the liability for that structure is determined at a national level. In the UK, provisions in the Petroleum Act 1998 (Sections 29 and 34) require that liability remain in perpetuity with the original owner of the structure. In Norway, future liability is determined by agreement between the operator and the State (Oil & Gas UK, 2012), and the State may assume future liability in return for financial remuneration.

The mean annual SST recorded in the North Sea ranges from about 10°C in the early 1980's to a recorded high of 11.7°C in 2014 (Van der Kooij *et al*., 2016; Emeis *et al*., 2015), and there are distinct differences between north and south. The south is generally shallow (up to 50 m), from 50 to100 m in the central North Sea, and gradually deepening further north from 100 to 200 m out to the continental shelf, while the Norwegian trench and Skagerrak Strait reaching depths of 270 and 700 m respectively (Verbeek & Jørgensen, 2011). The seafloor is largely comprised of fine sands with lenses of mud and coarse sand in the central region, and pebbles near coastal areas (Paramor *et al.,* 2009).

There have been several studies assessing fish aggregation in close proximity to platform structures. Brønstad et al. (1998) observed an increase in fish aggregation within a few meters of platforms indicating that the effect appears to be highly localised. Jørgensen et al. (2002) looked at the Albuskjell 2/4 Fox Platform, which is part of the Ekofisk field. The platform characteristics are somewhat comparable to those in New Zealand in terms of structure type and water depth. The Albuskjell 2/4 Fox platform was taken out of production in 1996, but was continually maintained up to the time of the 2002 study. Jørgensen et al. (2002) found that the targeted cod species (*Gadus morhua*) displayed a moderate attraction to the platform, with approximately half the tagged cod remaining close to the platform up to after 3 months after tagging.

1.4 Australia

Australia has a complex legal framework for administrating petroleum activities. State jurisdictions have the legislative capacity to grant dual titles to operators under state authority and delegated authority for the Commonwealth (Hunter, 2010). As a result, there are eight State petroleum jurisdictions (Western Australia, South Australia, Tasmania, Victoria, Australian Capital Territory, New South Wales, Queensland and the Northern Territory). The Commonwealth has the rights to all mineral resources on Commonwealth land and seabed within Commonwealth waters (Daintith, 2006). Commonwealth waters are defined as being three nautical miles seaward from the territorial sea baseline to the continental shelf (NOPSEMA, 2017a). Each State has jurisdiction from the coast out to the three nautical miles limit, however each state or territory may confer regulatory powers and functions back to the Commonwealth. Where the State or Territory does not confer, they retain regulatory responsibilities (NOPSEMA, 2017b).

Decommissioning of Australia's offshore petroleum installations operating within Commonwealth waters is regulated by four authorities; the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), the Department of Environment and Energy, the National Offshore Petroleum Titles Administrator (NOPTA), and the Joint Authority. The Joint Authority includes the relevant Federal and State ministers from the corresponding jurisdiction to which the petroleum title is located (NOPSEMA, 2017c).

NOPSEMA administers the Commonwealth Offshore Petroleum and Greenhouse Gas Storage Act 2006 (OPGGSA), which is the principal statute that regulates offshore oil and gas activities, including decommissioning. The OPGGSA states that:

A titleholder must remove from the title area all structures that are, and all equipment and other property that is, neither used nor to be used in connection with the operation: (a) in which the titleholder is or will be engaged; and (b) that are authorised by the permit, lease, license or authority.

Although there is a stated removal obligation for offshore infrastructure in the OPGGSA, Techera & Chandler (2015) noted that there are possible provisions to leave equipment in place if the company can meet the applicable legislative and regulatory requirements within the OPGGSA. Section 270 of the OPGGSA deals with the *consent to surrender title*, and provides that the Joint Authority may give consent to surrender if the applicant has:

(i) *to the satisfaction of NOPSEMA, removed or caused to be removed from the surrender area (defined by subsection (7)) all property brought into the surrender area by any person engaged or concerned in the operations authorised by the permit, lease or license; or*

(ii) *made arrangements that are satisfactory to NOPSEMA in relation to that property.*

Section 586 deals with the remedial directions to current holders of permits, leases and licenses and states that:

NOPSEMA may, by written notice given to the registered holder of the permit, lease or license, direct the holder to do any or all of the following things on or before the applicable date:

(i) *remove, or cause to be removed, from the title area all property brought into that area by any person engaged or concerned in the operations authorised by the permit, lease or licence; or*

(ii) *make arrangements that are satisfactory to NOPSEMA in relation to that property.*

In each case 'arrangements' could consist of leaving some or all of the structures *in situ*, however as there are no clear policy guidelines on what is considered satisfactory and under what circumstances, the possible future arrangements are unclear. Given the ambiguity of the policy guidance, the regulator's view can have significant influence over how the regulations are enforced in future decommissioning scenarios (Chandler *et al.,* 2017).

In general, an operator wishing to leave behind any equipment used for petroleum activities would need approval to be granted under the Environmental Protection (Sea Dumping) Act (1981), which is administered by the Department of Environment and Energy.

The process for approval to commence decommissioning requires the operator to submit a number of plans for consideration by the regulators. These include a Well Operations Management Plan (WOMP) and an Environmental Plan and Safety Case (NOPSEMA, 2017c). Prior to decommissioning, the operator must fulfil their obligations under the Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations (2009), which require a Safety Case that identifies health and safety risks associated with decommissioning, while addressing how the risks will be managed to what is considered 'As Low as Reasonably Practicable' (ALARP). The WOMP is required under the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations (2011), and is used to manage risks associated with maintaining the integrity of a well throughout all stages, including plugging and abandonment. The WOMP must also clearly demonstrate how the operator will reduce risks of maintaining the integrity of the well to ALARP.

The Environmental Plan is required under the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009. For decommissioning to commence, the operator must submit the plan for assessment and acceptance by NOPSEMA. The Environmental Regulations, 2009 also require the titleholders to consult with affected or relevant persons throughout the planning and implementation stages. The regulations have explicit requirements for the titleholder to identify, engage and assess any objections and claims raised by the relevant persons, with details of the consultation to be included in the Environment Plan. The plan must identify the risks and impacts to the environment and should consider the net environmental benefit of the proposed activity. For the plan to be accepted, the operator must clearly demonstrate how the environmental impacts and risks associated with the decommissioning activity will be ALARP. NOPSEMA's assessment explicitly considers the Environmental Protection and Biodiversity Conservation Act 1999 (NOPSEMA, 2017c), Australia's key piece of environmental legislation.

Once approval from NOPSEMA is received, the operator must apply to NOPTA and the Joint Authority in order to surrender the Title and begin decommissioning. To date only a few decommissioning–related Environmental Plans have been submitted. For example, in 2014 and 2015 one Environment Plan was submitted for consideration each year (NOPSEMA, 2015), and two were submitted in 2016 (NOPSEMA, 2016). All the Environmental Plans mentioned above have been accepted, in some cases, resubmissions and time extensions were required to meet NOSEMPA requirements. In 2017, there have been three decommissioning related Environmental Plans submitted to NOPSEMA, two have been accepted and one is currently under extended consideration due to dissatisfaction with the original plan submitted (NOPSEMA, 2017d).

Once a title has been surrendered, and the decommissioning obligations have been completed to the satisfaction of NOPSEMA and the Joint Authority, ongoing liability is transferred to the Government. NOPSEMA cannot compel a former titleholder to remove property after the title surrender has been accepted.

Australia's offshore installations are located in a wide range of marine environments that require a holistic approach when considering EOL options. For example, the ecological conditions in the Bass Strait differ considerably to conditions off the North West Shelf. The Bass Strait has mean seasonal SSTs of ~17.4°C in the summer and ~13.4°C in the winter (BOM, 2017a). Within the Bass Strait, the continental shelf extends out from the coast to a depth of 200 m at the shelf break, and has an average shelf depth of 60 m (Harris *et al.,* 2005). In contrast, the North West Shelf off Western Australia has a mean seasonal SST ranging from ~28.7°C in the summer to ~23.3°C in the winter, and an annual mean temperature of 26°C (BOM, 2017b). It has relatively shallow waters, with depths of less than 200 m covering over 40% of the region (DEWHA, 2008).

2 Offshore Decommissioning in New Zealand

Oil and gas activities within New Zealand are predominantly governed by the New Zealand Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act (2012) (the EEZ Act). Table 3 describes key information for each currently-producing offshore field, including the relevant jurisdiction. Other legislation relevant to New Zealand's international obligations that may apply to decommissioning activities, are included in Table 5.

Table 3 Key Domestic Legislation and Subordinate Regulations

Domestic Legislation	Subordinate Regulations
Resource Legislation Amendment Act 2017	Relevant changes have been incorporated into the EEZ Act. The regulations have not yet been drafted
Crown Minerals Act 1991	Crown Minerals (Royalties for Petroleum) Regulations 2013, Crown Minerals (Petroleum) Regulations 2007, Crown Minerals (Petroleum Fees) Regulations 2016
Maritime Transport Act 1994	Marine Protection Rules

Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012	EEZ and Continental Shelf (Environmental Effects-Permitted Activities) Regulations 2013, EEZ and Continental Shelf (Environmental Effects-Discharge and Dumping) Regulations 2015 EEZ (Environmental Effects - Non-notified Activities) Regulations 2014
Resource Management Act 1991	The Marine Pollution Regulations 1998.
Health and Safety at Work Act 2015	Health and Safety at Work (Petroleum Exploration and Extraction) Regulation 2016
Hazardous Substances and New Organisms Act 1996	Craft Risk Management Standard
Continental Shelf Act 1964	N/A – The Act makes provision for the exploration and exploitation of the New Zealand continental shelf, and historically has provided for the granting of licenses in relation to prospecting and mining minerals on the continental shelf. As of May 2013, the provision exploration and mining permits have been managed under the Crown Minerals Act 1991

2.1 Roles of the governing bodies relating to decommissioning

New Zealand has nine different governing bodies responsible for administrating the legislative requirements for offshore oil and gas activities relating to end-of-field life activities (Table 4). Figure 3 shows the interconnected way that the key legislation in New Zealand overlaps to inform the process of decommissioning.

Figure: 3 New Zealand's overlapping legislative frameworks.

Table 4 New Zealand Government Agencies and their roles at end of field life.

Departments responsible	Roles of each department and relevant legislation
Department of Conservation (DOC)	DOC is responsible for protected species under the Wildlife Act 1953 and Marine Mammals Protection Act 1978. The Department also administers the Code of Conduct for Minimising Disturbance to Marine Mammals from Seismic Surveys.
New Zealand Petroleum & Minerals (NZP&M)	NZP&M manage the Crown Mineral Estate. NZP&M is charged with managing and issuing permits for the use and exploitation of petroleum resources in New Zealand. NZP&M administers the Crown Minerals Act 1991 and Minerals Programme for Petroleum. Under the Crown Minerals (Petroleum) Regulations (2013) NZP&M may attach certain conditions when issuing permits and these could relate to end of life activities, such as decommissioning. Conditions typically include performing permit activities in accordance with good industry practice and complying with any other conditions attached to the original permit. NZP&M is part of Ministry for Business Innovation & Employment (MBIE), and reports directly to the Minister of Energy and Resources who is responsible for MBIE. NZP&M is also responsible for royalties that the Crown receives through the Crown Minerals (Royalties for Petroleum) Regulations 2013.
The Ministry for the Environment (MfE)	MfE is responsible for developing environmental policy and administering the legislation and regulations that apply to the EEZ and New Zealand's territorial waters. This includes providing policy advice on the EEZ Act (2012). The Ministry is also responsible for administering the RMA for proposals that are not of national significance, along with the relevant Regional Council.
The Environmental Protection Authority (EPA)	The EPA is the Government Crown Agency responsible for regulatory functions concerning New Zealand's environmental management. The EPA administers the Hazardous Substances and New Organisms Act, and is responsible for the day-to-day operations of the EEZ Act 2012, including monitoring and enforcement. The EPA regulates activities in the EEZ and continental shelf, and also manages the decision making process for proposals of national significance under the RMA. The Authority is also responsible for facilitating the process of issuing marine consents, dumping consents and discharge consents. An approval obtained through the consenting process is required to remove or discard a structure.
Maritime New Zealand (MNZ)	MNZ is the regulator responsible for maritime safety, security and environmental protection associated with maritime activities. MNZ administers the Maritime Transport Act (1994) and Marine Rules and Marine Protection Rules made under the Maritime Act. The Maritime Amendment Act (2013) transferred the management of discharges from offshore installations and dumping of waste in the EEZ from Maritime New Zealand to the EPA. However, MNZ is still responsible for issuing dumping permits outside of the EEZ limit.
WorkSafe New Zealand (WorkSafe)	WorkSafe is the work health and safety regulator, and administers the Health and Safety at Work Act (2015) and associated regulations. WorkSafe requires a revised safety case to be provided for approval before a production facility can be retired. All offshore petroleum exploration and extraction production or non-production installations brought into New Zealand waters, within the 200 nautical mile limit, are required to adhere to the legislative requirements set out in the Health and Safety at Work (Petroleum Exploration and Extraction) Regulations (2016).
Inland Revenue Department (IRD)	IRD manages the taxation regime under the Income Tax Act (2007). Under Section DT16 '*deduction for removal or restorative expenditure*' may apply for future decommissioning expenses.
Ministry for Primary Industries (MPI)	MPI administers the Biosecurity Act (1993), which provides for clearance of goods and management of incoming craft to reduce the risk of pests and disease being introduced. MPI may be asked for a Request for Advice under Section 44 of the EEZ Act (2012), to provide information on which to base an assessment of impact for any planned activities, including applications for Marine Consents and Marine Discharge Consents.
Ministry for Business Innovation & Employment (MBIE)	The role of the MBIE is the overarching administration of key legislation associated with the petroleum extraction activities.
Regional Councils (RC)	The Regional Councils administer the Resource Management Act (RMA) (1991), which governs activities occurring within territorial waters out to the 12 nautical mile limit.

There are four key documents required to commence EOL operations in New Zealand; Marine Consent, Decommissioning Plan, Safety Case, and Marine Dumping and Discharge Consent. However, prior to initiating any decommissioning activities, The Crown Minerals Act (1991) requires the Crown to assess and agree with the operator as to whether the maximum economic recovery of a field has been reached and cessation of production can occur. If tax deductions for decommissioning costs cannot be effectively utilised, this would be factored into the Crown's assessment. Premature decommissioning would result in lost revenue to the Crown in the form of foregone royalties and corporate taxes (IRD, 2017).

2.1.1 Marine Consent

The EOL considerations such as removal or decommissioning of an installation are likely to trigger multiple Section 20(2) activities under the EEZ Act, which require a notified marine consent to be granted by the EPA. Section 20 *Restriction on activities other than discharges and dumping*, states that no person may undertake an activity described in subsection 2 within the EEZ or continental shelf unless the activity is a permitted activity or authorized by a marine consent or Sections 21, 22 or 23 of the Act.

Section 38 (2) (c) requires a marine consent, marine discharge consent or a marine dumping consent to include an impact assessment in accordance with Section 39 and any other requirements prescribed in the regulations. Section 39 requirements include consideration for the current state of the environment and the likely cumulative effects and impacts on the environment from the proposed activity, while identifying the persons whose existing interests are likely to be adversely affected. The impact assessment must also include alternative options or methodology for undertaking the activity that may avoid or mitigate adverse effects. Additionally, the applicant must also specify the measures to avoid, remedy or mitigate the identified adverse effects.

Section 63 (1) provides the means for the EPA to attach conditions to the marine consent. These conditions can be wide ranging and cover considerations of adverse effects on the environment or existing interests.

Section 38 (3) states that if the activity is to be undertaken in connection with the decommissioning of an offshore petroleum installation, then the applicant must include an accepted *decommissioning plan* that covers the activity in the Marine Consent application and the activity must be carried out in accordance with the plan.

2.1.2 Decommissioning Plan

Under the Resource Legislation Amendment Act 2017, Part 5: *Amendments to the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012*, the recent addition of Section 100A '*Submitting decommissioning plan for acceptance'* stipulates that an operator may submit a Decommissioning Plan and consult with the EPA about the plan. The new legislation provides for public consultation regarding the submission of the plan to occur. The operator must also consider each public submission made regarding the plan and either amend the plan in response to the submission or explain to the EPA why the plan does not need to be amended in response to the submission. There will be additional supporting regulations, which will further specify the requirements for Decommissioning Plans. These regulations at present are under development by the Ministry for the Environment and expected to be in place by July 2018 (MfE, pers. Comm. 2017).

2.1.3 Safety Case

Under Section 23(2) (b) of the *Health and Safety at Work (Petroleum Exploration and Extraction) Regulations* 2016, the operator is required to have an approved Safety Case prior to commencement of operations. A revised safety case must be provided to WorkSafe if the operator proposes to modify or decommission an installation. A Safety Case requires the operator to provide safety documentation to support the operations, including a detailed description of the safety management system for all activities, a formal safety assessment of major accident hazards, and performance monitoring of identified accident hazard procedures and other mitigation measures.

2.1.4 Marine Discharge & Dumping Consents

Under the Exclusive Economic Zone and Continental Shelf (Environmental Effects-Discharge and Dumping) Regulations 2015, a Notified Discharge Consent is required for '*discharge of processing drainage, displacement water and production water from the drilling rig*' and a non-notified Discharge Consent is required for '*discharge of processing drainage, displacement water and production water from existing structures*'. The EEZ Act and the subordinate regulations are based on New Zealand's obligation to the 1996 London Protocol (Table 5). The key principle of the Protocol gives effect to the decision-making framework for the marine dumping consent process.

Table 5 New Zealand's International Treaty Obligations

New Zealand's International Obligations	Relevance to Oil and Gas Activities in New Zealand
United Nations Geneva Convention on Continental Shelf 1958 (in force 1968)	The Geneva Convention granted countries exclusive rights for the purpose of exploring in the continental shelf and the rights to exploit their natural resources. Article 5 states: *'Any installations which are abandoned or disused must be entirely removed'.* However the UNCLOS listed below effectively supersedes the Geneva Convention.
United Nations Convention on the Law of the Sea 1994 (UNCLOS)	Article 60 (3) *"Any installation or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard **by the competent international organization**. Such removal shall also have due regard to fishing, the protection of the marine environmental and the rights and duties of other State. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed".* Within Section 3 of Article 60, the term "***by the competent international* organization**", is wholly relevant as the IMO is considered such an organisation and therefore the standards in IMO Resolution A. 672 (16) supersede Article 60 (3) requirements. Article 210 addresses 'pollution by dumping', and requires the State to regulate and legislate to *'prevent, reduce and control pollution'*. In addition there are clear requirements that the national legislation '*shall be no less effective*' than international standards.

International Maritime Organisation Guideline and Standards 1989 (IMO)	(IMO Resolution A. 672 (16)). 1989 Guidelines and Standards for the removal of offshore installations and structures on the continental shelf and in the Exclusive Economic Zone. *2.1 The decision to allow an offshore installation, structure, or parts thereof, to remain on the sea-bed should be based, in particular, on a case-by-case evaluation, by the coastal State with jurisdiction over the installation or structure, of the following matters:* *i. any potential effect on the safety of surface or subsurface navigation, or of other uses of the sea;* *ii. the rate of deterioration of the material and its present and possible future effect on the marine environment:* *iii. the potential effect on the marine environment, including living resources;* *iv. the risk that the material will shift from its position at some future time;* *v. the costs, technical feasibility, and risks of injury to personnel associated with removal of the installation or structure; and* *vi. the determination of a new use or other reasonable justification for allowing the installation or structure or parts thereof to remain on the sea-bed.* While not legally binding, the resolution recommends that the Member Government take into account the aforesaid Guidelines and Standards when making decisions regarding the removal of abandoned or disused installations or structures.
London Protocol & London Convention 2006	The London Dumping Convention and Protocol regulates the dumping at sea of wastes and other matter, and is primarily implemented through the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act (2012), and the Maritime Transport Act (1994). Article III(1)(b)(ii) "*Dumping" does not include: 'placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention"*. The London Convention and Protocol Guidelines for the Placement of Artificial Reefs state; "*The installation of artificial reefs can be considered to be placement under the terms of the Convention or Protocol, rather than dumping, provided such placement is not contrary to the aims of the Convention or Protocol".* The Waste Assessment Guidelines, "*considered for dumping are intended for use by national authorities responsible for regulating dumping of wastes and embody a mechanism to guide national authorities in evaluating applications for dumping wastes in a manner consistent with the provisions of the London Convention 1972 or the 1996 Protocol thereto*".
Basel Convention 1989	The convention controls the trans-boundary movements of hazardous wastes and their disposal. This may influence how waste originating from decommissioning activity is disposed of. If waste is trans-shipped overseas for recycling, it needs a permit from the EPA and a permit from the receiving Authority
Noumea Convention 1985	The convention controls sources of pollution and the disposal of wastes at sea, however Article 2 (b) states:

	"dumping" means: *' –any deliberate disposal at sea of vessels, aircraft, platforms or other man-made structures'* "dumping" does not include: *'-placement of matter for a purpose other than mere disposal thereof, provided that such placement is not contrary to the aims of this Convention'.* Deliberate dumping is therefore prohibited, but placement with a specific purpose is not considered 'dumping' under the convention.

3 The environment in the South Taranaki Bight

By definition, an artificial reef is one or more objects of natural or man-made origin placed on the seafloor to influence social, economical, biological or physical processes related to the marine environment (Seaman Jr., 2000). Preliminary global evidence indicates that decommissioned platforms could be successful tools in rebuilding declining fish stocks in shallower waters (Macreadie *et al.,* 2011).

Artificial reefs can have positive effects on marine environments through enhancing pelagic diversity, while also producing a number of additional benefits like strengthening recreational fishing and providing diving opportunities (Dauterive, 2000; Johnson *et al.,* 1994; Sutton & Bushnell, 2007). To better assess whether these positive effects could be transferred to New Zealand from *in situ* reefing, we first consider the environmental conditions that exist in the South Taranaki Bight (STB).

Water temperatures recorded at the seafloor around installations in the central STB (Maari, Tui and Māui fields) range from ~13-15°C (Johnston *et al.,* 2015; Johnston *et al.,* 2014), and the mean sea surface temperatures range from 16-19°C with seasonal variation (Gardline, 2014). The general composition of the seafloor is dominated by medium to fine sands with fragmented shell hash (Hume *et al.,* 2013).

The three deeper fields (~110 m) (Maari, Tui and Māui) generally share similar ocean current conditions, with the predominant D'Urville Current flowing up the west coast of the South Island and into a circular route around the Taranaki Bight, subsequently flowing out into the Cook Strait (Bowman *et al.,* 1983; Carter, 1980) (Figure 1). There are strong semi-diurnal tidal currents, which work in an anti-clockwise direction, with the orientation of the tidal flow parallel to the coast in northeast and southeast directions (TTR, 2016). The predominant westerly winds direct the wind driven wave climate in north-easterly and south-easterly directions off Cape Egmont, transporting nearshore sediments along the coasts in both directions (MacDiarmid *et al.,* 2011). Cape Egmont separates the North Taranaki Bight (NTB) and STB, and acts as a geographical diversion to westerly driven ocean currents. Kupe lies in ~35 - 50 m to the south of the Cape. It generally experiences a lower wave energy environment than the deeper fields (Haggitt *et al.,* 2004).

The nearshore areas of the STB consist of persistently high wave energies that form oscillating currents, continuously shifting and redepositing sediments (MacDiarmid *et al.,* 2010; Orpin *et al.,* 2009). Within the nearshore areas, the dominant seafloor features are characterised by soft-sediments, which support a range of suspension-feeding bivalves and other benthic (epifaunal and infaunal) organisms (Anderson *et al.,* 2013). As a result of the high levels of natural sediment distribution within the water column, resilience of these benthic organisms tends to be high (Lohrer *et al.,* 2004).

Large boulder-platform reefs extend several kilometres seaward at a low gradient from the coast (Anderson *et al.,* 2013). These reefs are known to harbour paua and crayfish, which decrease with abundance as the substrate turns to mudstone (DOC, 2006). Due to the low benthic diversity within the soft sediment substrates found in the inshore regions, rocky outcrops and hard habitats form an important component for the general biodiversity and abundance in the broader region (Anderson *et al.,* 2013). Other hard substrates include shoals and traps like the Patea Shoals region, which often harbour high concentrations of benthic flora and fauna (Beaumont *et al.,* 2013). Apart from the boulder-platform reefs found in the shallow nearshore waters, and the Shoals/Traps, there is limited hard substrate in the mud and sand dominated inner shelf region.

The inner- and mid-shelf regions provide marine habitats that support a range of organisms such as reef fish, invertebrates, and demersal and pelagic fish species (MacDiarmid *et al.,* 2013). The most common benthic macrofauna communities found in the vicinity of the deeper water installations are mostly dominated by the presence of *polychaetes* and various molluscan and crustacean taxa (Johnston *et al.,* 2013).

The installations themselves provide habitat for marine life. Large congregations of up to 60 seals at a time are often reported sitting on the Raroa FPSO offtake hoses that float at the surface and large aggregations of kingfish have been reported near the Maari installation (M. Park, Österreichische Mineralölverwaltung Aktiengesellschaft [OMV NZ], pers. comm. 2017). Seals are also known to haul out in the turret of the FPSO *Umuroa* and are frequently observed swimming around the wellheads and other subsea structures in underwater video footage (A. Lane, pers. comm. 2017).

4 Social considerations

The Brent Spar case in the North Sea is the most commonly referenced example of how decommissioning an offshore installation can be heavily influenced by social factors (Hamzah, 2003; Schroeder & Love, 2004). During the planned decommissioning and deep-sea disposal of Brent Spar, a floating oil storage facility (Ekins *et al.,* 2006), the operator received the necessary legal derogation from the British Government to dispose of the disused installation in a deep-water trench in the North Sea (Jørgensen, 2012). However, there was no consultation and engagement to inform the public of the actual effects (Fowler *et al.,* 2014), and an international environmental group mobilised the public to exert pressure on to the operator and force a reconsideration of the proposed disposal method. This resulted in the eventual onshore disposal and recycling at a price of six times the initial decommissioning cost estimate (Hamzah, 2003). The Brent Spar case highlights how essential it is to engage the community in the decommissioning process (Chandler *et al.,* 2017; Baine, 2002).

In New Zealand there are several avenues for public consultation to occur prior to decommissioning. In the first instance, stakeholder consultation is required during the planning and development phase as operators seek the relevant consents through the EPA processes. A similar consultation process is anticipated to be required when operators submit their decommissioning plan as per the recent changes under the Resource Legislation Amendment Act, 2017.

When operators apply for a marine consent, they are obligated to identify stakeholders who have 'existing interests' that may be affected by their activities. These stakeholders commonly include iwi[1] and hapū[2] groups, tourism operators, commercial fishers, existing consent holders and recreational users of the ocean.

The EEZ Act provides two pathways for obtaining a marine consent; notified or non-notified. As part of a notified marine consent for a restricted activity, the Act allows for applications to be publicly notified (unless the operator has an accepted Decommissioning Plan), and for the views of the public and people with existing interests to be taken into account during the application process. The public can make verbal and written submissions and attend public hearings where people can speak directly to the decision-making committee. As part of the process for assessing and accepting decommissioning plans, the EPA is required to provide a forum under which consultation may take place.

New Zealand has a special relationship between Māori and the Crown, enshrined in New Zealand environmental and social legislation. There are over 30 pieces of legislation that refer to the Treaty of Waitangi or its principles (Te Puni Kokiri, 2001). Te Tiriti o Waitangi (the Treaty), was signed in 1840 by representatives of the British Crown and over 500 Māori chiefs, representing a large proportion of the hapu of New Zealand, and the Treaty forms an integral part of New Zealand's constitutional arrangements. While New Zealand does not have a written constitution, there is a collection of legislations and customs, which together form the framework of Government (Te Puni Kokiri, 2001), and give particular regard to kaitiakitanga[3] (guardianship), a term Kawharu (2001) described as having social and environmental dimensions, while keeping human, material and non-material elements in balance.

5 Economic

Liability for EOL options for oil and gas assets is very important in the context of decommissioning in New Zealand. Currently under New Zealand's corporate tax regime, the cost of decommissioning in the form of abandonment, removal and restoration activities is regarded as an operational cost, and is liable for tax deductions (Deloitte, 2014). The cost incurred during the decommissioning process can be used to offset previous years accounting profit (Rush, 2016). The accounting profit is then used to calculate the royalty payment of 20% to the Crown under the Crown Minerals Regulations (2013). As a result, the Crown has a vested interest in helping to find cost effective decommissioning options, as the total decommissioning cost is effectively spread between the operators and the public through tax deduction and loss spreading affecting the cumulative total value of royalties (Techera & Chandler, 2015). The Inland Revenue Department currently estimates that the Crown may be liable for up to 42% of decommissioning costs through tax and royalty rebates (IRD, 2017).

[1] Nation, people, collection of hapū
[2] Collection of families with common ancestry and common ties to land
[3] The Māori practice of environmental guardianship and holistic protection.

Importantly, the decommissioning costs, which may run into several billion dollars, are paid to the decommissioning industry. This is an important beneficiary grouping of marine heavy lift and drilling vessels, as well as skilled personnel who work on these vessels to decontaminate and deconstruct the infrastructure.

In the event of a sale or transfer of ownership of assets, liability for the cost of decommissioning is transferred to the new owner. Under the previous legislation, prior to the implementation of the Resource Legislation Amendment Act 2017, there were no statutory requirements for a security bond associated with decommissioning (Rush, 2016). However, since the amendments to the EEZ Act under s63(1)(i), the Crown now has the legislative tools to impose a financial bond, which is linked to marine consent conditions under which the operator would conduct decommissioning.

Currently with regards to future acquisitions, when an operator is marketing facilities for sale, the regulator places a stronger focus on abandonment liability, which is transferred to the new prospective owner. As part of the evaluation process for approving a transfer, the regulator considers whether a prospective buyer can meet the terms of the permit, and this includes the ability to cover future costs associated with abandonment, removal and environmental restoration.

6 Options for decommissioning offshore structures in New Zealand

New Zealand's offshore infrastructure consists of four normally unmanned wellhead platforms, one manned platform and two FPSOs. In terms of decommissioning, FPSOs are relatively straightforward as these vessels can be sailed or towed away and potentially reused elsewhere (O'Neill *et al*. 2005). More recent wellhead platform designs, such as those at Maari and Kupe have been designed with removal in mind, increasing the options available for their decommissioning. In contrast, the older designs will be more difficult and expensive to decommission.

In 2006, the FSPO *Whakaaropai* was demobilised from the Māui field, and the ship was sold and relocated overseas. Although some equipment - "*unused exploration wells and wellheads, and flexible flow-lines, anchors and ground wires"* - was left on the seabed (EPA, 2015), this is unlikely to set a precedent for future work as it was completed under the previous regulatory regime. At the time, the operators were granted a dumping permit under Maritime New Zealand (MNZ) marine protection rules to allow for the permanent burial of the ten anchors and temporary storage on the seabed of the remaining mooring system until December 2006 (Rush, 2016).

