NIWA
Taihoro Nukurangi

Assessment of the scale of marine ecological effects of seabed mining in the South Taranaki Bight:

Zooplankton, fish, kai moana, sea birds, and marine mammals

Prepared for Trans-Tasman Resources Ltd

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Executive summary

In 2016 Trans-Tasman Resources Ltd (TTR) intends to re-apply for a consent to annually mine up to 50 million (M) t of iron sands in the South Taranaki Bight (STB) from an area of 65.76 km^2 lying 22 to 36 kilometres offshore of Patea, at water depths of 19 to 42 metres. TTR requested that NIWA develop an overview of the effects of the proposed mining activities on key zooplankton, fish, kaimoana, seabird, and marine mammal species. This overview was required to take into account the spatial and temporal scales relevant to different components of the ecosystem, with a particular focus on addressing uncertainty relating to those effects.

This review of the spatial and foraging ecology of the key fauna occurring in the STB has identified that for all zooplankton, seabird, and marine mammal species, and most fish species, there should be negligible effects of mining 50 M t per annum according to standard evaluation criteria. This is principally because the scale of the mined area and the areas of elevated suspended sediment concentrations (SSC) are small compared to the area used by the populations of these species. Consequently they are likely to be displaced from, or experience a decrease in prey abundance or availability over a very small part of their distribution. For coastal kaimoana species, the proposed mining activity should not add significantly to the levels of suspended sediments currently experienced inshore in frequently turbid waters.

One species, eagle ray, may be affected to a moderate extent. Although the area potentially impacted by mining 50 M t per annum comprises less than 1% of the area of distribution of eagle ray in FMA8, about 8% of its core area of distribution (>50% occurrence) overlaps with the area of SSC elevated above 3 mg/l due to mining activities. Using this threshold, a minor to moderate proportion of the stock could be affected by mining through displacement of fish, or decrease in prey abundance or availability. During summer and autumn eagle rays tend to concentrate inshore in water less than 10 m deep where background SSC may reach over 100 mg/l. This suggests that eagle rays may be tolerant to SSC higher than the threshold of 3 mg/l used to assess the impact of SSC elevated by the proposed mining activities.

1 Introduction

In 2016 Trans-Tasman Resources Ltd (TTR) intends to re-apply for a consent to mine up to 50 million (M) t per annum of iron sands in the South Taranaki Bight from an area of 65.76 square kilometres lying 22 to 36 kilometres offshore of Patea, at water depths of 19 to 42 metres (Figure 2-1). It is proposed that processing of the excavated seabed material would take place aboard a Floating Processing Storage and Offloading (FPSO) vessel and the targeted iron sand would be separated from other seabed material which will be discharged (around 45 million tonnes per annum) to the seabed. While the courser sediments are expected to stay within the mining site, some finer sediments will form a plume of suspended sediment concentrations (SSC) higher than background levels down-current of the mining site (Hadfield and Macdonald 2015). The sediment modelling domain is indicated in Figure 2-1.

TTR requested that NIWA develop an overview of the effects of the proposed mining activities on key zooplankton, fish, kaimoana, seabird and marine mammal species. This overview is required to take into account the spatial and temporal scales for different components of the ecosystem, with a particular focus on addressing uncertainty relating to those effects. Much of the information necessary for this overview already exists in the reports and evidence previously submitted in support of TTR's original application for marine consent[1]. However, the Environmental Protection Authority (EPA) appointed Decision Making Committee (DMC) highlighted areas in its 2014 report[2] where, because of a lack of information, it was considered uncertainty exists. To reduce the uncertainty in the assessment of ecological effects we searched the literature (published and unpublished) for information that may fill the gaps highlighted by the DMC and compiled the material for zooplankton, fished species, seabirds, and marine mammals into a logical format to aid easy understanding of the scale and potential impact of the proposed mining activities in the context of the spatial and foraging ecology of each key species.

The effects of the proposed mining activities on pelagic and benthic primary production are reported separately (Cahoon et al. 2015).

2 Assessment of Impact

The effects or consequences of the proposed mining activities were evaluated for each component of the ecosystem being considered and scored using a standardised set of prepared consequence descriptions, ranging from negligible to catastrophic (Table 2-2). These take into account the proportion of habitat relevant to the species or group in question affected by mining activities, the severity of the impact on the population, community, or habitat, and the recovery period once the impact ceases. These standard descriptions were previously used by MacDiarmid et al. (2014) to assess the environmental risk of discharges of sediment during prospecting and exploration for seabed minerals, including iron sands.

[1] See http://www.epa.govt.nz/EEZ/trans_tasman/application/Pages/default.aspx

[2] EXCLUSIVE ECONOMIC ZONE AND CONTINENTAL SHELF (ENVIRONMENTAL EFFECTS) ACT 2012, Trans-Tasman Resources Ltd Marine Consent Decision, June 2014, See http://www.epa.govt.nz/EEZ/EEZ000004/Trans_Tasman_Resources_decision_17June2014.pdf

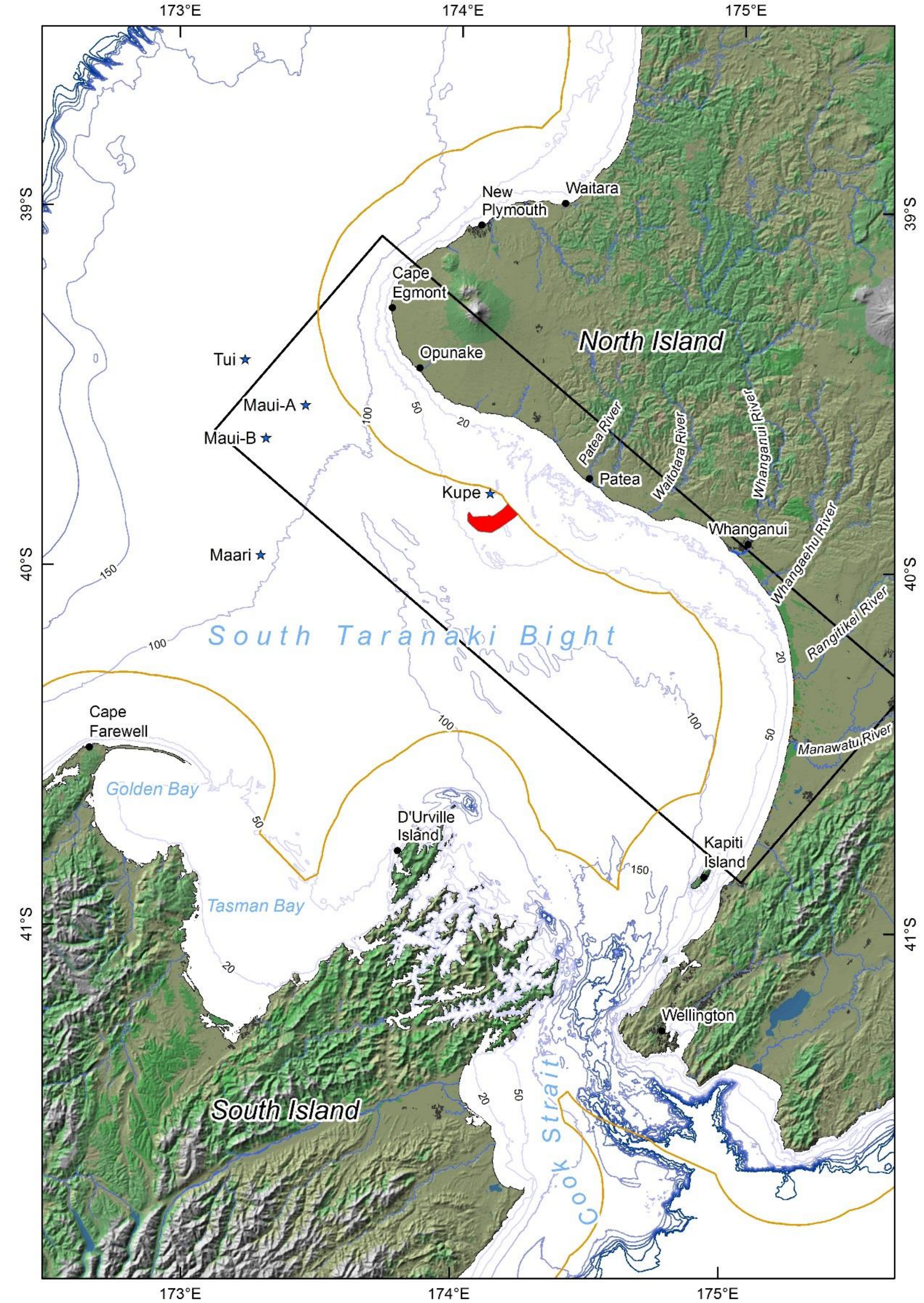


Figure 2-1: Map of the South Taranaki Bight showing the location of the proposed mining area. The bathymetry at various intervals is shown. The proposed mining area is shaded red, while the sediment modelling domain (SMD) is the box outlined in black. The orange line indicates the boundary of the Territorial Sea. Also shown are the towns and villages and the mouths of the principal rivers along the Taranaki and Manawatu coasts. Stars indicated named offshore oil/gas production platforms.

The effects taken into account in this study were clogging of respiratory surfaces and feeding structures of marine organisms, avoidance of the discharge area by mobile species, and reduced availability of prey due to either reduced underwater visibility or a reduction in prey numbers or biomass. The scale of effects will depend on the spatial distribution of ecologically consequential concentrations of suspended sediment compared to scale of distribution of the species or group in question and the capacity of different organisms to move. This will influence the duration that different organisms will experience the event. It is expected that highly mobile larger invertebrates, fish, sea birds, and marine mammals should be able to move away temporarily from sediment concentrations that cause stress, thus minimising direct effects and speeding recovery. Sedentary or attached species will be more vulnerable to effects occurring at a specific place. Zooplankton will be vulnerable for the period they transit through a plume. The background scale of distribution of organisms varied from the very broad for wide ranging seabirds and marine mammals, to the very constrained distributions of some sedentary or attached kai moana species. These are discussed in more detail in sections 3 to 6 below.

To determine ecologically consequential concentrations of suspended sediment we examined recent reviews of species responses to SSC. Reviews undertaken by Lowe (2013) and Page (2014) identified 2 mg/l as the lowest SCC avoided by pelagic fish and 3 mg/l as the as the lowest SCC avoided by demersal fish. Non-lethal and lethal impacts on fish occur at much higher SSC. Filter feeding bivalves, especially those occurring in naturally turbid environments can compensate efficiently for a decrease in food quality over a wide range of SSC by maintaining an effective preingestive mechanism of selection for organic particulate matter, as well as increasing filtration and rejection rates (Navarro and Widdows 1997). A laboratory experiment has indicated that SSC of 80 mg/l or higher have adverse effects on the condition of the horse mussel *Atrina zelandica* (Ellis et al. 2002). Green-lipped mussels, *Perna canaliculus,* decline in filtration rate only when SSC is above about 1000 mg/l (Hawkins et al. 1999). Concentrations of fine sediment greater than 20 mg/l can clog zooplankton respiratory surfaces and/or feeding apparatus as well as visually impair the ability of zooplankton predators to find prey (Arendt et al. 2011). There are no similar data available for sea birds or marine mammals. Thus we used the 2 mg /l as a conservative minimum threshold for all pelagic species of fish and invertebrates, sea birds, and marine mammals, 3 mg/l as a conservative threshold for all demersal and benthic species of fish and invertebrates. The size of the area where the proposed iron sand mining activities is estimated to elevate suspended sediment concentration above 2 and 3 mg/l s in surface and near-bottom parts of the water column are summarised in Table 2-1. For pelagic species the affected area was estimated based on the average of the surface and near bottom values (60.5 km^2). For demersal and benthic species we used the near-bottom value (47.5 km^2).

Table 2-1: Median area where the proposed iron sand mining activities are estimated to elevate suspended sediment concentration (SSC) above 2 and 3 mg/l s. The estimate was based on the average area of elevated SSC stemming from proposed mining at site A and at site B using the median SSC estimated by Hadfield and Macdonald (2015).

Annual mining volume	Height in water column	Area with SSC elevated above 2 mg/l (km^2)	Area with SSC elevated above 3 mg/l (km^2)
50 M t	Surface	45.3	20.5
	Near-bottom	75.7	47.5

Table 2-2: Consequence levels for the intensity of the activity. Summary descriptions of the six sets of consequence levels for the proportion of the habitat affected, the impact on the population, community or habitat, and the likely recovery period. From MacDiarmid et al. (2014).

Consequence level	Proportion of habitat affected	Population/ community/ habitat impact	Recovery Period
1 - Negligible	Affecting <1% of area of original habitat area	Interactions may be occurring but unlikely to be ecologically significant (<1% changes in abundance, biomass, or composition) or be detectable at the scale of the population, habitat or community	No recovery time required
2 - Minor	Measurable but localized; affects 1-5% of total habitat area	Possibly detectable with 1-5% change in population size or community composition and no detectable impact on dynamics of specific populations	Rapid recovery would occur if activity stopped – less than 8 weeks
3 - Moderate	Impacts more common; >5-20% of habitat area is affected	Measurable with >5-20% changes to the population, habitat or community components without there being a major change in function	Recovery in >2 months to 1-2 years if activity stopped
4 - Major	Impacts very widespread; >20-60% of habitat is affected/ removed	Populations, habitats or communities substantially altered (>20-50%) and some function or components are missing/ declining/ increasing well outside historical ranges. Some new species appear in the affected environment	Recovery occurs in 2-10 years if activity stopped
5 - Severe	Impact extensive; >60-90% affected	Likely to cause local extinctions of vulnerable species if impact continues, with a >50-90% change to habitat and community structure and function. Different population dynamics now occur with different species or groups now affected	Recovery period 1-2 decades if activity stopped
6 - Catastrophic	Entire habitat in region is in danger of being affected; >90% affected/ removed	Local extinctions of a variety of species are imminent/immediate. Total collapse of habitat, community or ecosystem processes. The abundance, biomass or diversity of most groups is drastically reduced (by 90% or greater) and most original ecological functional groups (primary producers, grazers etc.) have disappeared	Long term recovery to former levels will be greater than 1-2 decades or never, even if activity stopped

3 Zooplankton

3.1 Introduction

Zooplankton are animals that spend all (holoplankton) or part (meroplankton – usually larval stages) of their lives in the water column. They range in size from picoplankton (0.2-2 µm) such as bacteria and small eukaryotic protists, medium sized mesoplanktonto megaplankton (> 20 cm) such as jellyfish, ctenophores, salps and pyrosomes (pelagic Tunicata), small squid and large crustaceans. Their classification as zooplankton relates to their limited scale of movement in relation to the water currents that carry them from place to place. In contrast, more mobile fish and squid can move against the prevailing currents. Holoplankton, by virtue of their small size, are usually fast-growing and short lived with generation times of the order of hours (bacteria) to a year (some of the larger crustaceans).

3.2 Available data

Zooplankton communities in the STB were well sampled in the 1970s and 1980s with 90 stations sampled over a period of 13 years (Battaerd 1983, Bradford 1977, 1978, 1980, Bradford and Roberts 1978, Bradford-Grieve et al. 1993) (Figure 3-1). Zooplankton biomass data were collected at 62 stations for all species and for two key species at an additional four stations. Zooplankton species composition data were collected at 79 stations including 55 of the stations at which biomass data were collected. At one station, the Māui A platform, zooplankton species composition data were collected four times over a period of 10 months in 1981 and 1982 (Battaerd 1983). Most of the sampling stations (83%) (Figure 3-1) were over bottom depths of > 50 m. About 17% of zooplankton sampling stations were over bottom depths of < 50 m but few were taken close inshore.

Zooplankton in the STB was most recently sampled on 17-18 February 2015 (MacDiarmid et al. 2015). A 57 cm diameter conical net with 200 micron mesh (similar to the nets used by Bradford-Grieve et al. 1993) was used to sample zooplankton from the sea surface to just above the sea floor at 18 stations along two transects which ran approximately east-west and north-south through the centre of the proposed mining area (Figure 3-2).

3.3 Biomass

Biomass, as wet weight, may be elevated in summer in the STB compared with other near-shore regions around New Zealand (Bradford and Roberts 1978; Bradford 1980). Biomass estimates ranged from 100 to > 8000 mg m^{-3} in mid-January 1980 (Bradford et al. 1986) (top panel in Figure 3-3), 50 to > 300 mg m^{-3} in March 1983 and 50 to > 200 mg m^{-3} in April 1983 (Bradford-Grieve et al. 1993). In mid-January 1980 the highest zooplankton biomasses in the STB occurred east of the proposed mining site and were dominated by the salp *Thalia democratica*.

In mid-February 2015 zooplankton biomasses ranged from 229 to > 9,000 mg m^{-3} with the highest biomass occurring at sites near the proposed mining site and were dominated by the salp *Thalia democratica* (bottom panel in Figure 3-3).

3.4 Species composition

The mesoplankton community in the STB, dominated by omnivorous copepods, was typical of the nearshore zooplankton communities found around the North Island, New Zealand (e.g., Bradford-Grieve et al. 1993). The dominant species found at all sampling sites in the 1970s and 1980s (Maui-A platform, STB proper and Port Taranaki), as well as around the proposed mining site in 2015 were the omnivorous copepods *Oithona similis* and *Paracalanus* c.f. *indicus* (Battaerd 1983; Foster and Battaerd 1985; Bradford-Grieve et al. 1993, MacDiarmid et al. 2015) (see examples in Figure 3-4). Other species and groups that were frequently abundant were copepod nauplii (a developmental stage), the copepods *Microsetella rosea*, *Clausocalanus* spp., *Acartia ensifera*, *Corycaeus aucklandicus*, *Euterpina acutifrons,* and *Temora turbinata* (Battaerd 1983; Bradford-Grieve et al. 1993, MacDiarmid et al. 2015). A number of other species such as krill *Nyctiphanes australis* were consistently present but in smaller numbers. Gelatinous zooplankton such as appendicularians (*e.g.*, *Oikopleura* spp.) and salps (*e.g.*, *Thalia democratica*) were sometimes dominant (e.g., Figure 3-5).

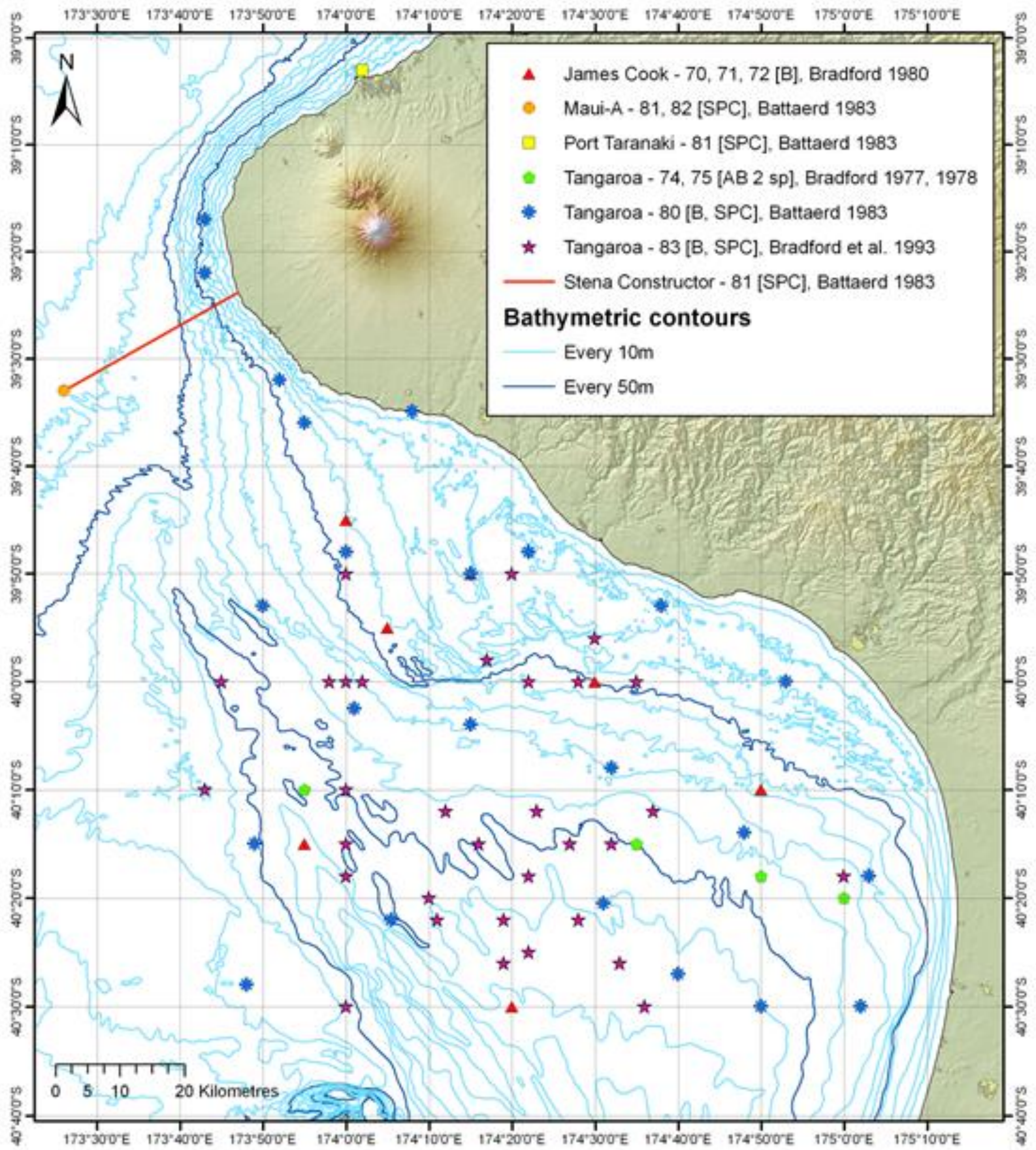
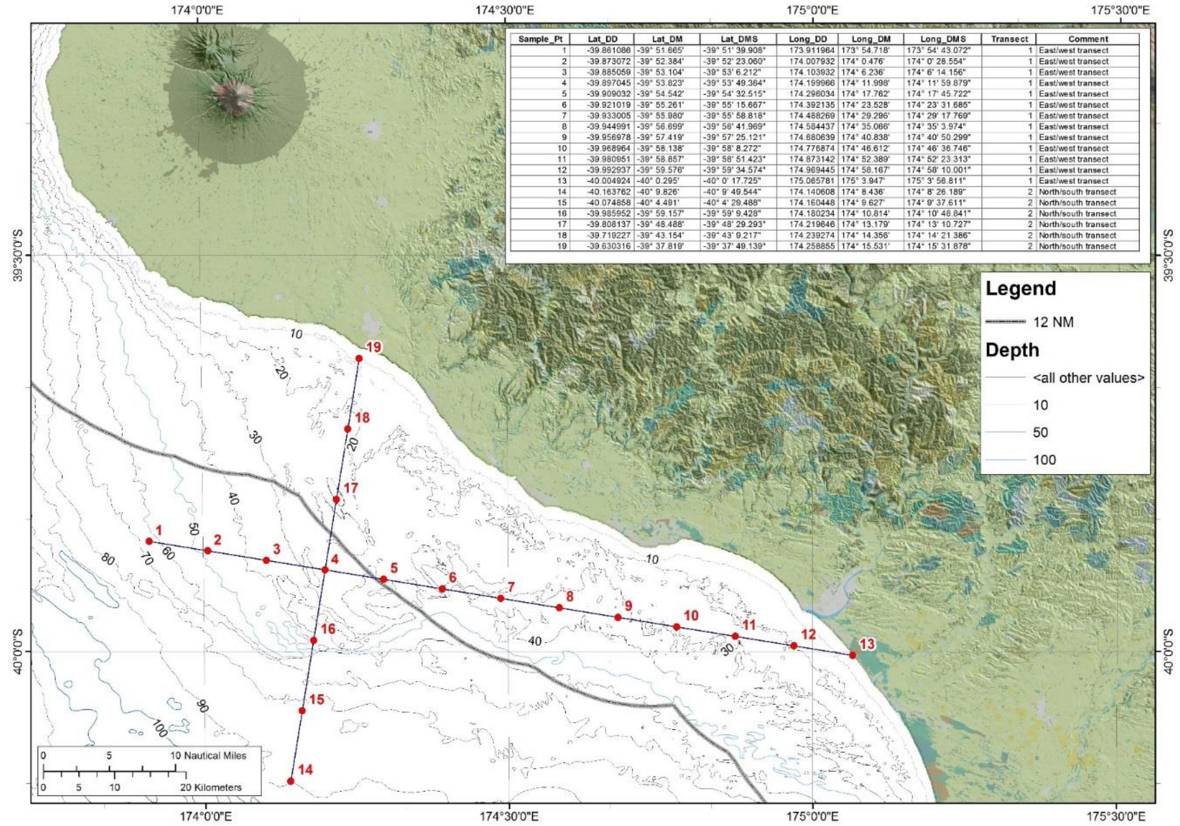


Figure 3-1: Locations in the northern part of the STB where mesoplankton sampling was conducted in the 1970s and 1980s. The legend shows the vessel or location, followed by the year of sampling and the reference. Codes refer to the types of samples that were collected where B=biomass, SPC=species composition, and AB 2 sp=abundance data for 2 individual copepod species. A total of 23 stations were sampled along a transect from Oaonui to the Maui-A gas platform (Stena Constructor).



Sample_Pt	Lat_DD	Lat_DM	Lat_DMS	Long_DD	Long_DM	Long_DMS	Transect	Comment
1	-39.861086	-39° 51.665'	-39° 51' 39.908"	173.911964	173° 54.718'	173° 54' 43.072"	1	East/west transect
2	-39.873072	-39° 52.384'	-39° 52' 23.060"	174.007932	174° 0.476'	174° 0' 28.554"	1	East/west transect
3	-39.885059	-39° 53.104'	-39° 53' 6.212"	174.103932	174° 6.236'	174° 6' 14.156"	1	East/west transect
4	-39.897045	-39° 53.823'	-39° 53' 49.364"	174.199966	174° 11.998'	174° 11' 59.879"	1	East/west transect
5	-39.909032	-39° 54.542'	-39° 54' 32.515"	174.296034	174° 17.762'	174° 17' 45.722"	1	East/west transect
6	-39.921019	-39° 55.261'	-39° 55' 15.667"	174.392135	174° 23.528'	174° 23' 31.685"	1	East/west transect
7	-39.933005	-39° 55.980'	-39° 55' 58.818"	174.488269	174° 29.296'	174° 29' 17.769"	1	East/west transect
8	-39.944991	-39° 56.699'	-39° 56' 41.969"	174.584437	174° 35.066'	174° 35' 3.974"	1	East/west transect
9	-39.956978	-39° 57.419'	-39° 57' 25.121"	174.680639	174° 40.838'	174° 40' 50.299"	1	East/west transect
10	-39.968964	-39° 58.138'	-39° 58' 8.272"	174.776874	174° 46.612'	174° 46' 36.746"	1	East/west transect
11	-39.980951	-39° 58.857'	-39° 58' 51.423"	174.873142	174° 52.389'	174° 52' 23.313"	1	East/west transect
12	-39.992937	-39° 59.576'	-39° 59' 34.574"	174.969445	174° 58.167'	174° 58' 10.001"	1	East/west transect
13	-40.004924	-40° 0.295'	-40° 0' 17.725"	175.065781	175° 3.947'	175° 3' 56.811"	1	East/west transect
14	-40.163762	-40° 9.826'	-40° 9' 49.544"	174.140608	174° 8.436'	174° 8' 26.189"	2	North/south transect
15	-40.074858	-40° 4.491'	-40° 4' 29.488"	174.160448	174° 9.627'	174° 9' 37.611"	2	North/south transect
16	-39.985952	-39° 59.157'	-39° 59' 9.428"	174.180234	174° 10.814'	174° 10' 48.841"	2	North/south transect
17	-39.808137	-39° 48.488'	-39° 48' 29.293"	174.219646	174° 13.179'	174° 13' 10.727"	2	North/south transect
18	-39.719227	-39° 43.154'	-39° 43' 9.217"	174.239274	174° 14.356'	174° 14' 21.386"	2	North/south transect
19	-39.630316	-39° 37.819'	-39° 37' 49.139"	174.258855	174° 15.531'	174° 15' 31.878"	2	North/south transect

Figure 3-2: Locations in the northern STB where mesoplankton sampling was conducted on the 17-18 February 2015. Station 13 was not sampled (from MacDiarmid et al. 2015).