Considering possible options for EOL such as 'reuse', has proven difficult from a logistical perspective for fixed structures (Maui A, Maui B, and Kupe platforms). There are some examples of successful reuse in the North Sea, where platforms like the North West Hutton where able to relocate the accommodation modules and create an office facility on another development (Oil & Gas UK, 2012). However, in New Zealand, with limited future developments on the horizon that could potentially line up with the anticipated EOL dates (Table 5), reusing components seems unlikely

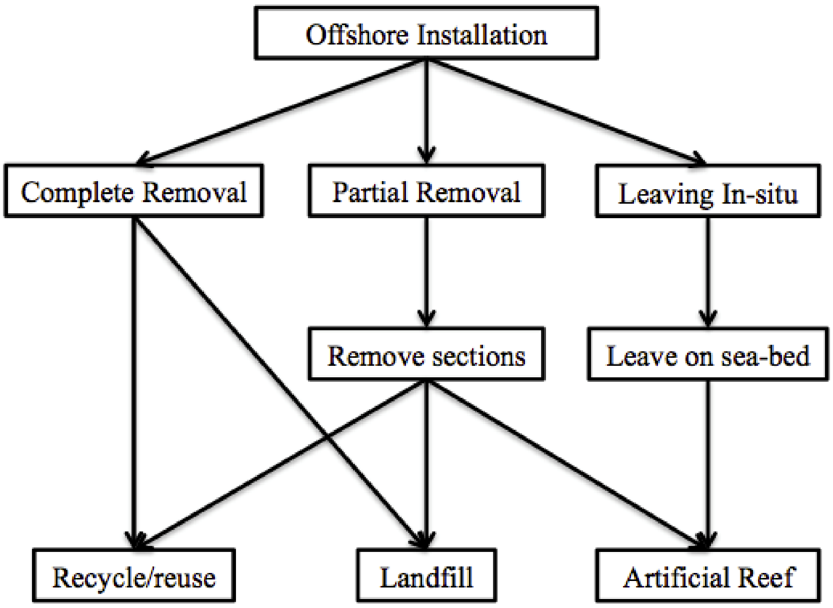

Figure: 4 New Zealand Decommissioning Options and likely consequences.

Figure 4 demonstrates the likely consequences of each decommissioning option in New Zealand. New Zealand has limited recycling capability for hazardous waste, but there is some capacity for large steel componentry such as that associated with the offshore structures. New Zealand legislation and international law provides no legal barrier to leaving components on the sea floor if an application is approved by regulators, taking into account potential impacts on the environment, existing interests and human health. However, consideration is required as to whether these components provide any ecological or social benefit, by enhancing the lives and wellbeing of people and communities. There are international examples where this is the case, and there appear to be demonstrable environment benefits in some examples.

7 Conclusion

The GoM has successfully demonstrated the important ecological benefits arising from *in situ* decommissioning and Californian studies have also demonstrated potential benefits for fisheries and marine ecosystem conservation. However, in the North Sea the benefits are more ambiguous, and deliver no or little apparent marine enhancement. On the Northwest Shelf of Australia there are potential ecological benefits, while the Bass Strait offers no discernible environmental benefits to be derived from in situ decommissioning, but there are unlikely to be significant adverse effects on the environment.

From a social prospective, the GoM has entrenched financial incentives that provide a benefit to wider marine users, equating to a degree of 'social license to operate'. California also has some financial spreading of benefits to marine conservation, which also contributes to a 'social license to operate'. Australia's regulatory mechanises provide for public consultation to occur, although the degree to which consultation occurs may be limited to 'relevant persons' which limits the overall social benefit. Australia provides no tangible financial benefits to the wider group of marine users outside of oil and gas activities.

In New Zealand there is anecdotal evidence that iwi expect operators to leave a clean seabed. This coupled with a lack of probable environmental benefits, means that despite there being legislative options to leave some components in the sea, 'social license' will require the complete removal of all parts. Although future decommissioning scenarios in New Zealand will continue to be subject to stringent national and international regulation, recent changes to the current legislation and the forth coming regulations highlight the Crown's intent to set a national framework, with guidance to allow the decommissioning process to follow global best practices. The first offshore installation to be decommissioned will set an interesting precedent for future activities.

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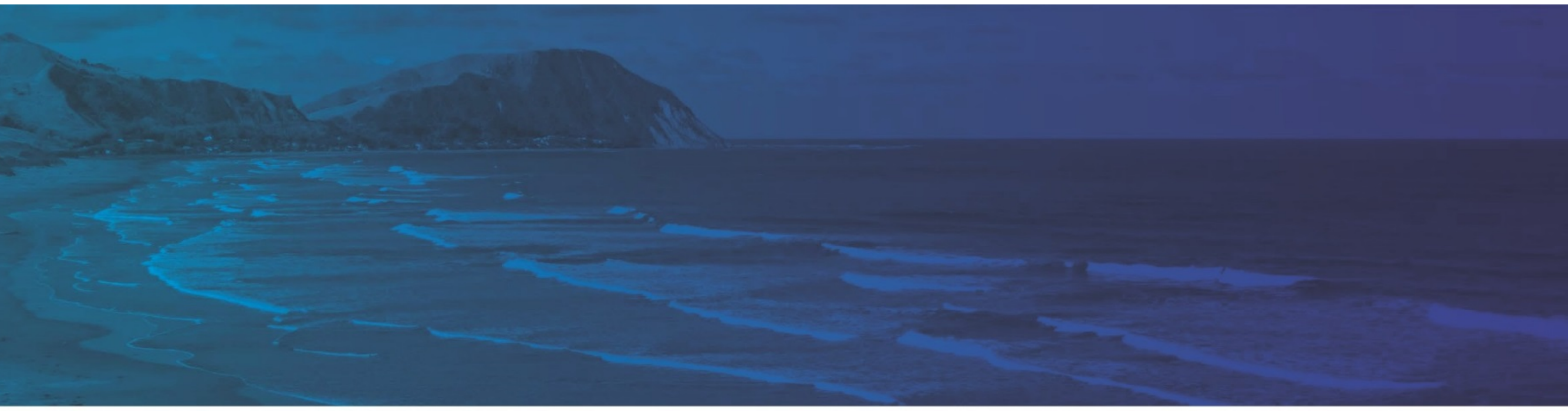

An analysis of the benthic diversity around offshore installations in the South Taranaki Bight

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Executive Summary

Effects of offshore platforms and infrastructure on the benthic community around South Taranaki Bight was investigated using environmental monitoring data provided by a number of New Zealand oil and gas operators operating in the area. Previous studies have shown that variability in benthic community structure was driven by interannual effects that may masks effects of offshore structure presences. The present study builds on the previous analysis and, through accounting for annual effects, investigates potential influence of predominant current flow and distance gradient from discharge source. There is no evidence that major current axis has an effect on benthic community structure, however a distance gradient effect is detected on older offshore infrastructures. While benthic community structures around the all offshore infrastructures are significantly different from the control sites, the older infrastructures are relatively more similar to the control sites.

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1 Background

In 2010, amendment to Part 200 of the Maritime Transport Act (MTA, 1994), Marine Protection Rules (MPR, 2011) prompted offshore oil and gas operators in South Taranaki Bight to undertake environmental monitoring on the potential impacts from operational discharges. In response to a perceived need for a standardised approach to monitoring discharges from offshore installations, Cawthron Institute developed the Offshore Taranaki Environmental Monitoring Protocol (OTEMP) in consultation with industry operators and regulators.

The two primary components of OTEMP are assessment of effects to soft-bottom seabed habitats and monitoring of discharge water and sediment quality. Cawthron Institute and SLR have conducted the environmental monitoring since the inception of OTEMP since 2012.

The benthic species assemblage data collected under the first component of OTEMP was collated and analysed previously (Guthrie et al., 2017). The aim of the study was to gather evidence of any type of effect the offshore infrastructures have had on benthic communities in the area, which would help decision makers evaluate environmental risks and benefits associated with different options for decommissioning in the future. The analysis compared benthic species assemblage from the five infrastructures and the two control sites and found that all the sites, including the two controls, differ significantly from each other.

This study is an extension of the previous analysis. It aims to use additional information available, namely, interannual variation, predominant current flow, and distance gradient, in explaining the previous results.

This study forms part of the author's requirement of work for STAT 487 with the following course objective: *"to carry out supervised individual research project that provides an experience of exploring the literature on a certain topic and writing a report that gives a coherent survey of findings and demonstrates mastery of the material."* The content of this report, after removing all information identifying operators and their facilities, will constitute the case study that demonstrates the author's competence in multivariate statistical analysis which includes, but not limited to: permutational analysis of variance, multidimensional analysis, and similarity percentages analysis.

2 Data

2.1 Benthic species counts

Benthic invertebrates are used as environmental indicators of biological integrity. In each environmental monitoring study, all macrofauna within the preserved samples were identified to the lowest practicable taxonomic level and counted with the aid of a binocular microscope. Pelagic species and species identified as not being exclusively benthic were excluded. The taxonomic data gathered from various years and installations were collated and standardised to account for variances in taxonomic detail to allow for direct comparisons. It was noted in one of the environmental monitoring reports (Forrest R, Skilton J, & McConnel H, 2016) that the taxonomic resolution was increased after 2012 so care must be taken when comparing 2012 with subsequent years. It was unclear whether this comment was relevant to other surveys on other facilities. It was assumed that the issue was resolved by the standardisation exercise in the previous study (Guthrie et al., 2017).

2.2 The five offshore structures

Figure 1 shows the locations of offshore installations in this study, together with the control sites, in the Taranaki Basin. The OTEMP methodology was specifically designed for monitoring soft sediment substrate around marine offshore exploration and production permitted areas in offshore Taranaki. The proximity of Site 5 Kupe to the shore and its dissimilar substrate type (coarser sized sediment fractions) and environment (high wave action) meant that benthic structure surrounding this site is not comparable with the rest of the sites. Therefore this site should be analysed separately.

The monitoring surveys should be performed during the same season, as various physical, chemical, and biological factors vary with season. This was achieved for the most part as the monitoring surveys were conducted during the summer months (January to March). The exception was the 2011 study for the Maui B site, which was conducted in August to October. Therefore the data collected in this survey was excluded from the analysis.

Samples were gathered at distances of 250 m, 500 m, 1000 m, 2000 m, 4000 m, and 6000 m from the offshore structure. Distance-graded sampling station allocation is suitably sensitive to assessing marine effects of point source disturbances (Ellis & Schneider, 1997). Discharge related benthic deposition effects were most likely to occur within 250-500 m of the discharge source (Johnston O, Barter P, Ellis J, & D, 2014).

It was also expected that the depositional patterns of discharges from the structure will be affected by major current flow, with discharges being dispersed greater and further along the major axis (Figure 2). Therefore to aid with discriminating between impacted and natural benthic variation, about 70-80% of sampling stations were allocated along the major flow axes. This cruciform sampling design on the offshore installations based on the dominant axis is illustrated in Figure 3. Triplicate samples in each sampling station collected using double Van-Veen grab sampler.

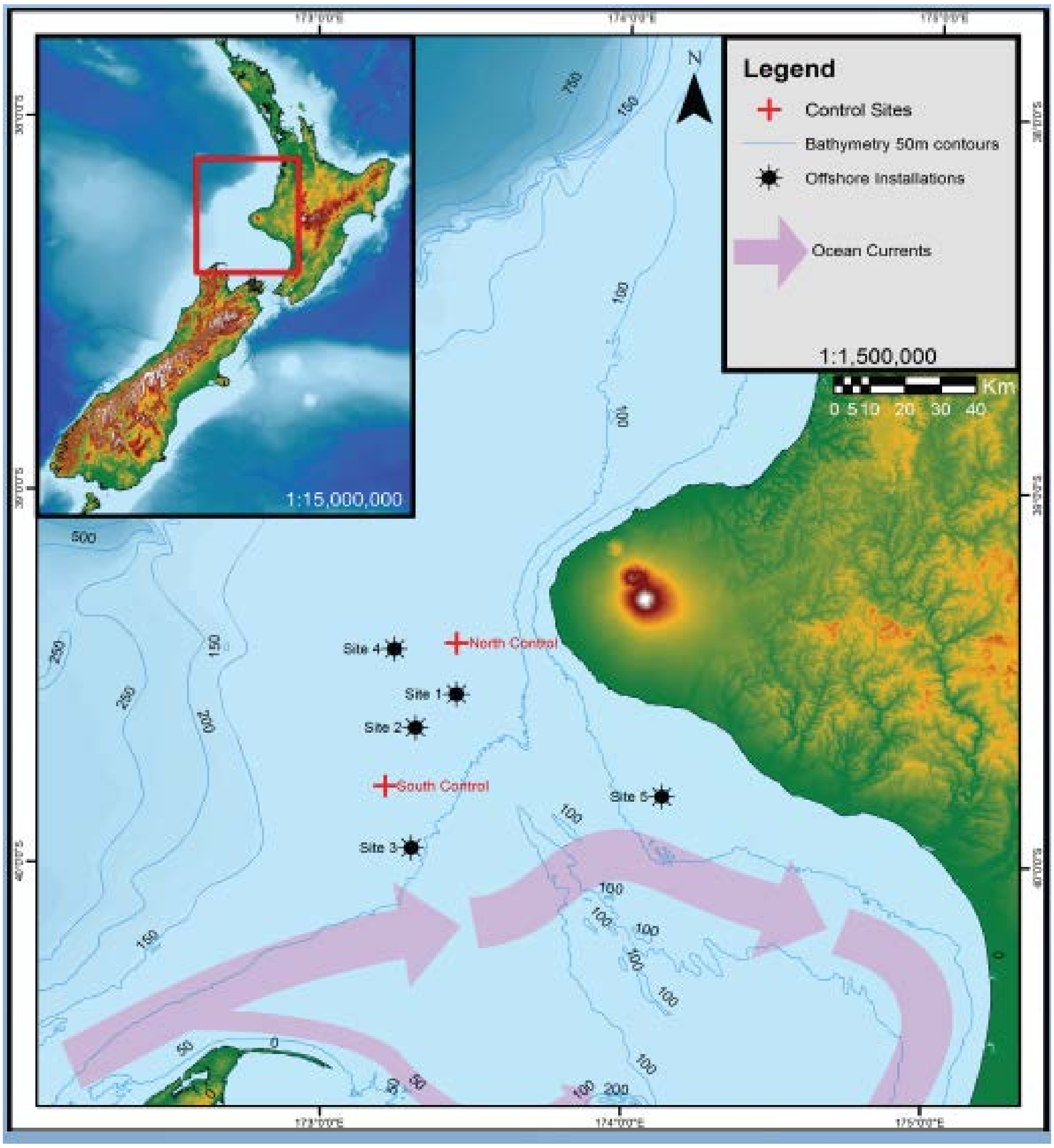

Figure 1: Map showing locations of offshore installations and control sites within the South Taranaki Bight. The purple arrows indicate predominate ocean currents in the area (Heath, 1969). Site 1: Maui A (MPA); Site 2: Maui B (MPB); Site 3: Maari (MAP: Maari Platform and MAF: Raroa FPSO); Site 4: Tui (TUI); and Site 5: Kupe (Guthrie et al., 2017).

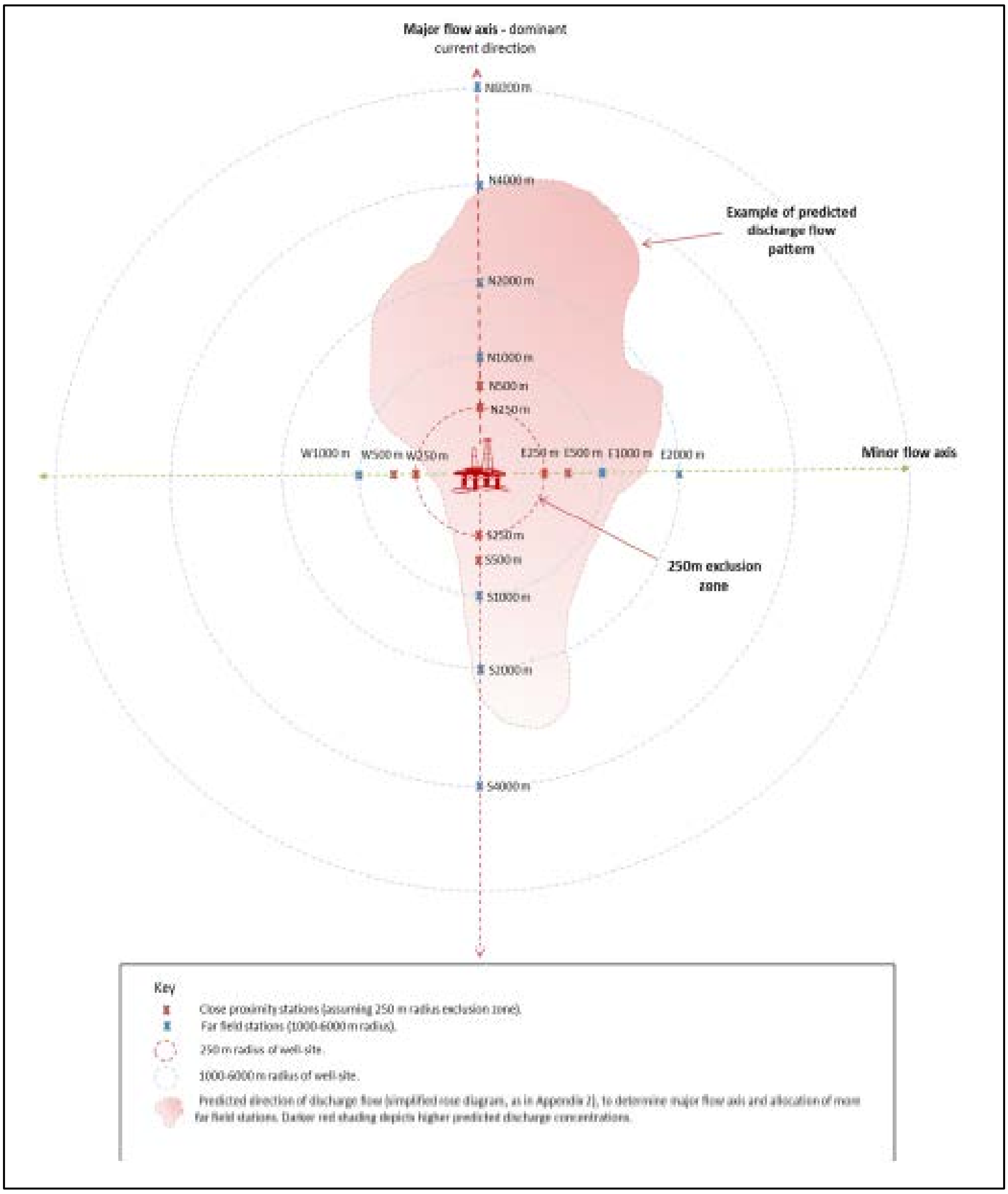

Figure 2: Schematic diagram showing predicted discharge flow pattern from offshore installation (Johnston O et al., 2014).

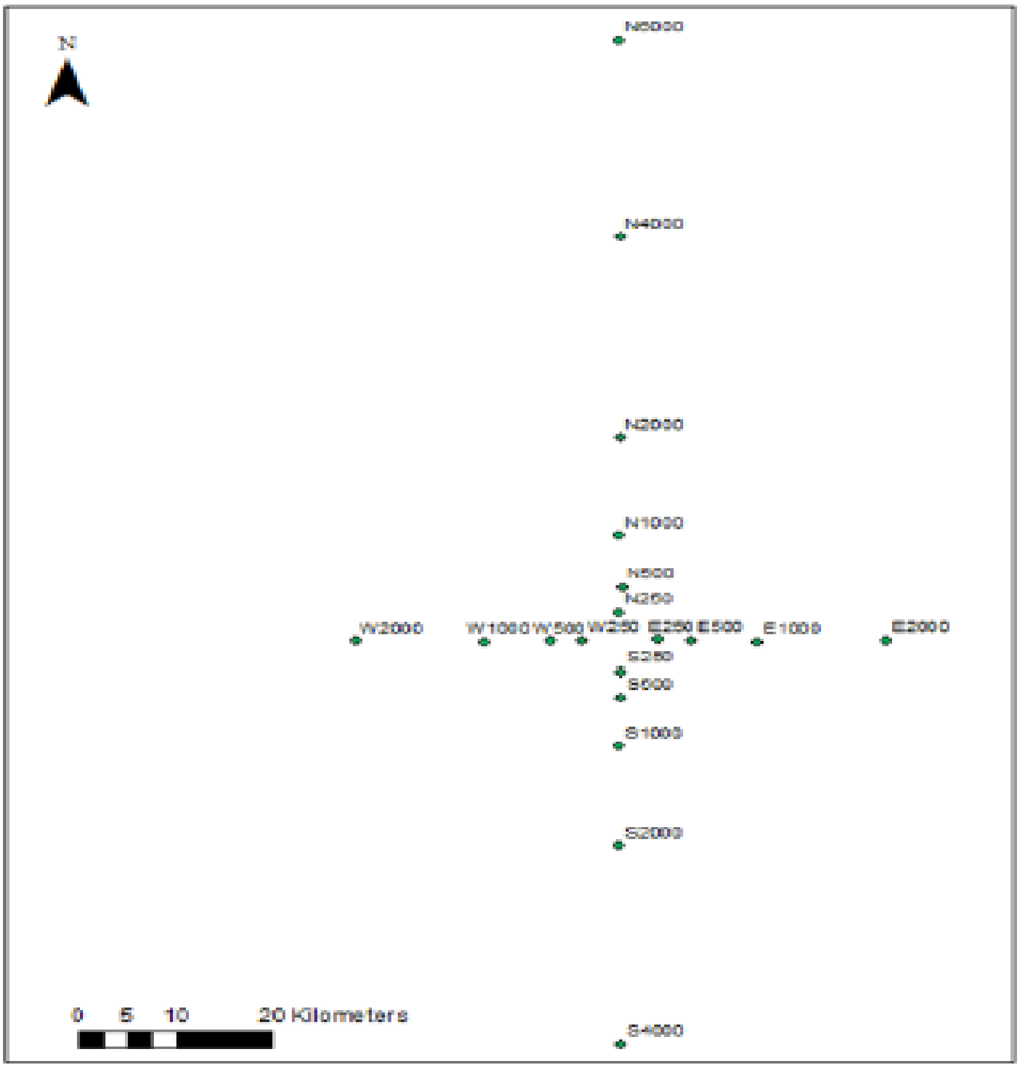

Figure 3: Generalised sampling strategy for offshore structures. Each station was sampled with three replicates (Johnston O et al., 2014).

2.3 The control sites

Discharge effects from offshore production platforms can span distances of 5 to 6 km (Neff, Bothner, Maciolek, & Grassle, 1989). Therefore the two control sites (North and South Control) used are outside of 10 km radius of existing production-related activities as well as currently known exploration sites (Figure 4). It was recommended in the OTEMP methodology that control sites are used by more than one operator and/or facility, rather than having a single control site for each facility. Inspection of the environmental monitoring reports from the different facilities indicated that the data from the control sites were collected from the same field trip which suggests that indeed the same sites were used in the annual surveys, however the benthic data provided from the offshore installations each contain counts for the control sites with some variation across the facilities. In this analysis the data for the control sites were taken from the Maui A data.

The North Control site used in 2012 was found to have elevated levels of mercury (Johnston O et al., 2014) so a different North Control site was used in the years after.

Figure 5 illustrates the sampling strategy for the control sites. A grid of 5x5 100 m x 100 m squares was overlaid in the area. Three grids were then randomly selected out of the 25 grids. Three replicate samples were then taken within the selected grid squares.

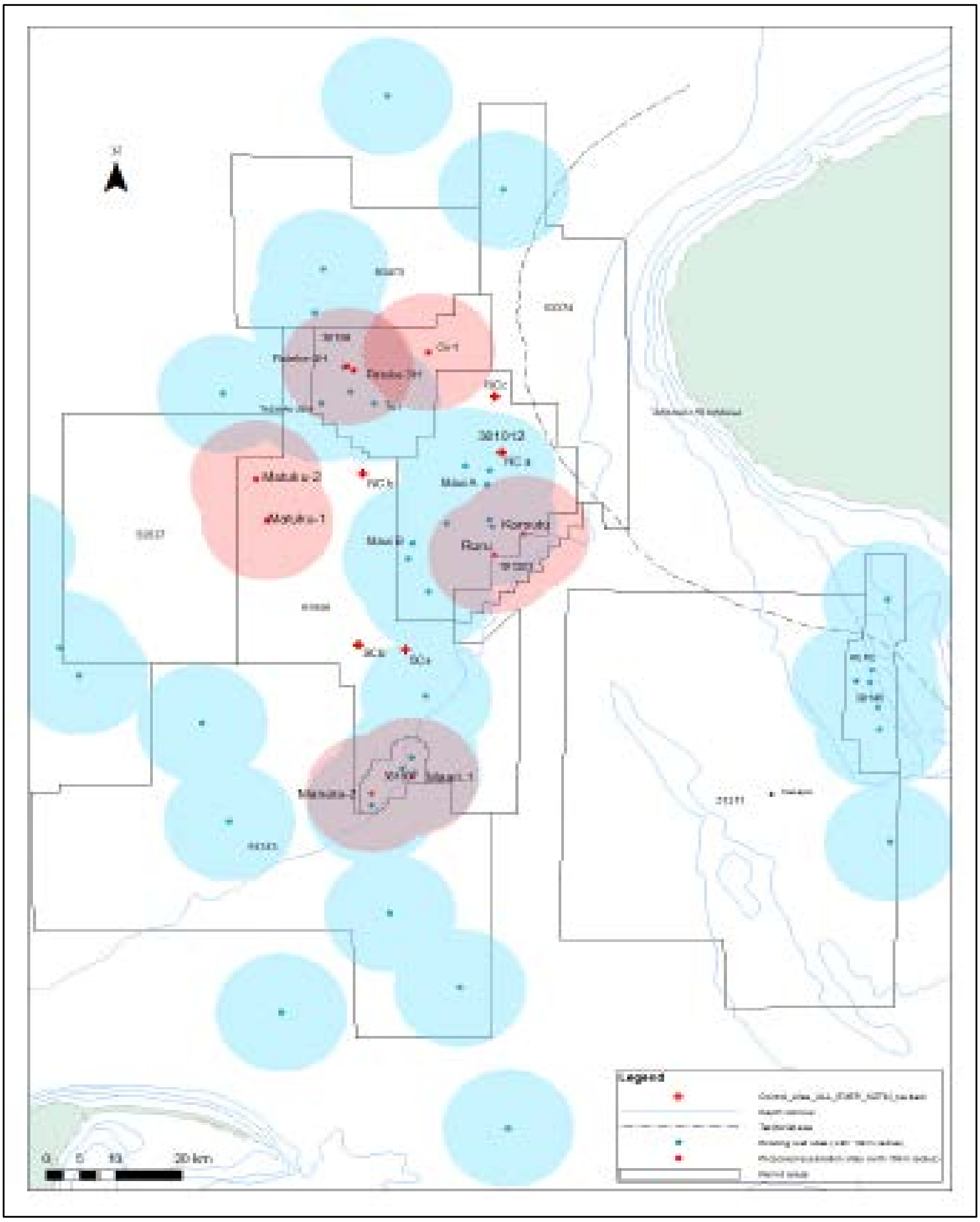

Figure 4: Taranaki region showing control stations (red crosses) amongst circular shaded areas corresponding to 10 km buffers from exploration and production-related sites (red and blue shaded areas respectively) (Johnston O et al., 2014).

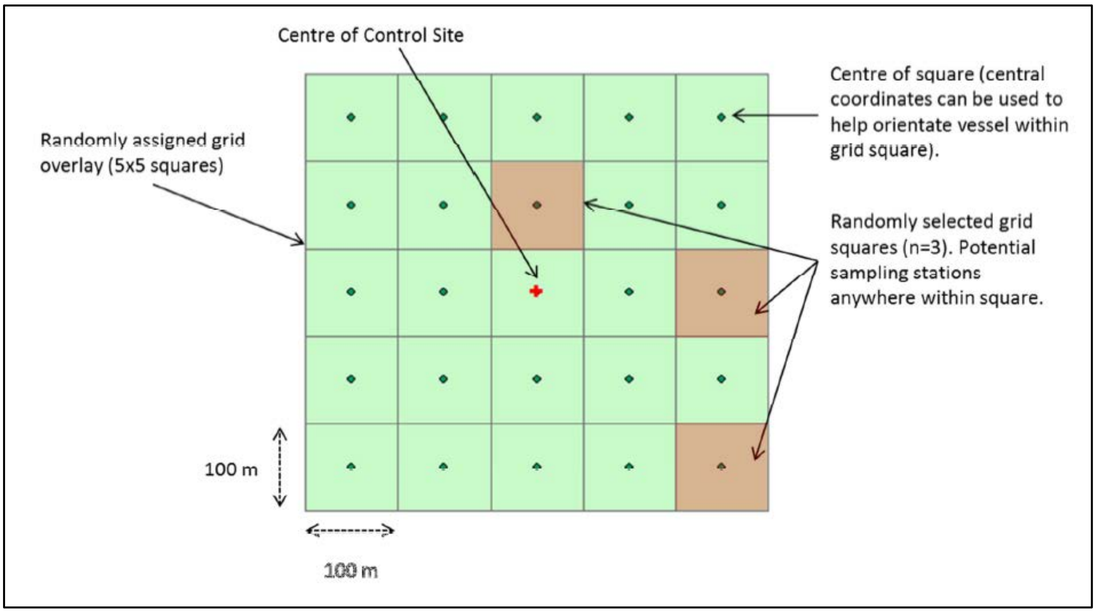

Figure 5: Schematic diagram of randomised control station allocation (Johnston O et al., 2014).

3 Previous studies

The effects of year, transect, and distance on the benthic community was already investigated as part of the environmental monitoring reports for the individual facilities. The results indicated that 'year' has the most significant effect. Differences due to transect and distance that may exist are smaller in comparison to the interannual variation. The two oldest sites Maui A and Maui B exhibited some distance gradient effect.

Comparison of the benthic community around the facilities with the North and South Control sites were also performed. There were significant differences found between the offshore installations as well as between the two control sites themselves. Since the two control sites also exhibited significant interannual variation, the conclusion was that year effect is more significant than the presence of the offshore installations themselves with respect to the benthic communities in the area.

The previous study (Guthrie et al., 2017) that collated and analysed the environmental monitoring surveys from the different facilities confirmed that the two control sites were statistically different; in addition all the sites generally differ from each other and the two controls. This study compared the benthic community structures between the different facilities and controls at a high level and did not investigate transect and distance effects.

It is therefore challenging to make conclusions about the effects that the installations may have in the area. The conclusions generally did not provide that the offshore installations have an effect, especially a negative effect, on the benthic community. If the offshore installations indeed have an effect on the benthic communities, the effects are overwhelmingly masked by natural interannual variation.

This study aims to build on the environmental report findings and the previous study. The collated contiguous dataset is analysed and investigate possible effects of transect and distance when comparing with the controls. To simplify analysis and interpretation of results, the individual transects were grouped to major and minor axes, as shown in Table 1.

Table 1: Grouping of individual transects to Major and Minor axes for each offshore installation.

Stn	Station Name	Major Axis				Minor Axis	
MAF	**Raroa FPSO**	East	West			North	South
MAP	**Maari**	East	West			South	
MPA	**Maui A**	North	South			East	West
MPB	**Maui B**	North	South			East	West
TUI	**Tui FPSO**	North	South	North-East	South-West	East	

4 Hypothesis

The main null hypothesis is: Offshore installations have no impact on the benthic community in the offshore Taranaki area.

Within the five stations:

- There is no difference between the benthic communities found along the Major and Minor axis around the offshore installations.
- There is no difference between the benthic communities found along the six distances around the offshore installations (no distance gradient effect).

For the seven sites (five stations and two control sites):

- There will be no difference between the controls and the five sites.

5 Methods

The following diversity indices were calculated from the standardised benthic abundance data collated from the previous study.

- Total Abundance: count of all organisms within a sample
- Number of taxa (S)
  - Count of total number of different taxa identified within a sample
- Shannon-Wiener Diversity (H)
  - $H' = -SUM\ [(p_i) \times \log_e (p_i)]$
    - p_i = Number of individuals of taxa i / total number of samples
  - A single value in the log scale that describes the number and variety of organisms in an assemblage. Ranges from value of 0 for communities containing a single species, to values that are dominated by a few species, to higher values for communities containing many species in relatively equal proportion.

Sampling effort was variable across year, offshore installation, axis, and distance, so the number of samples is included with the diversity indices.

The benthic abundance data was square-root transformed and Bray-Curtis similarity measure was calculated prior to performing multivariate analysis. Non-metric multidimensional scaling (nMDS) was used to visually display the differences between groups.

Differences in benthic community composition was investigated using permutational analysis of variance (PERMANOVA). The findings from PERMANOVA was visually assessed through the nMDS plots.

Within the five stations. An nMDS plot was constructed to visually assess the difference due to Year (2012, 2013, 2014, 2015, and 2016), Station (MAP, MAF, MPA, MPB, and TUI), Axis (Major and Minor), and Distance (1, 2, 3, 4, 5, and 6). A PERMANOVA analysis was also performed to formally test such differences and their associated interaction terms. The nMDS plot was again further inspected in detail to confirm the PERMANOVA findings. Control site data was excluded from this analysis.

For the five stations and two controls. An nMDS plot was constructed to visually assess the difference due to Year (2012, 2013, 2014, 2015, and 2016) and Station (MAP, MAF, MPA, MPB, TUI, NCC, and SCC). A PERMANOVA analysis was also performed to formally test such differences and the associated interaction term. The nMDS plot was again further inspected in detail to confirm the PERMANOVA findings.

Lastly, SIMPER (similarity percentages) analysis was performed to determine which taxa were contributing most to, or were most responsible for, any significant differences detected between various groups.

This analysis used the statistical programming software R (R Core Team, 2017) and various functions in the R package vegan (Jari Oksanen et al., 2017).

6 Findings

A. Analysis of univariate indices of diversity

Univariate indices (total number of taxa, total abundance, and Shannon-Wiener Diversity) describing the benthic macroinvertebrate communities are displayed in Figure 6 to Figure 9. The first of each set of four panels represents the relative sampling effort in the groups being compared. The sampling effort is a useful statistic when comparing the univariate measures of diversity between groups.

By year comparisons. Table 3 outlines the various drilling activities that occurred in the wellhead platform sites in different years. It is therefore difficult to compare the years with each other (Figure 6).

By site comparisons. The abundance, number of taxa, and diversity for two Maari sites (MAP and MAF) were centred higher compared with other sites. In contrast the measures for Tui were centred lower than others including the two control sites (Figure 7).

By axis comparisons. There are no obvious axis effect judging by the univariate indices. Compared with the two axes, the abundance at the control sites was centred lower, and the number of taxa and diversity were centred similarly (Figure 8).

By distance comparisons. The abundance for site closest to the installation was most highly centred and there is a suggestion of decreasing abundance with increasing distance from the installation, however abundance at 4000 m away from the station is centred lower than that 6000 m away. There is no obvious relationship between distance and the other two univariate measures (Figure 9).

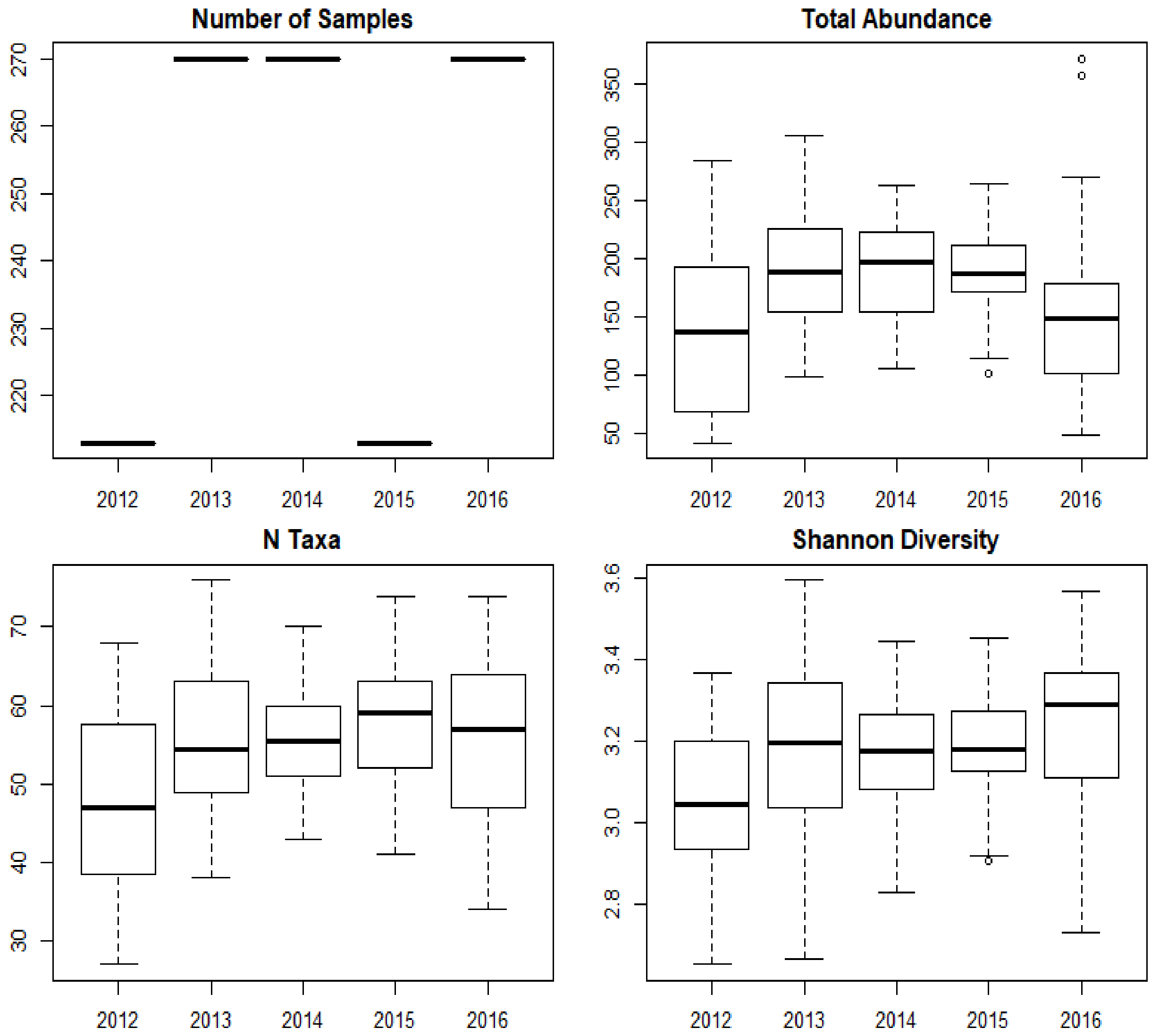

Figure 6: Sampling effort and univariate indices of infauna communities, by year. Environmental monitoring was not conducted in Maui B in 2012 and in Tui in 2015, therefore complete data exist only for 2013, 2014, and 2016.

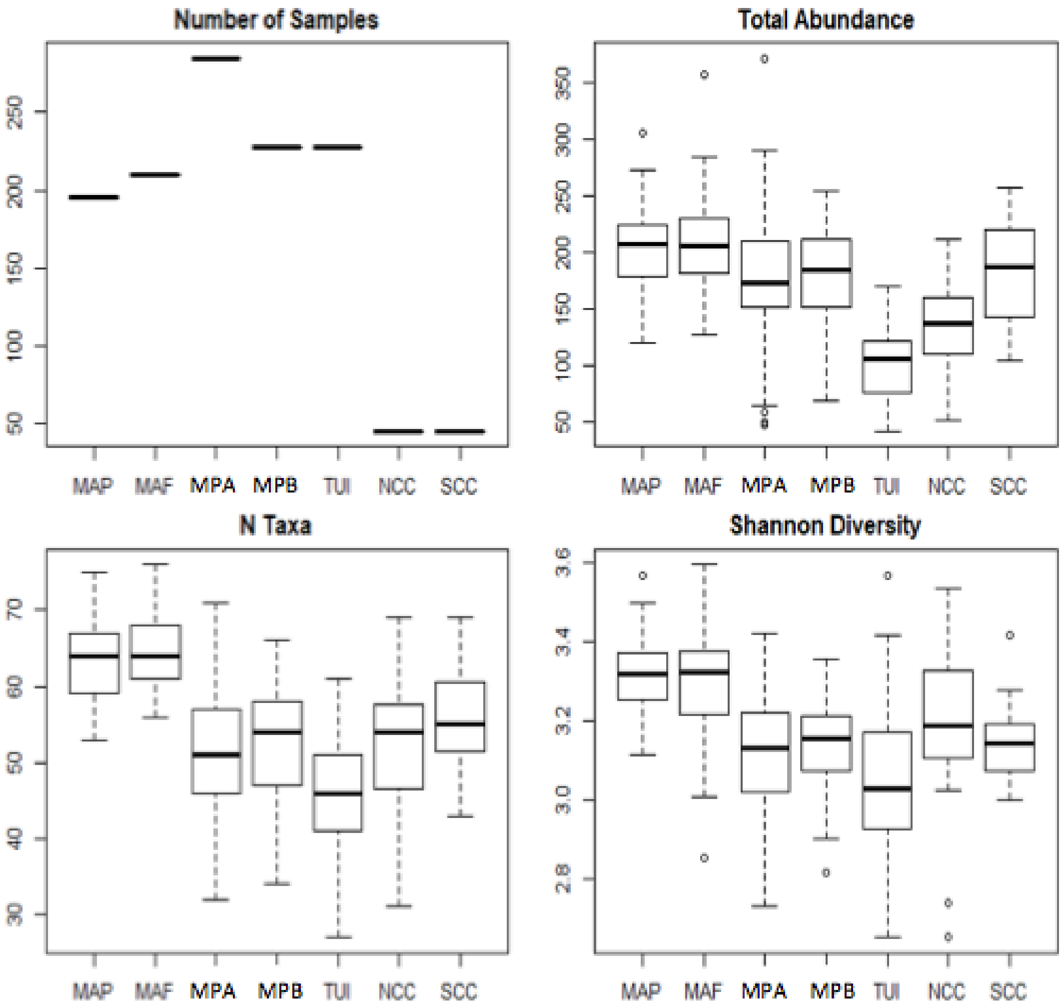

Figure 7: Sampling effort and univariate indices of infauna communities, by offshore infrastructure.

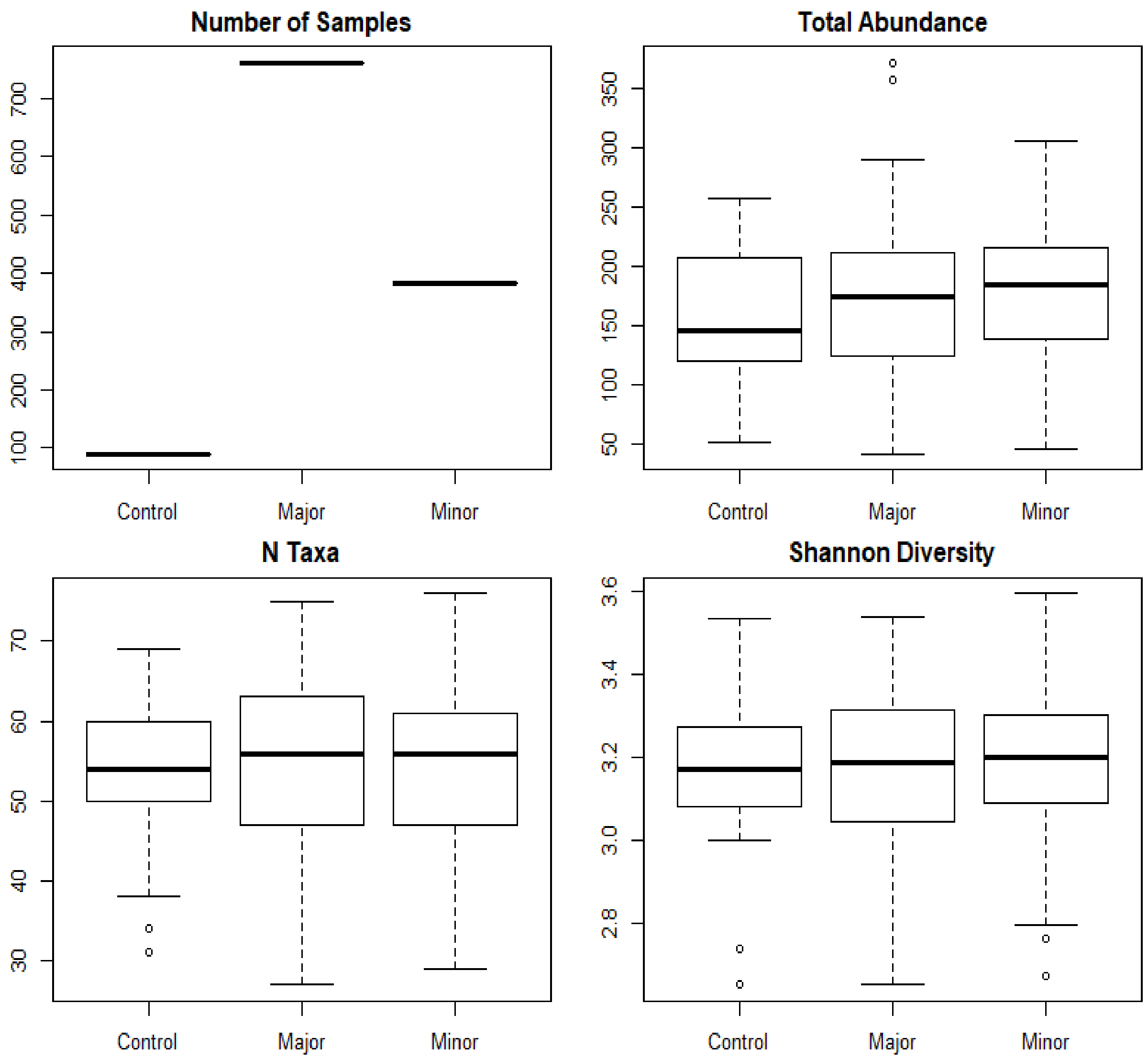

Figure 8: Sampling effort and univariate indices of infauna communities, by axis.

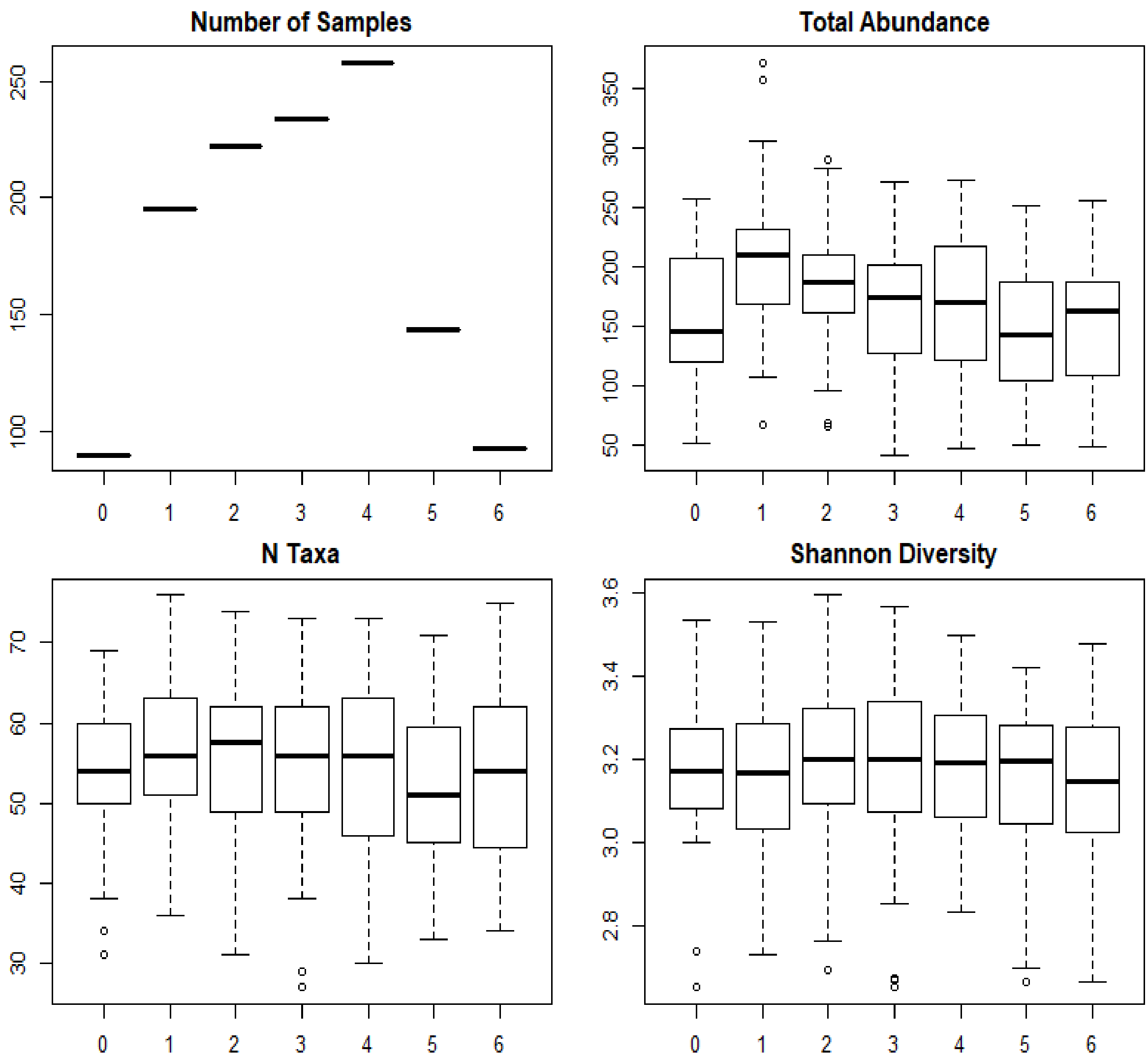

Figure 9: Sampling effort and univariate indices of infauna communities, by distance from offshore infrastructure, Distance = 0 refers to the two control sites. Distance 1: 250 m (except Tui: 300 m); Distance 2: 500 m; Distance 3: 1000 m; Distance 4: 2000 m (except Tui: 2250 m), Distance 5: 4000 m, Distance 6: 6000 m.

B. Within the five stations

Assemblage data was investigated for the five offshore infrastructures using nMDS (Figure 10 to Figure 13). The nMDS plot visualises the multivariate data in two dimensions to get a sense of the overall similarity of their benthic community structure. The coordinates of the points on the nMDS plot is relative and has no quantitative meaning so the axis were not labelled. The stress value associated with MDS plots indicate the amount of distortion required to display the data in two dimensions. A small value of stress indicates that there is a low amount of distortion required and therefore the two dimensional representation preserves the relationship between the data points well. A stress value of less than 0.2 is generally considered acceptable (Kruskal, 1964).

Figure 10 shows that grouping was most strongly influenced by site and year. The two Maari sites MAP and MAF are centred and dispersed similarly, with the exception in 2013 where the MAF points are centred above the MAP points. Also the 2013 points for these two sites are also visually distinct in the centre left part of the plot.

Figure 11 shows that the points for Maui A and B wellhead platforms overlap. However there is an obvious cluster of Maui B points at the centre top corresponding to 2016. Also there is some dispersion of Maui A points towards the top-left corner that are not exhibited by Maui B and do not seem to correspond to specific years. The points for Tui exhibits the most dispersal. There is no obvious visual pattern by axis or distance (Figure 12 and Figure 13).

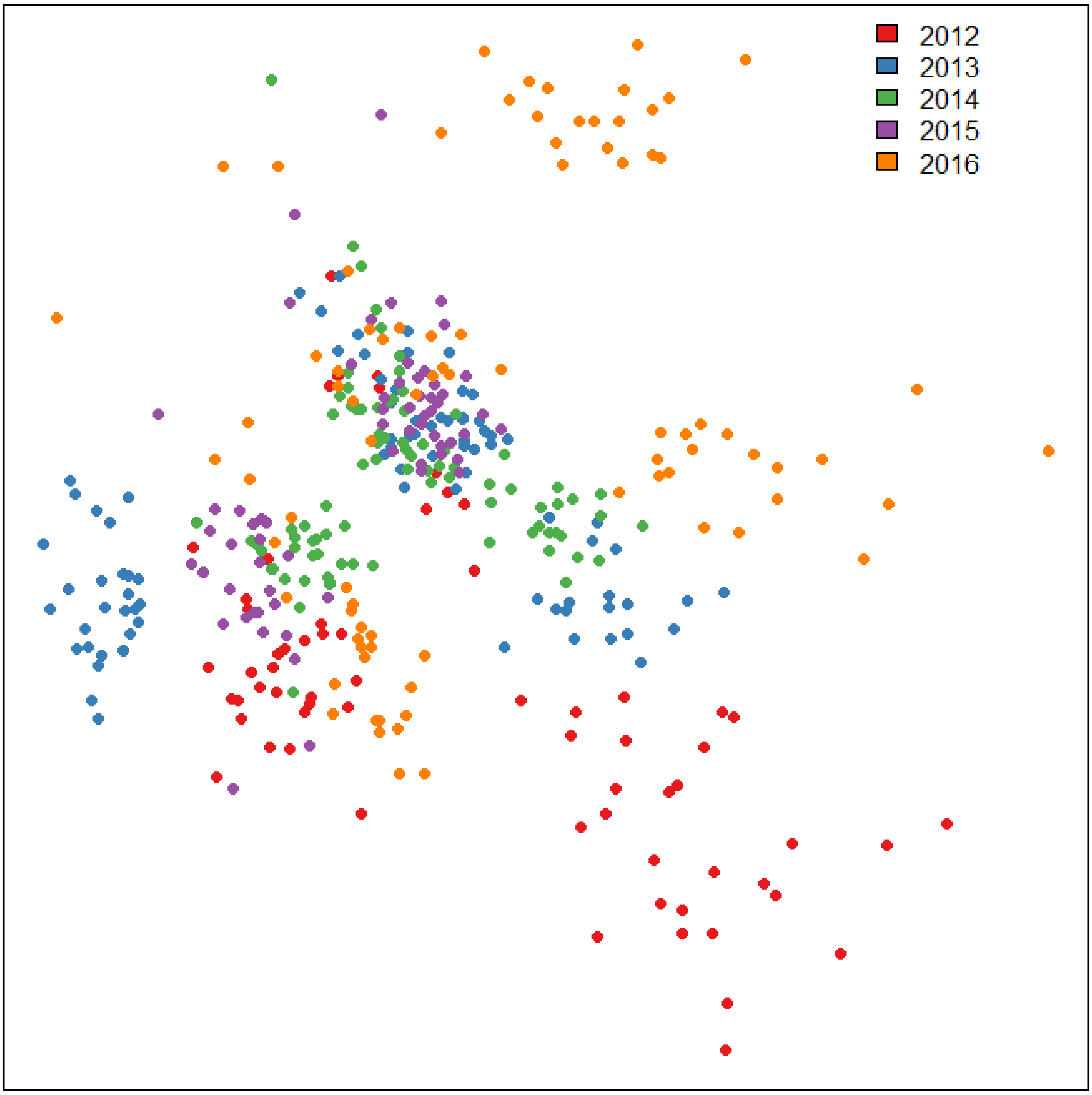

Figure 10: Non-metric multidimensional scaling results of the five offshore infrastructures, coloured by year (Stress = 0.1935215).

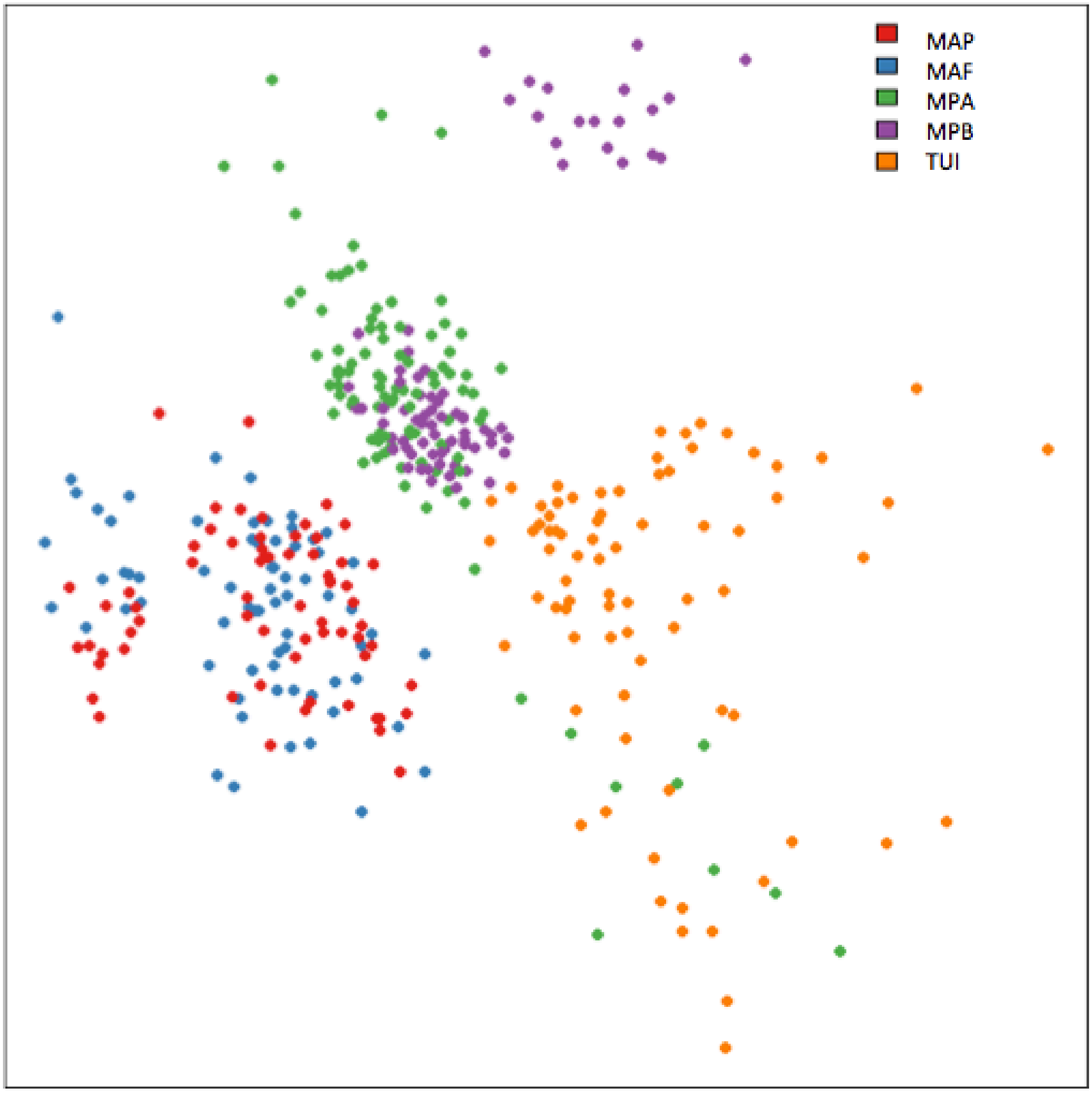

Figure 11: Non-metric multidimensional scaling results of the five offshore infrastructures, coloured by infrastructure (Stress = 0.1935215).

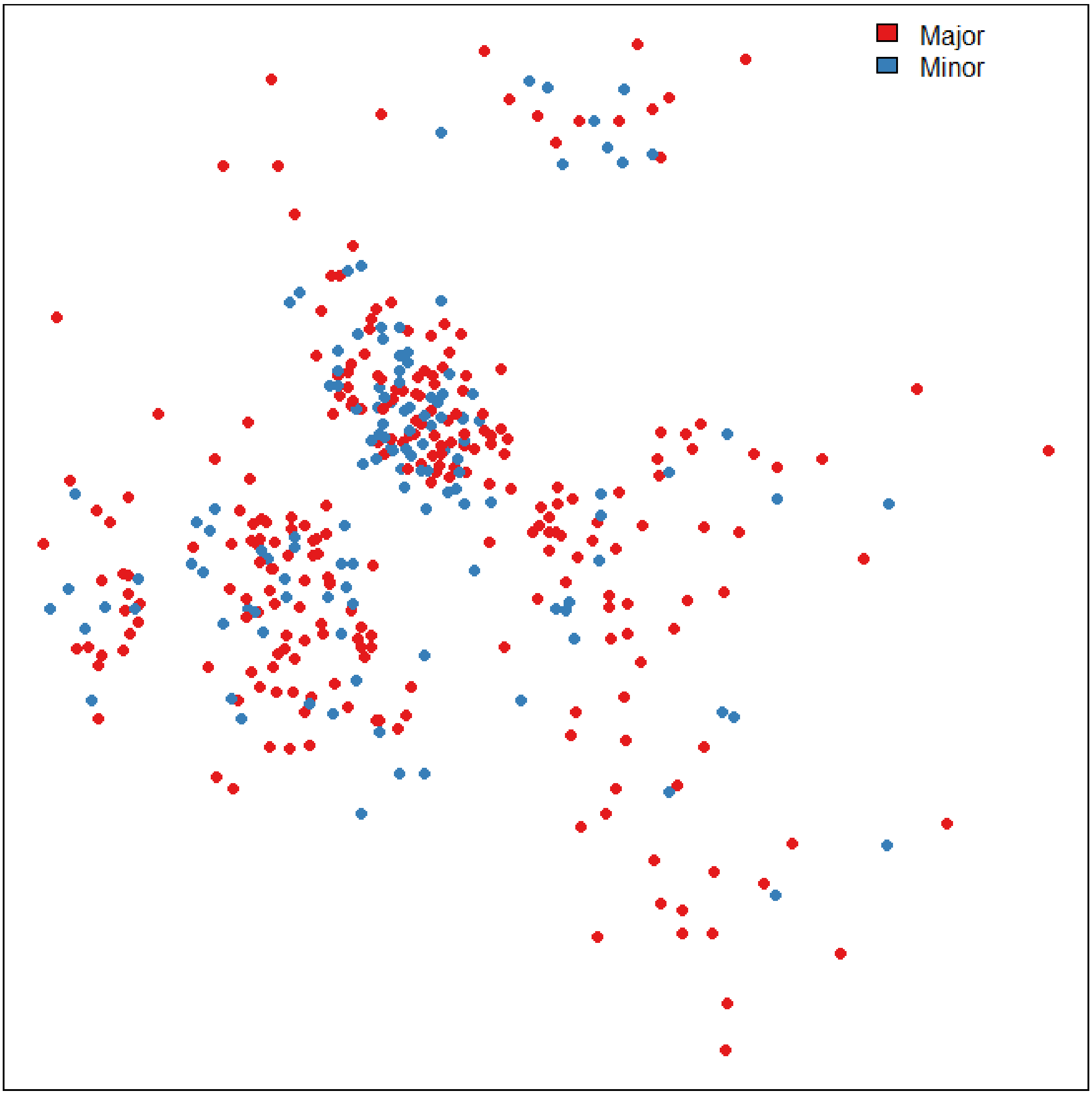

Figure 12: Non-metric multidimensional scaling results of the five offshore infrastructures, coloured by axis (Stress = 0.1935215).