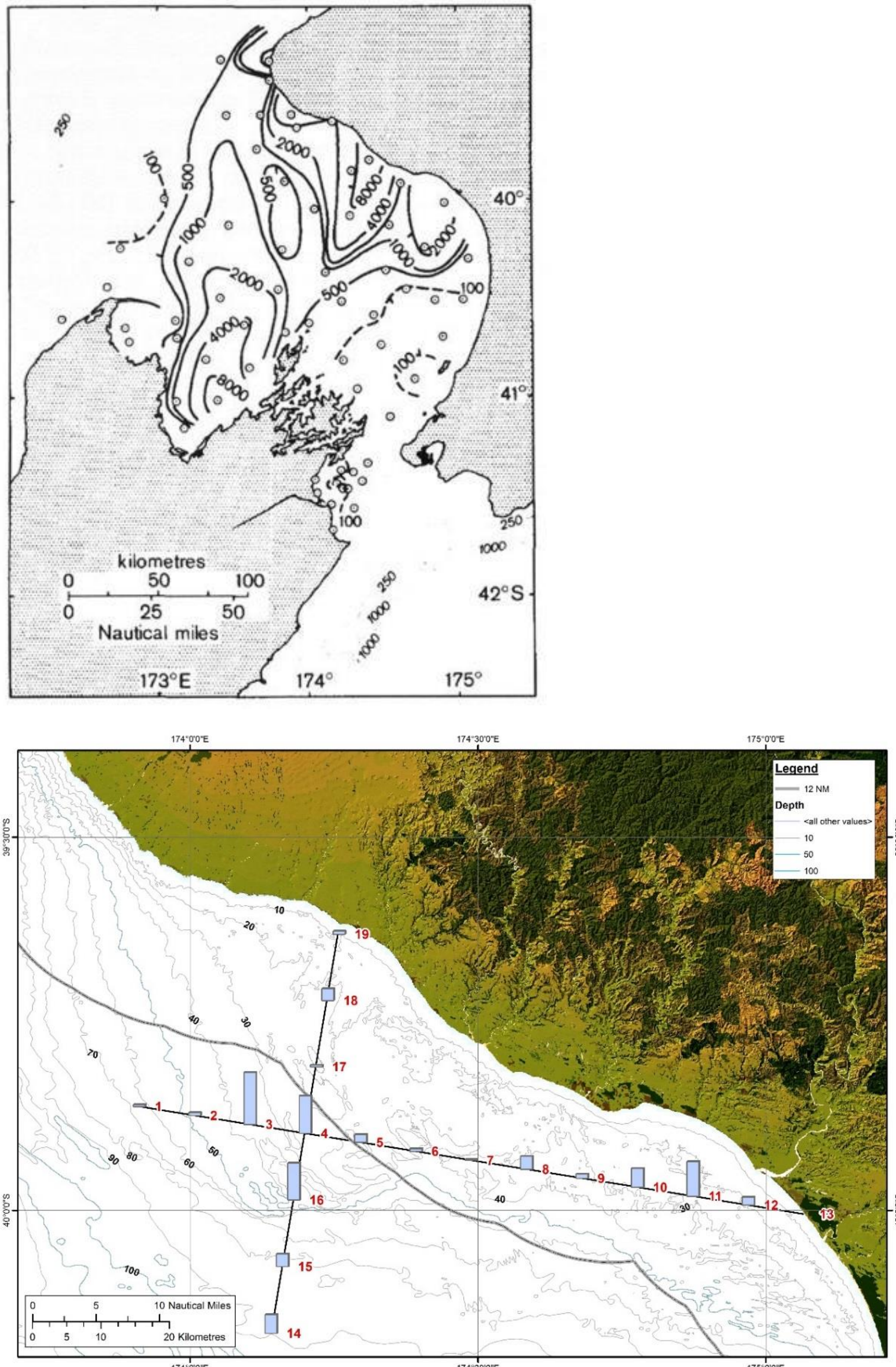


Figure 3-3: Integrated (water column from surface to near seafloor) zooplankton wet weight (mg m^{-3}) at localities sampled in the STB. Upper panel: 11-19 January 1980. Ticks directed towards regions of lower concentration. From Bradford et al. (1986). Lower panel: 17-18 February 2015 where the tallest column (site 3) is 9,380 mg m^{-3} and the shortest column (Site 7) is 229 mg m^{-3}. Site 13 was not sampled. Figure from MacDiarmid et al. (2015).

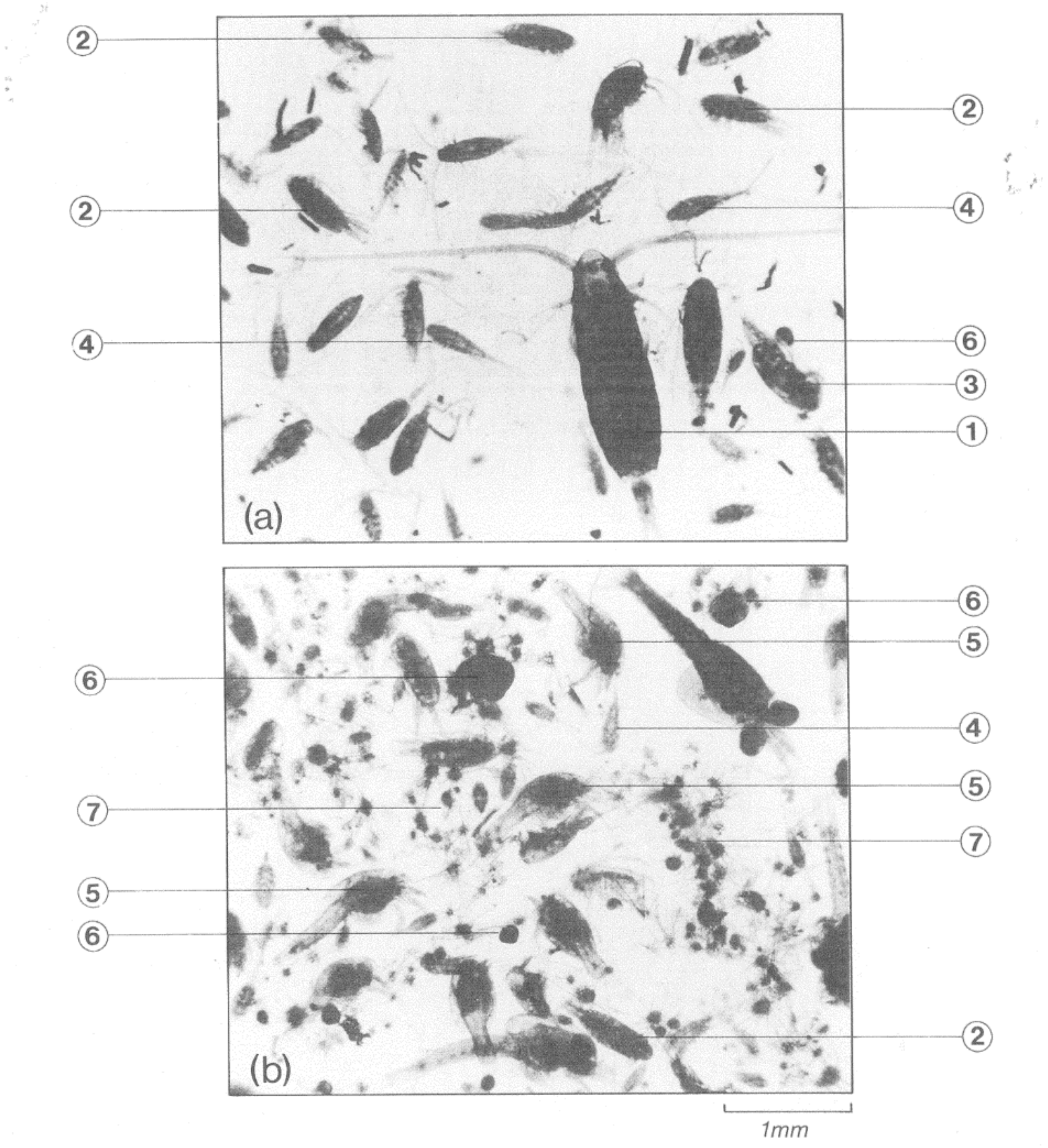


Figure 3-4: Samples of zooplankton from the STB. (1) *Calanus australis*; (2) *Paracalanus c.f. indicus*; (3) *Clausocalanus* spp. (4) *Oithona similis*; (5) calyptopsis of *Nyctiphanes australis*; (6) bivalve larvae; (7) acantherian protistans. From Bowman et al. (1982).

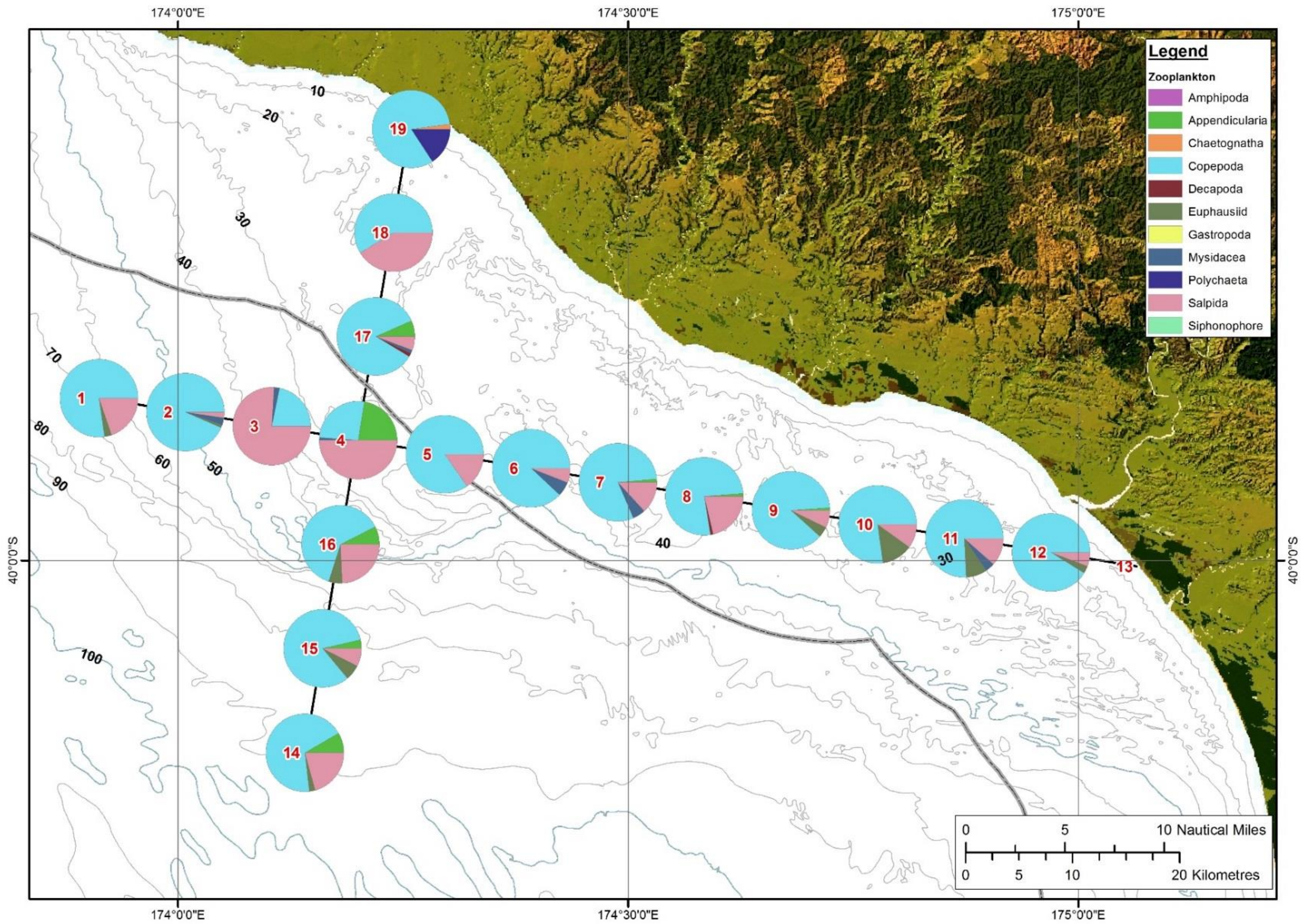


Figure 3-5: The broad taxonomic composition of zooplankton samples taken in the northern STB, 17-18 February 2015. From MacDiarmid et al. (2015).

3.5 General remarks

Some limitations of the available data for the zooplankton communities and related geophysical processes in the STB are that they are largely from the 1970s and 1980s with just 16% of samples from 2015, are mainly from the warmer months, and very few of the oceanographic studies included results from the shallowest regions of the STB. That is, most (about 70%) of the zooplankton data were for water offshore of the proposed iron sand extraction site. About 30% of the data were for waters that includes the proposed mining site and coastal waters shallower than about 50 m. None of the zooplankton sampling stations were located near-shore in the surf zone at depths <10 m as this zone is difficult to sample.

The STB is impacted by several large-scale, highly variable, physical phenomena that structure the distribution and biomass of zooplankton, mediated by the pattern of distribution of phytoplankton (algae) biomass and its primary production. These large-scale physical processes include the Kahurangi / Cape Farewell upwelling plume, tidal mixing, river plumes and surf beach processes. Of these the Kahurangi/Cape Farewell upwelling plume is the best understood in terms of plant nutrient renewal which impacts primary production and dynamics and its downstream impact on the zooplankton. A high degree of year-to-year and season-to-season variability in these processes and consequent patterns of plankton distribution and biomass is to be expected. Ten-year satellite observations of sea surface chlorophyll (Pinkerton et al. 2013), show impacts of summer upwelling off the Kahurangi Shoals and winter influence of near shore process including river inputs. Importantly, Pinkerton et al. (2013) found no evidence of long-term (decadal) trends in phytoplankton biomass suggesting that the plankton observations from the 1970s and 1980s provide insights relevant today.

The upwelling of cold nutrient-rich water off Kahurangi Point (see Figure 6.1) and its transport north-eastwards past Farewell Spit affects the zooplankton fauna in the STB, especially those in waters greater than 50 m depth, in a number of ways. First, there is evidence of passive transport on zooplankton assemblages. Oceanic species are carried inshore upstream in the upwelling plume then north-eastwards (Bradford-Grieve et al. 1993). Other species may be transported from Tasman and Golden Bays in the westerly or south-westerly flows between the upwelling plume and Farewell Spit (e.g., *Euterpina acutifrons, Temoria turbinata*, and *Corycaeus aucklandicus*).

Second, there is indirect evidence that *in situ* processes structure zooplankton populations through the growth and consumption patterns of the species involved. Although the Kahurangi/Cape Farewell upwelling plume, rich in inorganic nutrients, promotes phytoplankton growth above background levels (Bradford- et al. 1986; Viner & Wilkinson 1987), at the beginning of the upwelling plume primary production is not great enough to match zooplankton food requirements. Minimum breeding activity was indicated by low numbers of copepod nauplii and calculations showed that zooplankton ingestion exceeded potential phytoplankton production (James & Wilkinson 1988). The reverse applied downstream in the upwelling plume where nitrate levels decreased, ammonia levels increased, and concentrations of copepod nauplii were an order of magnitude greater than in the Kahurangi Point area as were the developmental stages of the krill *Nyctiphanes australis* (Bradford-Grieve et al. 1993; Bradford & Chapman 1988).

There were several stages in the development of copepod assemblages along the upwelling plume (Bradford-Grieve et al. 1993). Upwelling near Kahurangi Point resulted in an assemblage that had high average biomass, and was relatively rich in copepod species, including oceanic species, although the omnivore *Acartia ensifera* was numerically dominant. The upwelling reduced the proportion of copepod herbivores and favoured omnivore species (*Acartia ensifera, Oithona similis*) which are possibly best equipped to survive in a situation where zooplankton grazing was overtaking phytoplankton production (James & Wilkinson 1988). As this assemblage was transported north-eastwards, average biomass fell and further oceanic copepod species were entrained which produced high species richness, but two omnivorous copepods *Acartia ensifera* and *Oithona similis* were present in very large numbers. Further east the proportion of herbivorous copepods, species richness and zooplankton biomass increased. These are the populations that extend into waters less than 50 m deep in the STB and were recently sampled by MacDiarmid et al. (2015).

Krill, *Nyctiphanes australis*, a key prey species for some fish, blue whales, and some bird species (see Sections 4, 5, and 6) was most abundant at the "downstream" eastern end of a plume of cold, nutrient-rich, upwelled water, extending from the Kahurangi Point-Cape Farewell area north-eastwards into the STB (Foster & Battaerd 1985, Bradford & Chapman 1988; James & Wilkinson 1988 Bradford-Grieve et al. 1993) (see Figure 6-1).

In shallow coastal waters <50 m deep, even though tidal mixing occurs (Bowman et al. 1983), it does not result in nutrient renewal in January as the thermocline lies below the depth to which near shore waters are mixed. The phytoplankton chlorophyll *a* results available for this class of water are usually low (< 0.3 mg m^{-3}), patchy and probably influenced by river runoff or sandy beach nutrient recycling processes (Bradford et al. 1986). On at least one occasion, a huge biomass of the fast growing, gelatinous salp (*Thalia democratica*) was present in the STB (e.g. Figure 3-3) and may have been responsible for the low chlorophyll *a* levels measured (Bradford et al. 1986).

The zooplankton populations of shallow water in the STB, when not dominated by salps, are likely to be dominated numerically by *Oithona similis* (reaching 15,000 per 0.25 m^2 of sea surface), and moderately large numbers of *Acartia ensifera, Clausocalanus jobei, Paracalanus c.f. indicus* and copepod nauplii (Bradford-Grieve et al. 1993, MacDiarmid et al. 2015). That is, omnivorous copepods should dominate (66%) with 34% herbivores and 0.1% carnivores.

We have no direct knowledge of how such communities change closer to shore in shallow waters (< 10 m) where there are very high orbital velocities. It is possible that, in higher turbulence waters, zooplankton feeding rates decrease and some species might try to avoid high turbulence levels (e.g. Visser & Stips 2002). We might expect shallow near-shore zooplankton assemblages to include more groups that are more common in estuaries and low salinity waters than in water offshore, e.g. cladocera and the planktonic larval forms of benthic and intertidal animals (crabs, echinoderms, molluscs, fish, barnacles, etc.) which might be seasonally common (e.g. DeLancy 1987). A special case is the surf beach. Primary productivity measurements by Cassie and Cassie (1960) at Waitarere beach showed how productive this type of environment might be. It is likely that waters close inshore would be modified by buoyancy imparted by freshwater and additional riverine nutrients. It can be reasonably assumed that zooplankton communities in nearshore waters in the STB are presently responding to the high background suspended sediment loadings caused by river and coastal runoff combined with active re-suspension due to the wave turbulence.

3.6 Assessment of impact

Suspended sediments may affect zooplankton communities by shading phytoplankton thus reducing primary production and the amount of food available to zooplankton grazers. Pinkerton and Gall (2015) estimated that suspended sediments from the proposed mining operations could reduce the light available for phytoplankton over the modelled area of the STB by 1.6-1.9%. Concentrations of fine sediment greater than 20 mg per litre can clog zooplankton respiratory surfaces and/or feeding apparatus as well as visually impair the ability of zooplankton predators to find prey (Arendt et al. 2011). Modelling by Hadfield and Macdonald (2015) suggests that neither of the mining scenarios will generate SSC at or above these levels in surface waters, and rarely and only at the sediment discharge point in near-bottom waters.

The proposed mining activities will have a negligible impact on zooplankton, including krill, populations in the STB given that:

- The mesozooplankton community in the STB is typical of the nearshore zooplankton communities found around the entire North Island;
- The Kahurangi / Cape Farewell upwelling and its downstream propagation is a large scale process operating over a considerable but variable area of the STB, possibly 20,000 km^2;
- The area potentially affected by levels of suspended sediments elevated above background levels in the surface waters by mining 50 M t per annum (Table 2-1) occupies about 0.3% of the area affected by upwelling and lies on its northern margin;
- The water column light levels in the sediment modelling domain will on average be reduced by mining activities by about 1.6-1.9% (Pinkerton and Gall 2015);
- The proposed mining operations will rarely increase suspended sediment concentrations sufficiently high to clog copepod feeding apparatus.

Addition of suspended sediments nearshore from mining activities is unlikely to alter zooplankton communities presently responding to the background suspended sediment loadings caused by river and coastal runoff combined with active re-suspension of seafloor sediments due to wave turbulence.

4 Fished species

4.1 Approach

MacDiarmid et al. (2013) identified 20 commercial and/or recreational fish species with a high probability of occurrence (50% or more) in the STB coincidental with areas of interest to TTR. These included barracouta (*Thyrsites atun*), blue cod (*Parapercis colias*), carpet shark (*Cephaloscyllium isabellum*), eagle ray (*Myliobatis tenuicaudatus*), John dory (*Zeus faber*), jack mackerel (*Trachurus novaezelandiae* and *T. declivis*), kahawai (*Arripis trutta*), leatherjacket (*Meuschenia scaber*), lemon sole (*Pelotretis flavilatus*), red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), rig (*Mustelus lenticulatus*), school shark (*Galeorhinus galeus*), snapper (*Pagrus auratus*), spiny dogfish (*Squalus acanthias*), tarakihi (*Nemadactylus macropterus*), trevally (*Pseudocaranx dentex*), common warehou (*Seriolella brama*), and witch (*Arnoglossus scapha*). On pages 186-189 of the TTR's original application for marine consent[1], an additional 39 kaimoana species or species groups are identified as taonga for Ngati Ruanui.

For each species included in the Quota Management System (QMS) we determined the Quota Management Area (QMA) using maps from the latest Fisheries Plenary Report (Ministry for Primary Industries 2014). The South Taranaki Bight lies within Fisheries Management Area (FMA) 8 (see Figure 4-1), but for particular fish quota species this area is sometimes combined with all or part of adjacent FMAs to form a QMA, which in most cases is renamed after the fish stock. For example, for blue cod, the QMA is renamed BCO 8. If modelled fish distributions were available we used these to determine the area within each QMA utilised by the species. For non-quota species we summarised relevant available distributional data. The distribution of each QMS species and non-quota species was compared to the area with suspended sediment concentrations higher either 2 mg/l (pelagic species) or 3 mg/l (demersal and benthic species) (see Table 2-1) due to the proposed annual extraction of 50 M t of seabed iron sand (Hadfield and Macdonald 2015). We also searched the 2014 Fisheries Plenary Report and other sources for information about the diet, movement patterns, size of commercial, recreational, and customary fisheries, and the state of the stock of each species in the QMA encompassing the STB as these may influence the vulnerability of the fish stock to mining operations.

Relevant data were assembled for each commercial and recreational species in Table 4-1 and exclusively kaimoana species in Table 4-2 and the impact of the proposed mining activities were assessed according to the criteria outlined in Table 2-2.

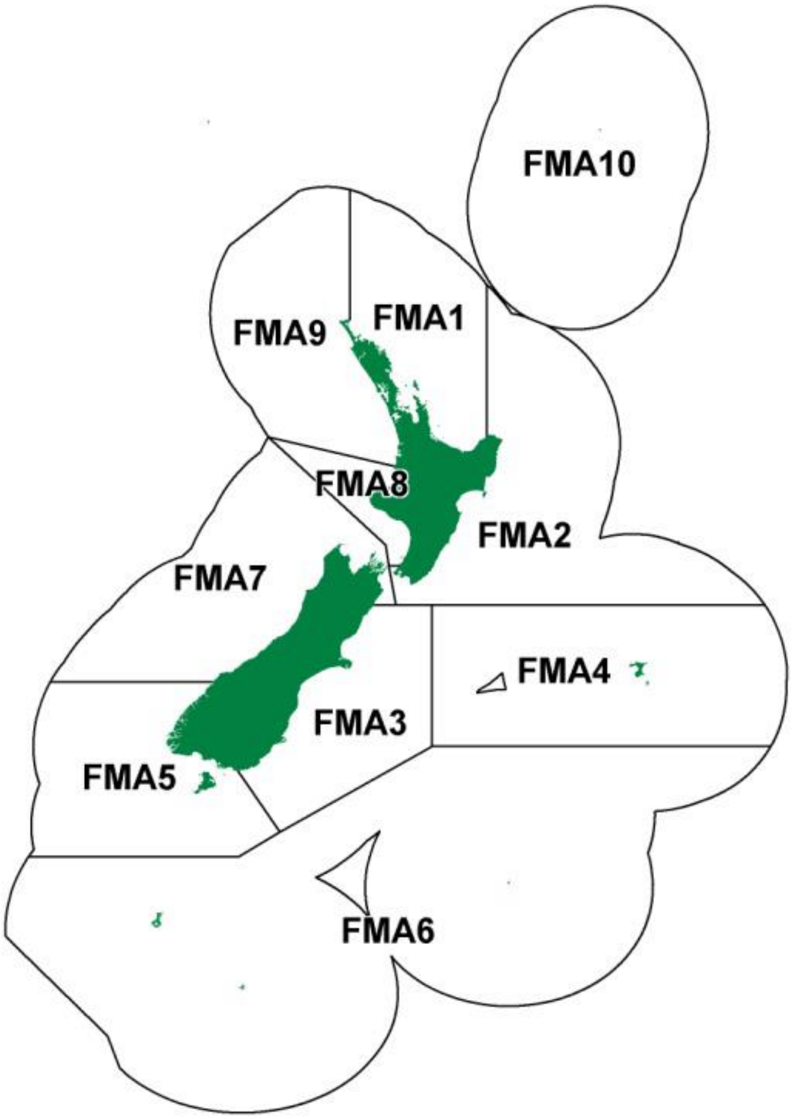


Figure 4-1: New Zealand Fisheries Management Areas (FMA). From Ministry for Primary Industries (2014).

Table 4-1: Fish summaries and assessments. Data, fish image and map of Quota Management Areas compiled from Ministry for Primary Industries (2014) unless stated otherwise. Distributional maps taken from MacDiarmid et al. (2013). The assessment of the impact for each species was made by the authors.

<table>
<tr><th>Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet</th><th>Relevant Quota Management Area occupied by species</th><th>Landings, TACC and Recreational catch</th><th>Status of stocks</th></tr>
<tr><td>

Barracouta (BAR) (*Thyrsites atun*)

- Occurs throughout shelf waters to depths of 400m.
- Tagged barracouta have moved considerable distances to spawn (up to 500 nautical miles).
- Diet comprises mainly small pelagic fish.

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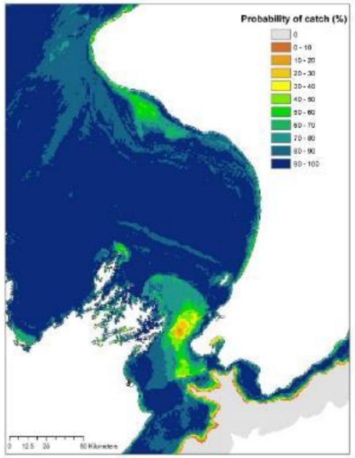
Area of distribution in BAR7 = 125,737 km^2



</td><td>

- Commercial landings for BAR7 averaged 9,737 t over last 10 years.
- BAR7 TACC of 11173 t
- The annual recreational catch of barracouta in BAR7 in the 1999-00 survey was 68–120 t with a CV of 28%
- Historically barracouta was a key species fished by Maori especially in southern NZ.
- Quantitative information on the current level of customary non-commercial take is not available.

</td><td>

- No biomass or yield estimates available

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Assessment of impact: Barracouta is a very widespread and wide ranging pelagic species that supports a moderate sized commercial and recreational fishery in the region. Given that the area potentially impacted by the proposed mining of 50 M t per annum comprises <0.1% of the area of distribution of barracouta in BAR7, any displacement of barracouta, or decrease in prey abundance or prey availability due to mining should have negligible effects on the state of the stock.

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</table>

<table>
<tr><th>Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet</th><th>Relevant Quota Management Area occupied by species</th><th>Landings, TACC and Recreational catch</th><th>Status of stocks</th></tr>
<tr><td>

Blue Cod (BCO) *(Parapercis colias)*

- Occurs to a depth of 150 m.
- Ten day pelagic egg and larval stage.
- Tagging studies in the Marlborough Sounds show most blue cod remain in the same area for extended periods. In Foveaux Strait although some moved as far as 156 km, 60% had moved < 1 km. Similar in Dusky Sound.
- Mainland New Zealand blue cod appear to show a pattern of Isolation-by-Distance or continuous genetic change among populations.
- Diet comprises almost any animal material including shellfish, crustaceans, salps, and small fish (Francis 2012).