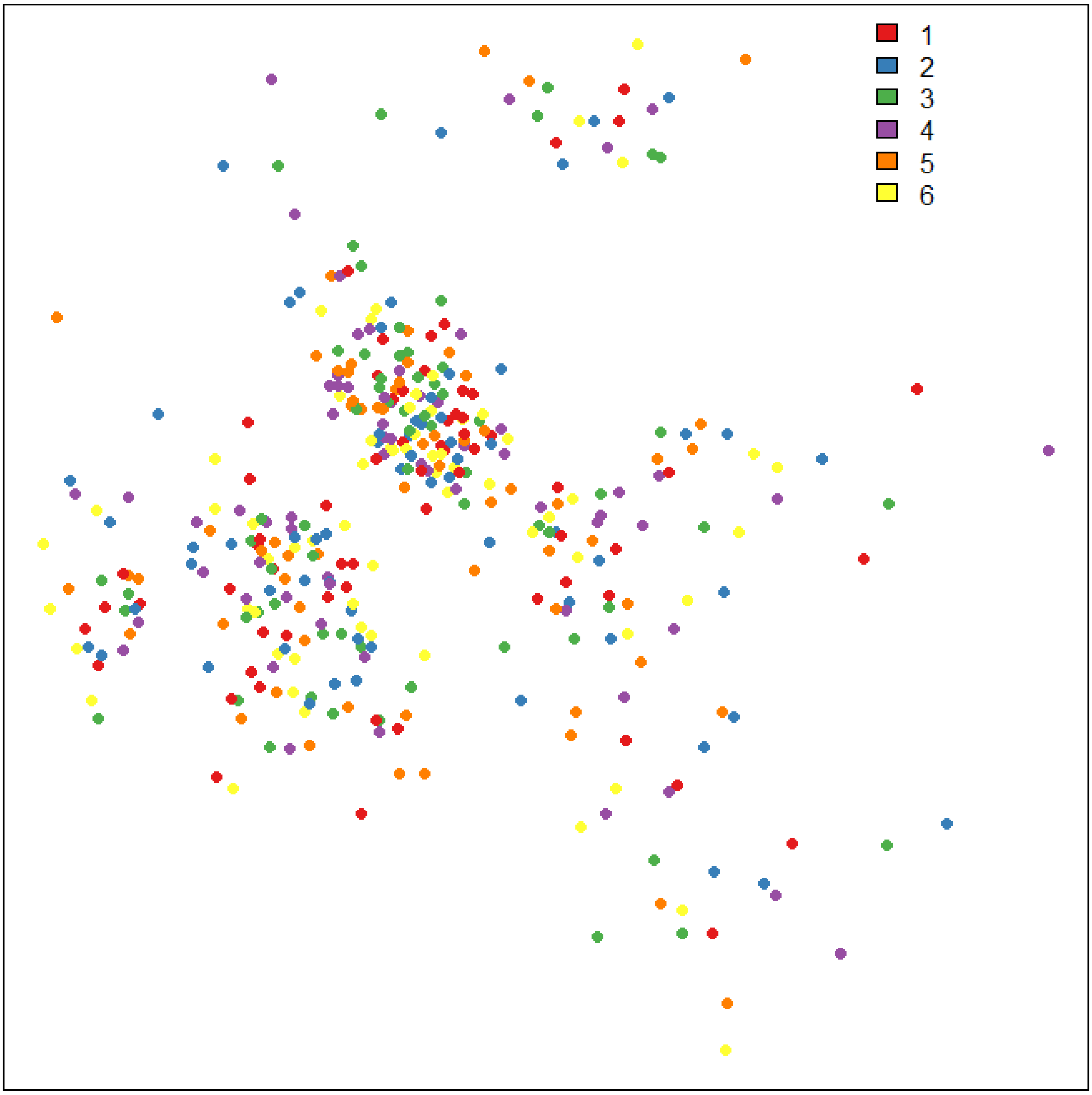

Figure 13: Non-metric multidimensional scaling results of the five offshore infrastructures, coloured by distance from offshore infrastructure (Stress = 0.1935215).

A PERMANOVA model was constructed to test for differences between year, stations, axis, and distance, and the associated interaction terms. It was found that the four-way interaction term was not significant; however several three-way interaction terms were significant. It was already known from previous studies that year and station drives the most of the variability in the data. The present results suggest that the effects of axis and distance on the community structure varied with year and station.

Effect of axis. Comparisons between major and minor axes for the same distance generally did not any yield significant difference except for Maui A in 2016 (Table 6.).

Effect of distance. Inspection of pairwise comparisons of different distances in each year and station (Table 7.) indicated that the most likely significant difference is between Distance 1 (250 m) and other distances. This set of comparisons is further investigated.

The Maari sites. For the Maari sites MAP and MAF, (Table 7) suggested that there may be significant difference between Distance 1 (250 m) and Distances 2, 3 and 4 (500 m, 1000 m, and 2000 m respectively) as there are some years where the comparisons were statistically significant. These significant differences occurred more in MAF comparisons as opposed to MAP. There were no significant difference between Distance 1 and the two furthest distances. There were also no significant difference in any distance pairs in 2013, which was before drilling operations were conducted in MAP.

Figure 15. and Figure 16. plot the nMDS results for MAP and MAF points only and compares Distance 1 with all other distances. . For Figure 15 all pairs of points for MAP seemed to be centred identically. The same was true for Figure 16 for MAF comparisons. The statistically significant comparisons detected between Distance 1 vs both of 3 and 4 were not shown by the nMDS plot. For both MAP and MAF, the 2013 points were distinct from the other years.

The Maui sites. For Maui A and B, Table 7suggested that there may be significant difference between Distance 1 (250 m) and Distances 2, 3, 4, and 5 (500 m, 1000 m, 2000 m, and 4000 m respectively) as there are some years where the comparisons were statistically significant. The nMDS plots confirm these results.

For MPA, Figure 17 shows that despite some overlap of points, there seem to be some separation between Distance 1 points and other distances. The 2012 points were distinct from the other points. A potential explanation is the possible lower taxonomic resolution in 2012 for the Maui A data as opposed to real differences in benthic community.

For MPB, Figure 18 shows that there is some distinction of points between Distance 1 and of 3, 4, and 5. There is relatively more overlap between Distance 1 and of 2 and 6. The 2016 points were centred further away from the other years.

The Tui site. Table 7 suggested that there is no significant difference between Distance 1 and any of the other distances, which was also confirmed by nMDS plot (Figure 19) Compared with other sites, there is less sampling effort in Distance 1.

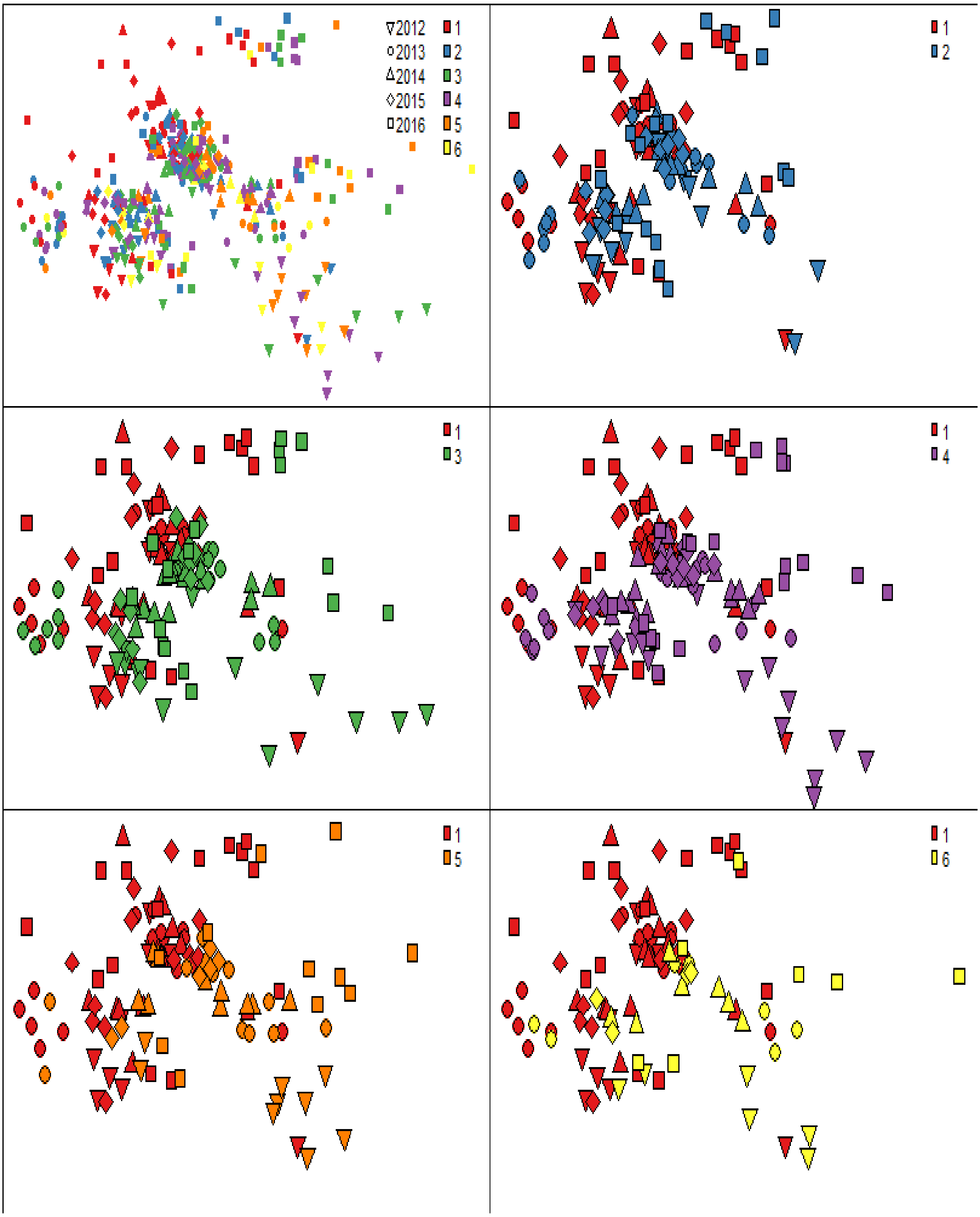

Figure 14: nMDS plots comparing Distance 1 and other distances across all stations.

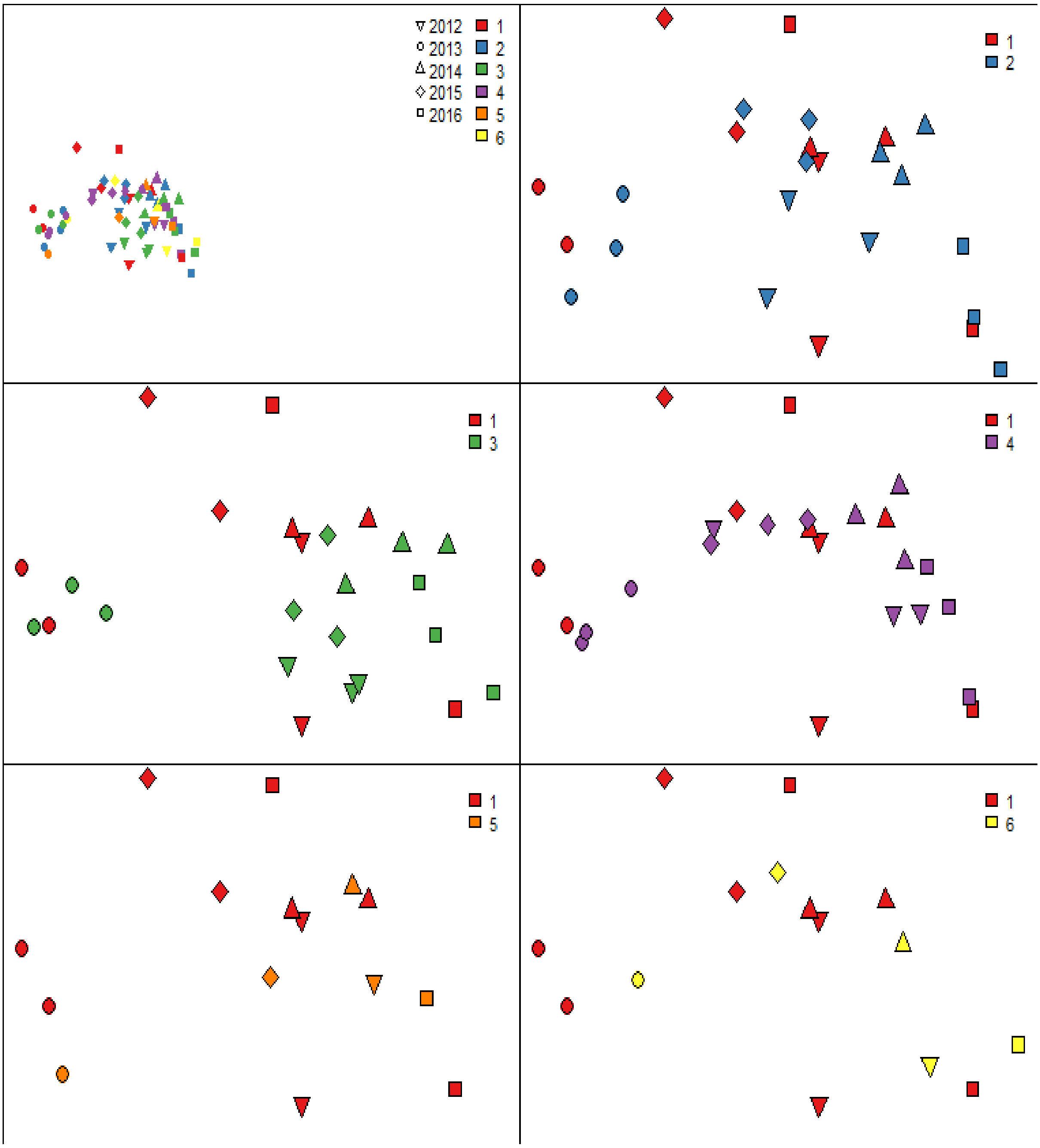

Figure 15: NMDS plots for MAP comparing Distance 1 and other distances.

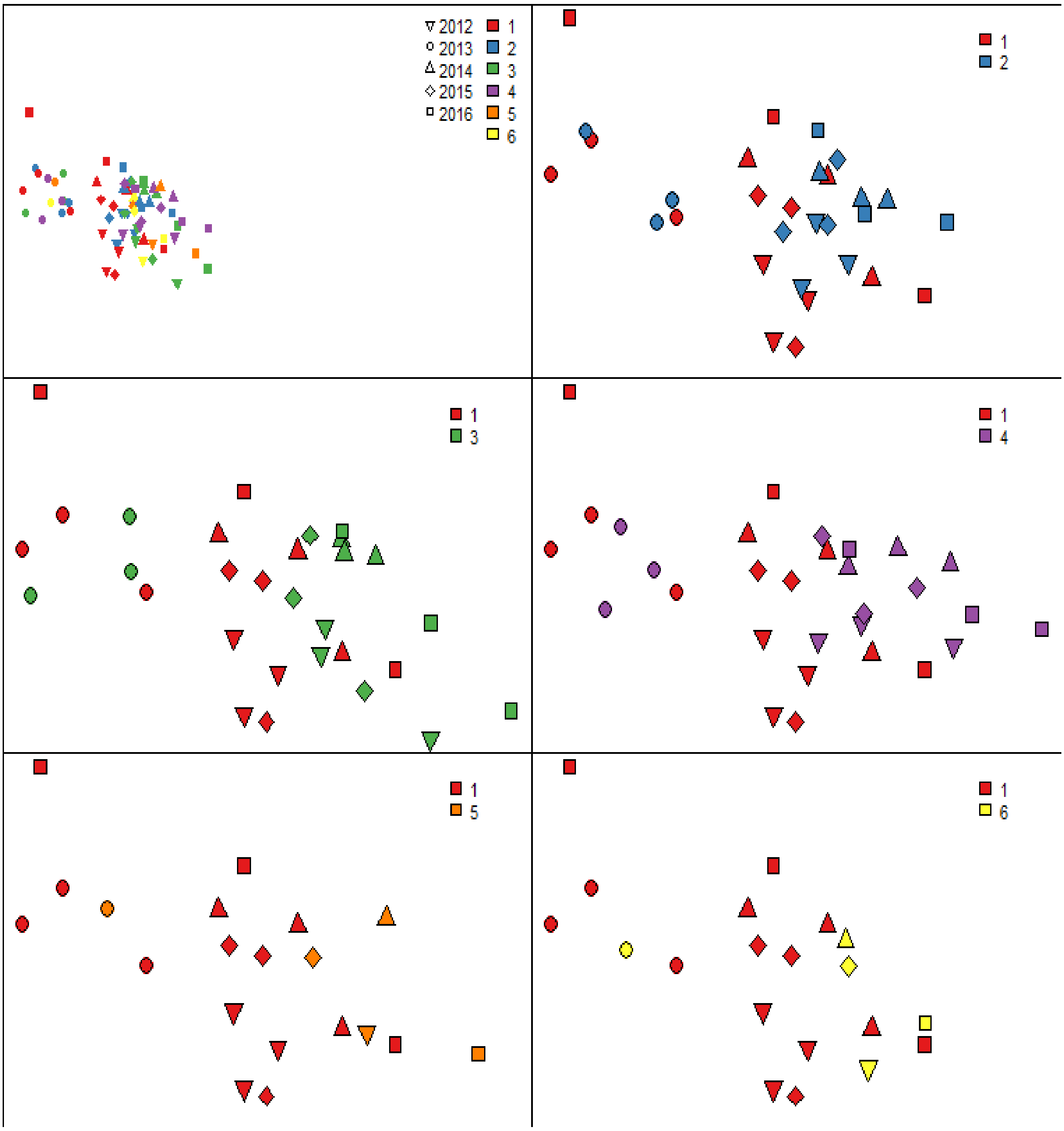

Figure 16: nMDS plots for MAF comparing Distance 1 with other distances.

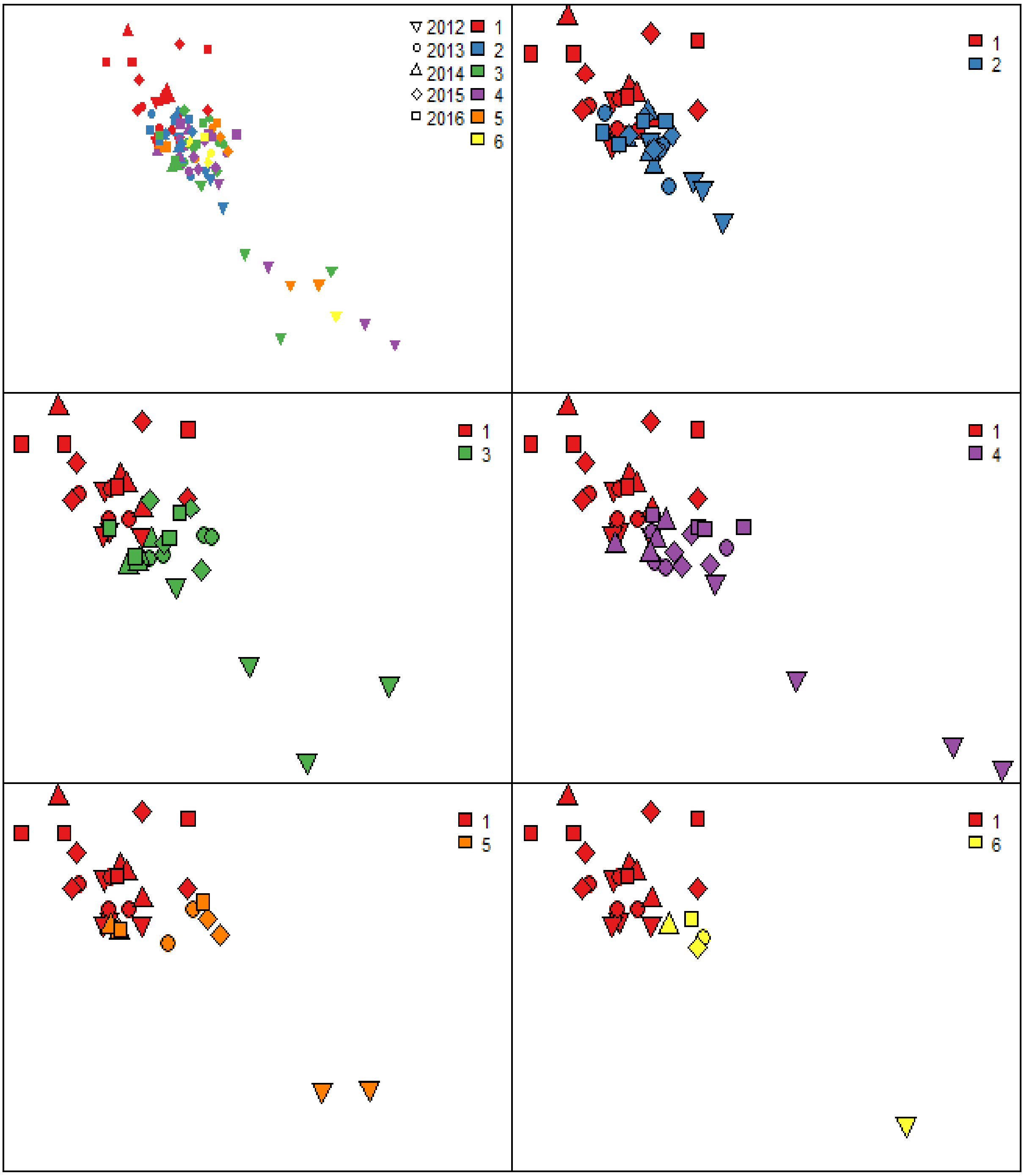

Figure 17: nMDS plots for MPA comparing Distance 1 with other distances.

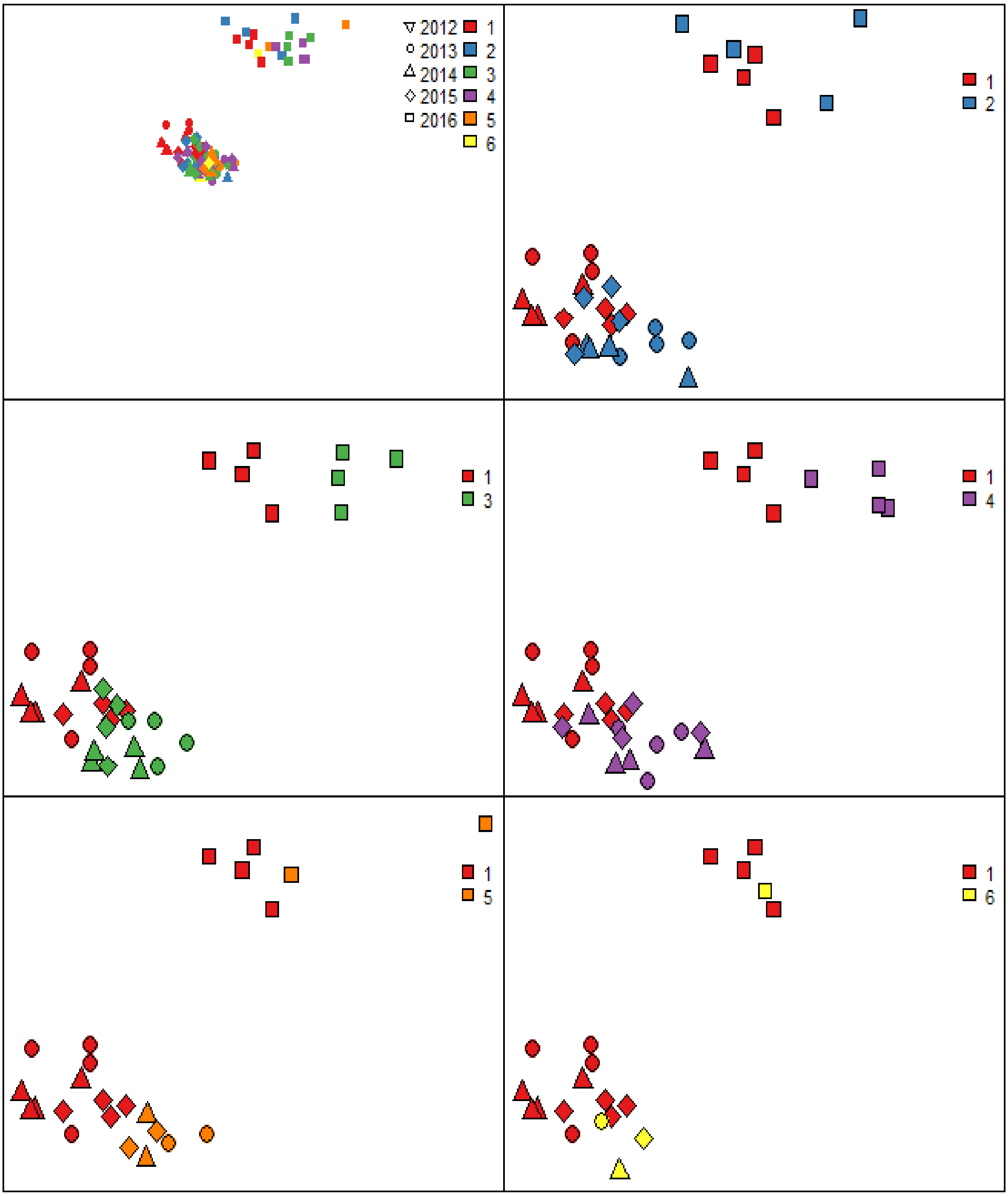

Figure 18: nMDS plots for MPB comparing Distance 1 with other distances.

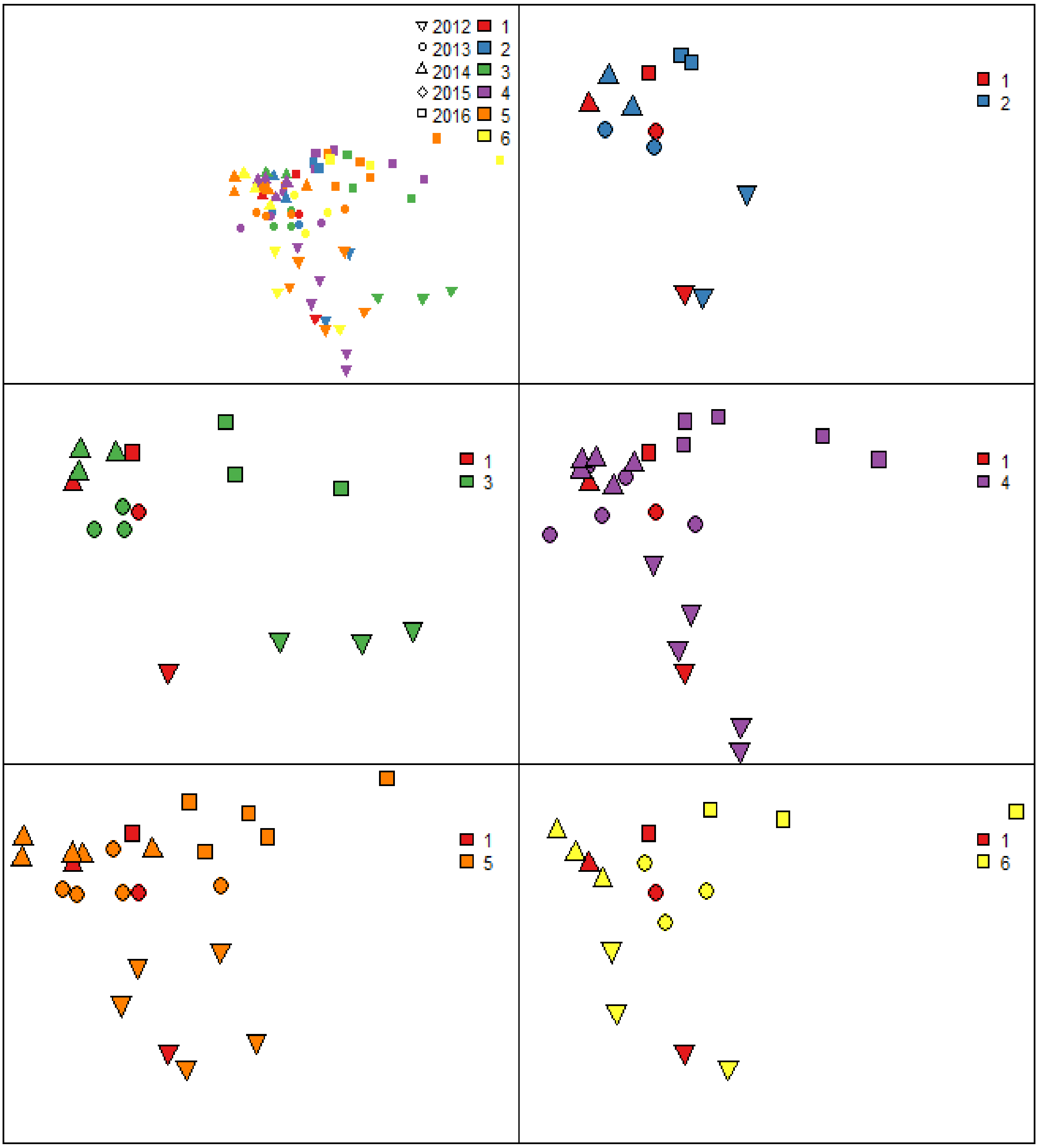

Figure 19: nMDS plots for TUI comparing Distance 1 with other distances.

C. For the five stations and two controls

Assemblage data for the five offshore infrastructures and the two controls were investigated using nMDS. Figure 20 shows the dispersal of North and South control points amongst the five offshore infrastructures. The North and South control points are generally distinct from one another. The 2012 points for both North and South controls are centred below the rest of the years, with the North Control noticeably further to the bottom left, apart from the rest of the control points. It was noted that the 2012 North Control site had elevated mercury levels so a different North Control site was used after 2012.

Figure 20 also shows that the stations are generally more similar to the control site that they are geographically closer to. The Maari points MAP and MAF are the southernmost infrastructures are geographically closer to South Control than the North Control and are centred closer to the South Control points in the nMDS plot even though there is no overlap in the regions they occupy. The Tui points are closer to the North Control and, apart from 2012, occupy a separate region to the North Control points. Maui A and B are also both geographically closer to the North Control and occupy a similar region with the North Control points.