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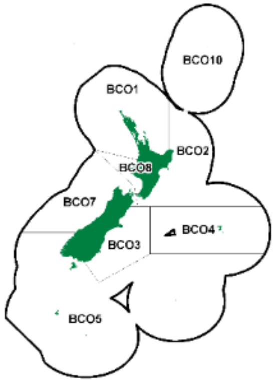
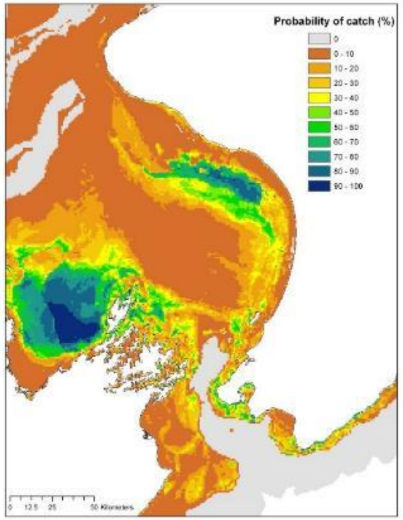
Area of distribution in BCO8 = 23,878 km^2





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- Annual commercial landings for BCO8 averaged 16.5 t over last 10 years.
- BCO8 TACC of 34 t
- Estimated annual recreational catch of blue cod in BCO8 in the 2012 panel survey was 48 t
- No quantitative data on historical or current blue cod customary non-commercial catch are available.
- An annual allowance of 2 t is made for customary non-commercial catch of blue cod in BCO 8.

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- Although there is no formal stock assessment for BCO8, recent commercial catch levels are considered sustainable.

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Assessment of impact: Blue cod is a relatively widespread but site attached (resident) demersal species, with its core area of distribution in the STB lying east and south of the proposed mining area. Blue cod supports a small commercial and a larger recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of blue cod in BCO8, the stock should be affected to a negligible extent. Because blue cod have a broad diet and take advantage of seafloor disturbance to prey upon newly exposed benthic species such as tube worms, brittle stars and small crustaceans, it is possible that mining activities will increase food availability to locally resident fish.

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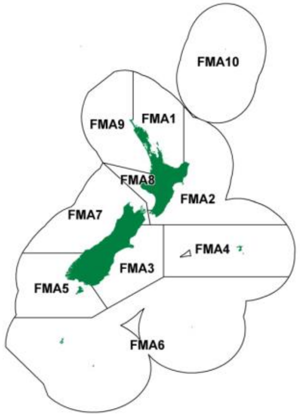
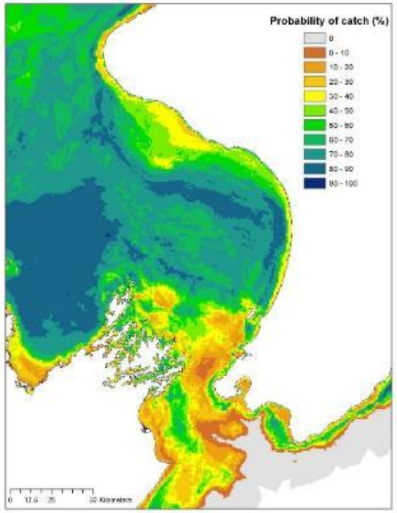
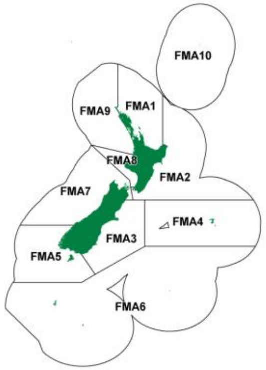
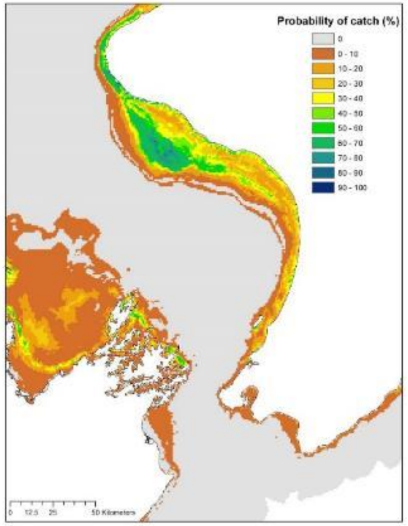
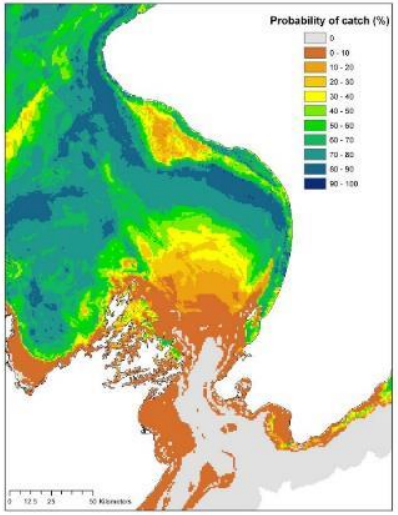
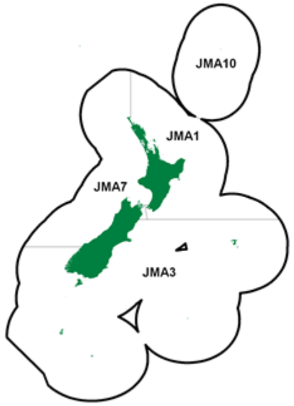
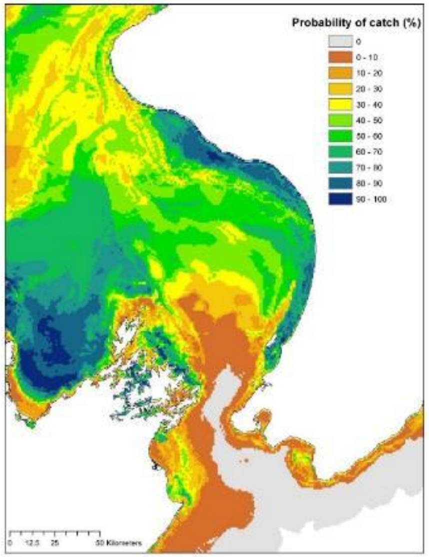
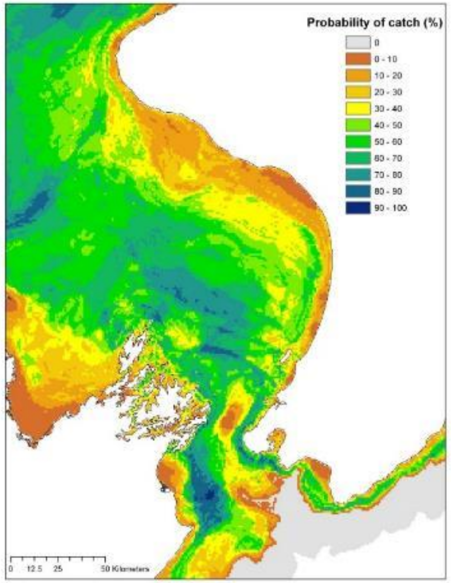
</table>

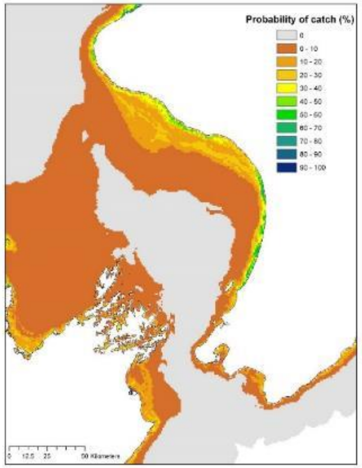
Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	**Relevant Quota Management Area occupied by species**	**Landings, TACC and Recreational catch**	**Status of stocks**
Carpet shark (CAR) (*Cephaloscyllium isabellum*)  • Occurs from 0 to 673 m, mostly <400 m, on soft substrates and rocky reefs (Francis 2003). • Nocturnal, feeding on fish, krill, crabs, crayfish, octopus and squid (Francis 2012). • Movement patterns are unknown (Francis and Lyon 2012).	Area of distribution in FMA8 = 34,905 km^2  	• Non-QMS species commonly caught as bycatch in trawl and rock lobster fisheries, and probably also in some set net fisheries. • Reported annual commercial catches NZ wide were 74 to 540 tonnes between 1988 and 1991 when a shark liver fishery was operating, but catches declined rapidly when this industry stopped. Since then, reported catches were less than five tonnes per year, and most carpet sharks were probably discarded. • No quantitative data on historical or current customary non-commercial catch are available.	• No formal stock assessment is available. • Because the NZ population seems healthy and free from significant threats, the International Union for Conservation of Nature (IUCN) has assessed this species as of Least Concern (Francis 2003).
Assessment of impact: Carpet shark is a widespread species that is caught mainly as a bycatch species but usually discarded alive. The area potentially impacted by the proposed mining of 50 M t per annum comprises 0.14% of the area of distribution of carpet shark in FMA8. Because the centre of distribution and abundance of carpet sharks in the STB is offshore of the shallow banks any decrease in prey abundance or availability due to mining activities should have negligible impacts on this stock.			

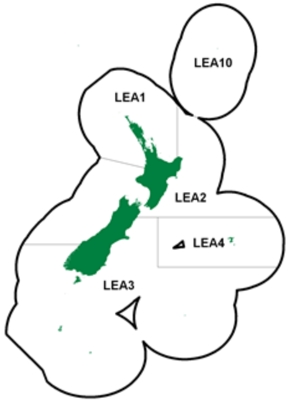
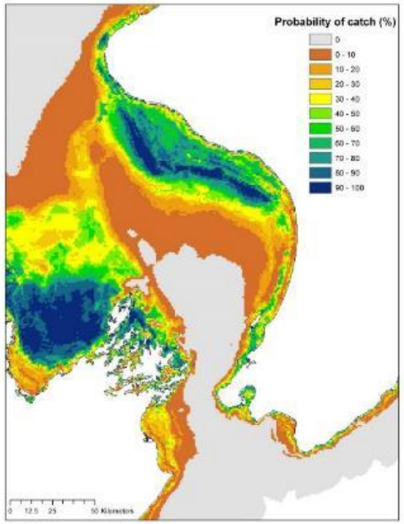
Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Eagle ray (EGR) (*Myliobatis tenuicaudatus*)  • Most common in northern NZ; rare south of Cook Strait (Francis 2012). • Found mainly over soft bottoms, including tidal flats in estuaries and harbours, also common on shallow rocky reefs. They tend to concentrate in water less than about 10 m deep during summer and autumn, and move offshore deeper than 20 m during winter. Rare deeper than about 50 m. (Duffy 2003). • Eagle rays display sophisticated navigation in tidal estuaries to avoid stranding (Davis 2010) and home to harbours if displaced up to 7 km (Marcotte 2014). • Reproduction is viviparous. Litter size and size at birth is poorly known. A captive female gave birth to a litter of 20 pups after six months in captivity (Duffy 2003). • Those found on reefs feed mainly on snails and hermit crabs. Those inhabiting soft bottoms feed on a variety of bivalves, small crustaceans (including crabs and shrimps) and polychaete worms. (Duffy 2003).	Area of distribution in FMA8 = 7,968 km^2   	• Non-QMS species mainly taken as bycatch in inshore trawl fisheries around upper North Island. Commonly taken by recreational line fishers. Also taken on set lines, and in drag and set nets. Sometimes speared, or harpooned for sport (Duffy 2003). • Although taken in a wide variety of fisheries this species is usually released or discarded, and appears to survive capture and release well (Duffy 2003). • No quantitative data on historical or current customary non-commercial catch are available.	• No assessment available
Assessment of impact: Eagle ray has a restricted distribution in the STB being most common in the area potentially impacted by the proposed mining activities. It moves offshore to water deeper than 20 m during winter and inshore to depths less than 10 m in summer when it is possibly site attached (resident). It is a non-QMS species caught mainly as bycatch but usually discarded alive. Given that the area potentially impacted by mining 50 M t per annum comprises 0.6% of the area of distribution of eagle ray in FMA8, but that about 8% of its core area of distribution (>50% occurrence) overlaps with the area of SSC elevated above 3 mg/l, a minor to moderate proportion of the stock could be affected by mining through displacement of fish, or decrease in prey abundance or availability.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
John Dory (JDO) (*Zeus faber*)  • John dory are widespread, being found in the eastern Atlantic Ocean, the Mediterranean Sea and around New Zealand, Australia and Japan. • They are common in the inshore coastal waters of northern New Zealand, and to a lesser extent in Tasman Bay and STB, to depths of 50 m. • John dory appear to reach the southern limit of their range off the north and northwest coasts of the South Island. • In the Hauraki Gulf, adults move to deeper waters during summer, and occasional feeding aggregations occur during winter. • Spawning fish and nursery grounds are found in all stock areas. • Eggs are large and pelagic, taking 12–14 days to hatch • Diet comprises small pelagic and reef fish species (Francis 2012).	Area of distribution off WCNI = 57,332 km^2   	• Landings from JDO2 are considered to be approximately equally split between FMAs 2 and 8. • This equates to average commercial landings over the last 10 years in FMA8 of ~75t • Substantial proportions of John dory landings are taken as bycatch in target trawl fisheries for jack mackerels in FMA 8 • The estimated annual recreational catch of John dory in JDO2 in the 2012 panel survey was 3 t. • No quantitative data on historical or current customary non-commercial catch are available.	• A standardised CPUE time series for the west coast North Island (parts of JDO1 and 2) suggests that John dory biomass was relatively stable since the late 1990s • Recent analysis suggested that the present QMA boundaries are not biologically appropriate and suggested five stocks around New Zealand: (1) Hauraki Gulf and east Northland; (2) Bay of Plenty; (3) west coast North Island (WCNI); (4) southeast North Island; and (5) northern South Island.
Assessment of impact: John dory is a widespread and relatively wide ranging species that supports a small commercial and a very small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises about 0.1% of the area of distribution of John dory in the recently defined stock area off the west coast of the North Island (FMAs 8 and 9), any displacement of fish, or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Jack mackerels (JMA) (*Trachurus novaezelandiae, Trachurus declivis*)   • *T. novaezelandiae* predominates in waters shallower than 150 m and warmer than 13°C; it is uncommon south of latitude 42°S. • *T. declivis* generally occurs in deeper (but less than 300 m) waters less than 16°C, north of latitude 45° S. • A third species, *T. murphyi*, is present in JMA7 but is not common. • The vertical and horizontal movement patterns are poorly understood. Jack mackerels are presumed to be generally off the bottom at night, and closer to the bottom during the day but fish also form feeding surface schools during the day. • Jack mackerels have a protracted spring-summer spawning season. • Spawning occurs in the North and South Taranaki Bights, and probably in other areas as well. • *T. declivis* spawning was found to be common on the southwest and northwest outer shelf North Island.	Area of distribution in JMA7 for: *T. novaezelandiae* = 102,381 km^2 *T. declivis* = 121,880 km^2  *T. novaezelandiae* distribution  	• Commercial landings in JMA7 have averaged 30,747 t over last 10 years. • JMA7 TACC of 32,537 t • Jack mackerels do not rate highly as a recreational target species although they are popular as bait • No quantitative data on historical or current customary non-commercial catch are available.	• Estimates of total mortality for *T. declivis* (JMD) and *T. novaezelandiae* (JMN) from catch curve analyses in 2011 suggest that fishing mortality was well below natural mortality (M) for JMD and about equal to M for JMN; i.e. it is unlikely (< 40% probability) that overfishing is occurring.

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
• *T. novaezelandiae* spawning was found to be common on the southwest and northwest inner and outer shelf North Island. • Diet comprises pelagic crustaceans and small fish (Francis 2012)	*T. declivis* distribution 		
Assessment of impact: Jack mackerels are widespread and relatively wide ranging species that support the largest commercial fishery in the region and a very small recreational fishery. Given that the area potentially impacted by the proposed mining of 50 M t per annum comprises <0.1% of the area of distribution of mackerels in JMA7, any displacement of fish, or decrease in prey abundance or availability due to these activities should have negligible effects on the state of the stock. Although there is no indication that the JMA 7 stock is overfished, the largest impact will be from fishing with an average 30,747 t removed annually.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Kahawai (KAH) *(Arripis trutta)*  • Kahawai are a schooling pelagic species • Occur mainly in coastal seas, harbours and estuaries and will enter the brackish water sections of rivers. • Spawning habitat of kahawai is unknown but is thought to be associated with the seabed in open water • Tagging returns suggest that most kahawai remain in the same QMA area for several years, but some move throughout the kahawai habitat. • Kahawai feed on small schooling fishes and pelagic crustaceans, especially krill (*Nyctiphanes australis*). Francis (2012) notes they sometimes feed on the bottom on crabs, worms and shellfish. Kahawai smaller than 100 mm mainly eat zooplanktonic copepods.	Area of distribution in KAH 8 = 28,987 km^2  	• Commercial landings for KAH8 have averaged 448 t over last 10 years. • KAH8 TACC of 520 t • Estimated recreational catch of 415 t (cv 0.12) in 2012 • An annual allowance of 385 t of recreational catch is made for KAH 8 • An annual allowance of 115 t of customary non-commercial catch is made for KAH 8.	• No accepted assessment is available for this region.
Assessment of impact: Kahawai is a relatively wide ranging inshore pelagic species with a restricted distribution in the STB being most common in shallow areas immediately adjacent to the coast. It supports a small commercial and a similar sized recreational fishery in the region. The area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of kahawai in KAH8. Given that the main distribution of kahawai in the STB is close inshore in the area already affected by relatively high background levels of suspended sediments, the proposed activities should have negligible effects on the state of the stock.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Leatherjacket (LEA) (*Meuschenia scaber*)  • Occurs on reefs but also on light foul ground. • Present around much of New Zealand, but is most common in the north. • Widespread in the STB • The males defend territories and eggs are laid within nests on the seafloor in spring and summer. • Leatherjackets will eat almost anything including sponges and tunicates but also salps and jellyfish from open water (Francis 2012).	Area of distribution in LEA2 = 36,698 km^2  	• LEA2 commercial landings have averaged 270 t over last 10 years. • LEA2 TACC of 1136 t • No estimated recreational catch is available but is believed to be small as leatherjackets are seldom caught by hook and line. • An allowance of 2 t per year is made for recreational catch in LEA2 • No quantitative data on historical or current customary non-commercial catch are available. • However, an annual allowance of 1 t is made for customary non-commercial catch in LEA2	• There has been no scientific assessment of the maximum sustainable yield, reference or current biomass of any of the leatherjacket stocks.
Assessment of impact: Leatherjacket is a relatively widespread species with a core area of distribution in the STB inshore of about the 60 m bathymetric contour. Leatherjacket support a small commercial fishery and no known recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of leatherjackets in LEA2, any decrease in prey abundance or availability due to mining should have negligible impacts on the stock.			

<table>
<tr><th>Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet</th><th>Relevant Quota Management Area occupied by species</th><th>Landings, TACC and Recreational catch</th><th>Status of stocks</th></tr>
<tr><td>

Lemon sole (LSO) ***Pelotretis flavilatus***

- Lemon sole occurs around the whole of New Zealand on sand or mud of the continental shelf and slope between 20 and 500 m (Francis 2012).
- Spawning occurs in winter-spring (Francis 2012).
- According to demersal fish models (MacDiarmid et a. 2013a), in the STB, the probability of occurrence of lemon sole is highest from about Patea to Kapiti, with only low occurrence and abundance on the mining site.
- Diet comprises a wide variety of small fish, shellfish, crustaceans, worms, and brittlestars (Francis 2012).

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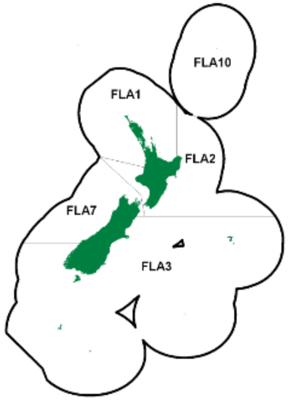
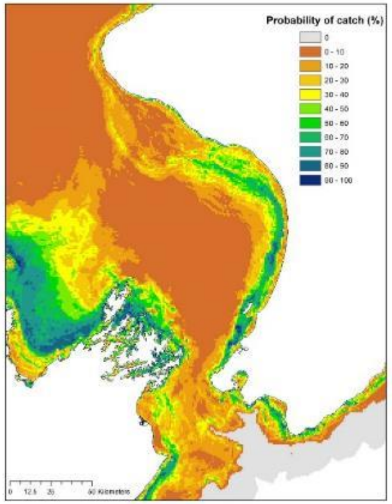
Area of distribution in FLA2 = 63,570 km^2





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- The average annual commercial catch of lemon sole in FLA2 is 4.4t. Approximately half may be expected to be caught in the western part of FLA2 (~2.2 t).
- No known recreational catch
- Quantitative information on the current level of customary non-commercial catch is not available.

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- There is no assessment of stocks in the STB

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Assessment of impact: Lemon sole is a widespread and relatively wide ranging benthic species and in the STB is most common at bottom depths < 50 m. It supports a tiny commercial fishery and no known recreational fishery in the region. Given that the area potentially impacted by the proposed mining of 50 M t per annum comprises < 0.1% of area of distribution of lemon sole in FLA2, and that the principal area of distribution and abundance of this species in the region is east and south of the mining area, any decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.

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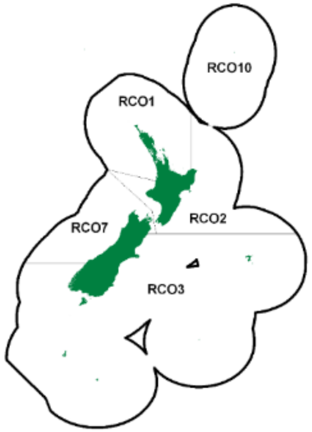
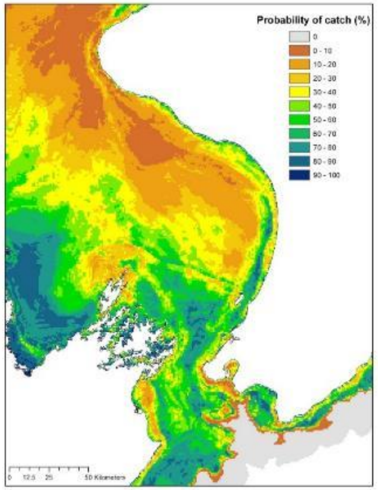
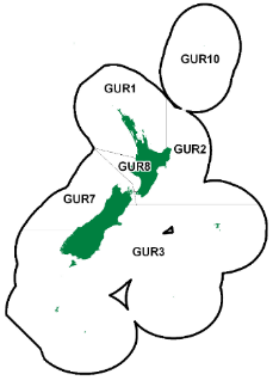
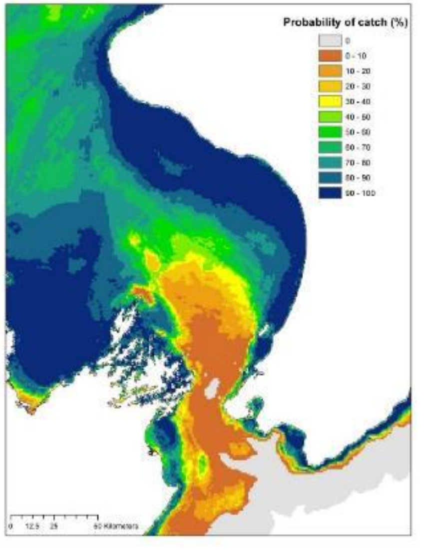
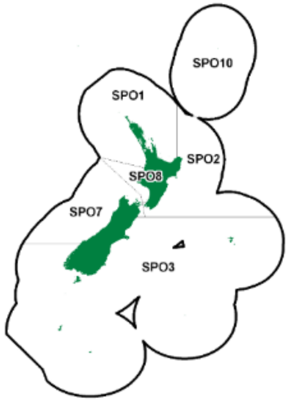
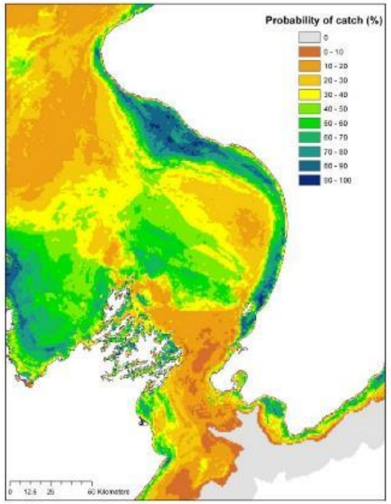
Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Red cod (RCO) (*Pseudophycis bachus*)  • Red cod are a fast-growing, short-lived species with few fish in the commercial fishery older than six years. • There have been large fluctuations in red cod abundance and landings, particularly on the east and the west coast of the South Island. • Red cod are seasonally abundant inshore in late spring till late autumn, moving offshore into deeper water on the edge of the continental shelf during winter and spring. • Small fish up to 25 cm long eat mostly benthic invertebrates while large individuals prey upon fish as well as crabs and whale krill (*Munida gregaria*) (Francis 2012).	Area of distribution in RCO2 = 60,616 km^2  	• RCO2 commercial landings have averaged 343 t over last 10 years. • RCO2 TACC of 500 t • The recreational catch of red cod in the 1999-00 survey was 8-14 t with a CV of 25% • Recruitment is highly variable resulting in large variations in catches between years. • Quantitative estimates of the current level of customary non-commercial catch are not available.	The MCY for RCO2 based on the MIAEL method was 500 t
Assessment of impact: Red cod is a widespread and relatively wide ranging species that supports a small commercial and a very small recreational fishery in the region. Given that the area potentially impacted by the proposed mining of 50 M t per annum comprises < 0.1% of area of distribution of red cod in RCO2, any displacement of fish or decrease in prey abundance or availability due to these activities should have negligible effects on the state of the stock.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Red gurnard (GUR) (*Chelidonichthys kumu*)  • Red gurnard reach sexual maturity at an age of 2–3 years after which the growth slows. • Red gurnard have a long spawning period which extends through spring and summer with a peak in early summer. • Spawning grounds appear to be widespread, although perhaps localised over the inner and central shelf. • Egg and larval development takes place in surface waters, and there is a period of at least eight days before feeding starts. • Small juveniles are often caught in shallow harbours, but rarely in commercial trawls. • Red gurnard produce vocalisations exceeding 60 dB over a frequency range of 100-500 Hz (Ghazali 2011) and presumably are sensitive to the same frequency range as they produce. • Diet comprises mainly crabs and shrimp, but also small fish, and worms (Francis 2012).	Area of distribution in GUR8 = 34,154 km^2   	• Commercial landings in GUR8 have averaged 272 t over last 10 years. • Red gurnard is a minor bycatch in the jack mackerel trawl fishery in the STB. • GUR8 TACC is 543 t • The red gurnard recreational catch in the 2012 panel survey was 46 t with a CV of 23% • Although red gurnard is an important species for customary non-commercial fishing, no quantitative estimates of customary non-commercial catch are currently available.	• It is not known if recent catch levels or the current TACC are sustainable.

Assessment of impact: Red gurnard is a widespread and relatively wide ranging species that supports a small commercial and a small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises just 0.1% of the area of distribution of red gurnard in GUR8, any displacement of fish or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Rig (SPO) *(Mustelus lenticulatus)*  • Around the South Island male and female rig attain maturity at 5–6 yrs (about 85 cm) and 7–8 yrs (about 100 cm), respectively. • Rig give birth to young in shallow coastal waters during spring and summer following a 10–11 month gestation period. • They grow rapidly during their first summer, and then move into deeper water as water temperatures drop in autumn–winter. • Rig make extensive coastal migrations, with one tagged female moving a least 1160 km. Over half of the tagged rig that were recaptured had moved over 50 km, and >50% of the females had moved more than 200 km. Females travel further than males, and mature females travel further than immature females. • Stock mixing occurs in the South Taranaki Bight to the Cook Strait and South Westland regions, and probably elsewhere. • Diet comprises mainly crabs, hermit crabs, and worms but also shrimps, crayfish, octopus and squid (Francis 2012).	Area of distribution in SPO8 = 34,780 km^2   	• Commercial landings in SPO8 (mainly by coastal setnet) have averaged 198 t over last 10 years. • SPO8 TACC is 310 t • The recreational catch of rig in the 1999-00 survey was 5-13 t with a CV of 48% • The SPO 8 bottom trawl fishery operates further offshore and takes rig as a bycatch in fisheries targeted at tarakihi, snapper and gurnard. • Maori fishers traditionally caught large numbers of "dogfish" during the last century and early this century. • Quantitative data on the current level of customary non-commercial take is not available.	• The SPO 8 set-netting CPUE analysis was variable with relatively large coefficients of variation. The overall pattern was one of gradual decline from 1990 to the mid-2000s, followed by a recovery to the present. • The SPO 8 bottom-trawl CPUE series showed no trend • Current catches are Unlikely (< 40%) to cause the stock to decline.
Assessment of impact: Rig is a widespread and wide ranging species most commonly found at depths < 50m. It supports a small commercial and a recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises 0.1% of the area of distribution of rig in SPO8, any displacement of rig or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.			

<table>
<tr><th>Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet</th><th>Relevant Quota Management Area occupied by species</th><th>Landings, TACC and Recreational catch</th><th>Status of stocks</th></tr>
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School shark (SCH) (*Galeorhinus galeus*)

- School sharks are distributed across the shelf, generally being inshore in summer and offshore in winter. They extend in smaller numbers to 600 m.
- School sharks are slow growing and long-lived. Age-at-maturity was estimated at 12–17 years for males and 13 to 15 years for females.
- Breeding was assumed to be biennial, but work on a Brazilian stock suggests that females have a 3-year cycle.
- Mating is believed to occur in deep water, probably in winter.
- Release of pups occurs November–January.
- Pup number increases from 5–10 in small females to over 40 in the largest.
- Nursery grounds include harbours, shallow bays and sheltered coasts. The pups remain in nursery grounds for 1-2 yrs and subsequently disperse across the shelf.
- School sharks feed predominantly on small fish, octopus, and squid.

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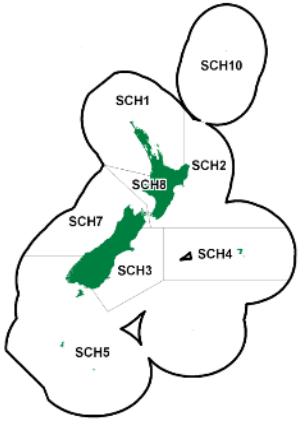
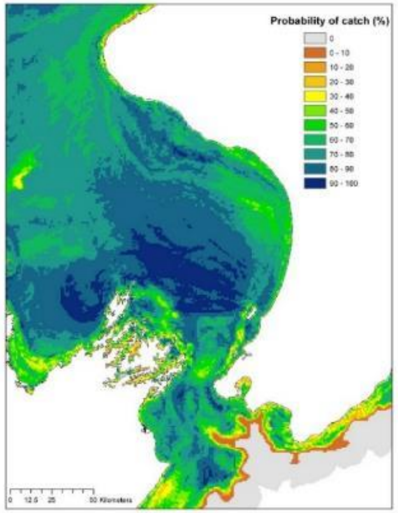
Area of distribution in SCH8 = 35,111 km^2





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- SCH 8 are caught mainly (66%) by setnet targeting school shark and rig; and by bottom longline (22%) targeting school shark and hapuku/bass. Ten percent is caught by bottom trawl targeting gurnard, tarakihi and trevally.
- Commercial landings in SCH8 have averaged 515 t over last 10 years.
- SCH8 TACC is 529 t
- School shark is not considered to be a particularly desirable target species in SCH8 at the present time.
- Maori made extensive use of school shark in pre-European times.
- Quantitative data on the current level of customary non-commercial take are not available.

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- Primarily based on the tagging evidence, there is probably a single biological stock in the New Zealand EEZ.
- The lognormal setnet series (nets set mainly at depths <50 m) shows a long and gradual declining trend.
- Stock is unlikely (< 40%) to be below 10% B_0
- Fishing pressure on large mature females should be minimised to maintain the productivity of this species.

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Assessment of impact: School shark is a very widespread and relatively wide ranging pelagic species that supports a small commercial and no known recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of school shark in SCH8, any displacement of fish or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.

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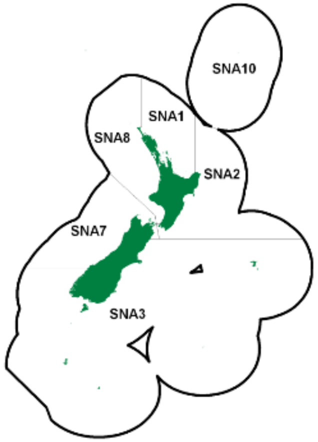
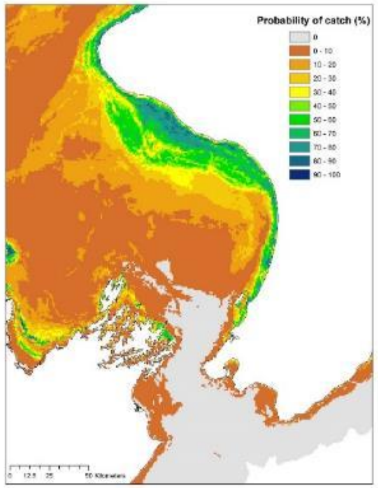
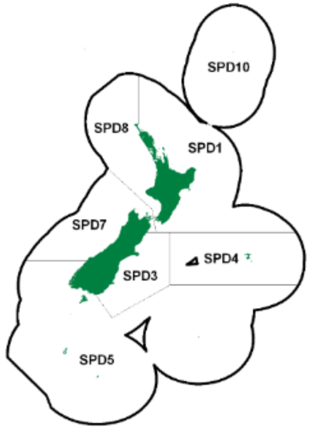
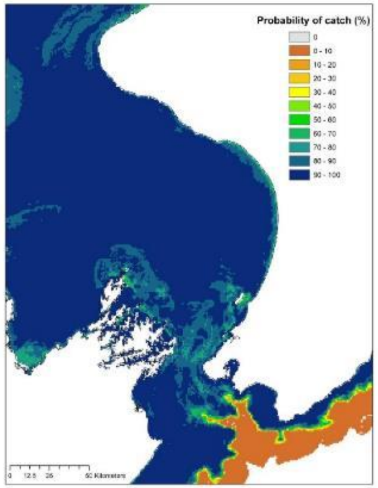
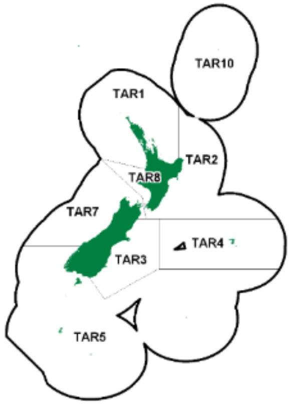
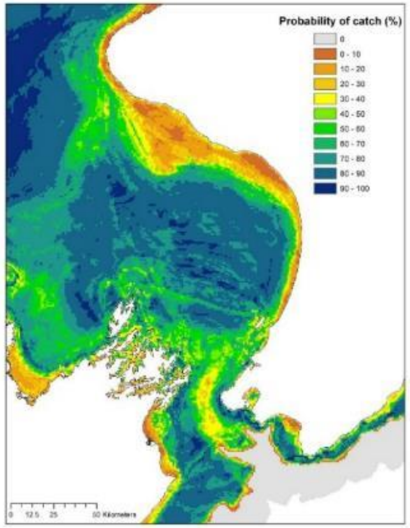
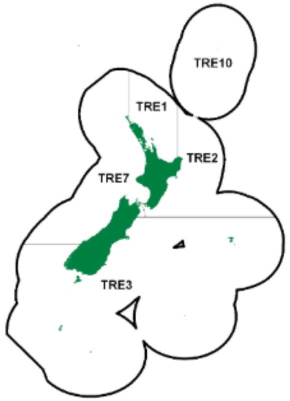
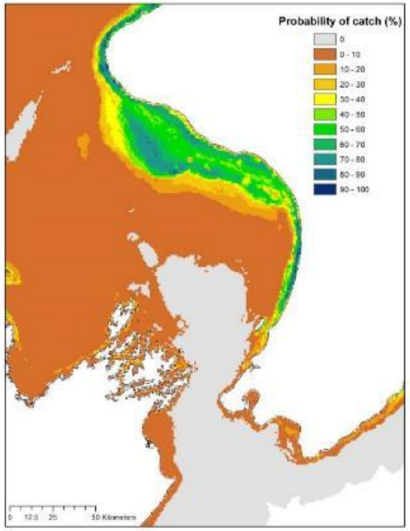
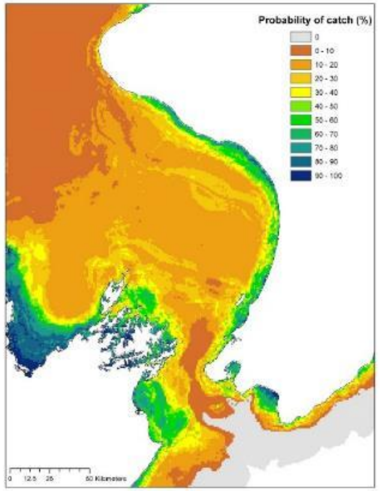
</table>

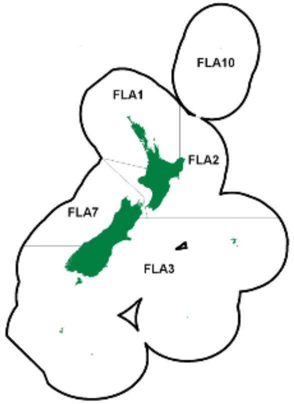
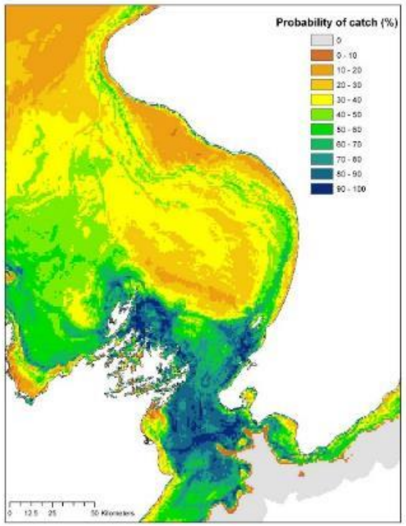
Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Snapper (SNA) (*Pagrus auratus*)  • Snapper are demersal fish found down to depths of about 200 m, but are most abundant at 15–60 m. • Snapper release many batches of eggs over an extended season during spring and summer. • The larvae have a relatively short planktonic phase. • Large schools of snapper congregate before spawning and move on to the spawning grounds. • After spawning the fish disperse, often inshore to feeding grounds. The winter grounds are thought to be in deeper waters where the fish are more widespread. • Juveniles eat mainly small benthic crustaceans, but as they grow include a wider range of crabs, worms and shellfish. Large snapper eat paua, bivalves, snails and fish (Francis 2012).	Area of distribution in SNA8 = 55,652 km^2  	• Commercial landings in SNA8 have averaged 1402 t over last 10 years. • SNA8 TACC is 1300 t • The SNA8 recreational catch of snapper in the 2007 Aerial-Access survey was 260 t with a CV of 10% • The SNA8 recreational catch of snapper in the 2012 Panel survey was 630 t with a CV of 16% • Snapper form important fisheries for customary non-commercial, but the annual catch is not known. • In SNA 8 an annual allowance of 43 t was made for customary non-commercial fishing.	• The 2005 stock assessment indicated that biomass (start of year 2004–05) was between 8% and 12% B_0 and was predicted to slowly increase at the TACC level of 1500 t. • From 1 October 2005 the TACC for SNA8 was reduced to 1300 t to ensure a faster rebuild of the stock. At this level the predicted rebuild to 20% B_0 will occur after 2018. • The age structure averages around 6 years making this stock very vulnerable to recruitment failure extending more than 2–3 years in duration.
Assessment of impact: Snapper is a widespread and wide ranging species most commonly found at depths < 50m. It is clear for this species that the size of the commercial and recreational fisheries relative to the strength of recruiting year classes are the key drivers of stock size. Given that the area potentially impacted by mining 50 M t per annum comprises < 0.1% of the area of distribution of snapper in SNA8, any displacement of fish or decrease in prey abundance or availability due to these activities should have negligible effects on the state of the stock.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Spiny dogfish (SPD) (*Squalus acanthias*)  • Occur on the continental shelf and upper slope down to a depth of at least 500 m, but are most common at depths of 50–150 m. • Schools are segregated by size and sex. • Spiny dogfish are born at a size of 18–30 cm total length (TL). • Males mature at 58 cm TL at age 6, and females mature at 73 cm TL at age 10. • Females give birth to young between April and September, mainly on the shelf edge at depths of 200–300 m. • Mating also occurs in deeper water (coincident with a movement of mature males offshore), after which females with young embryos move into shallower waters of 100 m or less. They remain there for 1 yr until the embryos are 15 cm long after which they return to deeper water to pup. • Young of the year move inshore into shallower waters shortly after birth. Over the next few years they move steadily into deeper water. • Diet comprises mainly crustaceans but also worms and small fish (Francis 2012).	Area of distribution in SPD8 = 163,114 km^2   	• Commercial landings in SPD8 have averaged 163 t over last 10 years. • SPD8 TACC is 307 t • The SPD8 recreational catch of spiny dogfish in the 1999-00 diary survey was 12.7–40.3 t with a CV of 52% • Maori fishers traditionally caught large numbers of “dogfish” including rig, school shark, and spiny dogfish. • Quantitative information on the current level of customary non-commercial fisheries take is not available.	No estimates of current or reference biomass are available
Assessment of impact: Spiny dogfish is a very widespread and relatively wide ranging species that supports a small commercial and a very small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises < 0.1% of the area of distribution of spiny dogfish in, any displacement of fish or decrease in prey abundance or availability due to these activities should have negligible effects on the state of the stock.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Tarakihi (TAR) (*Nemadactylus macropterus*)  • Tarakihi are caught in coastal waters down to depths of about 250 m • Tarakihi spawn in summer and autumn in several areas around New Zealand. • The post-larvae appear to be pelagic, occur in offshore waters, and are found in surface waters at night. • The long pelagic larval phase of 7–12 months indicates that larvae could be widely dispersed. • The results of tagging experiments have shown that tarakihi are capable of moving large distances around the coasts of the main islands of New Zealand. • Diet comprises worms, crabs, brittlestars, and shellfish (Francis 2012).	Area of distribution in TAR8 = 34,825 km^2  	• Commercial landings in TAR8 have averaged 215 t over last 10 years. • TAR8 TACC is 225 t • The TAR8 recreational catch of tarakihi in the 2012 panel survey was 22 t with a CV of 31% • No quantitative information on the level of customary non-commercial fishing is available	• Given the long, stable catch history of this fishery, current catch levels and TACCs are thought to be sustainable.
Assessment of impact: Tarakihi is a very widespread and wide ranging species that supports a small commercial and a very small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises 0.1% of the area of distribution of tarakihi in TAR8, and that its main area of distribution is offshore of the mining area, any displacement of fish or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.			

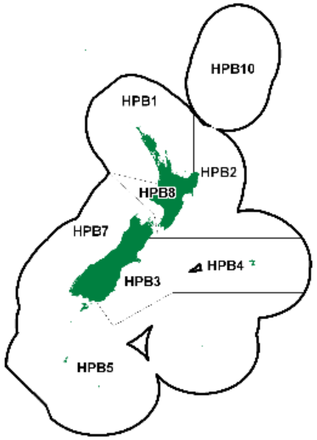
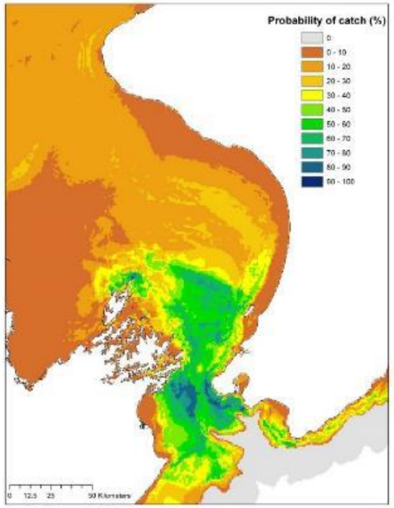
Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Trevally (TRE) (*Pseudocaranx dentex*)  • Trevally are both pelagic and demersal in behaviour. • Juvenile fish up to 2 years old are found in shallow inshore areas including estuaries and harbours. Young fish enter a demersal phase from about 1 year old until they reach sexual maturity. At this stage adult fish move between demersal and pelagic phases. • Trevally are known to reach in excess of 40 years of age. • Fecundity is relatively low until females reach about 40 cm FL. They appear to be partial spawners, releasing small batches of eggs over periods of several weeks or months during the summer. • Surface schooling trevally feed on planktonic organisms, particularly euphausids. On the bottom, trevally feed on a wide range of invertebrates.	Area of distribution in TRE7 = 76,455 km^2   	• Commercial landings in TRE7 have averaged 1827 t over last 10 years. • TRE7 TACC is 2153 t • The TRE7 recreational catch of trevally in the 2012 panel survey was 29 t with a CV of 17% • Trevally is an important traditional and customary food fish for Maori. • No quantitative information is available on the current level of customary non-commercial take.	• *Model run M = 0.1:* B_{2008} estimated to be 38% – 67% B_0 (median = 53% B_0); Very Likely (> 90%) to be at or above the target • Model Run M = 0.087: B_{2008} estimated to be 18% – 44% B_0 (median = 30% B_0); Likely (> 60%) to be at or above the target. • Relatively large proportions of fish > 10 years, including a healthy 20+ age group (as evidenced by the age structure of the commercial catch) suggest that TRE 7 have not been heavily exploited.
Assessment of impact: Trevally is a widespread and relatively wide ranging species with a core area of distribution in the STB inshore of about 60 m. It supports a moderate commercial and a very small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises < 0.1% of the area of distribution of trevally in TRE7, any displacement of fish, or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.			

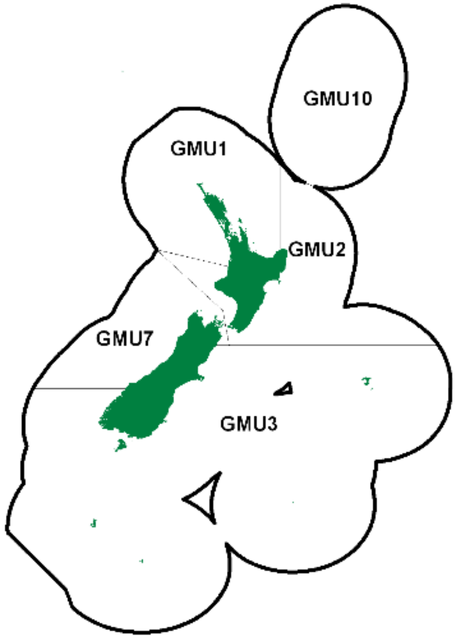
Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Common or blue warehou (WAR) ***(Seriolella brama)***  • Validated ageing of blue warehou shows rapid growth up to the time of first spawning (about 4-5 years), but negligible growth after about 10 years. • Female blue warehou grow significantly faster and reach a larger size than males. • Maximum recorded ages are 22 years for males, and 21 years for females. • Spawning in WAR8 has not been described but probably occurs in winter/spring. • Eggs are found in the surface plankton and juvenile fish are believed to occur in inshore areas. • The seasonal pattern of landings suggest that there is a coastal migration of blue warehou. • Blue warehou feed on a wide variety of pelagic prey, mainly salps but also euphausiids, krill, crabs and small squid.	Area of distribution in WAR8 = 34,346 km^2   	• Commercial landings in WAR8 have averaged 110 t over last 10 years. • WAR8 TACC is 233 t • The WAR8 recreational catch of blue warehou in the 1992–93 survey was 0.6 t with a CV of 102% • No quantitative information is available on the current level of customary non-commercial take	• Estimates of reference and current biomass are not available. • For all Fishstocks, it is not known if recent landings or TACCs are at levels which will allow the stocks to move towards a size that will support the maximum sustainable yield.
Assessment of impact: Blue warehou is a widespread and relatively wide ranging pelagic species with a core area of distribution in the STB close inshore. It supports a small commercial and a very small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of blue warehou in WAR8, and the main area of distribution is close inshore in naturally turbid water, any displacement of fish or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.			

Species (fisheries code), scientific name, depth range, movements, spawning times and areas, diet	Relevant Quota Management Area occupied by species	Landings, TACC and Recreational catch	Status of stocks
Witch (WIT) (*Arnoglossus scapha*)  Image: Peter McMillan, NIWA • Occurs around New Zealand on sand and mud to a depth of 500 m (Francis 2012). • Witch eat small fish, octopus, squid, crabs, shrimps, whale krill and sea cucumbers. Their diet suggests they hunt in mid-water as well as on the seafloor (Francis 2012).	Area of distribution in FLA2 = 58,362 km^2   	• Witch is less desirable than other flatfish species and seldom landed. • In 2001-02 just 28 t of witch were landed nationwide with just 2% coming from FLA2. • Quantitative information on the current level of customary non-commercial catch is not available.	• Not known

Assessment of impact: Witch is a widespread and possibly relatively wide ranging species that supports a very small commercial fishery and no known recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum comprises < 0.1% of the area of distribution of witch in FLA2, and the centre of distribution and abundance of witch in the region is further south, any displacement of fish or decrease in prey abundance or availability due to the proposed mining should have negligible effects on the state of the stock.

Table 4-2: Kaimoana summaries and assessments. Data, fish image and map of Quota Management Areas compiled from Ministry for Primary Industries (2014) unless stated otherwise. Distributional maps taken from MacDiarmid et al. (2013a).

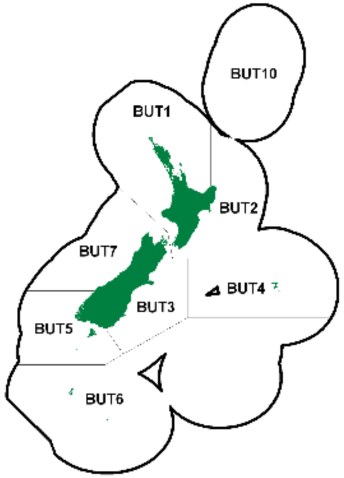
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Hapuku, groper, (*Polyprion oxygeneios*)  Image: Peter McMillan, NIWA • Hapuku occur mainly on rough ground in shelf and slope waters of the NZ mainland and offshore islands. • Occurs throughout the STB but most common in deeper water towards D'Urville Island and Kapiti Island and in Cook Strait. • Migration patterns are little known, but are probably related to spawning. Tagging of mostly immature fish in Cook Strait has shown a high level of site fidelity, but about 5% of these fish have moved up to 160 km north and south. • Quantitative information on the current level of customary non-commercial catch is not available from MPI. • Hapuku prey on a wide variety of fish and invertebrates, including red cod, tarakihi, blue cod, hoki and squid.	Area of distribution in HPD8 = 34,734 km^2   	Hapuka is a widespread and probably relatively site attached species that in HPB8 supports a small (80 t per annum) commercial fishery, a recreational fishery of 6-32 t per annum, and an unknown sized customary fishery. Given that the area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of hapuka in HPB8, and the centre of distribution of hapuka in HPD8 is to the south of the QMA, any displacement of fish or decrease in prey abundance or availability due to the proposed mining should have negligible effects on the state of the stock.

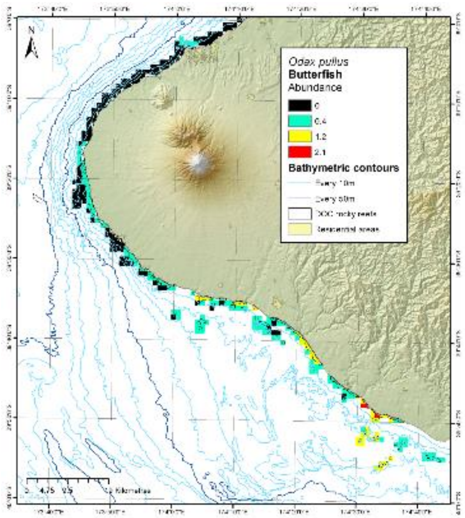
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	**Quota management areas, distributional maps**	**Assessment of impact**
Kanae, grey mullet, (*Mugil cephalus*)  • Grey mullet has a worldwide distribution, occurring along coasts, in estuaries, and in lower river systems between latitudes of 42° N and 42° S. • Grey mullet probably spawn in spring and summer along open coasts (Francis 2012). • Tagging studies indicate that movement patterns of adult grey mullet are complex. Some schools remain in one locality, while others appear to be on the move almost continuously. • Adult grey mullet typically feed on diatom algae and small invertebrates which are gulped from the seafloor or sea surface. • Reported commercial landings for GMU2 are <1 t per annum. No information is available from MPI on recreational or customary fisheries for grey mullet in GMU2.	 	Grey mullet is a widespread and relatively wide ranging species with an inshore distribution in the STB. It supports a very small fishery in the region. Given that the main area of distribution is close inshore in naturally turbid water, any displacement of fish or decrease in prey abundance or availability due to the proposed mining of 50 M t per annum should have negligible effects on the state of the stock.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact

Marari, butterfish, (*Odax pullus*)

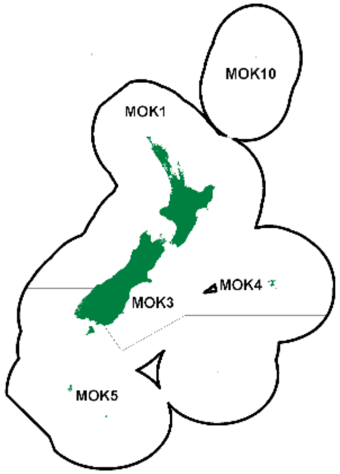
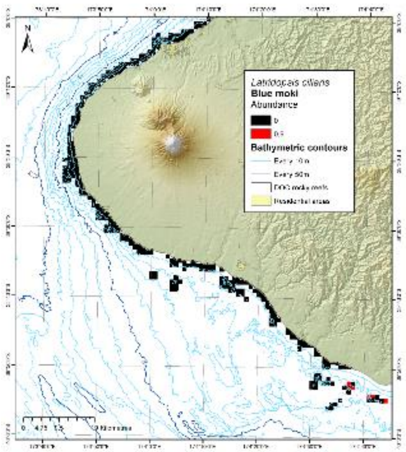
- Butterfish are endemic to New Zealand, and occur from North Cape to the Snares Islands.
- They occur on seaweed beds on rocky reefs in moderately turbulent water. Their main depth range is 0–20 m.
- Butterfish are almost exclusively herbivorous, feeding on several species of larger kelps.
- Reported commercial landings in BUT1 for 2012-13 were 2.1 t.
- Survey estimates indicate that the recreational catches appear to be of similar magnitude to those of the commercial fisheries.
- There is no quantitative information available from MPI on the current level of customary non-commercial catch.

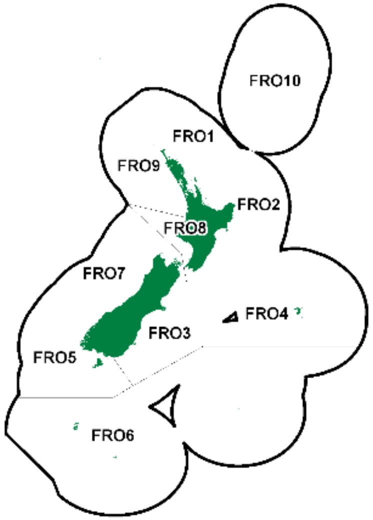
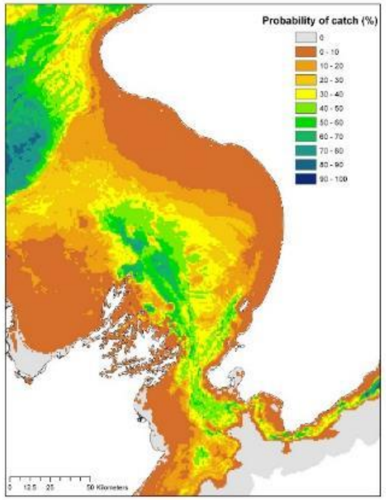


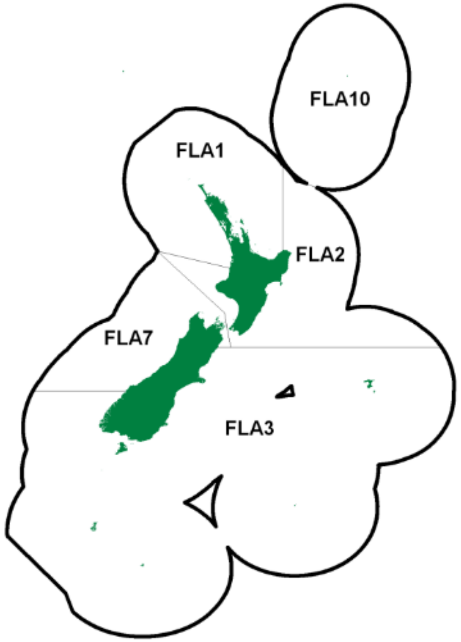


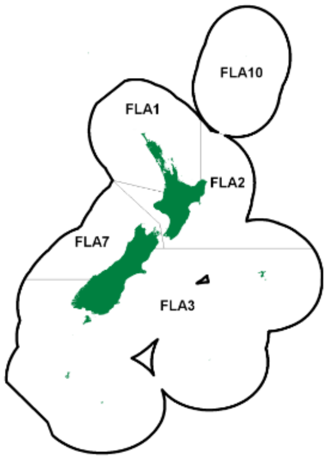
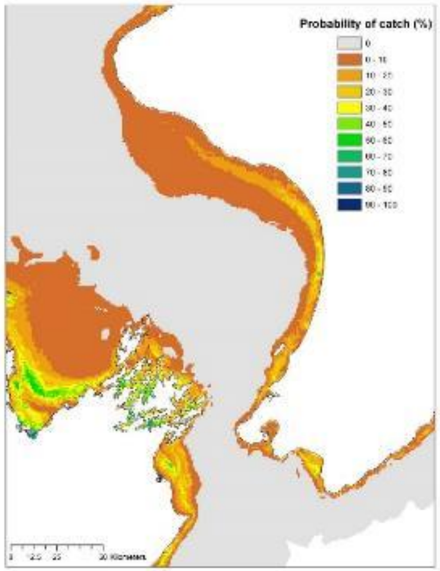
Modelled distribution and abundance of butterfish on Taranaki subtidal reefs (from MacDiarmid et al 2013a).