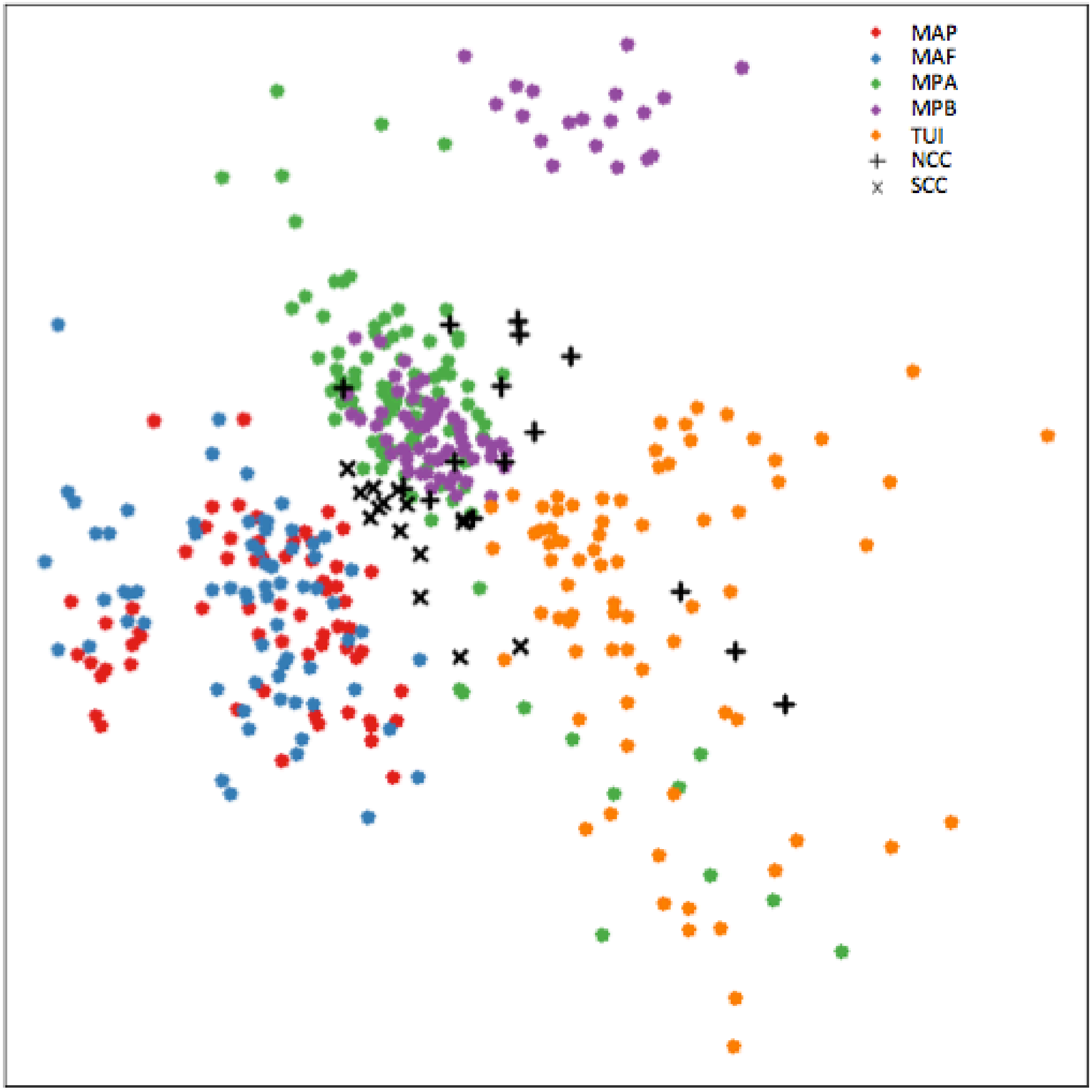

Figure 20: nMDS results coloured by station, displaying dispersal of North and South controls in the midst of stations (Stress = 0.1955807)

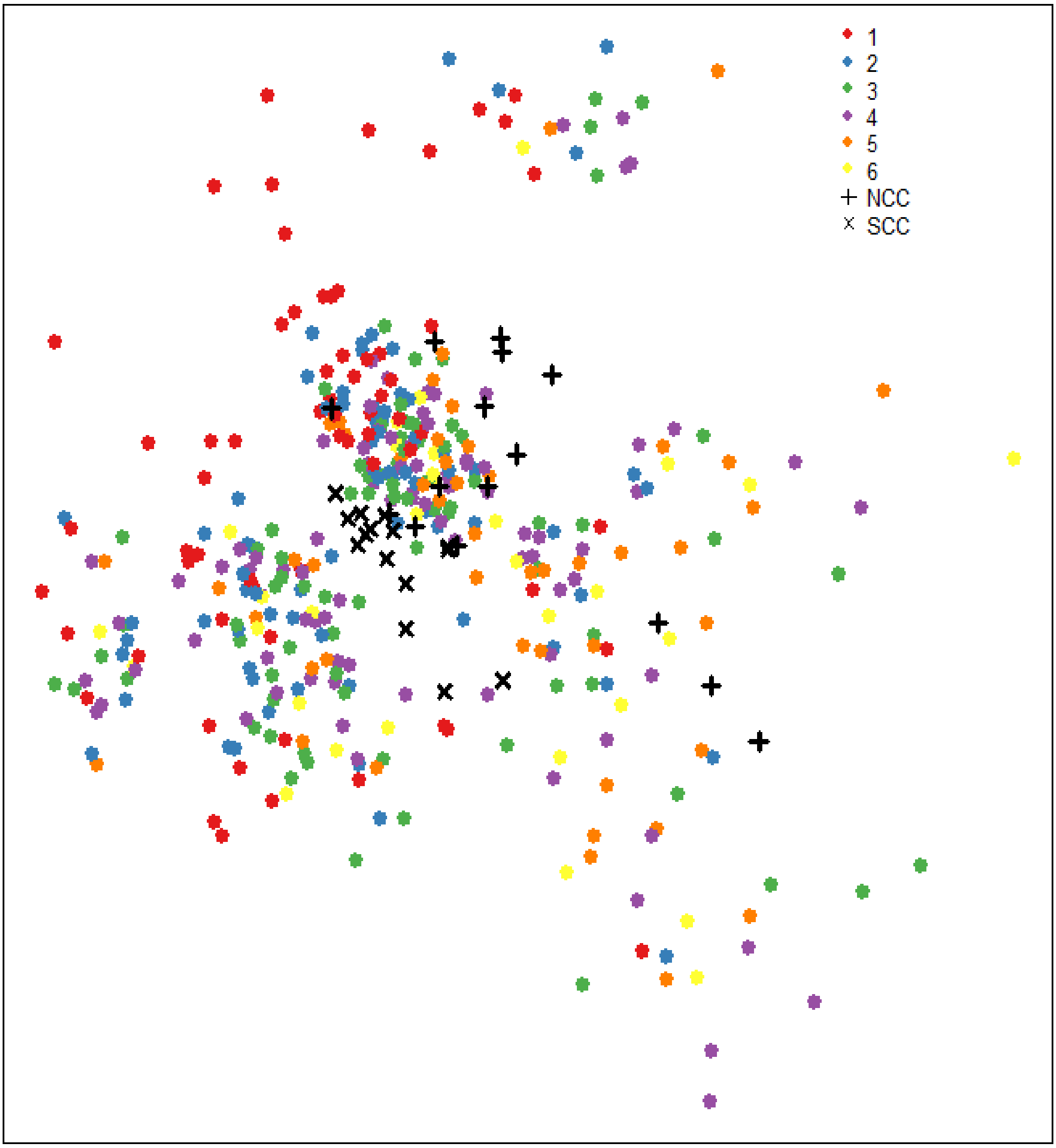

Figure 21: nMDS results coloured by distance, showing dispersal of North and South controls in the midst of stations (Stress = 0.1955807)

A PERMANOVA model was constructed to test for differences between year, stations (the five stations and two controls), and the associated interaction terms. It was found that the two-way interaction term was significant, which indicates differences between sites varied across years.

All pairwise comparisons of stations within each year are statistically significant, which is in agreement with the previous study. The previous section established a possible distance effect in MPA and MPB sites, so this was investigated further.

Figure 22 shows the difference between the North and South controls and each of the six distances for MPA. All the MPA points are distinct from the South Control points. Distance 1 is most distinct from North Control points, with the other distances less dispersed and occupying a similar region to the North Control points. This suggests that the area closest to the Maui A site is most different to the North Control, with areas further out more similar to the North Control.

Figure 23 shows the difference between the North and South controls and each of the six distances for MPB. Like the previous plot, all the MPB points are distinct from the South Control points. Apart from the distinct 2016 points at the top region of the graph, all the MPB points are very close to, and seem to occupy a similar region to the North Control.

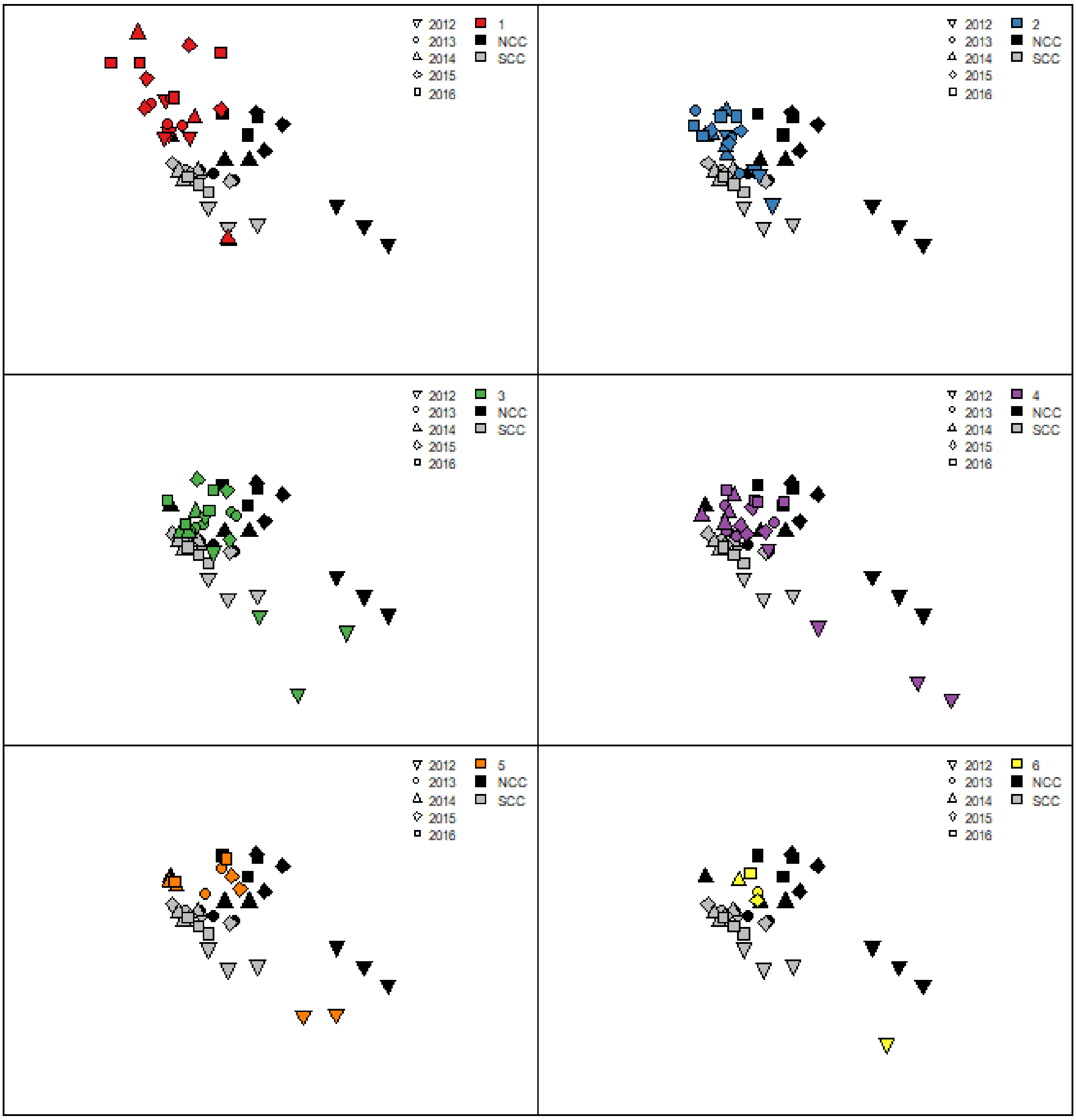

Figure 22: nMDS plots showing the difference between the North and South controls and each of the six distances for MPA.

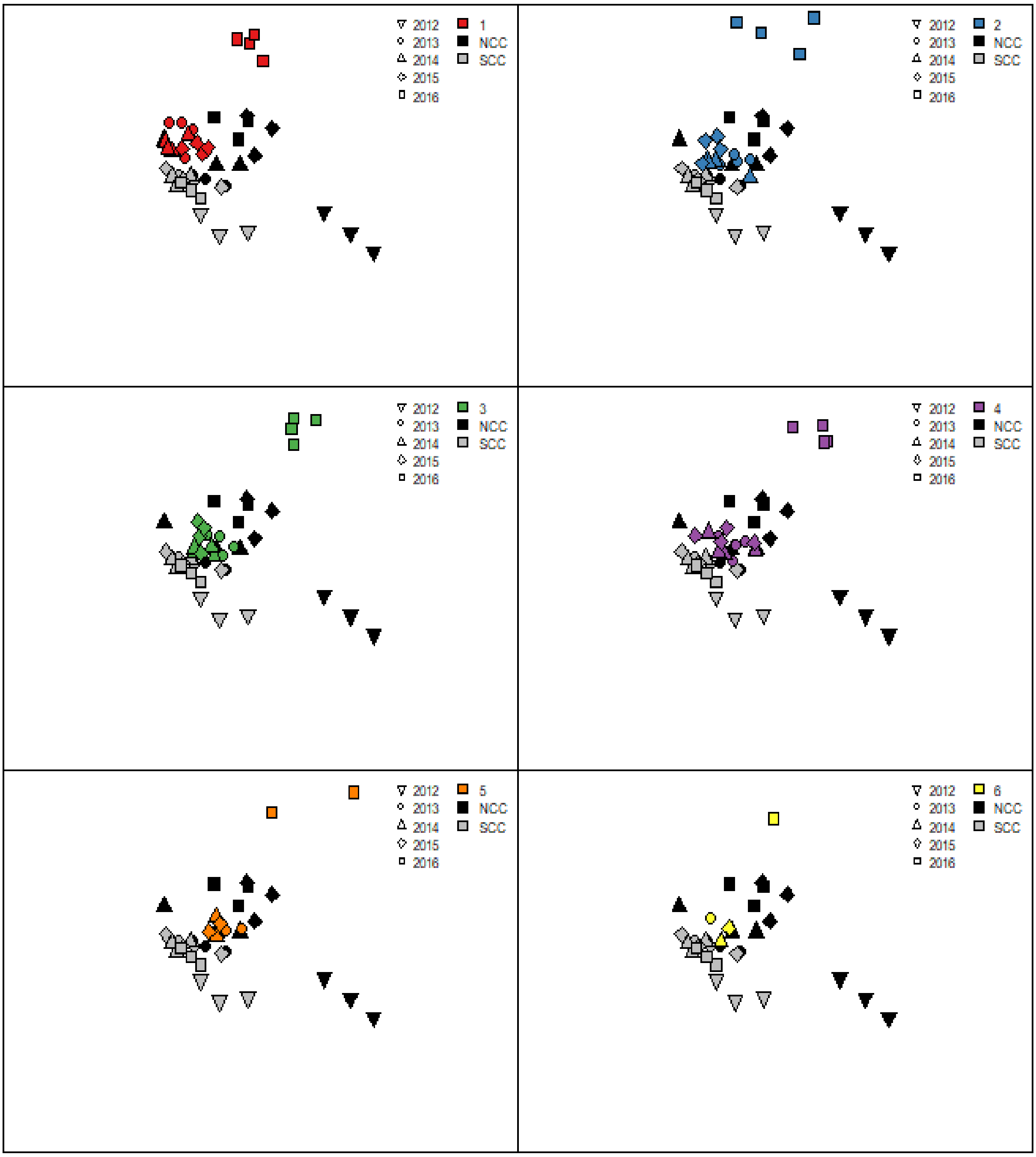

Figure 23: nMDS plots showing the difference between the North and South controls and each of the six distances for MPB.

D. SIMPER

To determine the taxa most responsible for driving the observed variability in benthic communities, SIMPER analysis was performed on year and station comparisons. The steps are outlined thus:

- SIMPER analysis was performed on each combination of year and stations. For five years, there were ten possible pairwise combinations. For the seven sites, there were 21 possible pairwise combinations.
- The top ten taxa identified driving the differences in the 10 and 21 pairwise combinations were collated.

The taxa presented in Table 2 were identified as influential in driving the variability across all the 10 pairwise combination of years. Table 2 indicates the number out of the 21 pairwise comparisons of stations that the given taxa was identified as driving the difference. Spionidae was found to be important in all the pairwise comparisons of stations, including the two controls. Cirratulidae was found to be significant in 18 out of the 21 pairwise combinations. The three pairs of stations that Cirratulidae was *not* within the top 10 influential species are: MAP vs MAF, MAP vs TUI, and MAF vs TUI. Full details are available on request. The average abundance of Spionidae across different years and stations is shown in Figure 24.

Table 2: Seven taxa contributing to variation in benthic community assemblages across the years and sites as identified by SIMPER analysis. The second column refers to the number of pairwise comparisons of stations (out of a possible 21) that the given taxa was influential in driving the difference. All these taxa were identified as driving the variability across years.

Taxa	Number of Comparisons in Top 10
Spionidae	21
Cirratulidae	18
Maldanidae	17
Paraonidae	16
Nephtyidae	15
Ophiuroidea (class)	12
Nucinellidae	5

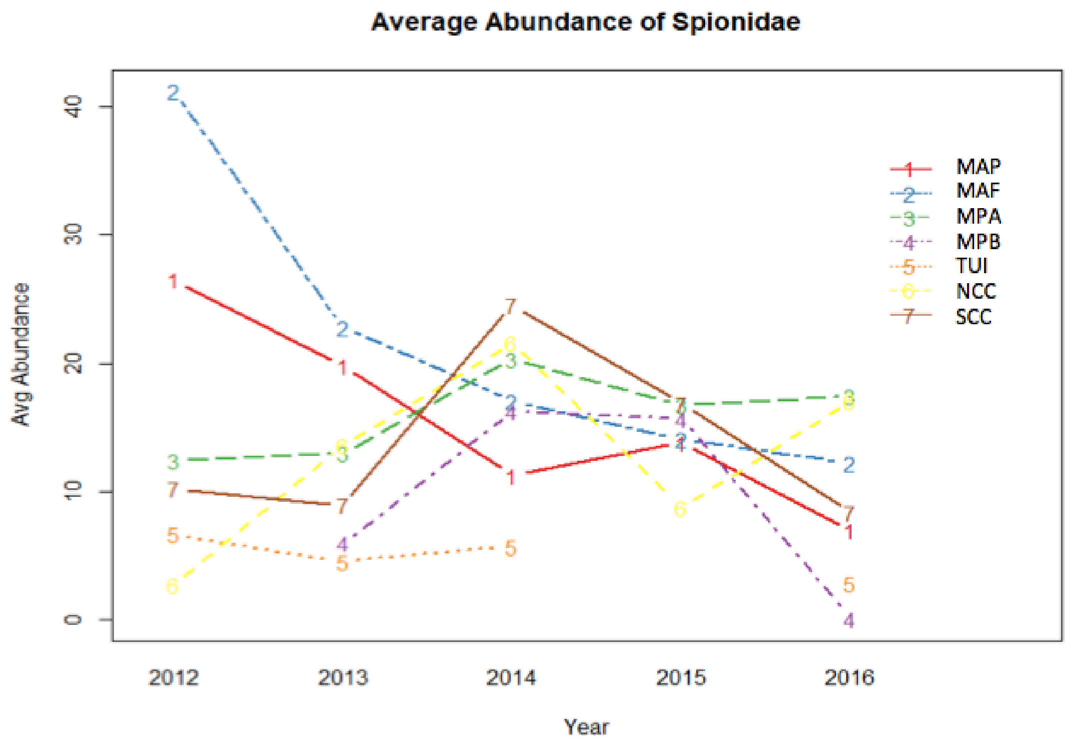

Figure 24: Average abundance of Spionidae across different years and stations.

7 Discussion

Previous studies have already determined that all the seven sites, the five stations and two controls, were statistically different from each other. This made it challenging to address the question of whether the offshore infrastructures have an effect, especially negative, on the local benthic communities.

The present study controls for the effect of site and year to investigate other potential effects of offshore platforms, namely axis and distance. The axis affect predicts that any production discharges would disperse more along the major current flow compared with along the minor current, so difference in benthic structure between sites along the major and minor current would indicate that the offshore installation has an impact in the area. No evidence of such a difference in the present analysis was found, which suggests at there being no impact of the installation. However this may also mean that the production discharges from the installation is also dispersed along the minor axis as much as along the major axes to cause a similar biological impact.

The distance gradient effect predicted that any effect due to the presence of offshore installations would be greater closer to the installation than further apart. Of the offshore installations studied, the ones with convincing distance effect are the Maui A and B platforms, the two oldest installations, which were operational in 1979 and 1993 respectively. Even so, the only difference detected is between 250 m and the intermediate distances at 500 m, 1000 m, 2000 m, and 4000 m. It should also be noted that the differences may have been the result of in-fill drilling activities in recent years. There was no evidence of a difference between 250 m and the furthest distance at 6000 m consistently across years. This may have to do with less sampling effort at 6000 m away from the station, and it was shown (Alekseyenko, 2016) that PERMANOVA suffers from loss of power and inflation of false positive error rate in the presence sample size imbalances. With respect to assessing distance gradient effect, sample size imbalance is inherent in the sampling methodology as there is less sampling in larger distances from the installations and only in the major axes where there is an expected difference to be found.

Also, there were no statistically significant difference between any distance pairs not involving Distance 1 that were found across multiple years. In addition it should be noted that year and station are the most important factors driving the variability in benthic community structure, and effect of distance, while present, is relatively minor.

The PERMANOVA results confirmed that the seven sites, even the two controls, are statistically different from each other in terms of surrounding benthic communities. When all the seven sites are taken together and visualised in the nMDS plot, the stations are more similar to the control station that they are closer to geographically. Also, the newer stations in this study occupy a distinct region to the controls. Production activities in the Maari and Tui field began in 2009 and 2007 respectively, and in the nMDS plot their points are distinct to the control site points. The older sites Maui A and B generally share the same region with the Control site, except the sites closest to Maui A station.

It should also be noted that PERMANOVA is sensitive to heteroscedasticity as well as unbalanced sample size. In other words, it simultaneously evaluates difference in *both* location and spread of the data from different groups in the multivariate space. That is, if the PERMANOVA test concludes that there is a difference attributed to the group, this means that the groups may differ in either location *or* spread *or both* in the multivariate space (b, c, and d in Figure 25). These various reason for the detected difference have different meanings from an ecological point of view.

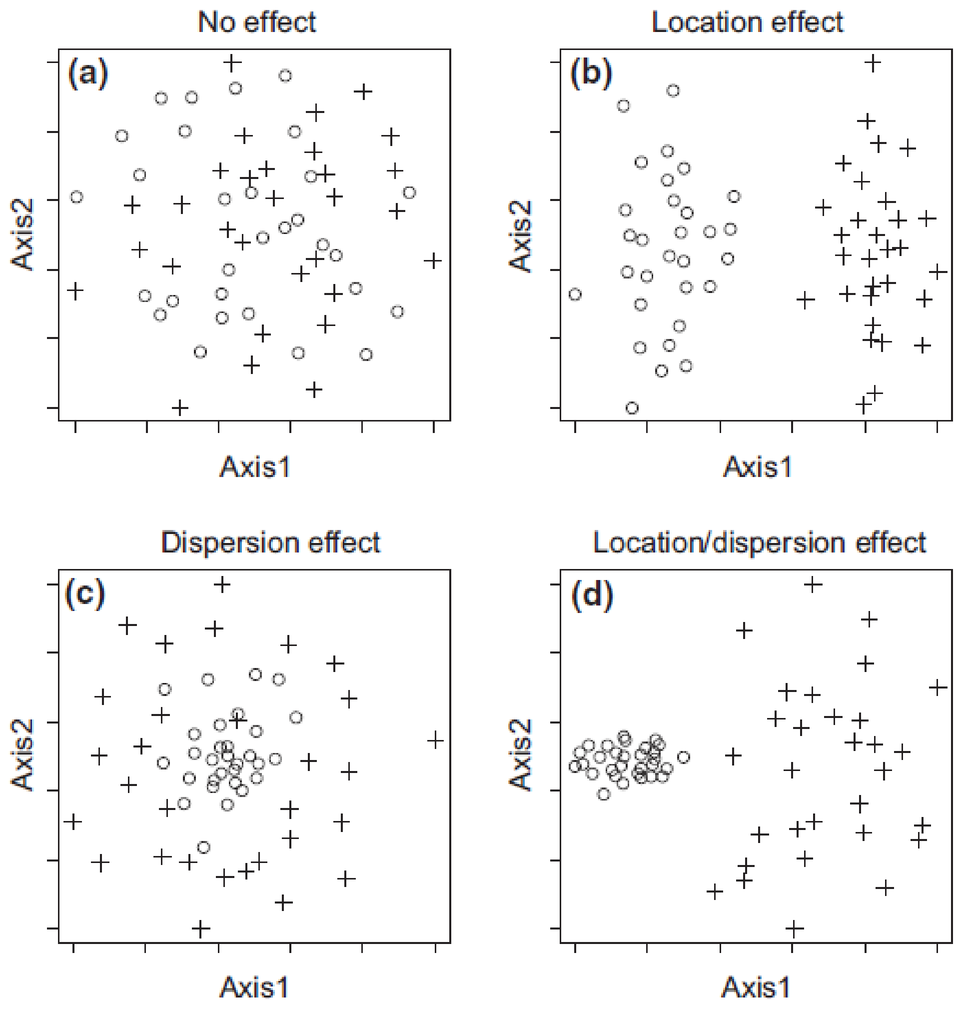

Figure 25: Schematic diagram (Anderson, Gorley, & Clarke, 2008) illustrating various types of differences between two groups that are often of ecological interest: (a) no effect; (b) location effect; (c) dispersion effect; and (d) location and dispersion effect.

In this study we have assumed that the directions along each axis is not different. The environmental reports for each site have investigated individual transects and found that they do not have a significant effect, or if an effect does exist, that it is minor relative to year and in some cases distance.

Guidance from ecological experts is required to determine which taxa, from the list of taxa identified in the SIMPER analysis as influential in driving variation amongst years and stations, warrant further study. For example, the abundances of specific taxa known to be sensitive to benthic environmental stress would help assess the net effects of offshore infrastructure in the region. Also since part of the environmental monitoring in the vicinity of the platforms also measured physical and chemical analysis of samples, another potential further work would be to link the benthic community data with these information.

8 References

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Appendix

Table 3: Summary of sampling effort in the offshore installations and controls by year. Samples were collected in the summer months (January to March) except Maui B in 2011, where the samples were collected in August to October. Maui B 2011 data was excluded in the present analysis. For the Wellhead Platforms, it was noted when known the drilling activities that occurred between 2011 and 2016. FPSO sites (Floating, Production, Storage, and Offloading) installations are tankers moored to location for a long term and incapable of drilling.

Key:

pre-drill
mid-drill
post-drill

Stn	Station Name	2011	2012	2013	2014	2015	2016	Comments
MAP	Maari		39	39	39	39	39	Developmental Drilling Programme Apr 2014 to Jul 2015
MAF	Raroa FPSO		51	51	51	51	51	
MPA	Maui A		57	57	57	57	57	Increased Recovery Factor Programme Jan 2013 to Aug 2014
MPB	Maui B	54		57	57	57	57	
TUI	Tui FPSO		57	57	57		57	
NCC	North Control		9	9	9	9	9	
SCC	South Control	9	9	9	9	9	9	

Table 4: Summary of sampling effort in the offshore installations along the major and minor axes.

Stn	Station Name	Major						Minor			
		North	South	North-East	South-West	East	West	North	South	East	West
MAP	**Maari**					60	75		60		
MAF	**Raroa FPSO**					60	90	60	45		
MPA	**Maui A**	90	75							60	60
MPB	**Maui B**	87	75							60	60
TUI	**Tui FPSO**	36	24	72	48					48	

Table 5: Summary of sampling effort by axis and distance from offshore installation. Distance 1: 250 m (except Tui: 300 m); Distance 2: 500 m; Distance 3: 1000 m; Distance 4: 2000 m (except Tui: 2250 m), Distance 5: 4000 m, Distance 6: 6000 m.

Stn	Station Name	Major						Minor				
		1	2	3	4	5	6	1	2	3	4	5
MAP	**Maari**	15	30	30	30	15	15	15	15	15	15	
MAF	**Raroa FPSO**	30	30	30	30	15	15	30	30	30	15	
MPA	**Maui A**	30	30	30	30	30	15	30	30	30	30	
MPB	**Maui B**	30	30	30	30	30	12	30	30	30	30	
TUI	**Tui FPSO**	12	12	24	48	48	36		12	12	12	12

Table 6: PERMANOVA results of comparison of major and minor axes for each of the distances. Highlighted values are significant at alpha = 0.05 / 4 = 0.0125 level.

Stn	Year	1	2	3	4	5
MAP	2012	0.2000	0.0243	0.0381	0.0123	
	2013	0.1000	0.0573	0.1092	0.2408	
	2014	0.2000	0.3918	0.9220	0.6176	
	2015	0.1000	0.4174	0.4190	0.0347	
	2016	0.4000	0.2400	0.3008	0.2603	
MAF	2012	0.0493	0.4082	0.0825	0.0113	
	2013	0.0360	0.0510	0.0242	0.0229	
	2014	0.2055	0.5794	0.9168	0.0141	
	2015	0.1323	0.8911	0.4799	0.9414	
	2016	0.1688	0.4278	0.0588	0.1012	
MPA	2012	0.2476	0.0182	0.0027	0.5132	
	2013	0.2350	0.0120	0.2189	0.0948	
	2014	0.0115	0.0346	0.9399	0.8057	
	2015	0.2488	0.5440	0.0797	0.0770	
	2016	0.0018	0.0112	0.0096	0.0021	
MPB	2013	0.1392	0.3892	0.0028	0.0524	
	2014	0.0752	0.0410	0.7519	0.1532	
	2015	0.1925	0.3830	0.6380	0.5280	
	2016	0.4218	0.5271	0.5676	0.1800	
TUI	2012		0.1000	0.9187	0.2259	0.1395
	2013		0.1000	0.0457	0.6790	0.0873
	2014		0.3000	0.0825	0.3451	0.2249
	2016		0.8000	0.0940	0.0098	0.1683

Table 7: PERMANOVA results of pairwise comparisons of distances. Highlighted values are significant at alpha = 0.05 / 15 = 0.0033 level.