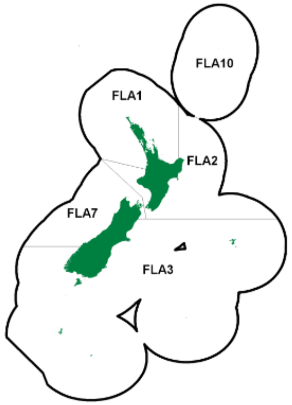
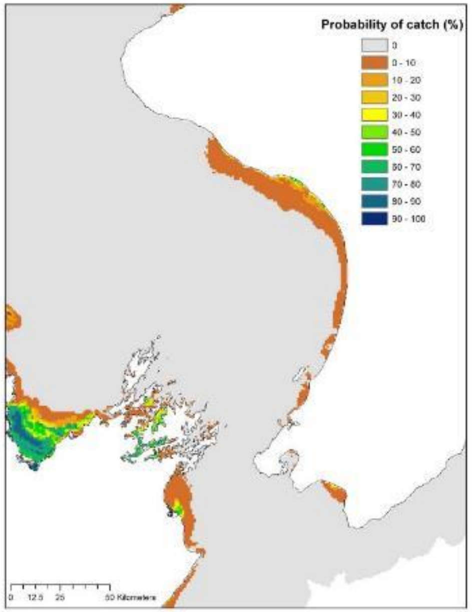
Butterfish is a widespread and site attached species with an inshore distribution on rocky reefs in the STB that supports a very small commercial and recreational fishery. Given that the main area of distribution is close inshore in naturally turbid water, any displacement of fish or decrease in prey abundance or availability due mining 50 M t per annum should have negligible effects on the state of the stock. Populations that occur on offshore reefs such as the North and South Traps could be affected to a minor extent as the plume will reduce the light available for kelps to grow by 10-20% (Pinkerton and Gall 2015).

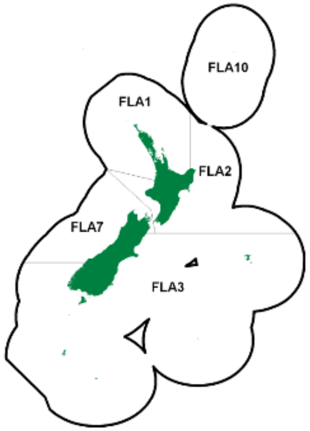
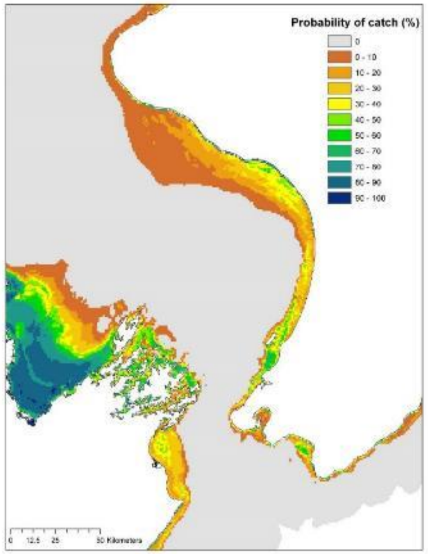
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Moki, blue moki, (*Latridopsis ciliaris*)  • Known only from New Zealand. Juvenile blue moki are found inshore, usually around rocky reefs, while most adults school offshore over mainly open sand or mud bottom. • Some adults do not join the adult schools but remain around reefs. • Modelling indicates that in the STB blue moki are predicted to occur on reefs only in the east of the region. • Many adults take part in an annual migration between Kaikoura and East Cape. • Juveniles on reefs eat small crustaceans amongst seaweeds while adults prey on crabs, other crustaceans, shellfish and worms which they suck from the sand or mud. • Commercial landings for MOK1 in 2012-13 were 385 t. • Popular with recreational fishers, blue moki are taken by beach anglers, set-nets, and spearfishing. • No quantitative information is available from MPI on the level of customary non-commercial catch.	  Modelled distribution and abundance of blue moki on Taranaki subtidal reefs (from MacDiarmid et al. 2013a).	Blue moki is a widespread and relatively wide ranging species in the STB, with juveniles occurring on rocky reefs and adults more widely distributed. It supports a moderate commercial and a small recreational fishery in the region. Given that the area potentially impacted by mining 50 M t per annum is probably <1% of the area of distribution of blue moki in MOK1, any displacement of fish, or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.

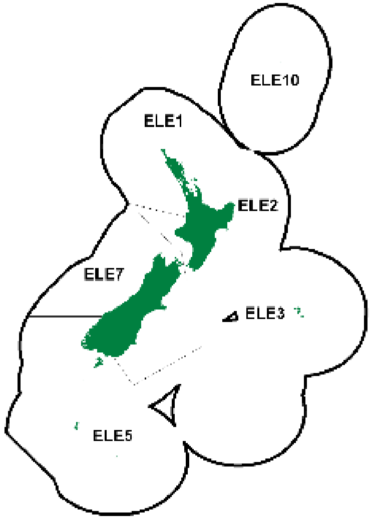
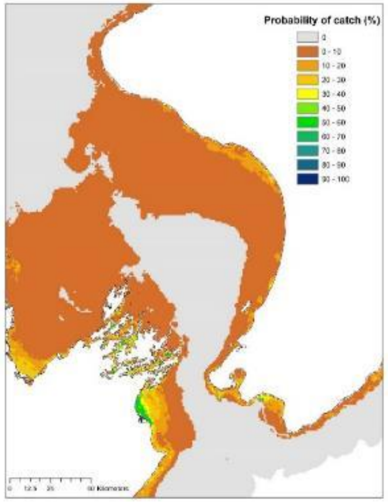
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	**Quota management areas, distributional maps**	**Assessment of impact**
Para, frostfish, (*Lepidopus caudatus*)  • Frostfish are widely distributed throughout the continental shelf and upper slopes of all oceans, except the North Pacific. In NZ they are most common between 36ºS and 44ºS in waters >200m deep. • In the STB frostfish occur throughout the region but are most common in deeper water to the west and south. • Frostfish migrate into mid-water at night and feed on crustaceans, small fish and squid. • Reported commercial landings for FRO8 in 2012–13 were 890 t. • Frostfish are occasionally taken by recreational fishers. • No quantitative information is available on the current level of customary non-commercial take. Maori have collected beach cast frostfish in the past.	Area of distribution in FRO8 = 35,067 km^2   	Frostfish is a widespread pelagic species that in FRO8 supports a medium size commercial fishery, a small recreational fishery, and an unknown customary fishery. Given that the area potentially impacted by mining 50 M t per annum comprises 0.2% of the area of distribution of frostfish in FRO8, and the centre of distribution of frostfish in the region is in deeper water to the west and south, any displacement of fish or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.

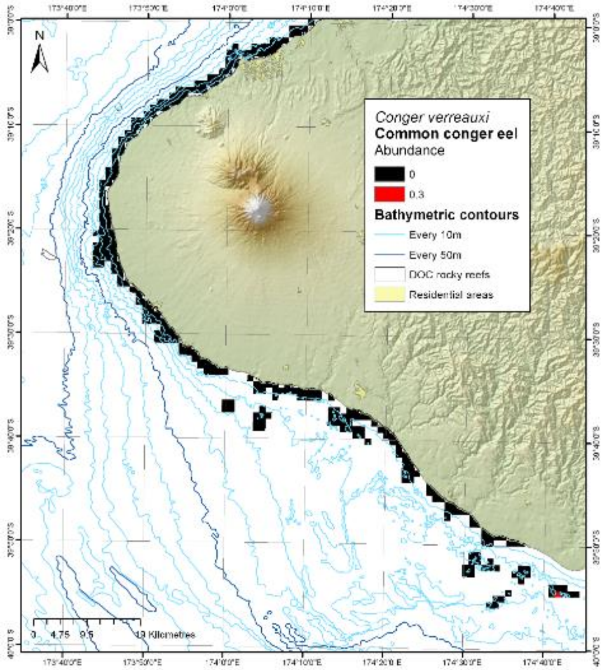
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Patiki mohoao, black flounder, (*Rhombosolea retiaria*)  • Endemic to NZ • They are primarily a coastal species, although they can penetrate well inland if the river gradient is not too steep. • Little is known about the life cycle of the black flounder. The larvae are undoubtedly marine, but where and when spawning takes place is a mystery. • Black flounder are a carnivorous species and probably eat a variety of bottom dwelling insects and molluscs. They are also known to feed on whitebait during the spring migration. • The average annual total NZ commercial catch of black flounder is 48 t with just 15% (7 t) coming from FLA2. • There are important recreational fisheries in most harbours and estuaries, throughout New Zealand. • No quantitative information is available from MPI on the level of customary non-commercial catch. •	 	Black flounder is a widespread coastal and freshwater species that supports small commercial, recreational, and customary fisheries. Given that its main area of distribution in the STB is close inshore in naturally turbid water, or in freshwater rivers, any displacement of fish or decrease in prey abundance or availability due to mining 50 M t per annum should have negligible effects on the state of the stock.

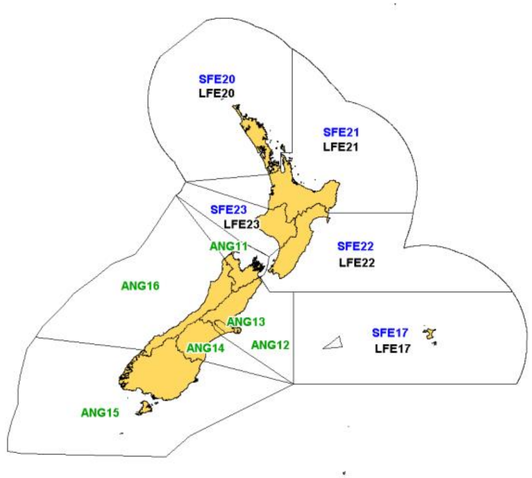
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	**Quota management areas, distributional maps**	**Assessment of impact**
Patiki rori, New Zealand sole, (*Peltorhamphus novaezeelandiae*) • Occurs around NZ on sand or mud bottom in estuaries, harbours, bays, and the inner continental shelf. • In the STB this species, though uncommon, occurs to a depth of about 100m. • Prey includes worms, crustaceans and small shellfish (Francis 2012). • The average annual total NZ commercial catch of NZ sole is 528 t with just 8% (42 t) coming from FLA2.	Area of distribution in FLA2 = 16,393 km^2  	New Zealand sole is a widespread coastal species that supports small commercial, recreational, and customary fisheries. Given that the proposed mining of 50 M t per annum should affect only 0.3% of its area of distribution in FLA2 and its main area of distribution in the STB is close inshore in naturally turbid water, any displacement of fish or decrease in prey abundance or availability due to mining should have negligible effects on the state of the stock.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Patiki totara, yellowbelly flounder, (*Rhombosolea leporina*)  • Endemic to NZ. • Lives on fine sand and mud in estuaries, harbours and coastal bays, rarely deeper that 30m (Francis 2012). • In the STB this species is confined to a coastal strip east and south of Hawera with the highest occurrence near Whanganui. • Eats shellfish, crabs and other crustaceans. • The average annual total NZ commercial catch of yellowbelly flounder is 201 t with just 2% (4 t) coming from FLA2. • There are important recreational fisheries in most harbours and estuaries, throughout New Zealand.	Area of distribution in FLA2 = 3,419 km^2   	Yellowbelly flounder is a shallow coastal species that supports small commercial, recreational, and customary fisheries. Given that yellowbelly flounder's area of distribution in the STB is close inshore in naturally turbid water with no overlap with the area where SSC could be elevated above 3 mg/l due to mining, the proposed mining activities should have negligible effects on the state of the stock.

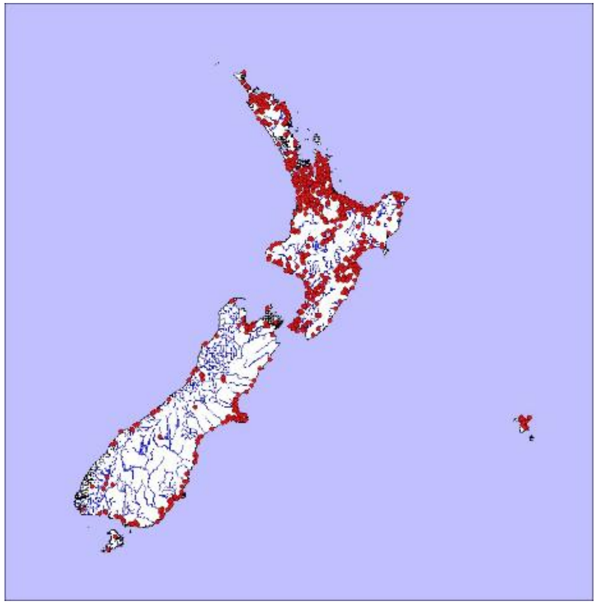
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Patiki, sand flounder, (*Rhombosolea plebeia*)  • Endemic to NZ. • Occurs on sand, mud, or gravel bottom in estuaries, harbours, bays, and the inner continental shelf (Francis 2012). • In the STB its main areas of distribution are close inshore. • Juveniles stay in shallow bays and harbours until they are 2 years old. • Adults migrate to spawning grounds in deeper water (30-50 m) in autumn-winter, and inshore in spring-summer (Francis 2012). • Adults prey on a wide variety of seafloor crustaceans, worms, brittlestars, and small shellfish (Francis 2012). • The average annual total NZ commercial catch of sand flounder is 399 t with just 13% (52 t) coming from FLA2. • There are important recreational fisheries in most harbours and estuaries, throughout New Zealand.	Area of distribution in FLA2 = 13,696 km^2   	Sand flounder is a shallow coastal species that supports small commercial, recreational, and customary fisheries. Given that the area of SSC potentially elevated above 3 mg/l due to the proposed mining activities comprises < 0.4% of sand flounder area of distribution in the STB, and that this species occurs mainly close inshore in naturally turbid water, any displacement of flounder or decrease in prey abundance or availability due to the proposed mining activities should have negligible effects on the state of the stock.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Reperepe, elephantfish, (*Callorhynchus milii*)  • Elephantfish occur south of East Cape on the east coast and south of Kaipara Harbour on the west coast. • They are uncommon in the STB to depths of about 200 m. • Adults migrate to shallow inshore waters in spring and aggregate for mating. Eggs are laid on sand or mud bottoms, often in very shallow areas. • After egg laying the adults are thought to disperse over the shelf and are difficult to catch; however, juveniles remain in shallow waters for up to 3 years. • Elephantfish prey mainly on seafloor shellfish and crustaceans (Francis 2012). • Reported commercial landings in ELE2 for 2012-13 were <1 t. • Estimates from the 1999–2000 recreational survey were 1000 fish in ELE 2. • Quantitative information on the current level of customary non-commercial catch is not available.	Area of distribution in ELE2 = 18,986 km^2   	Elephantfish is a widespread though uncommon species in the STB, with juveniles occurring inshore and adults more widely distributed. It supports very small commercial, recreational, and customary fisheries in the region. Given that the area potentially impacted by the proposed mining of 50 M t per annum is 0.3% of the area of distribution of elephantfish in ELE2, any displacement of fish, or decrease in prey abundance or availability due to these activities should have negligible effects on the state of the stock.

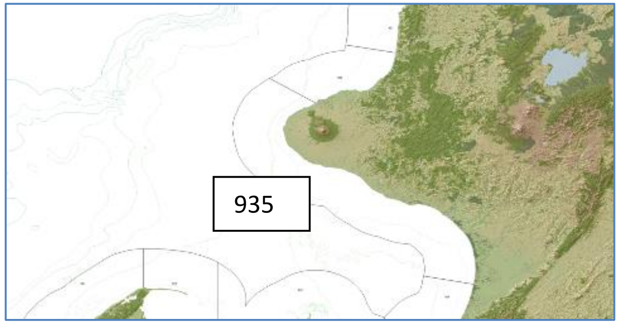
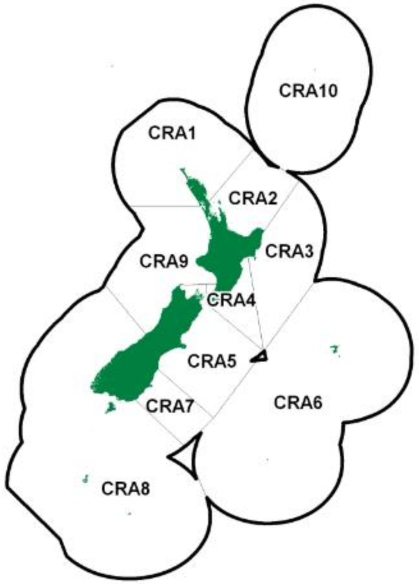
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Koiro, ngoiro, totoke, hao, ngoio, ngoingoi, putu, conger eel, (*Conger verreauxi*)  • Inhabits caves and crevices on rocky reefs. • Rare on reefs in the STB (see figure). Most abundant south of Cook Strait (Francis 2012). • Nocturnal preying upon fish, crabs, crayfish and octopus (Francis 2012). • Probably spawn once and then die (Francis 2012). • No known commercial fishery.	 **Modelled distribution and abundance of conger eel on Taranaki subtidal reefs (From MacDiarmid et al. 2013a).**	The common conger eel is a widespread and probably site attached rocky reef species in NZ, though rare in the STB, with no known commercial fishery. Given that the main area of distribution is close inshore in naturally turbid water, any displacement of fish or decrease in prey abundance or availability due to mining 50 M t per annum should have negligible effects on the state of the stock. Populations that occur on offshore reefs such as the North and South Traps or the Graeme Bank could be affected to a minor extent.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Tuna heke, long finned eel, (*Anguilla dieffenbachii*) **Tuna roa, short finned eel, (*Anguilla australis*)**   • The shortfin eel occurs throughout the South Pacific while the longfin eel is endemic (McDowall 2010). • The shortfin is principally a lowland species, while longfins prefer flowing water and hence are found extensively in main rivers, penetrating long distances upstream. • Adults are thought to breed in the ocean trenches near Tonga (McDowall 1990) though their migration routes from NZ are not understood. • The transparent leaf-like larvae drift on ocean currents for >1 year before reaching NZ coasts. • Historically, Maori had a highly developed fishery for freshwater eels (McDowall 2011. The extent of the present customary harvest is unknown (Jellyman 2012). • Average annual total commercial catch in SFE23 and LFE23 is about 33 t with long-finned eels comprising 67% (Jellyman 2012).	 Quota Management Areas for the New Zealand eel fishery. Separate stocks are designated for shortfins and longfins in the North and Chatham Islands. South Island eel stocks are designated as a single stock (ANG) for both species combined.	Few details are known about the marine phase of freshwater eels, so it is unknown whether these species occur in the vicinity of the proposed extraction site. However, given the relatively small area affected by the median near-surface and near-bottom plumes compared to the area of shelf waters in the STB, that the outgoing (migrating) adults are non-feeding, and incoming elvers are searching for river mouths, it is likely that mining 50 M t per annum should have negligible effects on the state of the SFE23 or LFE23 eel stocks.

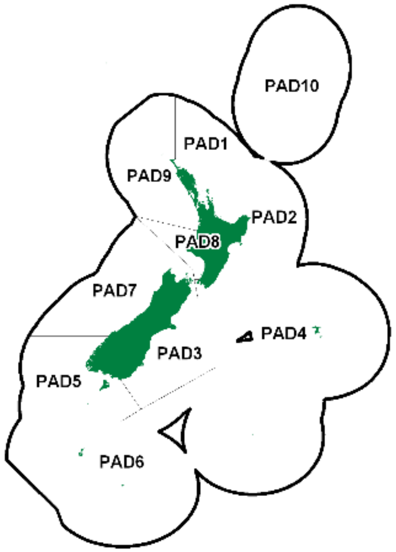
<table>
<tr><th>Maori name, common name, (Formal name), distribution, habitat, diet, fishery</th><th>Quota management areas, distributional maps</th><th>Assessment of impact</th></tr>
<tr><td>Paraki/ Ngaore, common smelt, (Retropinna retropinna)

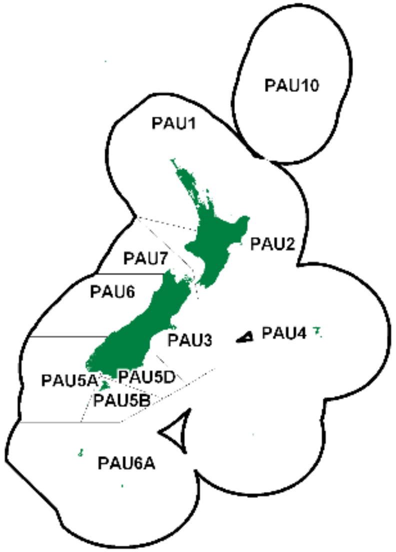
• Unless otherwise stated the information below comes from https://www.niwa.co.nz/freshwater-and-estuaries/nzffd/NIWA-fish-atlas/fish-species/common_smelt
• The common smelt is a widespread diadromous species (occurs in both marine and freshwater habitats) throughout New Zealand.
• The species is common in shallow coastal waters all around New Zealand (Ayling 1982) and also lives in freshwater rivers and lakes with some land-locked populations (see adjacent figure).
• Adults spawn in estuaries and rivers and die after spawning (Ayling 1982).
• Smelt school in the open waters where they feed on drifting food organisms.
• There is no commercial fishery but young smelts are often caught along with whitebait in recreational fisheries (Ayling 1982).
• Customary?</td><td>
From https://www.niwa.co.nz/freshwater-and-estuaries/nzffd/NIWA-fish-atlas/fish-species/common_smelt</td><td>Common smelt is a shallow coastal, estuarine, and freshwater species that supports small recreational, and customary fisheries. Given that its area of distribution in the STB is probably close inshore in naturally turbid water, mining 50 M t per annum should have negligible effects on the state of the stock.</td></tr>
</table>

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	**Quota management areas, distributional maps**	**Assessment of impact**
Kaeo, sea tulip, (*Pyura pachydermatina and P. spinosissima*)  • These filter feeding stalked ascidians occurs on rocky reefs in shallow waters around NZ. *Pyura pachydermatina* is most common in cooler southern waters while *P. spinosissima* occurs around the southern parts of North Island and northern South Island. • *Pyura pachydermatina* is a winter-breeding, annual species, with settlement of each new generation during late winter and early spring. For most of the year there is only one ascidian generation on the shore, with a brief overlap during the settlement of each new ascidian generation. The large, mature individuals of the preceding generation die off at this time (Egan 1984). • There is no commercial or recreational fishery for either species. • Customary use?		Sea tulips are shallow coastal species occurring on rocky reefs. Given that their area of distribution in the STB is close inshore in naturally turbid water, the proposed mining of 50 M t per annum should have negligible effects on the populations of these species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Koura, Rock lobster/Crayfish, (*Jasus edwardsii*)  • Rock lobsters occur on rocky reefs from 1 to 50 m and occasionally in deeper water where they may occur on sand flats adjacent to reefs. • Red rock lobsters may associate with a reef or reefs along one section of coastline for months or years. • Only about 17% of lobster larvae originating from CRA9 settle as juveniles in the same region. About 75% of lobster larvae settling in the CRA9 area, originate from CRA8, which includes Fiordland, the Southland coast and Stewart Island (Chiswell & Booth 2008). • Rock lobsters are nocturnal benthic predators preying upon a wide range of snails, bivalves, kina, other echinoderms, fish, and algae. • In the STB rock lobsters are caught commercially and recreationally, as well as customarily. The size of the customary fishery is not documented. • The average annual total commercial catch of rock lobsters in statistical area 935 over 2005-06 to 2010-11 was 23.6 t.	 • Rock lobster populations in the STB lie within statistical area 935 which is part of the broader CRA9 QMA.  	Rock lobster is a common and relatively site attached species with an inshore distribution on rocky reefs in the STB that supports a small commercial, recreational, and customary fishery. Given that the main area of distribution is close inshore in naturally turbid water, any displacement of lobsters or decrease in prey abundance or availability due to mining 50 M t per annum should have negligible effects on the state of the stock in area 935 or in CRA9. Populations that occur on offshore reefs such as the North and South Traps could be affected to a minor extent.

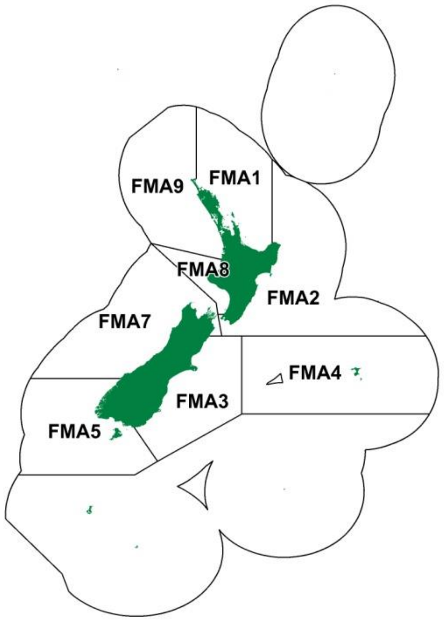
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Koeke, common shrimp, (*Palaemon affinis*)  • Occurs throughout New Zealand in intertidal rockpools, in the shallow subtidal, and in estuaries (Morton and Miller 1968). • Diet comprises diatoms, plant detritus, dinoflagellates, and brown algae, but will prey upon animal tissue if available (Morton and Miller 1968, Alfaro et al. 2006). • No commercial or recreational fishery		Given that the area of distribution of common shrimp in the STB is close inshore in naturally turbid water, mining 50 M t per annum should have negligible effects on the populations of this species.
Papaka parupatu, mud crab, (*Helice* sp.)  • Mud crabs occur intertidally in estuaries, harbours and on sheltered shores throughout New Zealand (Morton and Miller 1968). • Mud crabs feed on organic matter sifted from the muddy substrates in which they live (Sivaguru 2000). • There is no commercial or recreational fishery for this species.		Given that the area of distribution of this crab in the STB is in estuaries and on sheltered intertidal shores in naturally turbid water, mining 50 M t per annum should have negligible effects on the populations of these species.

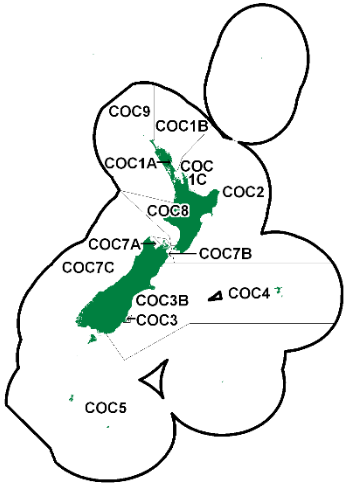
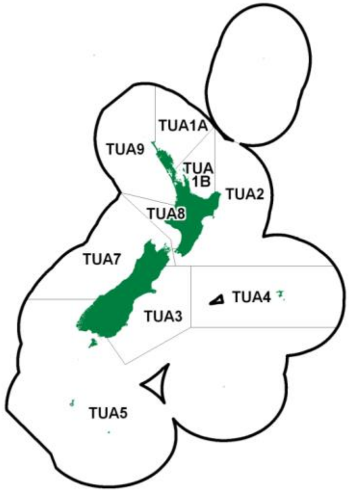
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Papaka, paddle crab, (*Ovalipes catharus*)  • Occurs on sandy seafloors around the coasts of New Zealand to depths of about 15 m (Wear and Haddon 1987). • Diet comprises mainly small bivalves, crabs, and amphipods (Wear and Haddon 1987). • In PAD8 there is an annual recreational allowance of 4 t and a customary allowance of 1 t. The TACC is 60 t.		Given that the area of distribution of this crab in the STB is in shallow naturally turbid waters, the proposed mining of 50 M t per annum should have negligible effects on the population of this species.
Wheke, octopus, (*Macroctopus maorum*)  • Occurs subtidally in the waters around New Zealand and southern Australia to depths >50 m. It is usually associated with soft-sediment shellfish beds, but may be found less commonly on reef habitats (Anderson 1999). • The smaller species *Octopus huttoni* was sampled near the proposed mining area. • Preys on crustaceans (including rock lobsters), scallops, and any fish that can be captured (Anderson 1999). • No commercial or recreational fishery		Although specimens of this species were not collected during NIWA sea floor sampling programme in the STB it is possible that they occur on inshore rocky reefs in naturally turbid waters and on offshore shellfish (dog cockle) beds that should be unaffected by seafloor deposition of mining derived sediments and largely unaffected by the near bottom plume. Given this distribution, mining 50 M t per annum should have negligible effects on the populations of this species in the STB. Populations that occur on offshore reefs such as the North and South Traps or the Graeme Bank could be affected to a minor extent.

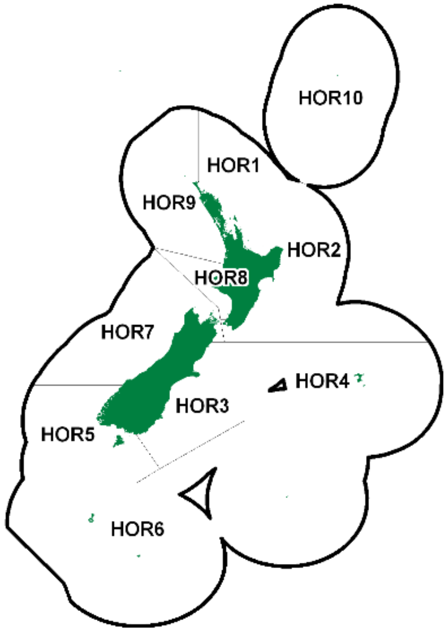
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Paua, (*Haliotis iris*) and Hihiwa, Paua – yellow foot, (*Haliotis australis*)  • Occurs on shallow rocky reefs around New Zealand to depths of 15-20 m. • Paua are sedentary herbivores grazing on drift and attached kelp. • Because of the small size of paua around Taranaki, the MLS for recreational fishers is 85 mm. • There are no reliable estimates of recreational catch and no commercial fisheries for paua in the region.		Given that the area of distribution of paua in the STB is close inshore on reefs in naturally turbid water, mining 50 M t per annum should have negligible effects on the populations of these species.
Rori, sea-snail, (*Scutus breviculus*)  • Occurs around New Zealand on intertidal and shallow subtidal reefs (Morton and Miller 1968). • Herbivore, grazing on a variety of seaweeds (Morton and Miller 1968). • No commercial or recreational fishery.		Given that the area of distribution of rori in the STB is close inshore on reefs in naturally turbid water, mining 50 M t per annum should have negligible effects on the populations of this species.

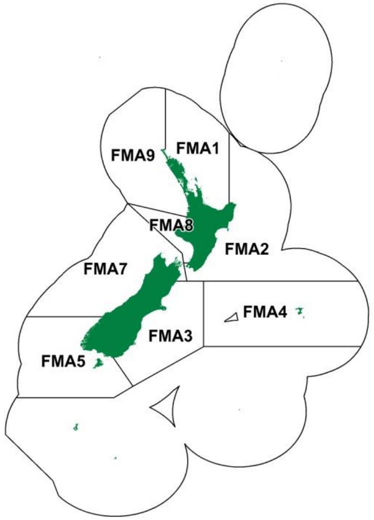
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Waikaka, mudsnail, (*Amphibola crenata*)  • Occurs on upper intertidal muddy shores around New Zealand (Morton and Miller 1968). • Grazer of benthic diatoms • No commercial fishery		Given that the area of distribution of mudsnails in the STB is intertidally in muddy estuaries, mining 50 M t per annum should have negligible effects on the populations of this species.
Pupu, cats eye, (*Lunella smaragda, Diloma* spps)  • These herbivorous gastropods all occur on rocky shores around New Zealand coasts • No commercial fishery		Given that the area of distribution of these grazing gastropods in the STB is intertidally on rocky shores, mining 50 M t per annum should have negligible effects on the populations of these species.

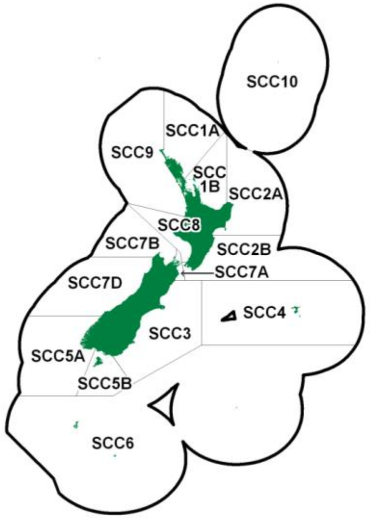
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Kutae/Kuku, green-lipped mussel, (*Perna canaliculus*)  • The endemic green-lipped mussel occurs on reefs at the low intertidal and shallow subtidal zones around New Zealand. • Mussels filter micro-algae and small organisms from the water column. • There is no commercial fishery for wild green-lipped mussels though mussel spat for aquaculture are collected from wild sources.		Given that the area of distribution of these filter feeding bivalves in the STB is on intertidal and shallow sub-tidal parts of rocky shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.
Kutae/Kuku, blue mussel, (*Mytilus galloprovincialis*)  • Like the green-lipped mussel, the blue mussel occurs on reefs at the low intertidal and shallow subtidal zones around New Zealand. • Mussels filter micro-algae and small organisms from the water column. • There is no commercial fishery		Given that the area of distribution of these filter feeding bivalves in the STB is on intertidal and shallow sub-tidal parts of rocky shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.

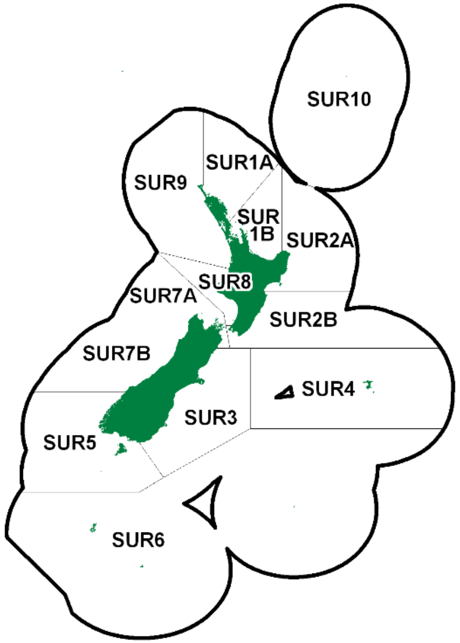
Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Pipi/kakahi, pipi, (*Paphies australis*)  • This filter feeding bivalve occurs on sheltered sand shores at the low intertidal around New Zealand. • There is no commercial fishery in the STB.		Given that the area of distribution of these filter feeding bivalves in the STB is on the low intertidal zone of sheltered sandy shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.
Purimu, surfclam, (*Dosinia anus, Paphies donacina, Spisula discors, Spisula murchisoni, Crassula aequilatera, Circomphalus yatei, or Dosinia subrosea*)   • These filter feeding bivalve molluscs live in the surf-zone off exposed sandy beaches around New Zealand. • Offshore clams are likely to have been harvested for customary use only when washed ashore after storms • There is a commercial fishery for some species off Foxton Beach.	 	Given that the area of distribution of these filter feeding bivalves in the STB is close inshore in the surf-zone of sandy beaches where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of these species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Tuangi, cockle, (*Austrovenus stutchburgi*)  • This filter feeding bivalve mollusc occurs in the mid to low intertidal zone on protected soft mud and fine sand shores around New Zealand (Morton and Miller 1968). • There is no commercial catch in COC8		Given that the area of distribution of these filter feeding bivalves in the STB is intertidally on protected soft mud and fine sand shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.
Tuatua, tuatua, (*Paphies subtriangulata*)  • This filter feeding bivalve mollusc occurs from the low intertidal to the shallow subtidal on ocean beaches with moderate wave exposure and fine, clean, fluid sands. • Tuatua support an extensive recreational fishery, with harvesting occurring in all stocks wherever there are accessible beds. • Tuatua are an important customary species. • There is no commercial fishery in TUA8.		Given that the area of distribution of these filter feeding bivalves in the STB is on moderately exposed ocean beaches where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Waharoa, horse mussel, (*Atrina zelandica*)  • This filter feeding bivalve occurs subtidally in muddy-sand substrates of mainly sheltered waters but also occurs in deeper waters (to 50 m) off open coasts. • None were sighted in NIWA surveys offshore or inshore. • There are no reported recreational or commercial landings in HOR8.		Given the likely restricted distribution of this bivalve in the STB to more sheltered waters nearshore where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.
Karaura, ngakihi, tio, repe, rock oyster, (*Crassostrea glomerata*)  • This filter feeding bivalve occurs in the intertidal zone on sheltered rocky shores especially in northern New Zealand (Morton and Miller 1968). • There is no commercial fishery.		Given that the area of distribution of these filter feeding bivalves in the STB is on sheltered intertidal rocky shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	**Quota management areas, distributional maps**	**Assessment of impact**
Kuakua/pure/tipa/tipai/kopa, scallop, (*Pecten novaezelandiae*)  • This filter feeding bivalve occurs on sandy shelf habitats around New Zealand most commonly at depths of 10 to 25 m. • Isolated individuals were observed by NIWA in camera transects within the TTR mining area and likely occur in low densities throughout the STB at depths < 50 m. • There is no targeted commercial fishery within FMA8		The likely wide distribution of scallops within FMA8 at depths less than 50 m totals about 14,000 km^2. Given that the area potentially impacted by the proposed mining activities is 0.3% of the area of distribution of scallops in FMA8, any displacement of scallops, or decrease in food abundance or availability due to these activities should have negligible effects on the state of the scallop stock in FMA8. .
Patangatana/ patangaroa/ pekapeka, starfish (Asteroidea)    • Several species of starfish occur on rocky reefs or sediment flats close to shore and may be harvested in customary fisheries. These include the cushion star *Patiriella regularis*, the prickly star *Coscinasterias*		Given that the area of distribution of starfish in the STB is on intertidal and shallow sub-tidal parts of rocky shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of these species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
calamaria and the reef star *Stichaster australis.* • The cushion star has a varied diet as predator, scavenger, grazer and detritus feeder, while the prickly star and reef star are strictly predators of sedentary prey. • There is no recreational or commercial fishery for starfish in the STB.		
Rore/rori, sea cucumber, (*Australostichopus mollis*)  • This detritus feeder occurs throughout New Zealand in shelf waters to 200 m in a wide range of habitats from rocky shores to muddy bottoms (Dawbin 1950). • In the STB 12 specimens were sampled by NIWA around the deep seaward margin of the Patea Banks at depths of 40-70 m. One further specimen was sampled from a small reef just to the north of the proposed mining area. This species was not sampled from the mining site or nearshore soft sediments. • There are no reported commercial landings from SCC8.	 	NIWA sampling indicates that in the STB this species is absent from the proposed mining site and restricted to inshore rocky reefs in naturally turbid waters and deep offshore sediments that will be unaffected by seafloor deposition of mining derived sediments and largely unaffected by the near bottom plume. Given this distribution, mining 50 M t per annum should have negligible effects on the populations of this species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Kina, sea urchin, (*Evechinus chloroticus*)  • Kina occur inter-tidally in rock pools and sub-tidally to about 15m around New Zealand coastlines. • Kina are herbivores grazing on micro and macro algae. • They are usually gathered by hand at low tide or by snorkelling in shallow water. Only mature individuals are gathered as the ripening roe is the prized target. • The commercial catch in the STB is very small with just 4 t reported catch in areas SUR8 and 9 combined in the 2012-13 fishing year. • The recreational catch is much larger at around 20 t per annum for SUR8 alone.	 	Given that the area of distribution of kina in the STB is on intertidal and shallow sub-tidal parts of rocky shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of this species.

Maori name, common name, (*Formal name*), distribution, habitat, diet, fishery	Quota management areas, distributional maps	Assessment of impact
Kotore/humenga, sea anemone, (Anthozoa)    • Several species of sea anemones occur on rocky reefs close to shore and may be harvested in customary fisheries. These include the wandering sea anemone *Phlyctenactis tuberculosa*, the red sea anemone *Actinia tenebrosa*, and the olive-green anemone *Isactinia olivacea*. • There are no commercial or recreational fisheries.		Given that the area of distribution of these anemones in the STB is on intertidal and shallow sub-tidal parts of rocky shores where the waters are naturally turbid, mining 50 M t per annum should have negligible effects on the populations of these species.

4.2 Assessment of impact

4.2.1 Commercial and recreational species

The commercial and recreational fish species commonly occurring (% occurrence >50%) in the proposed mining area (Table 4-1), fall into two distinct groups on the basis of the criteria used to assess impact (Table 2-2). The first group is large and includes all pelagic species and all but one of the demersal and benthic species. Given that the area potentially impacted by the proposed mining activities comprises less than 1% of their area of distribution in their QMA, that individuals are relatively mobile, and occur either close inshore in areas already impacted by high background levels of SSC, or principally offshore, any displacement of fish or decrease in prey abundance or availability due to the proposed mining activities will have negligible effects on the state of their stocks.

In the second group is one species, eagle ray. Although the area potentially impacted by mining 50 M t per annum comprises less than 1% of the area of distribution of eagle ray in FMA8, about 8% of its core area of distribution (>50% occurrence) overlaps with the area of SSC elevated above 3 mg/l. Using this threshold a minor to moderate proportion of the stock could be affected by mining through displacement of fish, or decrease in prey abundance or availability. During summer and autumn eagle ray tends to concentrate inshore in water less than 10 m deep where background SSC may reach over 100 mg/l (Hadfield and Macdonald 2015). This suggests that eagle rays may be tolerant to SSC higher than the threshold of 3 mg/l used to assess the impact of SSC elevated by the proposed mining activities.

4.2.2 Kaimoana species

The kaimoana species fished or gathered in the STB fall into three groups on the basis of the criteria used to assess the potential impact of the proposed mining activities (Table 2-2). In the first group are five fish species occurring close inshore or penetrating reaches of the river systems in the region, and a large number of invertebrate species fished or gathered from intertidal and shallow sub-tidal parts of rocky reefs or muddy or sandy shores where the waters are commonly naturally turbid. The fish include kanae (grey mullet), patiki mohoao (black flounder), tuna heke (long finned eel), tuna roa (short finned eel), and paraki/ngaiore (common smelt). The invertebrates include koeke (common shrimp), kaunga (hermit crab), papaka parupatu (mud crab), papaka (paddle crab), waikaka (mudsnail), pipi, purimu (surfclams), tuangi (cockle), tuatua, kotore or humenga (sea anemone), kina (sea urchin), patangatana (starfish), karaura (rock oyster), kutae/kuku (green lipped and blue mussel), pupu (cats eye), rori (sea-snail), paua and hihiwa (black- and yellow-foot paua), kaeo (sea tulip), and waharoa (horse mussel). Given that their main area of distribution in the STB is close inshore in naturally turbid water, or in freshwater rivers, they are highly unlikely to be affected by the mining activities or sediment plume and any displacement of fish or decrease in prey abundance or availability due mining 50 M t per annum will have no or negligible effects on the state of their stocks.

The second group includes two species, hapuka (groper), and para (frostfish), with a broad distribution in the STB but with their centre of distribution in deeper offshore waters, and seven other species including kuakua (scallop), and rore/rori (sea cucumber), moki (blue moki), patiki rore (New Zealand sole), patiki totara (yellowbelly flounder), patiki (sand flounder), and reperepe (elephantfish) occurring mainly in depths less than 50 m. Given that the area of SSC concentrations elevated over background levels by the proposed mining of 50 M t per annum comprises less than 1% of the area of distribution of these species in FMA8, any displacement of individuals or decrease in prey abundance or availability due to the proposed mining activities will have negligible effects on the state of their stocks.

In the third group are rocky reef, demersal or benthic species occurring mainly close inshore but with their distributions extending across the inner part of the shelf to depths of 50m wherever suitable habitat occurs.

This group includes marari (butterfish), koiro (conger eel), koura (rock lobster or crayfish), and wheke (octopus). Although their populations close inshore will be largely unaffected by mining 50 M t per annum, it is possible that individuals occurring at or near the mining site or areas affected by the near seafloor sediment plume, could be displaced or experience a decrease in food abundance or availability. However, for each species the impact on their overall population is likely to be negligible.

5 Seabirds

5.1 Introduction

Seabirds, particularly species in the order Procellariiformes (albatrosses, shearwaters, petrels, diving petrels and storm petrels), have relatively extreme life-history characteristics. These seabirds have relatively low reproductive rates, producing a maximum of one chick per breeding attempt. Some species do not breed every year if successful in rearing a chick to fledging: biennially-breeding species (including all the 'great' albatrosses and grey-headed albatross *Thalassarche chrysostoma*) breed in alternate years if successful. Deferred maturity is normal in this group, for example the mean age of first breeding in Buller's albatross *T. bulleri* was 12 years, and adult survival was relatively high, typically over 90% (Francis & Sagar 2012).

These relatively extreme life-history traits extend to foraging and migration patterns. Seabirds have to locate prey, which at relatively small spatial scales tends to be patchily-distributed and ephemeral in occurrence, over the expanse of the ocean, often travelling large distances on single foraging trips. The development of miniaturised electronic tracking technology has begun to reveal the scale at which seabirds operate when searching for food. For example, Cook's petrel *Pterodroma cookii*, a relatively small (200 g) seabird was tracked foraging up to 1,400 km from the breeding site (Rayner et al. 2010), and wandering albatrosses *Diomedea exulans* were estimated to travel a distance of more than 8.5 million km throughout an indicative lifetime of 50 years (Weimerskirch et al. 2014).

5.2 Seabird Distribution and Migration

In New Zealand, our understanding of where seabirds occur at sea is based largely upon ad hoc sightings from platforms of opportunity, and more recently through the deployment of a range of electronic tracking technology. There has been no systematic and quantitative at-sea survey of seabird abundance and distribution, and how these vary temporally, in New Zealand – this is perhaps not too surprising as such an undertaking would be considerable and require a relatively large amount of resource to achieve successfully. With the advent of tracking technology (Jouventin & Weimerskirch 1990) capable of recording in detail the movements of individual birds, we have been able to examine the extent to which seabirds traverse the ocean in search of food when constrained to return to a breeding site, and to determine the large-scale movements of seabirds during migrations away from breeding locations. Although tracking technology is relatively expensive, and the logistics of deploying and retrieving tracking gear are relatively challenging, data acquired from data-logging and transmitting devices attached to individual seabirds has enabled the scale of movements of birds of known provenance to be determined. Such insight is generally not possible by simply observing birds at sea, as for the majority of species it is not possible to know where observed birds are breeding or whether they are actively breeding.

When migrating, seabirds undertake some of the largest animal movements determined to date, again revealed by utilising data-logging tracking technology (for example, Shaffer et al. 2006, Egevang et al. 2010). It is clear that many species of seabirds breeding in New Zealand migrate large distances, often to areas outside New Zealand waters (for example, Stahl & Sagar 2000, Shaffer et al. 2006, Landers et al. 2011, Rayner et al. 2011), and can be considered to have a functional role in marine systems that extends to the scale of ocean basins.

5.3 Case Studies

Five species were selected to illustrate the scale of distribution and movement within New Zealand's Exclusive Economic Zone (EEZ) and beyond. For each species, information is provided about conservation status, both globally based on the International Union for the Conservation of Nature's (IUCN) Red List classification (see http://www.iucnredlist.org/) and nationally based on recent New Zealand classifications provided by Robertson et al. (2013). A summary of the current breeding population is provided together with information about diet and at-sea distributions in New Zealand, for most species derived from electronic tracking of individuals. Each of the four species outlined below is likely to occur within the south Taranaki Bight (STB), and each could occur in the area affected by the proposed mining activity. For comparative purposes, the affected area was estimated to be 60.5 km^2; the average spatial extent of surface and near bottom median SSC elevated above 2 mg/l due to mining 50 M t per annum (see Table 2-1).

5.3.1 Case study 1: Gibson's albatross

IUCN classification: Vulnerable
NZ conservation status: Threatened - Nationally Critical

Gibson's albatross (*Diomedea antipodensis gibsoni*) is endemicand breeds only at the Auckland Islands (Auckland, Adams and Disappointment islands) in New Zealand's sub-Antarctic zone.

It breeds biennially: pairs that successfully rear a chick in one year do not breed the following year, but breed again in the third year. Elliott & Walker (2014) presented estimated numbers of annual breeding pairs at the Auckland Islands from 1991 to 2014: from 1998 to 2004 the mean annual estimate was 7,221 pairs (range 4,926-8,701), in 2005 the estimate dropped to 4,158 and then fell further to a low of 2,816 pairs in 2006. The mean estimate for 2007 to 2014 was 4,054 (range 3,210-4,966). This overall decline in breeding population underpins the New Zealand conservation status of 'nationally critical' for this seabird.

Compared to other albatross species, Gibson's albatross exhibits a relatively restricted distribution. Tracking studies demonstrated a year-round distribution centred on the Auckland Islands and the Tasman Sea, but extending to the east of New Zealand as far as approximately 160°W and as far west as the southwest of Australia at approximately 120°E. The distribution extended as far north as 30°S and south to 55°S (Walker & Elliott 2006). More recently, further tracking work has revealed a shift within the overall distribution of Gibson's albatross, with areas to the east of New Zealand and south of Australia relatively more important after 2005 than before this date (Elliott & Walker 2014).

Based on the work of Walker & Elliott (2006), which employed satellite transmitting tags to track the movements of individuals from Adams Island in the Auckland Islands group, breeding birds were found to range over an area in excess of 13 million km^2 (Figure 5-1), including the STB. This range applies to the tracked, breeding population as whole, and individual birds are unlikely to utilise the full extent of this range, even over the course of an annual cycle. Nevertheless, Gibson's albatrosses, even when constrained to return to Adams Island to incubate an egg or feed a chick have the potential to forage for their mainly cephalopod prey (Marchant & Higgins 1990) over a wide area. In comparison, the area of SSC elevated above 2 mg/l due to mining 50 M t per annum is very small and represent less than 0.0001% of the area available to Gibson's albatrosses.

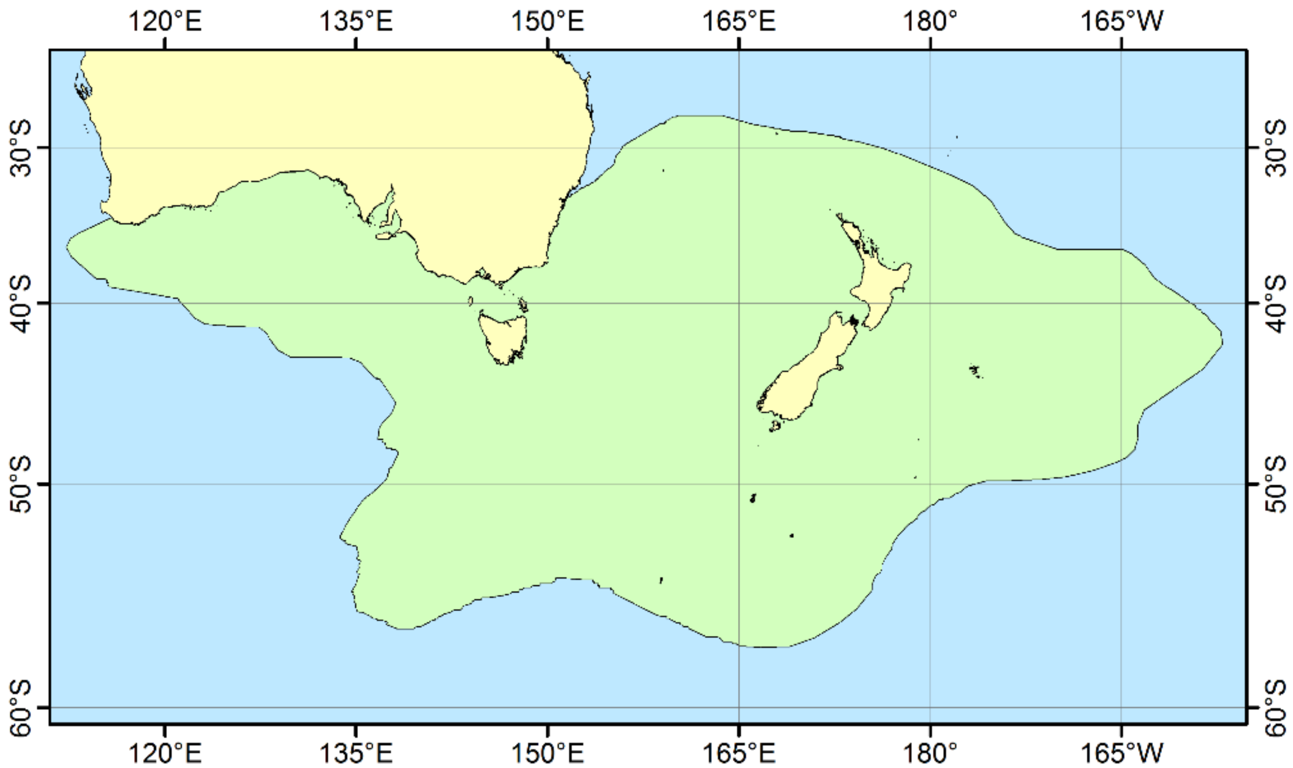


Figure 5-1: Foraging range of breeding Gibson's albatross based on tracking data. Adapted from Walker and Elliott (2006).

Assessment of impact: Gibson's albatross remains in the Australasian region throughout the year, so the distribution represented in Figure 5-1 approximates to our current understanding of the full spatial extent of this species' distribution. This area is clearly very large compared to the area affected by the proposed mining activity, and coupled with the findings of Walker & Elliott (2006), which found that the STB was not a particularly important area for Gibson's albatross, we conclude, using the criteria in Table 2-2, that the proposed mining of 50 M t per annum would have a negligible effect on this species.

5.3.2 Case study 2: Westland petrel

IUCN classification: Vulnerable
NZ Conservation Status: At Risk – Naturally Uncommon

The Westland petrel (*Procellaria westlandica*) is endemic to New Zealand and was described as recently as 1946, following information provided by pupils of the Barrytown Primary School (Falla 1946). It breeds during the winter months inland under forest in the coastal foothills of the Paparoa Range, Westland. Most nesting burrows are distributed below 200 m above sea level in an area between the Punakaiki River and Lawsons Creek (Jackson 1958, Best & Owen 1976). Based on burrow counts completed between 2002 and 2005, Wood & Otley (2013) estimated that the population was 2,954-5,137 breeding pairs.

When breeding in New Zealand, Westland petrels forage mainly for cephalopods, often bioluminescent forms taken at night (Imber 1976), primarily in waters to the west of South Island offshore from the breeding area and in an area from Taranaki, south-eastwards through Cook Strait and along the Chatham Rise (Landers et al. 2011). During the non-breeding period, part of the population migrates to South American waters, where the distribution extends from southern Peru to Cape Horn and into the southwest Atlantic Ocean as far east as Burwood Bank (Brinkley et al. 2000, Fraser 2009; Landers et al. 2011).

Considering the at-sea distribution of Westland petrels during the breeding season only and based on the work of Landers et al. (2011), tracking data revealed that petrels attained an average maximum distance from the colony during the breeding season of 961 ± 177 km (range 760–1186 km), and a total potential area of utilisation of approximately 311,000 km^2 (Figure 5-2). Although the area used by Westland petrels is considerably less than the area utilised by Gibson's albatrosses (see Figure 5-1), this area is still large in comparison to the areas of SSC elevated above 2 mg/l due to the proposed mining of 50 M t per annum. This represents <0.1% of the area available to Westland petrels.