Stn	Year	d1 vs d2	d1 vs d3	d1 vs d4	d1 vs d5	d1 vs d6	d2 vs d3	d2 vs d4	d2 vs d5	d2 vs d6	d3 vs d4	d3 vs d5	d3 vs d6	d4 vs d5	d4 vs d6	d5 vs d6
MAP	2012	0.0845	0.0067	0.0013	0.0109	0.0850	0.0013	0.0003	0.0237	0.0147	0.0873	0.1557	0.1528	0.8420	0.2129	0.8000
	2013	0.0652	0.0539	0.0083	0.0768	0.2001	0.1914	0.0391	0.1578	0.2911	0.0526	0.0828	0.2392	0.1158	0.3890	0.7000
	2014	0.0008	0.0033	0.0119	0.7752	0.0367	0.4326	0.0880	0.1227	0.0828	0.0141	0.6183	0.1631	0.8235	0.1548	0.3000
	2015	0.0101	0.0004	0.0023	0.0229	0.0265	0.5478	0.4105	0.1026	0.4732	0.0274	0.1408	0.1581	0.0053	0.1300	0.9000
	2016	0.1629	0.0970	0.0536	0.0550	0.1614	0.0813	0.1021	0.5301	0.1069	0.7315	0.3470	0.4308	0.4616	0.1825	0.9000
MAF	2012	0.0008	0.0001	0.0001	0.0043	0.0042	0.3313	0.5910	0.2389	0.0932	0.3800	0.3201	0.3001	0.5346	0.1872	0.5000
	2013	0.0876	0.0166	0.0060	0.1422	0.1302	0.0137	0.0272	0.0225	0.0137	0.4326	0.0151	0.1601	0.0077	0.2844	0.1000
	2014	0.0011	0.0001	0.0002	0.0157	0.0049	0.0419	0.4221	0.4107	0.5254	0.0165	0.1092	0.3118	0.4747	0.5165	0.9000
	2015	0.0244	0.0002	0.0001	0.0466	0.0791	0.0132	0.0247	0.2798	0.3520	0.6232	0.2570	0.0265	0.6480	0.0647	0.4000
	2016	0.0001	0.0002	0.0002	0.0052	0.0040	0.0039	0.1122	0.0046	0.0182	0.7867	0.2536	0.3687	0.2678	0.5803	0.3000
MPA	2012	0.0017	0.0001	0.0001	0.0002	0.0021	0.0027	0.0002	0.0001	0.0030	0.0944	0.1433	0.0547	0.1246	0.4363	0.3753
	2013	0.0010	0.0001	0.0001	0.0003	0.0020	0.0003	0.0069	0.0132	0.0035	0.0121	0.0281	0.0185	0.0361	0.0313	0.3084
	2014	0.0009	0.0001	0.0001	0.0003	0.0707	0.0001	0.0001	0.0095	0.1559	0.0001	0.0026	0.0071	0.3253	0.0537	0.5654
	2015	0.0002	0.0001	0.0001	0.0005	0.1906	0.1572	0.0001	0.0028	0.0088	0.3458	0.4298	0.3140	0.5197	0.4833	0.6889
	2016	0.0004	0.0001	0.0001	0.0001	0.0096	0.0500	0.0002	0.0005	0.0055	0.2505	0.0251	0.0693	0.3267	0.3096	0.5791
MPB	2013	0.0026	0.0005	0.0001	0.0005	0.0277	0.0526	0.0105	0.0111	0.1143	0.1852	0.1328	0.1752	0.0632	0.7734	0.0589
	2014	0.0010	0.0004	0.0002	0.0002	0.0024	0.0518	0.0184	0.0001	0.0104	0.5805	0.0848	0.0413	0.5742	0.2672	0.1223
	2015	0.2286	0.0132	0.0001	0.0005	0.0633	0.3297	0.1951	0.0181	0.2574	0.8954	0.1832	0.7362	0.6554	0.9646	0.7351
	2016	0.0369	0.0001	0.0001	0.0019	0.1492	0.0196	0.0523	0.1001	0.3015	0.3862	0.5815	0.1375	0.2816	0.2501	0.1692
TUI	2012	0.1770	0.0546	0.4560	0.0902	0.2357	0.0449	0.4207	0.1174	0.1227	0.0059	0.0001	0.0001	0.2393	0.4133	0.4949
	2013	0.0591	0.0099	0.0097	0.0034	0.0210	0.3267	0.4834	0.4436	0.5394	0.0116	0.0208	0.0061	0.1890	0.2022	0.0290
	2014	0.2009	0.0169	0.1581	0.2224	0.2073	0.2015	0.0914	0.1019	0.0806	0.4773	0.0193	0.0562	0.1752	0.0166	0.1207
	2016	0.0136	0.0135	0.0523	0.0198	0.0212	0.0462	0.1702	0.0924	0.0372	0.0880	0.3728	0.0350	0.2991	0.0256	0.0918

Table 8: Comparison of station and year and distance with the controls. Highlighted values are significant at alpha = 0.05 / 12 = 0.00417 level.

Stn	Year	North Control						South Control					
		1	2	3	4	5	6	1	2	3	4	5	6
MAP	**2012**	0.00020	0.00005	0.00007	0.00001	0.00458	0.01338	0.00017	0.00004	0.00005	0.00006	0.00880	0.04614
	2013	0.00014	0.00005	0.00005	0.00007	0.00471	0.00454	0.00022	0.00007	0.00007	0.00007	0.00469	0.00465
	2014	0.00031	0.00007	0.00005	0.00003	0.00457	0.00441	0.00023	0.00006	0.00009	0.00006	0.00450	0.00444
	2015	0.00016	0.00005	0.00009	0.00008	0.00435	0.00427	0.00015	0.00005	0.00001	0.00004	0.00503	0.00471
	2016	0.00019	0.00007	0.00009	0.00002	0.00468	0.00458	0.00025	0.00008	0.00002	0.00005	0.00850	0.00470
MAF	**2012**	0.00006	0.00003	0.00018	0.00005	0.00501	0.00440	0.00004	0.00004	0.00058	0.00012	0.00926	0.00418
	2013	0.00005	0.00005	0.00003	0.00002	0.00455	0.00419	0.00003	0.00007	0.00004	0.00007	0.00437	0.00495
	2014	0.00005	0.00007	0.00007	0.00006	0.00416	0.00480	0.00005	0.00007	0.00005	0.00006	0.00462	0.00446
	2015	0.00003	0.00004	0.00013	0.00002	0.00454	0.00469	0.00003	0.00003	0.00004	0.00006	0.00465	0.00469
	2016	0.00006	0.00006	0.00003	0.00007	0.00434	0.00454	0.00007	0.00006	0.00005	0.00008	0.00919	0.00466
MPA	**2012**	0.00001	0.00001	0.00002	0.00004	0.00027	0.00482	0.00001	0.00001	0.00001	0.00002	0.00067	0.00442
	2013	0.00001	0.00001	0.00001	0.00001	0.00025	0.00482	0.00001	0.00001	0.00001	0.00002	0.00021	0.00414
	2014	0.00001	0.00001	0.00001	0.00001	0.00026	0.01309	0.00001	0.00001	0.00001	0.00002	0.00014	0.00446
	2015	0.00002	0.00001	0.00001	0.00003	0.00891	0.03163	0.00002	0.00001	0.00001	0.00002	0.00019	0.00896
	2016	0.00001	0.00001	0.00001	0.00003	0.00021	0.61847	0.00001	0.00001	0.00001	0.00001	0.00016	0.00462
MPB	**2013**	0.00002	0.00001	0.00002	0.00001	0.00018	0.00429	0.00001	0.00002	0.00001	0.00001	0.00017	0.00435
	2014	0.00001	0.00002	0.00001	0.00002	0.00026	0.00480	0.00001	0.00004	0.00014	0.00004	0.00057	0.02253
	2015	0.00001	0.00001	0.00001	0.00001	0.00020	0.00476	0.00002	0.00002	0.00001	0.00002	0.00018	0.03720
	2016	0.00001	0.00001	0.00001	0.00001	0.00018	0.00481	0.00001	0.00001	0.00001	0.00002	0.00021	0.00435
TUI	**2012**	0.00887	0.04906	0.00269	0.05698	0.00255	0.00053	0.00448	0.00021	0.00005	0.00001	0.00001	0.00003
	2013	0.00451	0.00019	0.00004	0.00001	0.00001	0.00007	0.00875	0.00018	0.00004	0.00001	0.00001	0.00004
	2014	0.00469	0.00014	0.00009	0.00001	0.00001	0.00002	0.00487	0.00019	0.00006	0.00001	0.00001	0.00006
	2016	0.00464	0.00022	0.00007	0.00001	0.00001	0.00005	0.00403	0.00055	0.00003	0.00001	0.00001	0.00004

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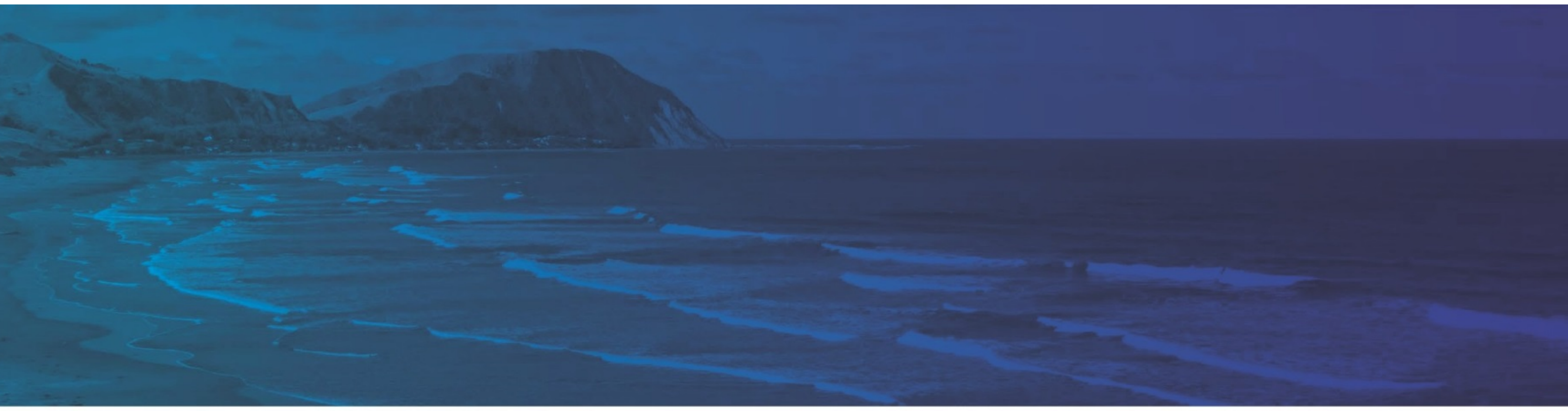

Decommissioning of Offshore Structures in the Taranaki Bight and Potential Effects on Marine Fauna

June 2017

Elemental Environment

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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.

Most 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 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).

Table 1: Examples of multiple sighting entries

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

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.

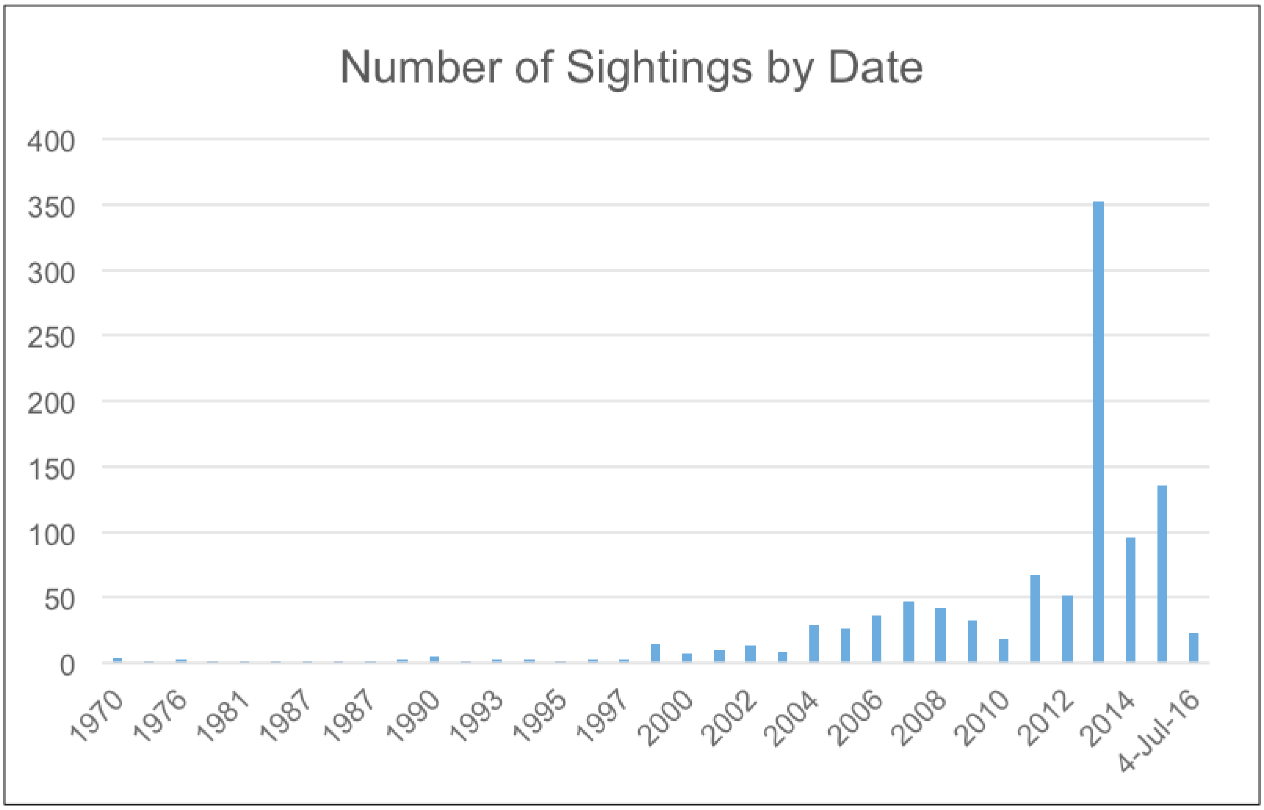

Figure 1 Number of sightings by date, 1970 to 4 July 2016

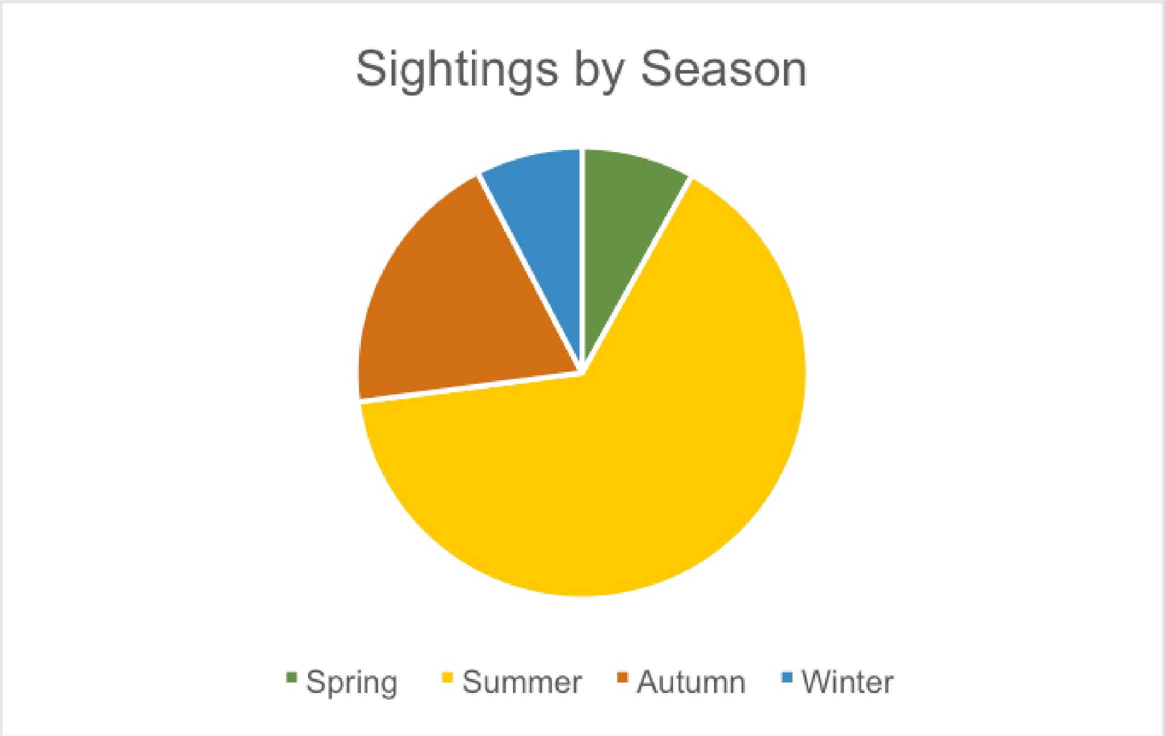

Figure 2 Sightings by season

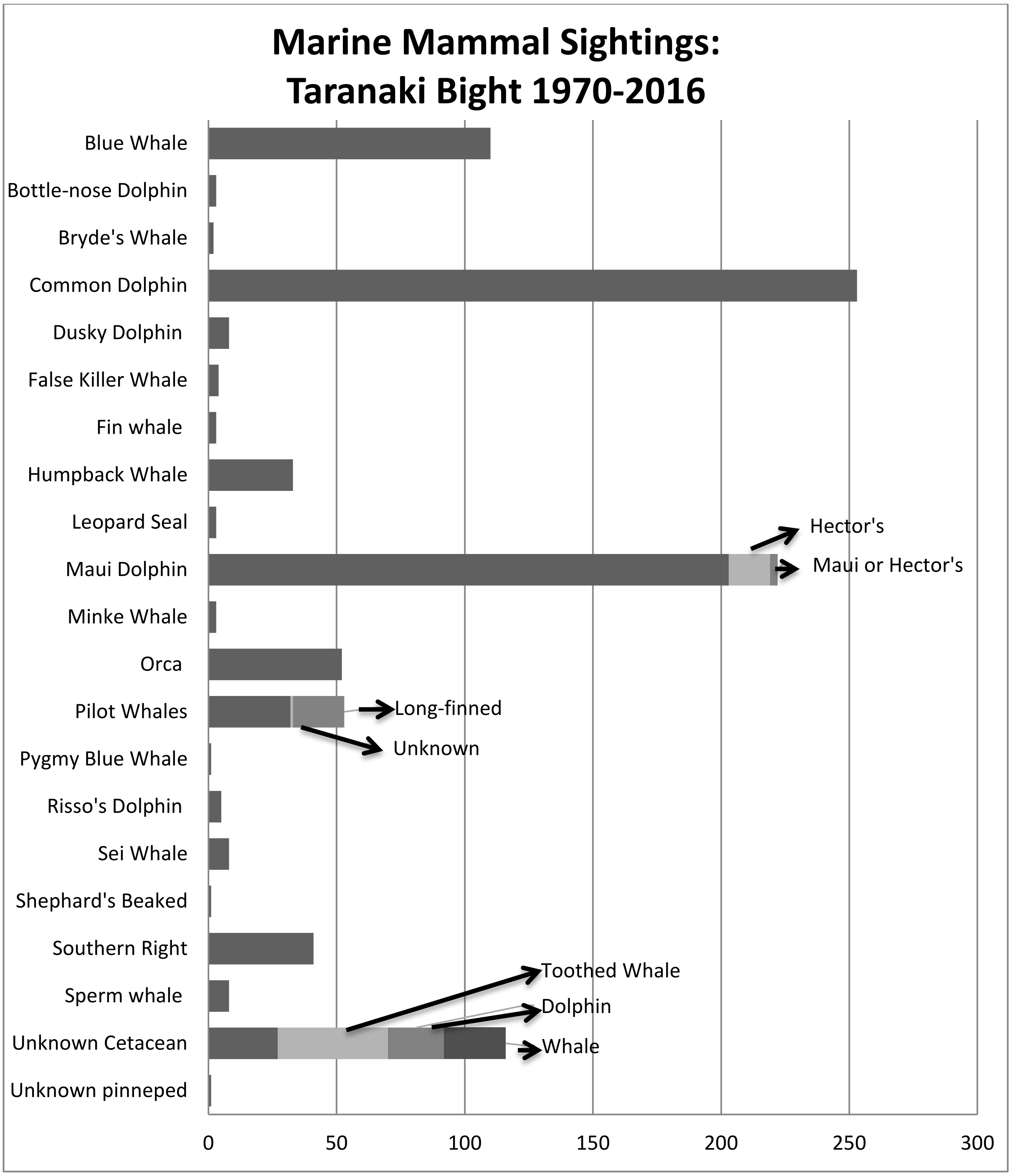

Figure 3 Marine mammal sightings by species within the Taranaki Bight 1970 – 2016. Species recorded as Māui, Hector's and Māui or Hectors; unknown Pilot whale, Long or Short-finned pilot whale; and unknown cetacean, toothed whale, unknown dolphin or unknown whales have been compiled in the same bar.

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.

2.3 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.

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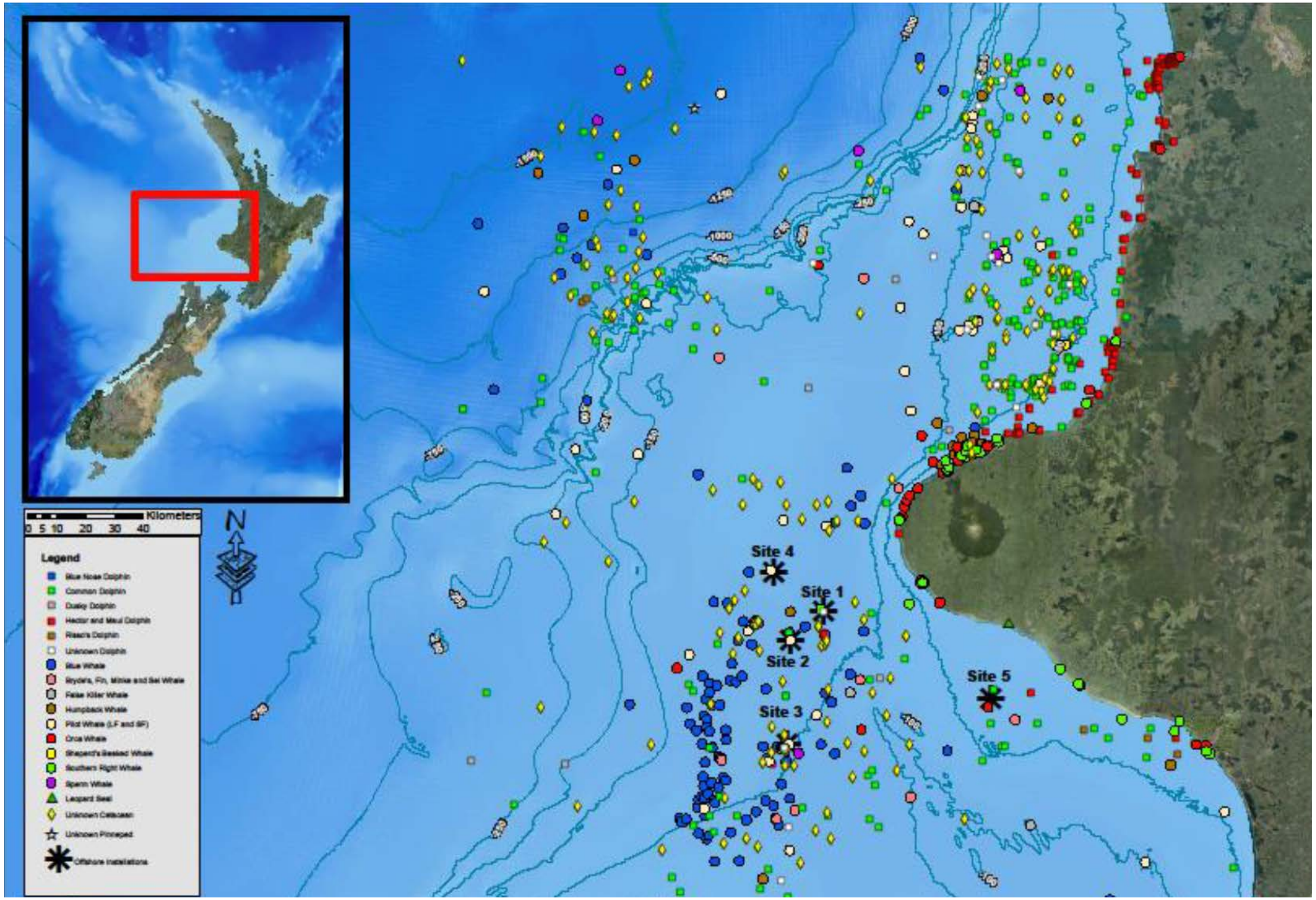

APPENDIX 1: *Map of the Department of Conservation recorded marine mammal sightings by species, Taranaki Bight 1.1.1900 – 12.12.2016*

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National Science Challenges
"Sustainable Seas"

National Science Challenges
SUSTAINABLE SEAS
Ko ngā moana whakauka

Cost Benefit Analysis

Re-use of offshore infrastructure and platforms: Assessing value to communities, industry and the environment

November 2017

Author(s): B Rogers, A Revfeim

Rev 0

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Executive Summary

This Cost Benefit Analysis forms part of the first phase of the Sustainable Seas project "The re-use of offshore infrastructure and platforms: Assessing value to communities, industry and the environment". The project comprises two phases. Phase 1 reviews environmental data available from offshore installations that have been in place for an extended period, and includes a desktop study of potential risks and benefits to the environment of *in situ* marine structures. The study considers marine species that are known or expected to utilise these structures over time, along with a comparison of global examples relevant to the New Zealand context.

Phase 2 investigates whether *in situ* marine infrastructures have the potential to bring value to the Taranaki community where offshore structures are currently in place, and whether there is potential to "value-add" during decommissioning. For example, do these structures have potential to provide protection and enhancement of particular in-shore fishery resources or present tourism opportunities? The assessment of "value-add" potential will be achieved by conducting surveys of affected stakeholders—primarily people representing the fisheries, tourism and petroleum industries, together with iwi in the focal area.

Three policy settings were investigated:

- Policy 1: total removal;
- Policy 2: partial removal of topside structures so that some structures remain on the seabed; and
- Policy 3: alternate use - sale of the infrastructure *in situ* for repurposing.

The Cost Benefit Analysis looked at New Zealand's five offshore petroleum fields currently in production that will reach their commercial end-of-field lives (EOL) over the next 32 years.

The fields reviewed are Maui, Maari, Tui, Kupe and Pohokura. The decommissioning cost for these have been based on oil and gas company annual reports. The cost for total removal is estimated to be $2.4 billion. The costs for partial removal and alternate use are estimated to cost $1.77 billion and $1.37 billion respectively.

On a discounted cashflow basis, we have identified the main beneficiaries associated with the different options. These figures are indicative only but are expected to clearly show the basis of the cost benefit components under the three policy settings.

The main beneficiary will be the commencement of a restoration industry in New Zealand. We estimate that approximately 70% of decommissioning work is likely to go to overseas decommissioning contractors and the remaining 30% would be spent on local contractors.

Oil and Gas operators will fund the restoration with support from the Crown in the form of tax repayments (Table 1). The net present cost to these parties is in the billions and hundreds of millions of dollars respectively.

The decommissioning industry will be the largest beneficiary for all Policy settings. This group includes the specialist international, local equipment and engineering companies that would carry out the works. The maximum value to this group has been estimated at $1.28 billion under Policy 1.

Minor benefits from under all policies may be gained for commercial fishing in Taranaki through operational efficiencies and possible increase in fish catch of 1.3% due to the removal of the exclusion zones surrounding the current oil and gas infrastructure.

A separate study is ongoing to identify what costs or benefits Iwi in Taranaki may derive from restoration of these facilities.

Recreational users including divers and fishers under Policy 2, partial removal, may gain new, better sites but we have been unable to quantify this benefit, however they are expected to be relatively small.

Policy / Affected Party	Policy 1 - Total Removal		Policy 2 - Partial Removal		Policy 3 - Alternate Use	
		Benefit (Cost)		Benefit (Cost)		Benefit (Cost)
Operators	**$**	**(934)**	**$**	**(680)**	**$**	**(529)**
Crown	**$**	**(432)**	**$**	**(315)**	**$**	**(245)**
Decommissioning Industry	**$**	**1,280**	**$**	**932**	**$**	**725**
Fisheries	**$**	**20**	**$**	**20**	**$**	**20**
Recreational Marine Users		**N/D**		**N/D**		**N/D**
Iwi		**N/D**		**N/D**		**N/D**
Purchaser		**N/D**		**N/D**		**N/D**

*N/D – not determined

Table 1: Parties affected by each Policy, and discounted benefit or cost associated with each option (NZ$ million).

What this study clearly shows is a material economic boost for the restoration via removal of facilities and wells at the end-of-life, predominantly benefiting marine service providers and service companies engaged in engineering, labour, materials handling or recycling onshore. This value is estimated to be $1,280 million to $725 million across the three policy options.

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1 Introduction

1.1 What is Cost Benefit Analysis?

This Cost Benefit Analysis[1] is first and foremost an organising principle; a way of organising information in a consistent and systematic way. It is about making best use of whatever information is available.

'Social' Cost Benefit Analysis is a cost benefit analysis that must identify all the economic (including social and environmental) impacts of decisions on people, whether or not they can be quantified. Comparison of different alternatives is not possible unless decision-makers form a view about the relative size of the various impacts. This first phase of the cost benefit analysis includes impacts which can be quantified as well as identifying parties who may be affected, but those impacts are not able to be quantified. Further social surveying will be used to add to this, currently quantitative, cost benefit analysis.

1.2 Offshore Oil and Gas Infrastructure in New Zealand

Over the last 40 years, five oil and gas accumulations have been developed with wells, platforms, pipelines and/or vessels offshore in the Taranaki basin, New Zealand. To date, no other New Zealand offshore or onshore basins have commercially developed oil or gas other than the Taranaki basin.