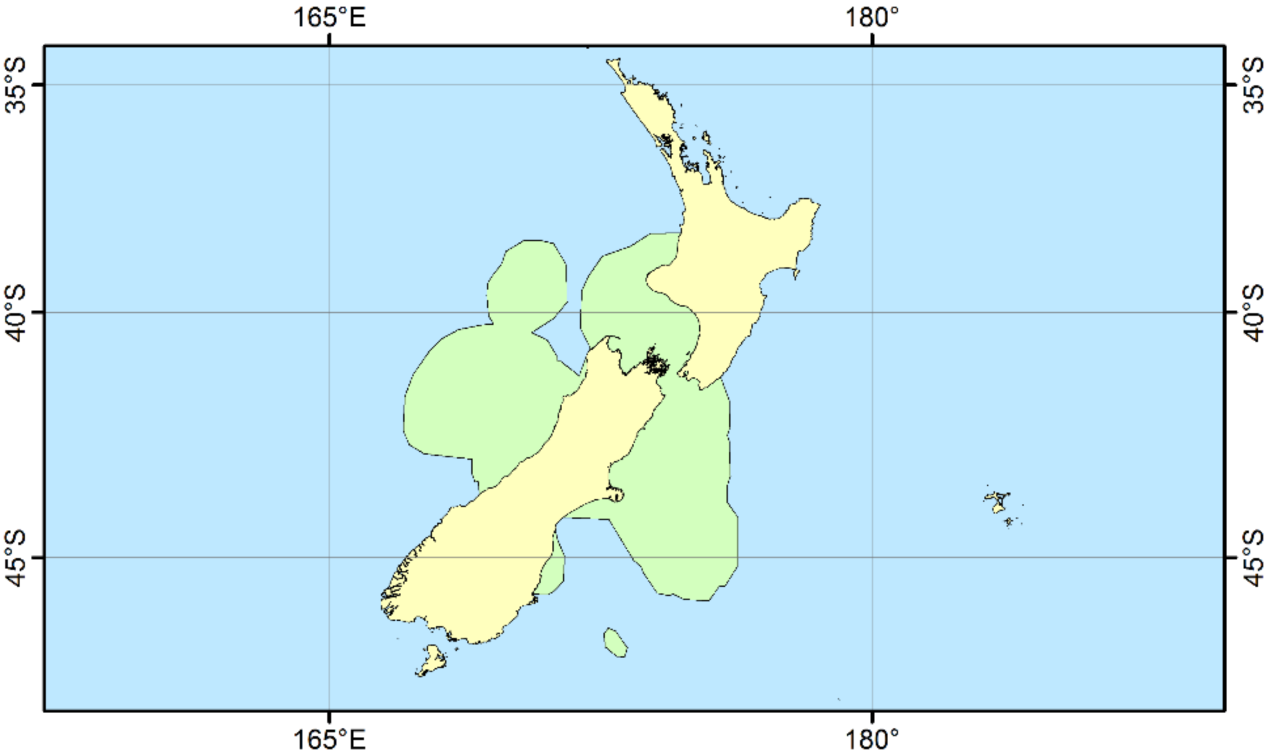


Figure 5-2: Foraging range of breeding Westland petrel based on tracking data. Adapted from Landers at al. (2011).

Assessment of impact: Although Westland petrel is not classified as 'threatened' under the New Zealand threat classification system, this species is nevertheless of high conservation concern due to its very restricted mainland breeding distribution and modest population size. The at-sea distribution of this species during the winter breeding season spans central New Zealand, with birds foraging offshore but relatively close to the breeding site, through Cook Strait and southwards east of South Island, and also throughout the STB (Figure 5-2). It is likely that this species could occur in the area affected by the proposed mining activity. However, since the area affected by the proposed mining is relatively small compared to the overall distribution of Westland petrels (<0.1%), it would be extremely difficult to detect any effect of displacement and exclusion from the proposed mining area and resulting sediment plume. According to the criteria detailed in Table 2-2, any effect of the proposed mining activity on Westland petrels would be negligible.

5.3.3 Case study 3: Sooty shearwater

IUCN classification: Near Threatened
NZ Conservation Status: At Risk – Declining

In New Zealand, Sooty shearwaters (*Puffinus griseus*) breed from the Three Kings Islands in the north to Campbell Island in the south, including Stewart Island, and the other sub-Antarctic Islands plus the Chatham Islands, although it is extinct on main Chatham Island (Marchant & Higgins 1990, Taylor 2000). On the mainland it is almost extinct, with the exception of a few pairs at Stony Bay on Banks Peninsula (Wilson 2008), to Otago, and then from Fiordland as far north as Perpendicular Point, near Greymouth, on the West Coast (Jackson 1957; Hamilton *et al.* 1997).

There are no accurate estimates of the total population in New Zealand, but Taylor (2000) estimated that the total population was likely to be in the order of five million pairs in New Zealand (about 15-30 million birds), but Newman et al. (2009) estimated that the population was about 21 million birds.

The sooty shearwater is probably the most abundant and widespread seabird in New Zealand seas during the breeding season (September to May). When breeding, they can be encountered throughout New Zealand's EEZ, and birds forage as far south as 67°S (Shaffer et al. 2009). The majority of birds migrate to the north Pacific Ocean after breeding and spend this period in one of three distinct zones: to the east of Japan, in the Gulf of Alaska or further south off the coast of California (Shaffer et al. 2006). Throughout the annual cycle, sooty shearwaters feed on a mixture of small fish, cephalopods and euphausiid crustaceans (Marchant & Higgins 1990), although detailed information on the diet in New Zealand is scarce.

Taking the tracking work of Shaffer et al. (2009) as an example of the spatial extent to which sooty shearwaters exploit marine resources, it is clear that this species has the capability to range over vast distances in search of food (Figure 5-3). Tracking birds from North East Island in the Snares Islands group, Whenua Hou (Codfish Island) off Stewart Island and from Mana Island, Shaffer et al. (2009) focussed on the chick-rearing phase of the shearwaters' breeding cycle, and found that birds exhibited a bimodal distribution of foraging trips: short trips (average duration 1.93 days) that extended to 515 km from the breeding colony, and long trips (average duration 14.5 days) that extended to 1,970 km from the colony. Birds undertaking long trips visited polar waters far to the southwest or southeast of New Zealand. Estimates of total distance flown by shearwaters conducting long trips to oceanic waters along the Polar Frontal Zone ranged between 4,500 and 12,700 km (Shaffer et al. 2009). Based on these tracking data, the total area available to sooty shearwaters during the chick rearing phase, included the STB, was 9,035,639 km^2 (Figure 5-3), or about 150,000 times the spatial extent of the surface sediment plume due to the proposed mining of 50 M t per annum.

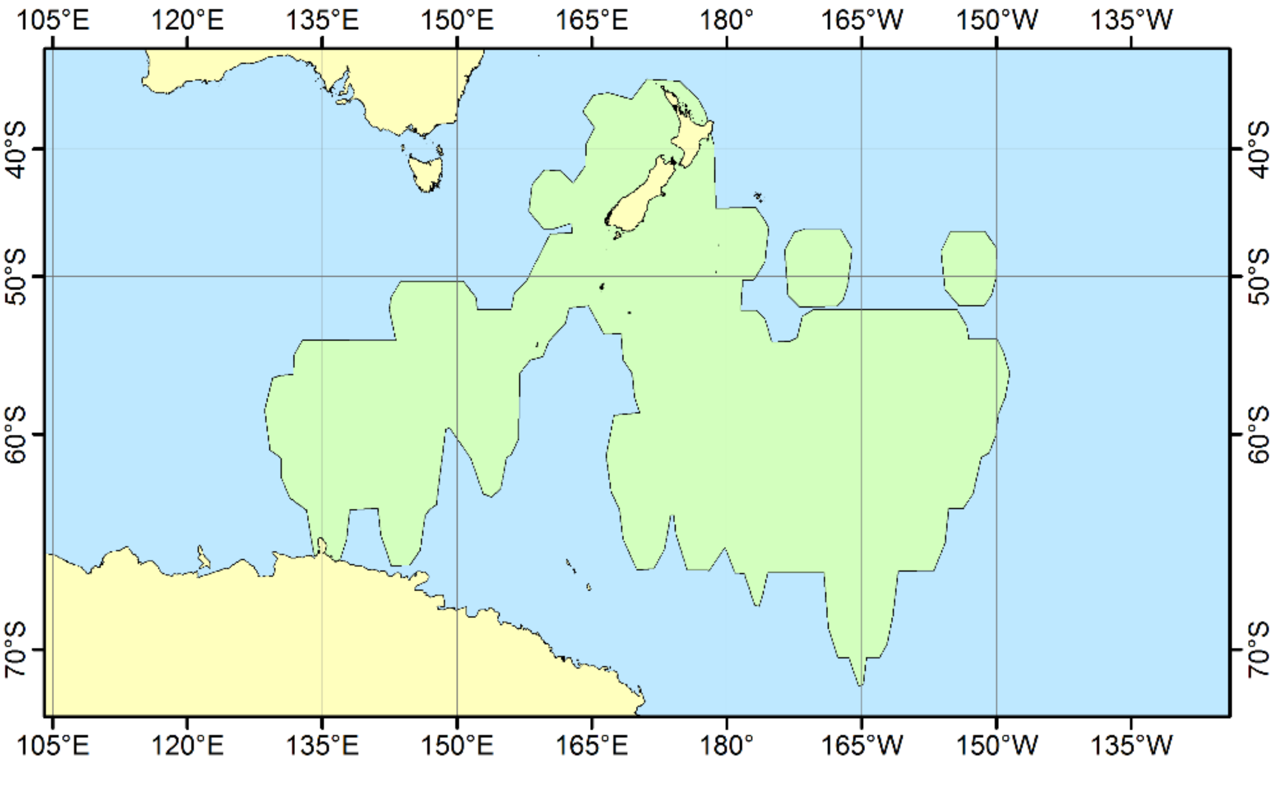


Figure 5-3: Foraging range of breeding sooty shearwater based on tracking data. Adapted from Shaffer et al. (2009).

Assessment of impact: Sooty shearwaters have a very widespread distribution when breeding in New Zealand that extends throughout the EEZ and beyond. Foraging trips far to the south when birds are raising chicks are not uncommon (Figure 5-3), although these long trips appear to be interspersed with shorter trips that include visiting the STB. It should be noted that the distribution depicted in Figure 5-3 represents that of breeding birds from only three breeding sites and only during the chick-rearing period: the full extent of the at-sea distribution of the New Zealand population as a whole, throughout the breeding season, will be larger. Nevertheless, based on this relatively conservative estimate of the spatial extent of sooty shearwater distribution, the area of surface SSC elevated above 2 mg/l due to mining 50 M t per annum would represent less than 0.01%. Therefore according to the criteria detailed in Table 2-2, any effect of the proposed mining activity on sooty shearwaters would be negligible and would be extremely unlikely to be detectable.

5.3.4 Case study 4: Red-billed gull

IUCN classification: Least Concern
NZ Conservation Status: Threatened - Nationally Vulnerable

Red-billed gull (*Larus novaehollandiae scopulinus*) is primarily a coastal species in New Zealand, breeding on offshore islands and stacks and at mainland sites across a very wide range of locations, from the Three Kings Islands in the north to Campbell Island in the south. They also breed away from the coast at a small number of inland sites in the Rotorua district (Gurr & Kinsky 1965). The three largest breeding colonies are at the Three Kings Islands, the Mokohinau Islands and at Kaikoura (Gurr & Kinsky 1965), although recently all of these colonies have undergone declines in breeding numbers. For example, at Kaikoura, where the population was extensively monitored, between 1983 and 1993 numbers remained relatively stable (16,000 to 19,000 individuals), but by 2003 the population had declined by 51% compared to the 1983 total (Mills et al. 2008).

The main food of red-billed gulls at the largest breeding colonies is the euphausiid *Nyctiphanes australis* (krill). At Kaikoura during the breeding season birds are dependent upon an abundant and regular supply of the surface-swarming krill for successful breeding. Greater availability of euphausiids increased the likelihood of breeding and the recruitment of young individuals to the breeding population, caused earlier laying, and resulted in an increase in the condition of adults, egg volume of gulls laying two-egg clutches, clutch size and fledging success (Mills et al. 2008).

In New Zealand, red-billed gulls occur around the entire coastline of both main islands, and similarly around the coast of Stewart Island, the Chatham Islands, the Snares Islands, the Auckland Islands and Campbell Island, with sightings reported from the Bounty Islands (see http://ebird.org/content/newzealand/). We are unware of any tracking work on red-billed gulls in New Zealand, but the bird sightings database (see above) provides information on the distribution of red-billed gulls away from the coast. Using sightings in this database we have assigned a distance of 100 km out from the entire coast, including around the islands noted above, to produce a likely zone utilised by red-billed gulls, which incorporates the STB (Figure 5-4). It is very likely that areas close to large breeding colonies will be used more extensively by gulls compared to areas far removed from aggregations of gulls, as will areas close to, rather than offshore from, the coast. However, the coastal strip depicted in Figure 5-4 represents a reasonable estimation of the area that could be used by red-billed gulls in New Zealand. As for the more offshore and pelagic species above, the coastal zone area that could potentially be used by red-billed gulls is relatively large (approximately 684,853 km^2) compared to the areas of surface SSC elevated above 2 mg /l due to mining 50 M t per annum (Table 2-1).

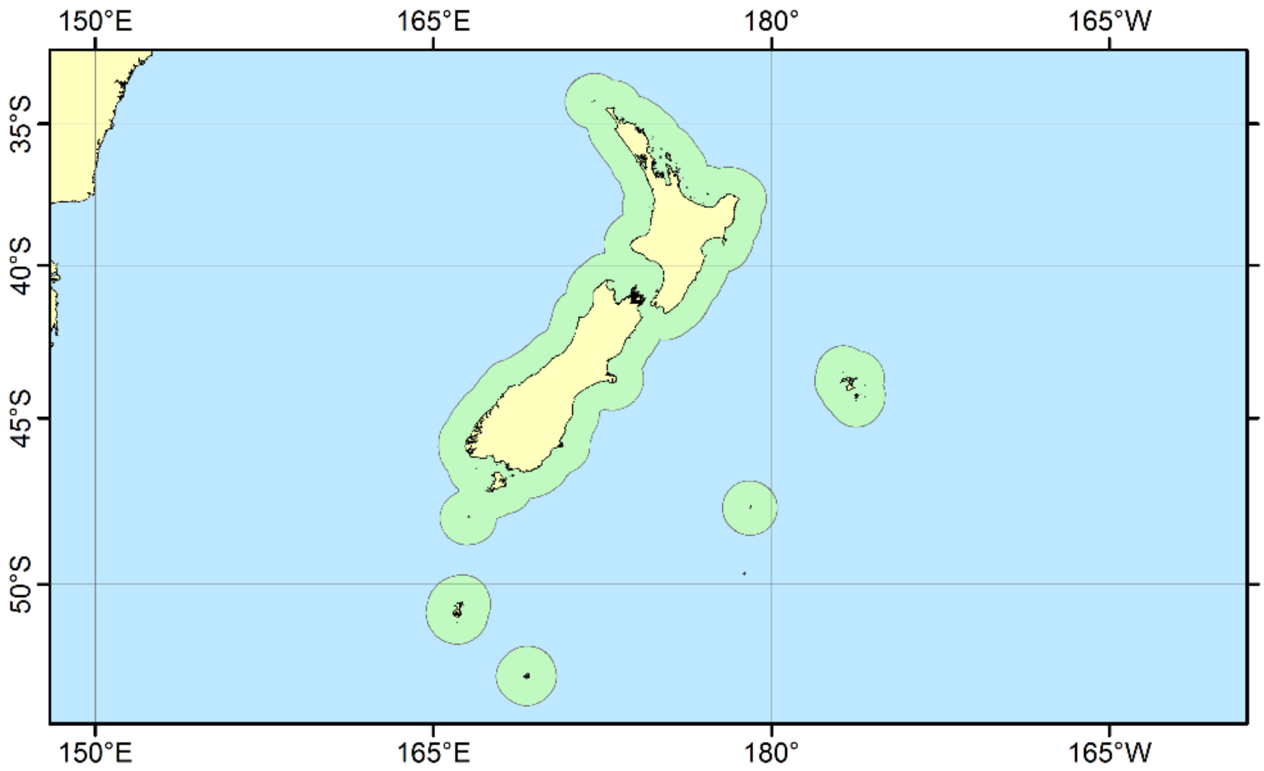


Figure 5-4: Foraging range of red billed gulls based on sightings observations at sea.

Assessment of impact: Red-billed gulls tend to utilise coastal marine areas and have a widespread distribution around the entire coastline of both main islands. This species will occur in the STB, possibly including the area affected by the proposed mining area. However, numbers of red-billed gulls in the STB will likely be relatively low compared to near this species' main breeding colonies (Three Kings Islands, the Mokohinau Islands and at Kaikoura), and overall the area affected by the sediment plume represents <0.1% of the coastal distribution of this species. Even if a zone of only 50 km from the coast was considered, the area of SSC elevated above 2 mg/l due to mining 50 M t per annum represents <0.2% of the area utilised by gulls. Any effect of the proposed mining activity on red-billed gulls would be negligible according the criteria in Table 2-2.

5.3.5 Case study 5: Little blue penguin

IUCN classification: Least Concern
NZ Conservation Status: At Risk – Declining

Blue penguin (*Eudyptula minor*), also known as little or fairy penguin, occurs around the coast of both main islands, the Chatham Islands and Stewart Island, together with offshore islands. Major breeding areas include islands in the Hauraki Gulf, Wellington Harbour, islands in Cook Strait and Marlborough Sounds, the west coast of South Island, Fiordland, Motunau Island in Pegasus Bay, Banks Peninsula, Oamaru, Otago Peninsula, islands in Foveaux Strait and around Stewart Island, and the Chatham Islands (Marchant & Higgins 1990).

In a study of blue penguin diet at Banks Peninsula, Oamaru and Stewart Island, Flemming et al (2013) found that penguins fed on a range of small fish species, a cephalopod species and stomatopod (mantis shrimp) larvae, with dietary difference between the three locations. For example, Graham's gudgeon (*Grahamichthys radiata*) was the most important prey item by weight at Oamaru, ahuru (*Auchenoceros punctatus*) and slender sprat (*Sprattus antipodum*) were the most important prey items by weight at Banks Peninsula and arrow squid (*Nototodarus sloanii*) was the most important prey item by weight at Stewart Island (Flemming et al. 2013).

When foraging away from breeding sites, blue penguins tend to travel relatively modest distances. Pelletier et al. (2014) found that penguins travelled on average 20 ± 4 km (maximum 50 km) from a breeding site at

Phillip Island in Australia, and Collins et al. (1999) reported that even during the non-breeding period, when birds were not so constrained to return to land to tend to chicks, 95% of all birds located were within 20 km of the coast. However, Collins et al. (1999) also noted that during the non-breeding period blue penguins travelled up to 500 km from the Phillip Island breeding site during trips lasting longer than a month.

Analogous to the coastal distribution for red-billed gulls (Figure 5-4), and based on the findings of the studies cited above, Figure 5-5 depicts the likely spatial extent of blue penguin distribution in New Zealand as a 'coastal strip' out to 50 km. While it is recognised that some penguins may occur beyond this 50 km zone, most likely during the non-breeding season, this area represents a reasonable approximation of blue penguin distribution. In keeping with results for other seabird species, this coastal zone for blue penguins is relatively large (309,749 km^2) compared to the areas of SSC elevated above 2 mg/l due to mining 50 M t per annum (Table 2-1).

Assessment of impact: Blue penguins utilise coastal marine zones and have a widespread distribution around New Zealand. However, blue penguins are not an abundant species in the STB, and the closest breeding sites (Kapiti Island and islands in the Marlborough Sounds) are more than 50 km from the surface sediment plume area. At a population level, the area of surface SSC elevated above background levels due to the proposed mining of 50 M t per annum represents less than 0.1% of the area available to blue penguins and any effect of the proposed mining activity on blue penguins would be negligible according to the criteria in Table 2-2.

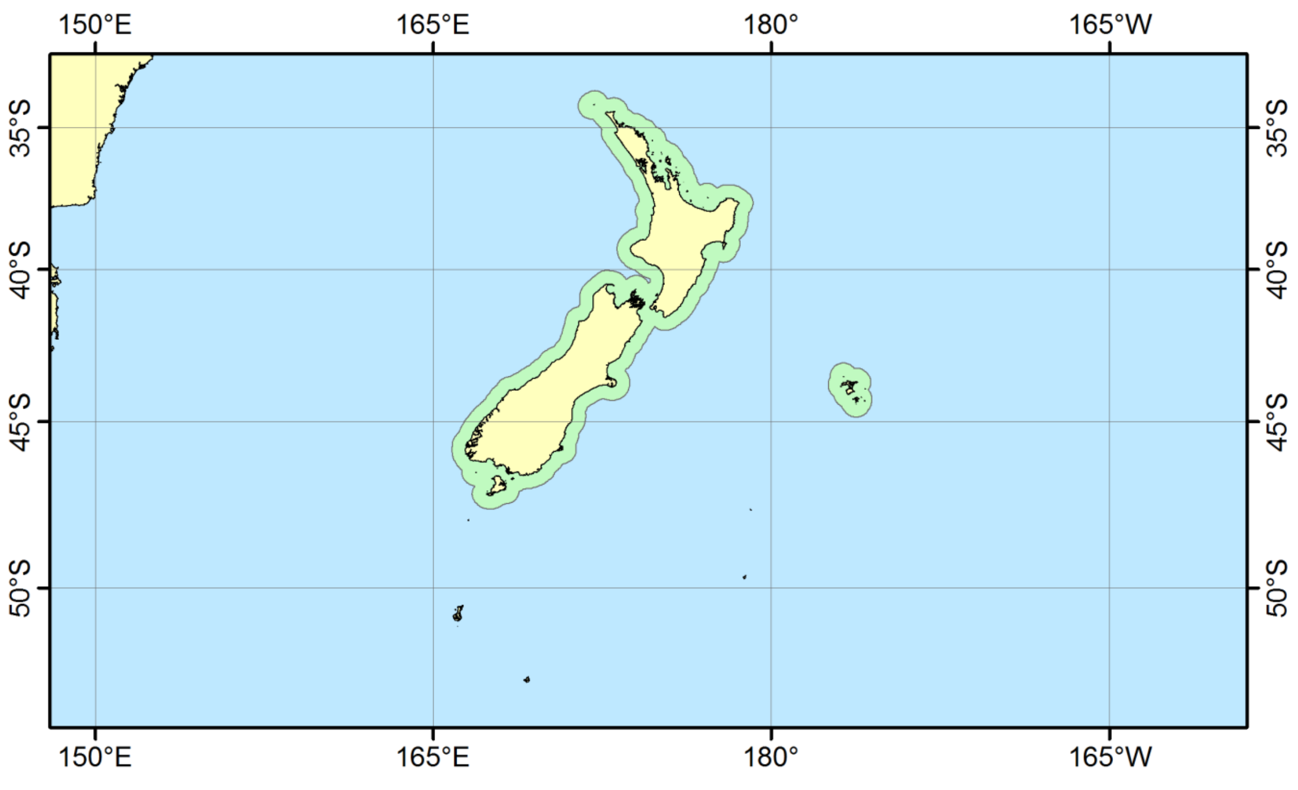


Figure 5-5: Foraging range of blue penguins.

6 Marine mammals

6.1 Blue whales

Torres (2013a) collated the available sightings, catch records, and ecological information to describe a potential blue whale foraging ground in the STB where whales feed on aggregations of krill (the euphausiid *Nyctiphanes australis*) that develop in response to upwelling plumes of cold nutrient rich water off Kahurangi Point, north-west South Island (Figure 6-1). This was followed by a dedicated field programme that confirmed the presence of blue whales (probably the slightly smaller pygmy blue subspecies *Balaenoptera musculus brevicauda*) feeding on krill in the western entrance to the STB in January/February 2014 (Torres et al. 2014).

Pygmy blue whales occur in temperate and tropical waters northward from the sub-Antarctic zone of the southern Indian Ocean and south western Pacific Ocean (Sears and Calambokidis 2002). Pygmy blue whales recorded in New Zealand and the South Taranaki Bight may represent a separate population from other blue whales in Australian waters and the rest of the southern hemisphere (Joint statement of experts in the field of effects on marine mammals including noise[3].).

The available sightings data indicate blue whales occur in the western and central part of the STB (Figure 6-1 and Figure 6-2) (Torres 2013a, Torres et al. 2014) predominatly between the 50 and 150 m bathymetric contours. Twelve aerial surveys for cetaceans over a 26 month period from July 2011 to September 2013 failed to detect any blue whales (or any other cetaceans apart from one pod of common dolphins) in the vicinity of the proposed mining activities (Martin Cawthorn Associates Ltd 2013) (Figure 6-3). The Joint Statement of Experts in the Field of Effects on Marine Mammals including Noise[1] concluded that the proposed mining area may represent the edge of the blue whale feeding grounds in the STB. If this is the case, the potential feeding ground of blue whales in the STB can be defined as the area enclosed by a line running across the northern entrance of Cook Strait just south of Mana Island to Cape Egmont along the 20 m contour and west to the 150 m bathymetric contour and thence southwards along this contour to run inshore opposite the base of Farewell Spit, and excluding Tasman and Golden Bays and the Marlborough Sounds; an area of about 29,930 km^2. Where in this feeding ground blues whale forage probably varies over days to weeks as well as from year to year depending on the particular pathways taken by the developing patches of krill.

There are insufficient data to determine whether blue whales forage in the STB year round or seasonally. Off Western Australia pygmy blue whales migrate in March from summer feeding grounds off Perth reaching potential breeding grounds in Indonesian waters by June, with a southwards return journey starting in September to arrive in the subtropical frontal zone, south of western Australia in December (Figure 6-4). Whether the blue whales observed in the STB undergo a similar migration is unknown and awaits further dedicated research.

Assessment of impact: Blue whales have been predominately sighted in the western entrance to the STB between the 50 and 150 m bathymetric contours. A dedicated aerial cetacean survey over two years failed to detect any blue whales in the vicinity of the proposed mining areas which the Joint Statement of Experts in the Field of Effects on Marine Mammals including Noise concluded may represent the edge of the blue whale feeding grounds in the STB. The potential feeding area of blue whales in the STB is approximately 29,930 km^2 if areas shallower than 25 m are excluded. Given that that the areas of SSC elevated above 2 mg/l due to the proposed mining of 50 M t per annum (Table 2-1) represents only 0.2% of this potential feeding area, and lies on the margins of blue whale feeding grounds, any displacement of blue whales or decrease in krill abundance or availability due to mining should have negligible effects on blue whales while in the STB.

[3] (see http://www.epa.govt.nz/eez/EEZ000004/EEZ000004_Effects%20on%20Marine%20Mammals%20including%20Noise%20joint%20witness%20statement.pdf).

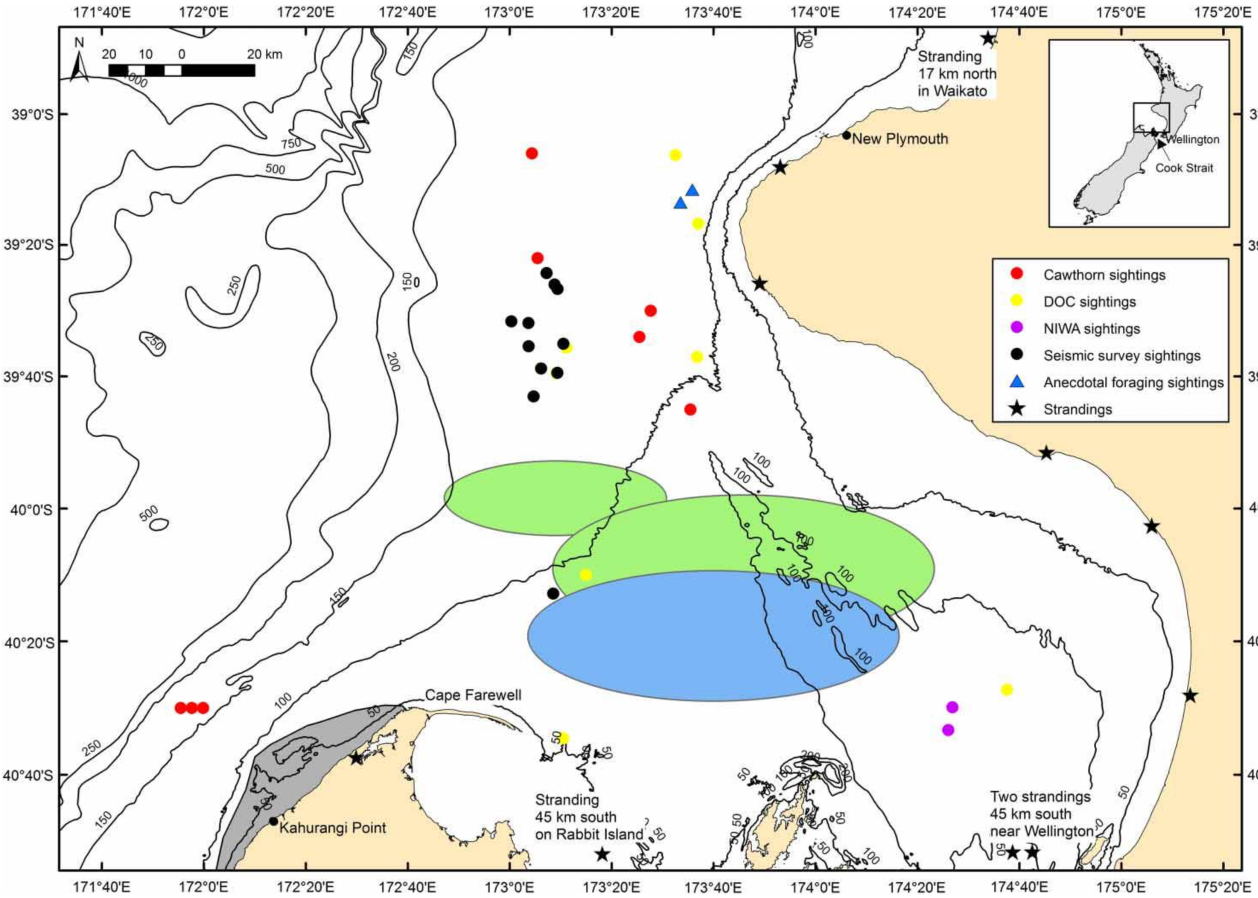


Figure 6-1: Distribution of blue whale sightings and strandings within the South Taranaki Bight. Shown are regional bathymetry, the location of the Kahurangi Point upwelling system, and sampled areas of high blue whale prey density. Incidental, survey and anecdotal sightings are symbolised by source. Inset map shows New Zealand with a black box around the STB that is enlarged. Black lines indicate bathymetry isobaths at 50 m intervals. The centre of upwelling off Kahurangi Point is demarcated in grey; tongues of upwelled water extend as a plume to the north and northeast. The ellipses indicate the approximate areas of increased krill, *Nyctiphanes australis,* density sampled in March and April 1983 (green ellipses; Bradford & Chapman 1988; James & Wilkinson 1988) and February 1981 (blue ellipse; Foster & Battaerd 1985). Figure from Torres (2013).