[1] Paraphrased introduction to "Guide to Social Cost Benefit Analysis" by Gabriel Makhlouf, Secretary to the NZ Treasury

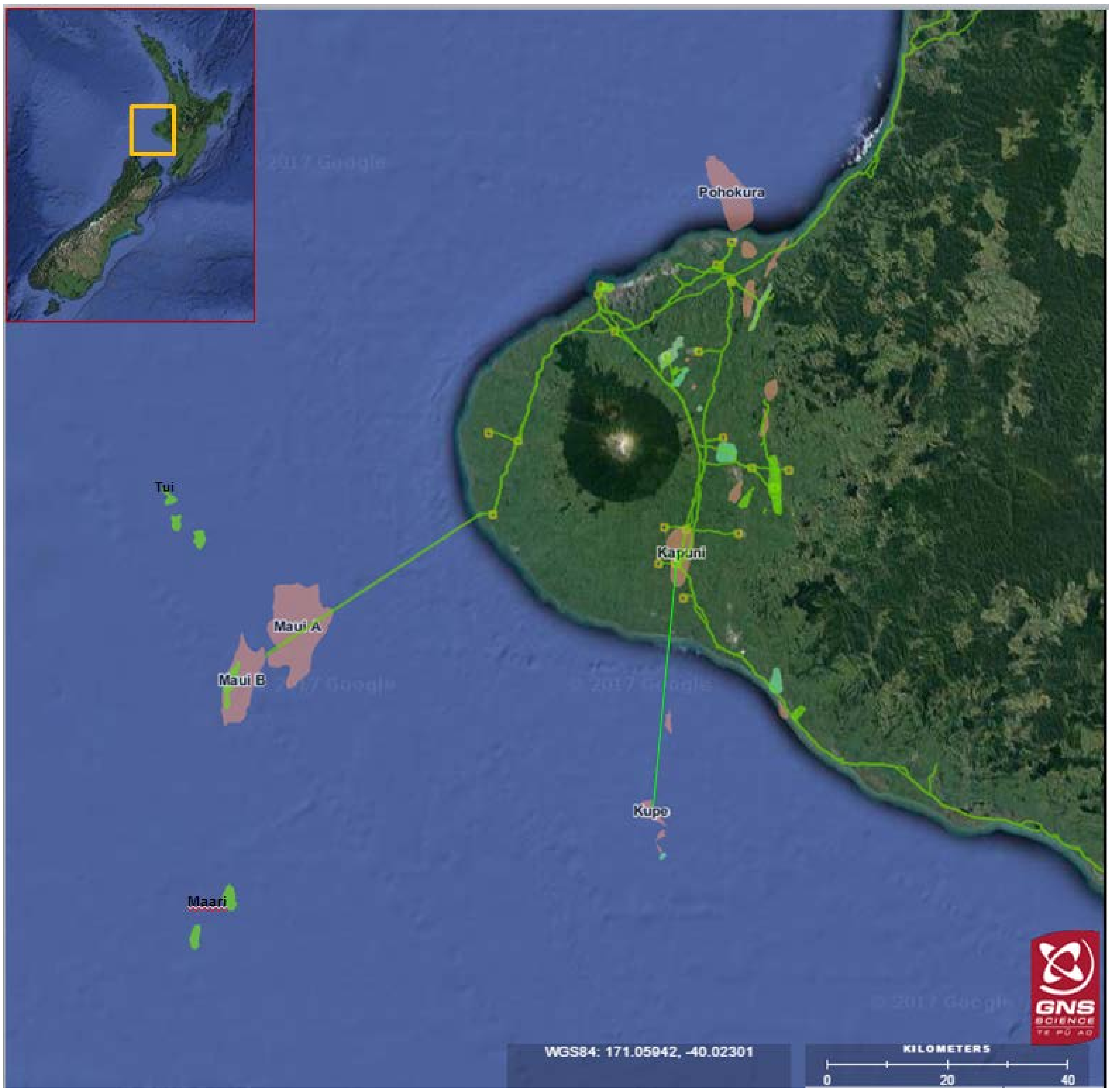


Figure 1: Location of oil and gas fields and infrastructure in Taranaki, New Zealand.

Figure 1 shows fields located across Taranaki. Those in pink are gas fields and green represents oil fields. The green lines are gas and oil pipelines, both on and offshore. Figure 2 shows the platforms and floating production storage and offloading vessels that are currently in use offshore in the Taranaki Bight.

The offshore facilities, in order of the year of installation, are:

- Maui Platform Alpha (MPA) (1976/77).
- Maui Platform Bravo (MPB) (1992).
- Maui oil field *Whakaaropai* floating production storage and offloading vessel (1996), removed 2006.
- Tui field floating production storage and offloading vessel *Umuroa* with subsea wells (2004).
- Pohokura Platform B (PPB) within the Pohokura field (2005).
- Maari field platform *TiroTiro* (2008) plus floating production storage and offloading vessel *Raroa.*
- Kupe field platform and pipeline/umbilicals (2008).

One offshore oil facility has already been decommissioned from New Zealand waters. This was the floating production, storage and offtake vessel *Whakaaropai*, which was sold in 2006 after ten years of production. Sections of the mooring lines and two flexible pipelines remain on the seabed.

In addition to the visible platforms and oil vessels there are a range of anchoring/mooring equipment, pipelines, umbilicals and well equipment associated with extracting oil and gas. This infrastructure is located on the seabed or in the water column and includes:

- Anchoring and mooring systems are used to keep FPSOs in place. These are generally steel chains and cables.
- Pipelines are generally of two types, carbon steel welded pipelines, and flexible, composite, multi-armoured pipelines.
- Umbilicals are deployed on the seabed to supply necessary control, energy (electric, hydraulic) and chemicals between facilities and/or subsea wells.
- Wells are drilled between 3 to 8 km depth from either platforms or subsea with the top of the well resting on the seabed. Wellheads themselves may be located either on the seabed or on the platforms in some cases.

The offshore fields had produced 4,900 Petajoules (PJ) of gas and 353 million barrels (bbl) of oil to end 2015. By the end of field lives, MBIE expect another 1,300 PJ gas and 42 mm bbls of oil to be produced [2] by the combined fields.

The expected future production is worth $7 billion to New Zealand's GDP.[3] The timing of end of field life can be difficult to "get right". Shutting in the field early reduces production funds to the oil and gas companies, the Crown, the major contractors and people employed on the fields. Likewise, leaving restoration commencement too late increases the cost, running past the economic life of the field(s).

Maximising recovery from these fields is a large "value add" to New Zealand. In terms of the cost benefit analysis, we have assumed this optimisation has been achieved, ie the oil and gas companies forecast the end of field life correctly.

[2] Energy Data File 2016, NZPAM

[3] This is premised on current pricing of gas at NZ$4/GJ and oil at US$50/bbl, being gas worth of $5 billion and oil worth of $2 billion This pricing is indicative only. We expect these prices to swing between +200% and -66% and hence the value of these products remains uncertain.

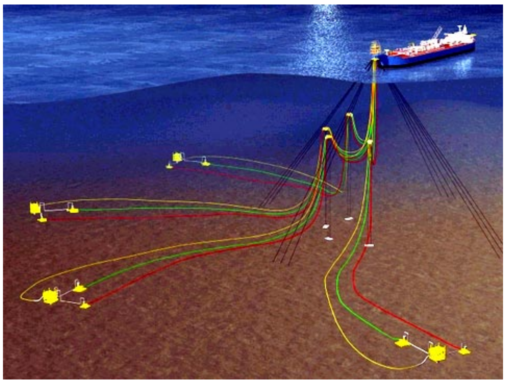
MPA in 110 m water (photo courtesy of STOS) 	MPB in 110 m water (photo courtesy STOS) 
Maari Tirotiro and *Raroa* (background) in 110 m water (stuff.co.nz) 	Kupe in 35 m water (Stuff.co.nz) 
Tui FPSO *Umuroa* in 140 m water [4] (offshore-technology.com) 	Pohokura platform in 35 m water (Radio NZ) 

Figure 2: New Zealand offshore facilities and FPSOs

[4] Pictorial does not include Pateke-4H well installed in 2014

2 Scope of Work

The following is the scope of work agreed under the Sustainable Sea project for the cost benefit analysis.

"The cost benefit analysis forms part of Phase 1 of this Sustainable Seas project 'the re-use of offshore infrastructure and platforms: assessing value to communities, industry and the environment'.

The monetary costs of removing offshore structures or modifying them for remaining in place can be relatively easily assessed through engineering estimates. However, many of the benefits or potential negative outcomes of either of these courses of action will be harder to estimate in pure economic terms.

Where a cost or benefit can be assessed in economic terms we have used standard discounted cash flow techniques with discount rates reflecting the long-term and sovereign level nature of the decisions (i.e. lower than typical commercial rates). The economic value of the benefits and/or negative impacts over time are derived, where possible, from peer-reviewed research references (be that local or international references).

Where the cost or benefit of an action (or inaction) cannot be reasonably assessed in economic terms then we ranked its impact against the economic impacts using a relative scale. That cost or benefit can then be carried through the CBA as if it had its relative economic impact.

The probability of occurrence/success of all outcomes occurring as a result of actions (or inaction) taken with an offshore structure will be one of the targeted outcomes of the overall project. The final assessment of a particular course of action will be derived from a matrix of Impact (economic and non-economic) versus Probability of the various outcomes and compared to alternative courses of action."

2.1 Methodology

The methodology for the CBA uses the NZ Treasury recommended approach to:

1. Define the status quo and the policy options;
2. Identify who benefits and who loses;
3. Identify and value the costs and the benefits;
4. Discount and compare the costs and benefits; and
5. Document the results.

The status quo represents producing assets. In this study we have identified policy options because there is no status quo when it comes to offshore oil and gas restoration in New Zealand. The policy options (counterfactuals) are derived from information from other offshore jurisdictions applied to the New Zealand status quo (ie five fields).

The parties affected are based on current understanding within the Taranaki context and will be refined by the social surveying of local groups and iwi engagement sessions held as part of phase 2.

Costing the options will use financial data from the local oil and gas operators, UK North Sea decommissioning norms and statement by the Crown regarding its tax and royalty liabilities. This allows a local and international overview to be developed for the varying options and sense check varying methods.

The costs are apportioned over the relevant time periods based on MBIE published end of field life estimates and these have been discounted at industry norms recommended by the NZ Treasury.

3 Restoration Assumptions

The restoration assumptions used in this study are framed by the international practice and the relevant Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ) and Resource Management Act 1991 (RMA) requirements.

Decommissioning projects can be large and complex. While multiple jurisdictions can be used for comparison with the New Zealand context, we have used the New Zealand Operators' financial statements, UK North Sea decommissioning estimates and Crown estimates of their tax and royalty liabilities for our restoration cost estimates.

The use of the Operators' financial reporting estimates for restoration is the best approach to use as it provides their view based on New Zealand conditions and the characteristics of their specific infrastructure. This includes environmental, regulatory, technical and logistical considerations.

3.1 Restoration Estimates using Annual Reports

The 2016 Companies Office financial filings and published company annual reports provide publicly available insight into the existing restoration provisions for New Zealand fields. Insights may be gathered from any company that is a joint venture participant within a field (ie an equity ownership). Companies may hold varying equity positions in different fields and it is possible to estimate the field restoration estimates from these reports.

The Shell NZ 2016 filing has a restoration provision of NZ$1,424 million. At the time of the filing, Shell held interests in the following fields:

- 84% of Maui (offshore and onshore);
- 48% of Pohokura (offshore and onshore);
- 50% of Kapuni (onshore); and
- miscellaneous interests in other related businesses (onshore tank farms, pipelines, etc).

OMV, the second largest offshore operator by installation size, have a restoration provision of $358 million to cover their interests including:

- 69% Maari (offshore only).
- 26% Pohokura (offshore and onshore).
- 10% Maui (offshore and onshore).
- Various offshore exploration permits (no assets).

Origin Energy and Tamarind both have interests in Kupe and Tui respectively. In our search, no published restoration data was available from either company.

In 2016, the Kupe field was held by publicly listed companies Genesis and New Zealand Oil and Gas (NZOG) at 31% and 15% respectively.

Genesis reported provisions of $123 million including "*the rehabilitation and restoration provision relates to the Meremere generation site, the Huntly ash ponds and the Kupe production facility…. The key assumptions that could have a material impact on the Kupe production facility rehabilitation estimate relates to foreign exchange rates, scrap-steel prices, labour rates, concrete removal costs, offshore supply vessel and jack-up rig rates, and associated mobilisation and demobilisation costs. The majority of costs are* *based in United States dollars and, therefore, are sensitive to fluctuations in foreign exchange rates. Given the equipment required to complete the rehabilitation comes from overseas, the mobilisation and demobilisation costs can fluctuate significantly depending on the volume of other work the contractor has at the time the rehabilitation is required to be completed. If the foreign exchange rate were to decrease by 10 per cent and if the transportation costs for the mobilisation and demobilisation were unable to be shared with other entities, the provision would increase by $18.1 million. Also affecting the provision are regulations around the removal of the subsea pipeline. Currently, there are no regulations around this and, as such, the provision assumes the subsea pipeline will be flushed and left in situ. The rehabilitation is estimated to be completed in*

approximately 13 years" [5]. From this, we assume that the Kupe liability is at least $80 million of the provision.

Pan Pacific Petroleum had a $17.5 million provision for its 15% Tui share. They reported "*The restoration and rehabilitation provision is recorded at the present value of the estimated cost of legal and constructive obligations to restore operating facilities and well sites within the Tui Oil Area. The nature of the restoration activities includes the removal of facilities and restoring affected areas. The timing of required restoration is between 1 and 3 years, with a discount rate of 1.6% (2015: 2.30%) applied to present value of the future restoration costs*"[6]. This would account for a Tui field restoration provision of $117 million.

Similarly, NZOG reported $77 million for their 15% Kupe, 27.5% Tui and 2.5% Cue Energy consolidated provisions[7];

- Tui share of restoration is $32 million ($117 m x 27.5% from Pan Pacific estimate) then
- Kupe should cost NZOG $35 million for its 15% of 100% Kupe restoration, and
- Maari share held by Cue is $6 million.

By cross-plotting what we understand from annual reporting of restoration provisions, we have allocated assumed field restoration costs. The offshore restoration costs applied to fields by the current study are shown in Table 2.

ALLOCATION	Maui	Maari	Tui	Kupe	Pohokura
Genesis	-	-	-	80	-
NZOG	-	6	32	39	-
Shell	1,310	-	-	-	96
OMV	156	176	-	-	52
Pan Pacific	-	-	18	-	-
"Other" parties	94	73	67	139	52
Balance	**1560**	**255**	**117**	**258**	**201**

Table 2: Company Restoration Provision Applied to Fields (NZ$ million).

Some restoration projects use the reverse construction method to estimate the restoration cost. Using our offshore construction knowledge and experience, we estimate wells, offshore construction and onshore

[5] Genesis Energy Annual Report 2016
[6] Pan Pacific Annual Report 2016
[7] NZOG Annual Report 2016

construction to account for 37%, 54% and 9% respectively. **Error! Reference source not found.** shows Maui has the highest restoration cost while Tui, which has the simplest development structure because the floating production storage and offloading vessel is able to sail away, therefore has the lowest cost.

Field	TOTAL	Maui	Maari	Tui	Kupe	Pohokura
Wells	860	468	153	82	77	80
Offshore	1,303	936	102	35	129	101
Onshore	228	156	-	-	52	20
TOTAL	**2,391**	**1,560**	**281**	**117**	**258**	**201**

Table 3: Field Decommissioning Estimates by Spend Type (Well / Onshore / Offshore) (NZ$ million).

Decommissioning costs for offshore assets, based on the information published by oil and gas companies, could be $2.4 billion over the next thirty years, split into $860 million for wells, $1.3 billion for offshore structures and another $228 million for onshore restoration. It is not clear from the restoration estimates whether this includes removal of all equipment or partial removal of platforms and/or platforms and wells.

3.2 North Sea Analogues

The water depths of the existing New Zealand assets are similar to UK North Sea assets. The UK North Sea assets are more numerous with 153 projects projected for restoration over the next decade. The UK cost estimates for restoration cover smaller shallow (~40 m) and larger, deeper (~110 m) facilities, and state a restoration cost of £17.6 billion (NZ$31 billion)[8]. This includes restoration activities of:

- Well plugging and abandonment;
- Facilities and pipelines making safe and topside preparation;
- Topside and substructure removal;
- Subsea infrastructure decommissioning;
- Pipeline decommissioning;
- Onshore recycling and final disposal; and
- Site remediation and monitoring.

The Insight Oil & Gas UK (2016) reports 894,000 tonnes of facilities, platforms, pipelines and subsea equipment to be removed or decommissioned. This gives an approximate restoration cost of £20,000/tonne (NZ$35,000/tonne). **Table 4 Error! Reference source not found.** describes New Zealand's existing offshore oil and gas infrastructure. The total tonnage is 40,100 tonnes, giving a restoration cost estimate of $1.40 billion for the New Zealand facilities based on the UK costs per tonne of materials.

[8] 2016 Decommissioning Insight Report, Oil and Gas UK

Fields	Māui		Tui	Maari	Kupe
	Māui A	Māui B			
Water Depth	108 m	108 m	120 m	100 m	34 m
Infrastructure	11,800 (T) Jacket & 9,000 (T) Topside Manned Platform, 14 wells, two 35 km submarine pipelines to onshore production facility	5,000 (T) Jacket & 3,300 (T) Topside. Unmanned Wellhead Platform), 12 wells, 15 km submarine pipeline to Māui A	Five Subsea Wells and FPSO Umuroa	10,000 (T) Unmanned Wellhead Platform and FPSO Raroa	1,000 (T) Unmanned Wellhead Platform, 5 wells, subsea pipeline to shore

Table 4: New Zealand Offshore Infrastructure

This is around 59% of the $2.39 billion estimated using company annual reports. The reasons for the discrepancy could be:

- Mobilisation of the large restoration vessels from overseas ports is not included in the UK estimate. Specialist equipment companies are nearby and highly active in the North Sea. Mobillisation costs will form a large part of the cost for New Zealand restoration costs.
- Training and workforce development costs are potentially higher for the New Zealand restoration.
- New Zealand estimates may assume the need for development of new restoration infrastructure onshore.
- Operating costs to keep facilities functional during decommissioning are not explicitly covered in the UK report.
- UK oil and gas operators are able to obtain derogations to enable them to partially abandon offshore structures. This may explain the lower unit cost for restoration because the facilities removed are less than the total in place structures.

3.3 Government Estimates

Hansard[9] reported that on 21 March 2017, Hon. Judith Collins advised Parliament that "..*the Crown will typically rebate between 42 to 48 percent of decommissioning costs to petroleum producers, and the Ministry of Business, Innovation and Employment has estimated the total cost to the Crown for all fields is between $800 million and $855 million over the next 25 or so years,* .." On this basis, total decommissioning costs estimated by the New Zealand government can be inferred to cost between $1,670 million to $2,040 million.

9 https://www.parliament.nz/en/pb/hansard-debates/rhr/document/HansS_20170321_053700000/12-offshore-oil-and-gas-rigs-decommissioning-cost

4 Define the Status Quo and Policy Option(s)

The status quo is:

1. there are five groups of producing oil and gas fields with petroleum structures and associated subsea and well infrastructure; and
2. New Zealand is signatory to a range of international accords which outline how to deal with these obligations including UNCLOS and IMO's 1989 requirements.

There are three simple policy options which can be explored.

4.1 Policy Option 1 – Total Removal

The following activities are assumed as elements of this policy:

- Wells will be abandoned to just below the seabed using cement and specialist plugs as required under the Health and Safety at Work (Petroleum Exploration and Extraction) Regulations 2016.
- FPSOs will be sailed away overseas for sale, re-use or recycling.
- Platform topsides will be made clean and safe by removing trace chemicals, oils, gas and condensate and normal industrial chemicals. They will then be sold intact or as scrap, either within New Zealand or overseas. The topsides and equipment will be lifted clear of the platform jackets using heavy lift vessels.
- The major subsurface structures and platform jackets will be cut into sections and removed from the seabed using heavy lift vessels. In shallow water, jack-up drilling rigs are likely to be used to decommission smaller platforms (Kupe and Pohokura) as the jack-up rigs will be required onsite to abandon the wells.
- The mooring systems, pipelines and umbilicals will be made clean and retrieved with pipelay or heavy lift vessels.

4.2 Policy Option 2 – Structural Partial Removal to 55m Below Sea Level

The 1989 Requirements of the International Maritime Organization, of which New Zealand is a member state, says in regard to installations and structures.

"*Any abandoned or disused installation or structure, or part thereof, which projects above the surface of the sea should be adequately maintained to prevent structural failure. In cases of partial removal referred to in paragraphs 3.4.2 or 3.5, an unobstructed water column sufficient to ensure safety of navigation, but not less than 55 m, should be provided above any partially removed installation or structure which does not project above the surface of the sea*".[10]

This requirement has been adopted as part of national guidelines in other jurisdictions to ensure navigability, while saving costs for oil and gas companies and providing local reefs for the fishing industry, recreational fishers and divers. It would also allow leaving the cleaned pipeline, mooring cables and umbilicals in place and would require abandonment of the wells in accordance with Health and Safety at Work (Petroleum Exploration and Extraction) Regulations 2016.

[10] Resolution A.672(16) of IMO, 1989

The following activities are assumed as elements of Policy Option 2:

- Wells will be abandoned to just below the seabed using cement and specialist plugs as required under the Health and Safety at Work (Petroleum Exploration and Extraction) Regulations.
- FPSO vessels will be sailed away overseas for re-use or recycling.
- Platform topsides will be made clean and safe by removing trace chemicals, oils, gas and condensate and normal industrial chemicals. They will then be sold intact or as scrap, either within New Zealand or overseas. The topsides and equipment will be lifted clear using heavy lift vessels.
- The major jacket structures will be cut into sections and removed from surface to 55m below sea level. This would be done using heavy lift vessels. In shallow water, jack-up drilling rigs are likely to be used to decommission smaller platforms (Kupe and Pohokura).
- The mooring systems, pipelines and umbilicals would be cleaned and left *in situ*.

In this policy setting we estimate a cost of leaving structures in place to be 50% of the offshore restoration cost. This is premised on a high level 50/50 weight split between topsides and jackets.

4.3 Policy Option 3 – Sell for Alternative Use

If the infrastructure were sold *in situ* for a nominal sum, e.g. $1 for each facility, a range of re-use options may be possible, with some examples shown below:

- Gas hub for further discoveries (Pohokura, Kupe, Maui pipeline infrastructure);
- Carbon sequestration opportunities (Pohokura, Kupe, Maui pipeline infrastructure);
- Aquaculture;
- Tourism (e.g. whale watching, recreational fishing);
- Commercial fish opportunities; and
- Another use (e.g. marine energy, hotels/casinos).

The activities to achieve alternate re-use of the platforms include:

- Wells will be abandoned to just below the seabed using cement and specialist plugs as required under the Health and Safety at Work (Petroleum Exploration and Extraction) Regulations.
- FPSO vessels will be sailed away overseas for sale, re-use or recycling.
- Platform topsides will be made clean and safe as clean “land”. The topsides and equipment will be lifted clear using heavy lift vessels to leave jackets standing. A flat platform could then be put in place to provide a building base for alternative uses.
- The pipelines will be made clean and left in place.

In this policy setting we estimate a cost of leaving structures in place to be 20% of the offshore restoration cost.

5 Who Benefits and Who Loses?

5.1 Oil and Gas Companies

Oil and gas companies (should) have received market returns on their oil and gas investments. "Part of the deal" is the subsequent restoration obligation which comes at the end-of-field life for oil and gas assets. The annual reports we reviewed show the current operators are committed to discharging this obligation and have already accounted for this on their balance sheets and the costs to companies should therefore be neutral.

Shell[11], holder of the largest restoration obligation, explains the "*abandonment provision recognises the present value of the estimated liability for decommissioning the field assets. The amount recognised is based on present day cost estimates adjusted for inflation to the estimated date of decommissioning and discounted to balance date. The timing of outflows associated will occur when the field is decommissioned which is dependent on the level of economically recoverable reserves. This is expected to occur between 1 to 20 years from balance date.*[12]

The major uncertainties affecting the amount and timing of cash outflows are dependent on the continuing economic life of the individual producing assets which are difficult to accurately forecast."

Shell consider that for abandonment costs, a "*provision for the full cost expected to be incurred at the end of the life of each asset on a discounted to net present value basis is recognised at the beginning of each project and capitalised as part of the cost of the asset. The capitalised cost is amortised over the estimated life of the asset and the annual increase in the net present value of the provision for the expected cost is included in finance costs*."

If the cost goes above their provision they can be said to "lose". Alternatively, if the cost decreases or the field continues to produce better than planned, they can be considered to "win".

5.2 Crown

Based on the Shell comments in 5.1 on how it has amortised the abandonment cost over the life of the field, the Crown has received lower taxes and royalties. They have therefore contributed to the restoration fund via tax timing.

Where companies have not done this, the Crown will repay tax at the time of restoration. This is outlined by Hulbert[13], who recognised that:

- Current tax policy intent is to provide tax deduction benefits to petroleum miners; and
- Inland Revenue's proposed alternative tax credit model allows a refundable tax credit in the year decommissioning costs are incurred.

Alternatively, there will also be income and withholding taxes payable to the Crown during the decommissioning phases. These taxes come from local contractors and offshore contractors involved in restoration projects.

[11] Shell FY2016 Annual Report, Companies Office, www.companies.govt.nz
[12] Kapuni and Maui are short term, Pohokura is a longer-term obligation}
[13] Brent Hulbert at 2017 Petroleum Conference

5.3 Decommissioning Industry

Significant restoration industries have developed in other global jurisdictions. When restoration activities begin in New Zealand, there are likely to be significant local economic benefits. The most direct beneficiaries would be those marine service companies that provide equipment to offload and remove large structures. This includes drilling vessels for restoration of the wells, heavy lift vessels for the topsides and jacket recovery, and pipeline vessels for the pipeline recovery. In the absence of an existing New Zealand industry and the intermittent nature of any restoration activities, these industry contractors are expected to be predominantly based overseas and would only be present in New Zealand while works were undertaken. These companies are expected to engage a large number of smaller service companies and personnel. The restoration process is similar to large engineering projects, in reverse. However, we expect the high cost of mobilisation of “de-installation” vessels to New Zealand will make these projects more expensive than in other jurisdictions. In the absence of specific data or examples for New Zealand restoration, the assumption used in the economic model is that the decommissioning will be split 30% local and 70% international.

5.4 Commercial Fisheries

Commercial fisheries in New Zealand operate under a quota system managed by Ministry of Primary Industries (MPI). At its simplest, a Total Allowable Commercial Catch (TACC) is set for each Fisheries Management Area (FMA) for various fish species. The intent of the system is to ensure that the fisheries are managed in a sustainable manner. Fisheries Management Area 8, as shown in Figure 3 is the area, and includes all of the Taranaki existing oil and gas offshore infrastructure.

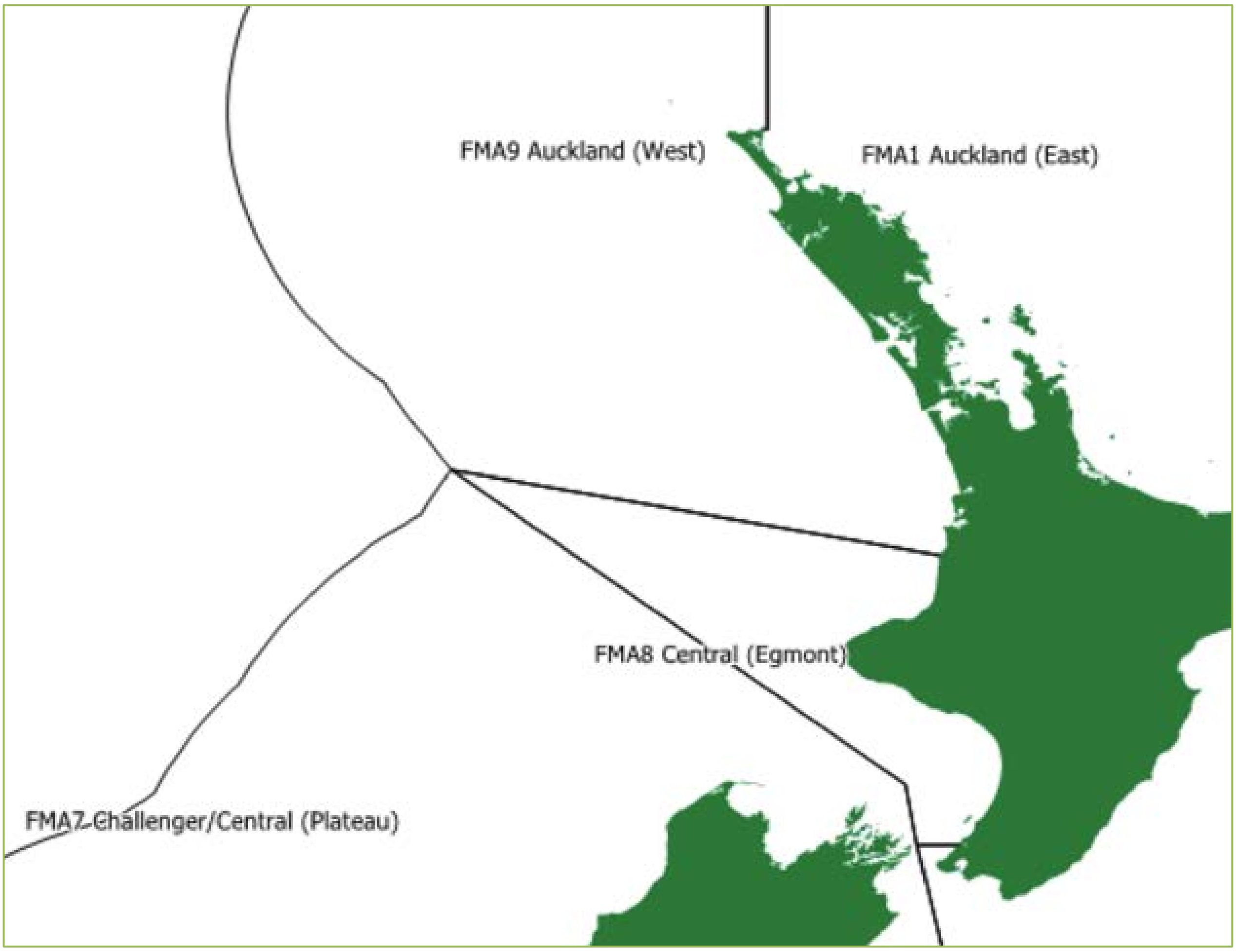


Figure 3: Fishing Management Areas around Cape Egmont.

An estimate of the value of this fishery has been made using Talley's fishing catch data[14]. The catch and value of the Talley's fishing is presented in **Error! Reference source not found.**. Talley's "caught "[15] 2,700 tonnes with a market value of $7.2 million. The biggest fish catch is the deepwater Jack Mackerel and the most valuable is Snapper. The TACC is the total quantity of each fish stock that the commercial fishing industry can catch in a given year. These figures were then applied to the FMA 8 catch estimate of 39,556 tonnes to give an estimated market value of $132 million as shown in Table 5.

[14] presented by Douglas Saunders-Loder at the Trans Tasman Resources EPA hearing during 2017
[15] Caught means caught by the party and/or someone else who caught the quota on behalf

Species/Area	Tonnes	% of TACC	Quota Price $/tonne	Talley Value ($'000)	FMA8 Tonnes	FMA8 Value ($'000)
Blue Cod	7	20.5%	5,000	34,9	34	171
Flatfish	39	5.4%	3,500	138	730	2,554
Gurnard	202	37.2%	4,000	810	544	2,176
Jack Mackerel	1,900	5.8%	1,000	1,900	32,759	32,759
Leather Jacket	321	28%	1,500	481	1,146	1,719
Red Cod	39	6.3%	3,000	117	620	1,858
Rough Skate	3	14.4%	2,500	8	21	53
Snapper	50	3.8%	60,000	2,977	1,306	78,354
Terakihi	21	9.2%	6,000	125	227	1,359
Trevally	117	5.4%	5,000	586	2,170	10,852
TOTAL	2,700			7,177	39,556	131,854

Table 5: Talley's catch data (Column 1-5) and extrapolation for FMA 8 (columns 6-7)

Figure 4 shows the size of the navigation exclusion zones at Kupe to Maari, Maui, Tui and Pohokura clockwise from bottom right. Fishing vessels are not allowed to enter, to fish, or anchor over these areas.

The NZ maritime charts NZ45 and NZ443 advise that the "*offshore gas production and pipelines areas are Safety Zones. The unauthorised entry of any vessel into the 500 metre safety zones around Maui A & B, Kupe, Pohokura and Maari production platforms, the FPSO Raroa and the FPSO Umuroa is prohibited. All vessels are prohibited from anchoring or fishing within the Protected Area of the gas pipelines to Maui A & B, Kupe, Pohokura and Maari production platforms, the FPSO Raroa and the FPSO Umuroa. The gas pipelines from Maui A & B, Pohokura and Kupe production platforms contain flammable gas under high pressure; any vessel damaging them would face an immediate fire hazard*".

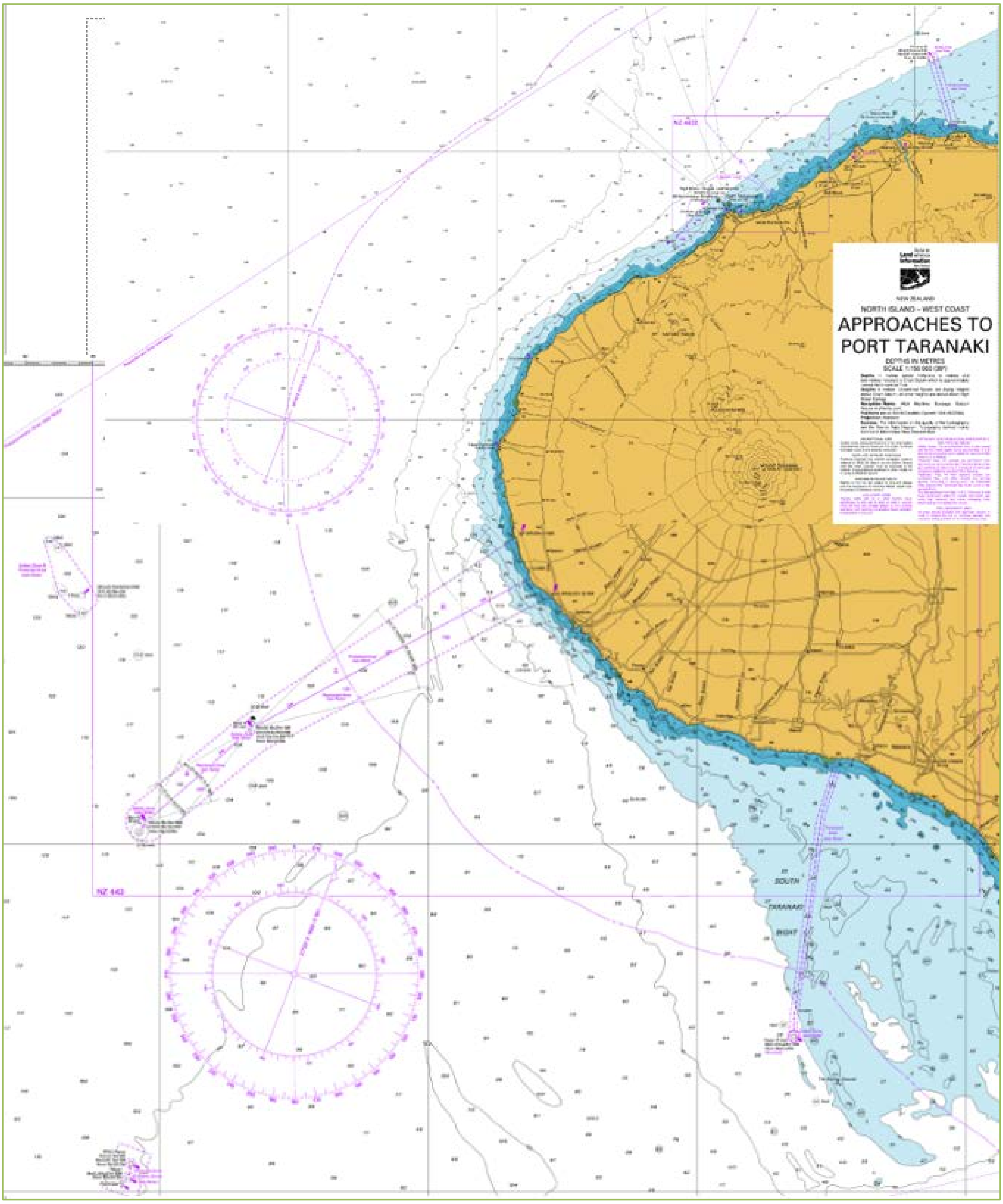


Figure 4: Navigation / fishing exclusion zones in the Taranaki Bight (NZ45 & 443 Extract)[16].

[16] http://www.linz.govt.nz/sea/charts/paper-charts/nz202-chart-catalogue/nz45

The area of these exclusion zones comes to approximately 392 km^{2}, with Maui the largest at 296 km^2. The area of FMA 8 is approximately 29,600 km^2. Therefore, the combined exclusion zones account for 1.3% of the total FMA 8.

The simplest assumption is that when the exclusion zones are removed, a proportional increase in fishing would be realised. On this basis, the TACC would be increased by 1.3% and an additional 520 tonnes/annum of fish worth $1.7 million/annum would be caught.

Conversely, the exclusion zones may represent an "easement" that some marine industries would like to use for protecting their "to be developed" aqua-farming. There is currently no aquaculture in the region so this could be a new industry in the region, and may be viewed as a social benefit by some members of the community. This has not been explored with potential aquaculture parties and is purely hypothetical.

Initial discussions[17] with local inshore set net fishermen indicate that the removal of the zones would provide no benefit in terms of catch improvement or cost reduction. Alternatively, crayfishers have indicated that removal might greatly improve their catch and reduce costs.

5.5 Recreational Fishers and Divers

Leaving structures in place may represent a new diving and fishing opportunity for recreational users within Taranaki. Both Pohokura and Kupe are shallow enough (<40 m) to be readily accessible for diving if left in place, even though Kupe is 30 km offshore.

The benefit from access to a new reef structure at Pohokura and/or Kupe could be expected from increased access to marine life. Maui A and Maui B, are far offshore and access would be limited by generally severe offshore sea conditions. Maari and Tui will have no structures following restoration.

5.6 Marine Mammals

Marine mammals routinely pass by, and seals in particular 'frequent' oil and gas infrastructure. The presence of artificial islands (structures) and equipment will probably not have a major impact on these mammals but it may provide a basis for marine mammal watching. Whether these structures can maintain a business which can afford to maintain the structures is considered unlikely.

5.7 Iwi

Cultural considerations are part of decision-making and, along with environmental considerations, are valued as equally as other considerations such as economic factors (at least decision makers attempt to make that value equal).

We understand that several iwi may have a cultural or historical expectation that everything that was put in place is to be completely removed (or that people leave an area better than they found it). There also seems to be an expectation that cost should not be the deciding factor in whether structures are removed or left in place. (This is currently unverified and constitutes a key part of the next phase of the project).

[17] Facilitated by Keith Mawson, Egmont Seafood

6 Identifying and Valuing the Costs and the Benefits

The costs and benefits, where quantifiable, are dependent on the policy setting. The three major points in a spectrum of policy settings are:

1. Policy 1 – Complete Removal.
2. Policy 2 – Partial Removal.
3. Policy 3 – Alternate Use.

6.1 Oil and Gas Companies Restoration Costs

The costs associated with restoration of oil and gas infrastructure are outlined in **Error! Reference source not found.**. This is broken down by field and is split out by policy setting.

Breakdown of Costs ($ million)	Maui	Maari	Tui	Kupe	Pohokura	Total
Policy 1 – Full Removal	1,560	281	117	258	201	**2,416**
Policy 2 – Partial Removal	1,092	230	99	194	151	**1,765**
Policy 3 – Alternate Use	811	201	89	155	121	**1,376**

Table 6: Restoration costs in NZ$ million broken down by field and infrastructure type (estimated from available Company Annual Reports)

As mentioned previously, Policy 2 and Policy 3 costs are estimated by assuming 50% and 20% respectively of the offshore costs are borne by the restoration operation.

The probable Maari offshore costs are estimated to be much lower than the Maui costs because the platform is re-useable[18]. The bottom of the platform is a large suction pile which is designed to enable refloating, facilitating recovery and reuse. The Maui platforms are pile driven jackets with topsides placed on top. The Maui jackets will require cutting of the jacket legs while a heavy lift vessel recovers the jacket.

The other scope which has a strong bearing on decommissioning is the well abandonment. All of the policy settings assume the wells must be abandoned in accordance with good international practice and New Zealand regulations.

6.2 Crown

The Crown has provisions for both tax and royalty credits. On the basis that the company tax rate is currently 28% and that royalties average between 5 and 20%, we have treated these as negative transfers from oil and gas companies to the Crown.

The Crown will benefit if more production occurs than currently appraised or restoration costs are smaller than estimated.

[18] Author's industry experience

6.2.1 Income Tax

New Zealand Income tax for petroleum restoration is currently being updated in the Taxation (Annual Rates for 2017–18, Employment and Investment Income, and Remedial Matters) Bill. The change is summarised as follows:

"*At the end of production, a petroleum miner must incur significant decommissioning costs. …. To reduce compliance and administration costs, the Bill proposes to replace the existing spread-back mechanism for petroleum mining decommissioning expenditure with a refundable tax credit. This will be similar to other refundable tax credits already included in the Income Tax Act 2007, most relevantly the refundable tax credit for mineral mining rehabilitation expenditure, which was introduced in 2014*."

The Crown will therefore issue tax credits to decommissioning miners at 28% of the cost of the restoration.

6.2.2 Royalties

New Zealand Petroleum and Minerals (NZPAM) administer the royalty regime for petroleum permits or licences.

The actual costs for decommissioning are allocated using a spread-back mechanism which is covered in sections 23 and 26 of the 2013 Royalty Regulations.[19] This allows for the larger of a 5% *ad valoreum* royalty (AVR) or 20% accounting profits royalty (APR).

Ad valoreum royalty is applied to the product revenue.

Accounting profits royalty are applied to the revenue after deducting expenses and depreciation.

For licences issued prior to 1995, these have individual royalty agreements in place which allow a provision for decommissioning to be claimed throughout the life of the asset (based on the percentage of total production to date divided by total expected production). These calculations are supported by independent third-party estimates of the decommissioning costs. These royalty rates are generally AVR 5% (Maui) and 10% (Kupe).

We have used an average royalty claim back of 10%.

6.3 Offshore Restoration Industry

The offshore industry can be expected to benefit from the restoration work as income. This is the opposite of the cost outlined in section 6.1 and consists of $2,416 million for Policy 1, $1,765 million for Policy 2 and $1,376 million for Policy 3. We estimate that 70% of all costs will be spent on offshore (overseas) organisations and 30% to local organisations.

We estimate that 70% of the restoration spend will be on overseas contractors with heavy lift vessels, supply boats, pipelay vessels and drilling rigs. Non-Resident Contractor Withholding Tax of 15% is assumed to apply for the Crown's benefit.

The estimated remaining 30% is assumed to be spent locally on subsidiary services such as personnel and materials from local suppliers. Accounting for personnel PAYE and income tax effects, we estimate another 15% tax on these goods and services.

[19] www.legislation.govt.nz/regulation/public/2013/0126/latest/whole.html#DLM5156989

The restoration industry will therefore be a contributor to the tax base. In our modelling, the non-resident contractors and resident contractors contribute $224 million (Policy 1), $164 million (Policy 2) and $128 million (Policy 3) in taxes.

6.4 Commercial Fisheries

We have considered whether fisheries would benefit or be disadvantaged from the removal of offshore oil and gas infrastructure and exclusion zones. Using the assessment in section 5.4, we allocated a benefit of $1.7 million/annum once the infrastructure is removed. This applies to all three policies **unless** Policy 3 results in the retention of marine exclusion protected gas export activities via the pipelines.

6.5 Recreational Fishers and Divers

We were unable to value the recreational fishers and divers. For the three policy settings:

- There would be no benefit for Policy 1 as no accessible infrastructure is created;
- There would be some benefit for Policy 2 as some artificial structures may remain; and
- The benefit for divers and fishers is unknown for Policy 3 as it depends on the alternative use chosen.

6.6 Iwi

If Policy 3 was a profitable iwi owned enterprise, there could be benefits to iwi.

If Policy 2 enhanced fisheries and the fishing licenses are iwi owned, there would be benefit to iwi.

Policy 1 benefits iwi who value a clean sea bed as a promise.

7 Discount and Compare the Costs and Benefits

It is possible to value future cash flows to today's money using discounting. This recognises that $100 today is worth more than a $100 next year. Using a 7% discount rate means that the $100 in a years' time would only be worth $93 today i.e. $100/(1+0.07). The present value of receiving two payments of $100, one now and one a year later, would therefore be worth $193 in today's money.

We completed discounted cash flow analysis by placing the restoration costs at the time they are estimated to occur and applied the 2016 New Zealand Treasury discount rate for energy industry cost benefit analysis of 7%[20].

The end of field life dates for our model have been taken from the MBIE Energy 2017[21] collation of oil and gas companies estimates of their end-of-field lives, namely:

- Tui 2019
- Maui 2022
- Maari 2023
- Kupe 2034
- Pohokura 2049

The Costs (-ve) and Benefits (+ve) are outlined in **Error! Reference source not found.**. This shows that the oil and gas operators, followed by the Crown, are the biggest contributors to restoration costs. The major beneficiaries are the restoration industry, including New Zealand industry player, which may grow to service these projects.

The tax impacts have been addressed as the Crown is a major contributor to the restoration but also a beneficiary through income and non-resident withholding tax accruing from the projects.

The discounting has a reasonable impact on the assessment as some projects are very far out (Pohokura end of life at 2049). By far the biggest restoration amount is Maui, which occurs in 2022.

[20] www.treasury.govt.nz/publications/guidance/planning/costbenefitanalysis/currentdiscountrates
[21] www.mbie.govt.nz/info-services/sectors-industries/energy/energy-data-modelling/publications/energy-in-new-zealand

Affected Party \ Policy	Policy 1 - Total Removal		Policy 2 - Partial Removal		Policy 3 - Alternate Use	
		Benefit (Cost)		Benefit (Cost)		Benefit (Cost)
Operators	**$**	**(934)**	**$**	**(680)**	**$**	**(529)**
Crown	**$**	**(432)**	**$**	**(315)**	**$**	**(245)**
Decommissioning Industry	**$**	**1,280**	**$**	**932**	**$**	**725**
Fisheries	**$**	**20**	**$**	**20**	**$**	**20**
Recreational Marine Users		**N/D**		**N/D**		**N/D**
Iwi		**N/D**		**N/D**		**N/D**
Purchaser		**N/D**		**N/D**		**N/D**

*N/D - not determined

Table 7: Discounted Cashflow Summaries for Decommissioning Policy Settings (NZ$ million).

8 Discussion and Conclusion

Presently, the status quo is the presence of five groups of oil and gas infrastructure in the offshore waters from Taranaki. Policy options that can be applied for restoration at the EOL are total removal (Policy 1), partial removal (Policy 2) or alternative use (Policy 3).

We have used three sources for estimating the restoration costs for each field by looking at:

1. oil and gas companies' annual reports for restoration provisions;
2. cost per tonne estimates from the UK North Sea; and
3. the Crown's estimate of its decommissioning exposure.

Overall, these costs are considered to paint a good picture of the correct order of magnitude for New Zealand's restoration cost.

The expected timing for restoration shows a wide date range from 2019 to 2049 (30 years). The median around this activity however is driven by Maui and Maari which are forecast to occur in 2022 and 2023 respectively and represent $1,841 million of the total $2,416 million restoration spend (Policy 1).

When the timing of the expenditure, the tax and royalty transfers and time value of money are accounted for in the discounted cashflow model, the net benefits and effects are calculated as shown in **Error! Reference source not found.**.

Affected Party	Policy 1 Total removal	Policy 2 Partial removal	Policy 3 Alternative use
Oil and gas companies	(934)	(680)	(529)
Crown	(432)	(315)	(245)
Restoration industry	1,280	932	725
Commercial fishers	20	20	20

Table 8: Net Benefit for varying parties under three policy settings (NZ$ million)

The three main industry groups benefitting from or funding offshore restoration work are;

1. Oil and gas companies (funder).
2. The Crown (net funder).
3. Restoration Industry (beneficiary).

Commercial fishery groups operating in FMA 8 are expected to be small scale beneficiaries over the next 30 years.

9 Glossary

APR	accounting profits royalty (usually 20%).
AVR	ad valoreum royalty (usually 5%).
FPSO	Floating Production Storage and Offloading vessel.
Maui	NZ's largest gas field.
MPA	Maui Platform Alpha.
MPB	Maui Platform Beta.
mmbbl	million barrels of oil.
NZPAM	NZ Petroleum and Minerals.
PJ	Petajoule (10^{15} Joules) – measure of energy.
PPB	Pohokura Platform B.

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Note: A lot of information sourced from stos.co.nz is being transferred to shell.co.nz following the name change of Shell Todd Oil Services to Shell Taranaki Limited in August 2017.

END OF DOCUMENT

National Science Challenges
“Sustainable Seas”

National Science Challenges SUSTAINABLE SEAS Ko ngā moana whakauka

Focus Group Discussions with Recreational Marine Users

Re-use of offshore infrastructure and platforms: Assessing value to communities, industry and the environment

March 2018

Author(s): K Bromfield & C Lau

Rev 0

Elemental Environment

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Introduction

The aim of this project was to discuss risks and benefits of different decommissioning options with three types of stakeholder groups in the Taranaki region: recreational marine users (e.g., divers and fishers), commercial marine users (e.g., commercial operators and fishing charters), and general community members. We recruited participants for focus groups by initially emailing invitations to community clubs and/or organisations, and followed up with a phone call if there was no response. We contacted six recreational clubs, five commercial operators, and two community clubs, of which the majority did not respond, discontinued communication after initial contact, were not interested, or were no longer operating. As a result of time restraints, we only managed to run one focus group with recreational marine users with two participants. Given the importance of stakeholder perspectives, we urge a more extensive engagement process in the future or investigate why there is a barrier to engagement on this topic.

Our focus group with recreational marine users gave us valuable insight into their decision-making process. During the focus group, participants were provided with information about the structures and given a summary document based on the existing (albeit limited) research conducted by our project team on the environmental, economic, and social consequences of decommissioning options. As the discussion unfolded, preferences for decommissioned structures changed. Although initially inclined towards complete removal, participants began to discuss the potential for re-use to benefit the community. However, after recognising and discussing the risks involved, their opinion reverted back to support for complete removal as it is the most realistic option. Their thoughts, as well as their recommendations for future engagement and research, are summarised below. It should be noted that, since we only engaged with a limited number of individuals, we cannot easily generalise these perspectives but they do provide us with a good starting point.

Decommissioning Options: Benefits and Risks

Re-use

Participants noted that if the structure was re-used, it would have to become a commercial operation due to the costs involved. It is also a priority to participants that whatever the structure is converted into provides benefits to the community. However, if leaving the structures in-situ harms the marine environment, this option would be unacceptable.

Ideas were proposed to convert the structures for diving tours and/or observation decks for marine life. This is based on accounts from our participants' associates who have worked on the rigs and told "magical" stories about the marine mammals that circulate the platforms. However, as the logistics of re-use are explored, the participants question its feasibility due to concerns outlined below.

Accessibility

Participants noted that the structures cannot be easily accessed because they are located too far out at sea and often, the ocean conditions are too rough. They said that recreational boaters can generally go 22 km offshore but only in very calm sea conditions and, if lucky, this is limited to 20-25 days of the year. This is an issue because the closest structure is Kupe which is situated 35 km from shore. There is also a limited period between tides that people can take their boat out and come back. It is recognised that one way to reach the structures is by helicopter (usually used to carry rig workers). This would require helicopters that carry specialised equipment (e.g., safety gear, exposure suits) and are designed for flying over the rough ocean conditions. Highly trained staff would also need to operate on the helipad with harnesses. This means that the structures would still not be accessible to everyone as trips would be expensive and would require individuals to undergo training.

Safety

The participants recognised that a tourist venture on the structures is associated with a myriad of health and safety issues. They noted that some members of the club who have worked on the rigs have talked about how dangerous it is to work on them, and how they must be extremely aware of themselves and everyone else working around them to ensure their safety. Participants also believe that there is a high potential for accidents given the height of the platform and the surrounding ocean conditions, and were also concerned about parts of the structure breaking apart and becoming hazards. Moreover, it is recognised that emissions at the Kupe rig (the closest offshore platform) already breach air quality standards, so a tourism venture would not be favourable in these conditions. One participant states, “if you’re going out on holiday, the last thing you want to be thinking about is your own safety.”

Liability

Participants raised concerns about oil and gas operators no longer being liable for the structures if they were re-used. In particular, this refers to ongoing maintenance which could cost up to one million dollars per year. Our participants state that it is unlikely that the community or a commercial operator could afford this cost. Re-use then would only be supported if oil and gas operators agree to an insurance coverage for ongoing maintenance, thus ensuring their liability into the future. This is something our participants believed was fair given that complete removal of all the structures could cost up to one billion dollars and maintenance would require up to one million per year, thereby allowing operators to save money. To our participants, if there is (or the risk for) a substantial economic cost to the local or New Zealand government then re-use would be completely unacceptable; “you don’t want to leave the community with a costly problem.”

Complete Removal

Potential consequences of complete removal were provided. However, with the approval of seabed mining in the South Taranaki Bight, participants expressed that relative risks between projects needs to be considered during evaluation. For example, there is a possibility that sound intrusion from removal could affect the behaviour of marine mammals (Jervis, 2017) but participants noted that this noise would be subdued by seabed mining which already operates at the decibel range that blue whales communicate. Additionally, removal of the largest structures would be carried out in the summer over approximately 2-3 years, but approval for seabed mining has been approved for 35 years. Given that the potential negative effects of complete removal are less significant than seabed mining, this option is supported despite these risks.

One participant also recognised that the structures would corrode eventually even if materials were used to prevent it from happening, implying that the structures would have to be completely removed anyway.

The only cost of complete removal acknowledged was that there is potential for the structures to benefit the community, and complete removal would take away this potential. By the end of the focus group, however, participants agreed that the risks of re-use greatly outweigh this potential benefit.

Partial Removal

Participants did not perceive any benefits from partial removal. The only benefit (compared to re-use) is that navigation would be opened up because the jacket would be cut 55 metres below sea level. However, they said that commercial fishers would still hesitate to go near these areas in case they lose equipment which would be costly.

Recommendations

Addressing Research Gaps

Our participants identified information (listed below) that would have been helpful in their decision-making. Ideally, a complete assessment of all risk scenarios associated with all relevant factors in leaving the structure(s) in-situ should be provided.

- Research on how leaving the structures in-situ would affect the marine environment
- Monitoring of marine life at the two closest offshore structures (Kupe and Pohokura)
- More information about what happens during re-use (e.g., tourism possibilities, ongoing maintenance, funding)
- Risk assessment of structure(s) deteriorating or breaking apart
- Expenses to regional council and government

Strategies for Further Engagement

One participant noted that respect for Māori about this topic is paramount. To be respectful, other decommissioning options should only be examined after iwi are consulted and have agreed that there is potential in using the structures for alternative purposes.

Furthermore, our participants believe that lack of knowledge about decommissioning options and the potential opportunities available for re-use is a big issue as “you can’t expect people to make informed decisions running blank.” Education is therefore required as a “community service”. In addition to scientific information (e.g., environmental research), participants argued that community members should be informed about successful partial removal or re-use scenarios in overseas examples. This would stimulate ideas for other possibilities. However, one participant noted that it is important to keep the New Zealand context in mind as not all possibilities are feasible in the New Zealand marine environment.

To explore practicalities of re-use, it is important then to foster discussions among the community as decision-making is not a straightforward process. One participant told us that when they asked other members of the club about their opinion, their intuitive response was to “get rid of it [and] take it back to how it was” but after thinking about it some more, they realised “oh I suppose it could be of use really.” As indicated by our focus group, once logistics and risks of re-use are discussed, preferences might change again. Similar to focus groups, community workshops would be a useful way for community members from diverse backgrounds and skillsets to come together to brainstorm and analyse potential opportunities.

National Science Challenges
“Sustainable Seas”

National Science Challenges SUSTAINABLE SEAS Ko ngā moana whakauka

Iwi Engagement – Summary of Hui Discussions

Re-use of offshore infrastructure and platforms: Assessing value to communities, industry and the environment

March 2018

Author(s): K Bromfield

Rev 0

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Introduction

The iwi representatives we engaged with acknowledged that any post-operational plans and associated clean up will be unique to each structure because each has different oceanographic and environmental conditions and different engineering designs.

On land, decommissioned wells are plugged and the land restored as far as possible to its original condition. Representatives noted a similar expectation at sea, aiming to see an active restoration and a defined period of time over which restoration occurs. Whether this active restoration process involves the complete removal of all infrastructure and restoration to a clean sea bed, or whether any components of the platforms could be left in place during decommissioning, needs careful negotiation between iwi, the operators and the New Zealand government, so that core values are not compromised and Treaty Rights are recognised. This requires consideration of three specific questions during decommissioning planning:

- What are you going to do to restore the environment?
- What are you going to do to appropriately include relevant iwi or hapū in the development and application of decommissioning plans?
- How are you going to ensure core values are not compromised and Treaty Rights are respected?

Iwi representatives noted that initial promises were made to leave a clean sea bed at the end of a well life. Breaking this promise was considered worse by some than damaging the environment during the decommissioning process. However, for most people, the environmental perspective is as important as the cultural perspective because for iwi the environment sits within and is founded on a Māori cultural context.

Pros and Cons Associated with the Option to Leave Some of the Jacket Legs

Representatives are looking for the best culturally and environmentally appropriate solution in the long term. All structures deployed as artificial reefs experience varying rates and degrees of degradation over time. Exposure to major storm events can exacerbate this process. Utilising probabilistic models for corrosion, the lifespan of a cathodically unprotected[1] reefed jacket following toppling will range from ~100 to more than 300 years (Blue Latitudes 2017). A limited number of alternative uses associated with partial removal of topside components have been identified, including recreational fishing and diving, or aquaculture opportunities.

Fishing and Diving

Maori fisheries representatives consider that the structures must provide bait fish with shelter which in turn improves the fishing of predatory fish.

“We’ve observed that the legs, pipelines and cables associated with oil and gas activities attract fish, and provide shelter”.

[1] Cathodic protection: a technique for protecting metal structures, such as steel ships and pipelines, from

For this reason, recreational fishers have expressed the opinion that they might consider having the legs left *in situ*. In addition, recreational divers might enjoy diving on the remains of structures that are closer to the shore or in shallower waters. However, on structures further out to sea and if the legs were cut to 55 metres below sea level, while some commercial fishing activities would be hampered, the commercial shipping lanes would be open again. However, recreational fishers consider that 55 meters is too deep to be useful to them. Therefore, this is likely only a feasible option for inshore structures, and iwi and hapū representatives appear to see no value from leaving the legs and cables from structures that are far offshore *in situ* to serve this purpose.

Aquaculture

Some representatives expressed the opinion that if the structures were cleaned and were not toxic, then iwi owned and operated aquaculture farms could be considered. There was no interest among Māori in having a new and different international company acting as the operator, but there might be support for an iwi led aquaculture venture. Future work in this area would include feasibility studies of the potential to use the structures for aquaculture now and in the future. However, aquaculture would involve a whole range of obligations to engage with other fishing companies, and marine and coastal fishing interests, would require consideration of customary fishing lines, and there would be regulatory and cultural obligations that would need meeting. This type of venture would open a whole new raft of considerations, and is unlikely to get significant iwi support.

Pros and Cons of a Clean Sea Bed

The following feedback was received from one group consulted "*The agreement as we understand it is the environment will be restored to its original state as much as possible. Any environmental benefit would have to be significant to warrant breaking the promise*."

While the representatives we engaged with are encouraged that there are not significant positive or negative biophysical effects on the environment from the platforms and structures, there are polarised views on the potential impact to the mauri[2] of the sea if they were left *in situ.* Some noted concern about disturbing the sea bed when removing structures, while others considered their removal would enable a long term restoration of mauri by the inherent power of the sea. However, overall representatives noted concern about the long term impact of continuing to leave artificial structures in the ocean over time. Although the mauri of the ocean may have an inherent ability to adapt over time, representatives were concerned about at what stage a cultural tipping point might be reached. "*This type of thinking removes our responsibility to tikanga*[3]".

With regards to removing all structures from the sea bed, the promise to restore the environment to its original state is considered paramount. It is therefore imperative that if other options are being considered, iwi and hapū representatives will need to be brought along as decisions are being made.

According to the iwi and hapū representatives we engaged with, decommissioning should mean not just removing infrastructure, but making sure the environment is restored as much as possible.

2 Life force or life principle.
3 The customary system of values and practices that have developed over time and are deeply embedded in the social context

The decommissioning documents provided by operators need to demonstrate how that restoration will happen, including what tests need to be conducted, who signs off, and how long recovery is expected to take. From an intergenerational perspective, it might be better to remove all structures, and allow the environment to restore itself given time and the appropriate conditions. Conversely, the slow break down over time may be a better way to avoid short-medium term impacts and allow the environment to re-establish.

Option to Re-purpose the Full Platform

The general opinion among iwi and hapū representatives that we engaged with is that placing new and different obligations onto groups who probably cannot meet such requirements in perpetuity, is not an appropriate way to decommission a structure in New Zealand. There would have to be bonds held as financial safe guards, and there is no apparent willingness on behalf of the government to hold these bonds. Repurposing of the topsides would represent a new suite of invasive practices, health and safety obligations, waste management etc. No research station or tourist venture could afford the responsibility of repurposing, and it defers the responsibility of decommissioning to a future time. If any options to repurpose existed, they would have to be financially beneficial to the relevant iwi and hapū groups.

Summary

There is a general feeling that the structures could be cut off and the legs left to decompose slowly in the sea, but our engagement indicates that this is by no means the consensus of iwi in Taranaki. If there is no significant environmental harm from the structures then as a generality, Māori consider that removing them now may do more damage than leaving the legs, pipelines and cables. However, a core value expressed repeatedly is the need to ensure that Māori are a central party in decision-making. The analyses and communication that leads to any particular decision has to be transparent and robust. There must be evidence that all probabilities have been equally assessed, equally weighted and considered.

Ideally, operators would be negotiating with mana whenua[4] on the best options on a case by case basis.

Whatever activity is decided, there needs to be a genuine engagement process that provides ample opportunity for collective agreement. Ideally solutions presented in a decommissioning plan would be co-developed with relevant iwi and hapū groups. This approach is far more likely to lead to an enduring decision-making outcome that meets the needs of communities and industry. Leaving such engagement to the public consultation phase of a regulatory process (such as a marine consent) is likely to create unnecessary confrontation and opposition, which can be costly to all concerned.

[4] Authority over land or territory