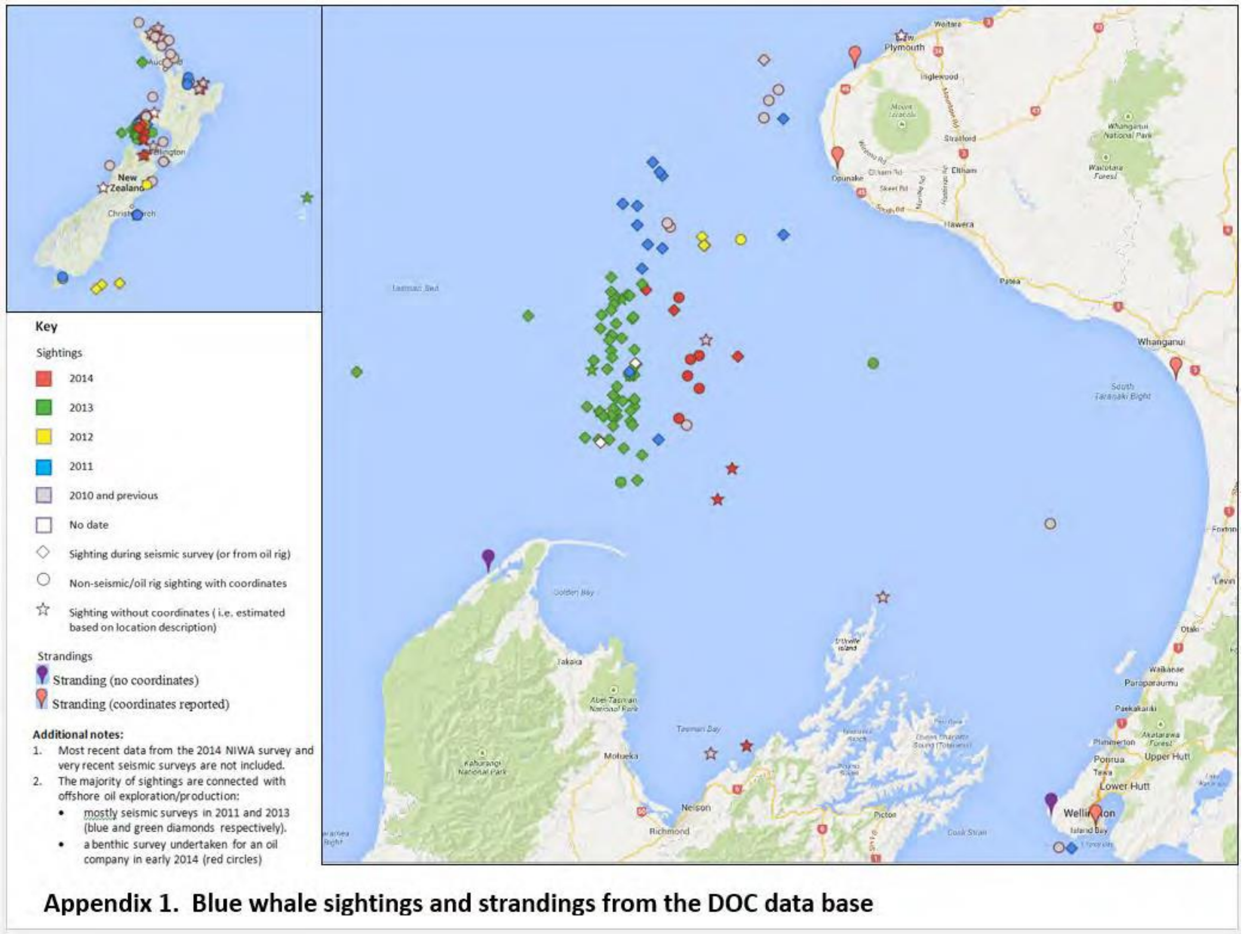


Figure 6-2: Blue whale sightings and strandings from the DOC data base. From the Application under Section 38 of the Act for Marine Consents by Trans-Tasman Resources Limited, Appendix 1 in the Joint statement of experts in the field of effects on marine mammals including noise[1].

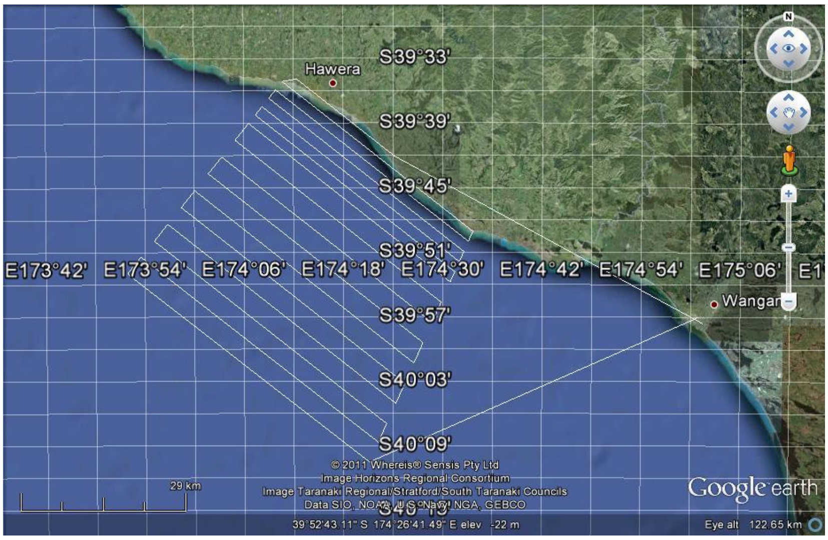


Figure 6-3: Aerial transect layout for cetacean surveys from January 2012 to September 2013.

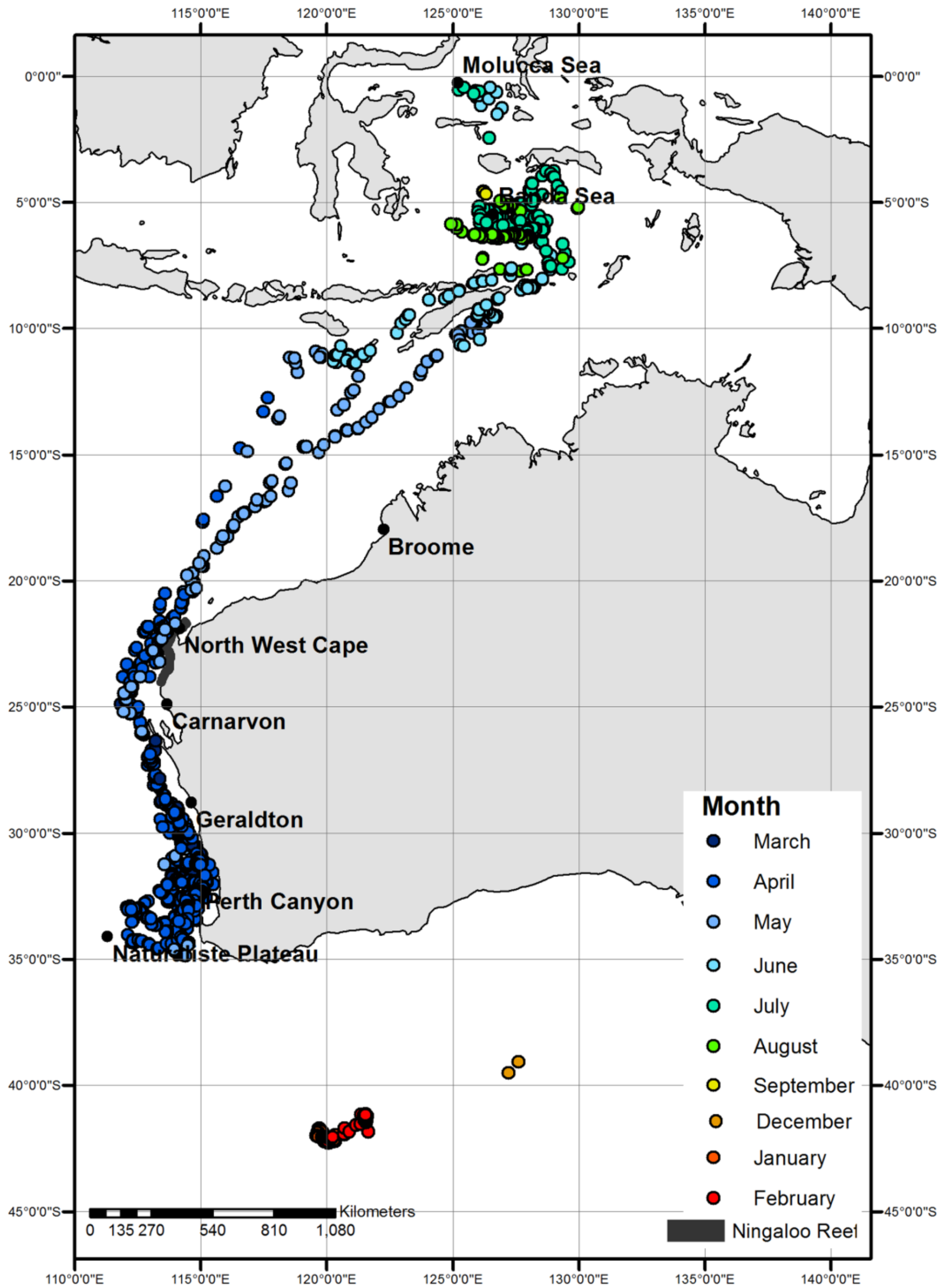


Figure 6-4: Filtered satellite tag derived locations of pygmy blue whales (n = 11) by month. Individuals were tagged in March (2011: n = 7) and April (2009: n = 3; 2011: n = 1) in the Perth Canyon. The northern terminus of migration occurred in Indonesia. A single whale was tracked intermittently until February 2012 at which time it was located in the subtropical frontal zone south of Western Australia. From Double et al. (2014).

6.2 Southern right whale

Torres (2013b) developed a New Zealand habitat suitability model for southern right whales (*Eubalaena australis*) during the winter calving, suckling and migration period. She incorporated all available sightings data and used environmental parameters from each sighting location to build a probabilistic model of habitat suitability throughout New Zealand coastal waters to a depth of 350 m. Habitat suitability was highest in areas with shallow water (< 20 m), low wave heights during extreme events (between 0 and 2 m), high concentrations of dissolved organic matter (> 0.2 m-1), and with tidal current velocity greater than 1 m/s. The spatial predictions of southern right whale distribution (Figure 6-5) based on model results illustrate their preference for sheltered shallow coastal waters around New Zealand during winter months. The prediction map indicates several areas with relatively high habitat suitability (P) (P > 0.7), including protected harbours and bays along the north-west and east coasts of North Island in Golden Bay, Marlborough Sounds and Cook Strait regions and the south and south east coasts of the South Island. These are all locations where southern right whales were historically sighted during the winter calving season (Carroll et al. 2013).

The modelling undertaken by Torres (2013b) predicted that the suitability of habitat for southern right whales in the STB during winter months was generally low (P < 0.08; Figure 6-5). The coastal region inshore of the TTR proposed project area had slightly increased predicted habitat suitability (P<0.38). Only a few sightings of southern right whale have been recorded in the northern region of the STB. This low level of sightings is possibly due to low observer effort in the region, historical extirpation of southern right whales from the region, naturally low prevalence, or a combination of these factors. The persistent low to moderate level (P<0.54) of predicted habitat suitability along the coast of the STB may reflect a migration pathway that southern right whales use while transiting to more suitable wintering grounds to the north or south. Southern right whale cows are known to 'hug' shorelines while migrating with calves in order to avoid predators (Elwen & Best 2004).

According to NOAA[4], in general the feeding habitats of southern right whales occur in higher latitudes where cold, nutrient rich waters generate large amounts plankton, principally dense aggregations of copepods, krill, or pteropods (Kenney 2002). Calving, nursing, and breeding habitats occur in lower latitudes where warm, shallow waters are favourable for reproduction. Thus, it is unlikely that southern right whales occurring in the STB during winter months are feeding on locally available pelagic food sources.

Assessment of impact: Given that southern right whales are unlikely to be feeding on locally available prey during the period they transit through the inshore waters of the STB, and that modelling suggests that the majority of the STB is unfavourable habitat for southern right whales during the winter calving, suckling and migration period, the proposed mining activities are unlikely to affect this species through any ecological effect. Ship strikes and underwater noise remain a possible threat but these can be mitigated through adoption of standard procedures.

[4] http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/rightwhale_southern.htm

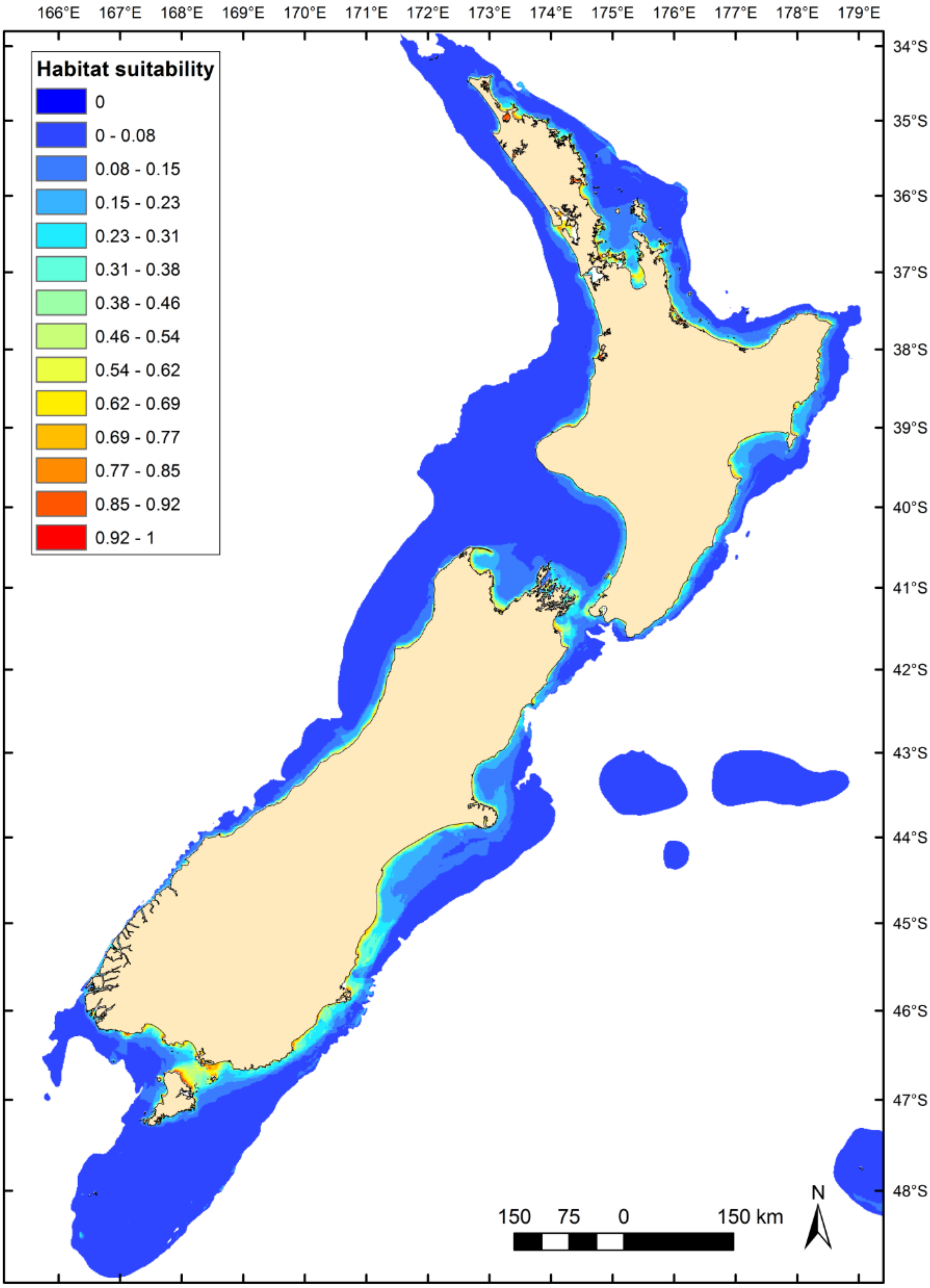


Figure 6-5: Winter habitat suitability predictions for southern right whales derived from the habitat use model. Full extent of model within the 350 m isobaths of mainland New Zealand. The habitat suitability index is a logistic output from the Maxent model (warm colours showing the highest habitat suitability). Figure from Torres (2013b).

6.3 Killer whale

Killer whales (*Orcinus orca*) have a broad global distribution and are found in all oceans of the world (Ford 2009). They also have a broad diet including fish, rays, marine mammals and sharks (Constantine et al. 1998, Ford 2009, Visser 1999, Visser et al. 2000). They inhabit a range of habitats from deep pelagic waters to coastal areas (Baird & Dill 1995, Ford 2009, Iniguez 2001). The entire New Zealand population is small (mean estimate = 119 ± 24 SE) and known to be broadly distributed around both the North and South Island (Visser 2000).

Torres (2013b) developed a New Zealand habitat suitability model for killer whales. She incorporated all available sightings data and used environmental parameters from each sighting location to build a probabilistic model of habitat suitability throughout New Zealand's EEZ and extended continental shelf (ECS) due to the broad distribution of this species. Habitat suitability was highest (P > 0.75) at a few coastal areas; the southern Hauraki Gulf, Mahia Peninsula, Marlborough Sounds, Golden Bay, the southeast tip of South Island, and Te Waewae Bay on South Island (Figure 6-6). The remaining areas of high suitability habitat for killer whale presence were predicted by Torres (2013b) to be in offshore areas including off the northeast tip of Northland, over the Chatham Rise, offshore of Banks Peninsula and Canterbury Bight, and along the shelf break along the Otago coast (Figure 6-6).

Torres (2013b) found that the predicted habitat suitability for killer whales in the STB ranges from low to moderate (0.08 > P < 0.62; Figure 6-7). The band of increased habitat suitability (yellow areas in Figure 6-7) corresponds to an area of increased sea surface temperature gradient and begins approximately 8 km seaward of the proposed project area. Killer whales may be using this habitat as a foraging ground as it is known to have increased abundance of prey fish such as school shark (*Galeorhinus galeus*) (MacDiarmid et al. 2013a). Close to shore in this region there is generally decreased killer whale habitat suitability.

Assessment of impact: Given that modelling suggests killer whales are distributed over a very large proportion of the EEZ and ECS, the most favoured habitats lie well away from the region, the majority of the STB is only moderately favourable habitat for killer whales, and its prey species occur over a wide area in the STB, the proposed mining activities are unlikely to cause significant or measurable displacement, or decrease prey abundance or availability during the periods that killer whales visit the region.

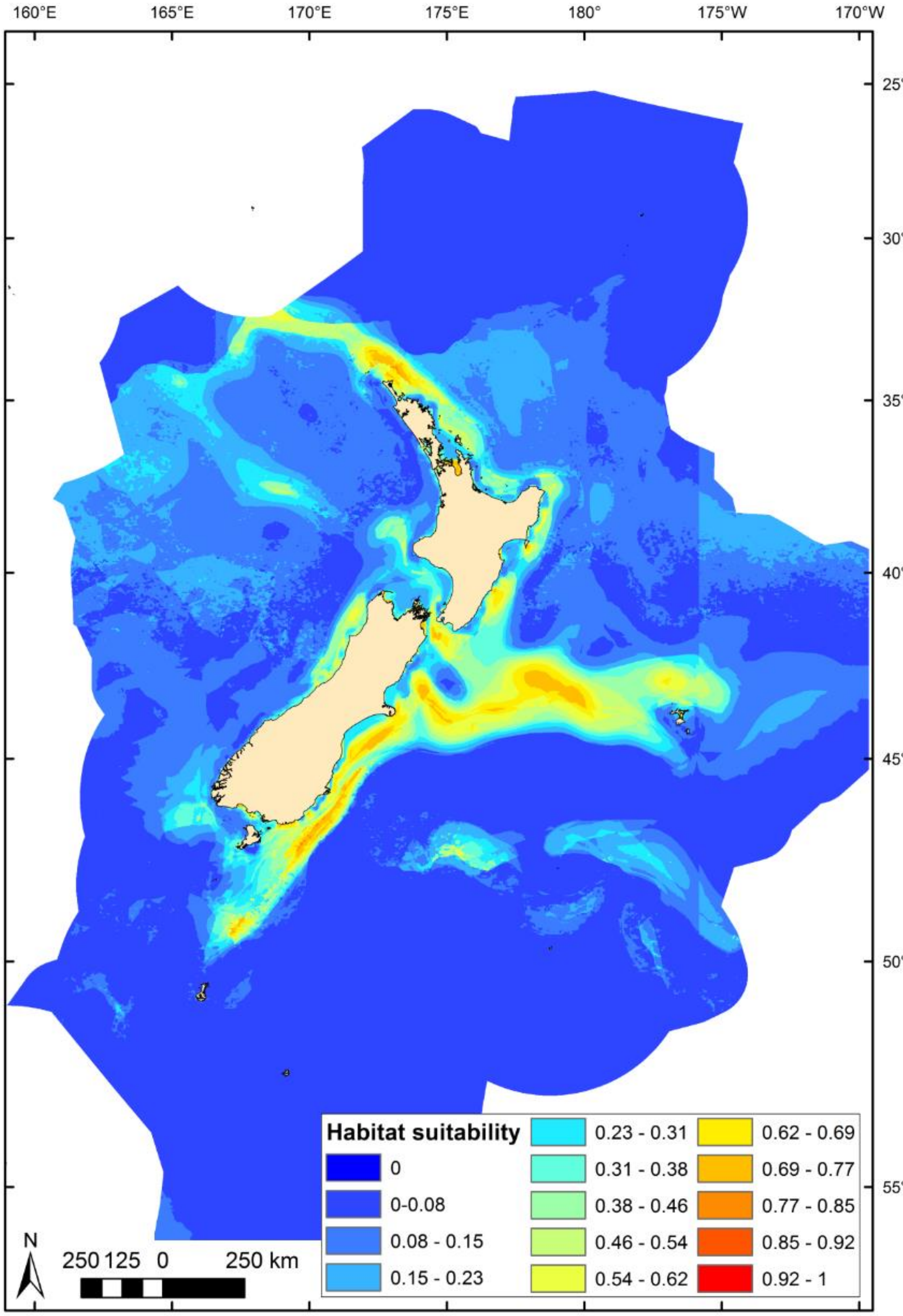


Figure 6-6: Habitat suitability predictions for killer whales from the habitat use model with bias grid correction. The full extent of model within New Zealand's extended continental shelf is displayed. The habitat suitability index is a logistic output from the Maxent model (warm colours showing the highest habitat suitability). Figure from Torres (2013b).

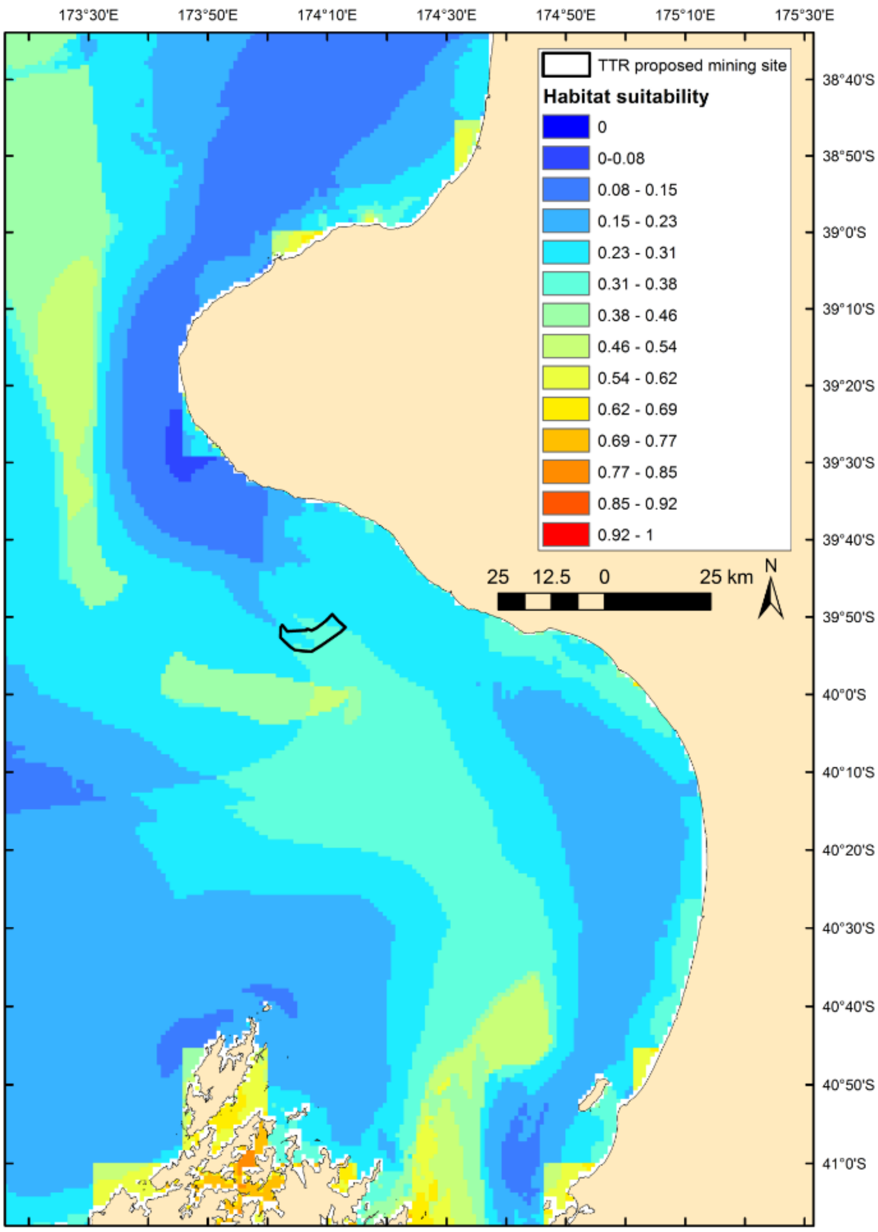


Figure 6-7: Habitat suitability predictions for killer whales in the North and South Taranaki Bight derived from the habitat use model with bias correction. TTR's proposed project area is outlined in black. The habitat suitability index is a logistic output from the Maxent model (warm colours showing the highest habitat suitability). Figure from Torres (2013b).

6.4 Hector's Dolphin

Torres (2013b) developed a New Zealand habitat suitability model for Hector's dolphin (*Cephalorhynchus hectori* and the sub-species Maui's dolphin *C.h. maui*). She incorporated all available sightings data and used environmental parameters from each sighting location to build a probabilistic model of habitat suitability throughout New Zealand coastal waters to a depth of 350 m (Figure 6-8). Torres's (2013b) model of Hector's dolphin habitat suitability predicted that preferred areas are those with high concentrations of dissolved organic matter and high primary productivity. These results correspond with existing knowledge of Hector's dolphin ecology, determined through *in situ* habitat use studies, showing a preference by this species for turbid waters. Bräger et al. (2003) found that most Hector's dolphins were encountered in waters with low clarity (Secchi disk visibility <4m). Other studies have determined increased occurrence of Hector's dolphins near river mouths (Brager & Schneider 1998, Clement et al. 2010). Increased Hector's dolphin occurrence near shore and river mouths may be due to increased abundance of targeted prey items and increased hunting efficiency in turbid waters due to echolocation capabilities that enable the ability to detect and surprise prey in waters with low visibility (Brager et al. 2003, Clement et al. 2010).

Torres (2013b) found that the predicted suitability of habitat for Hector's dolphin in the STB was generally low (P < 0.08). However, pockets of increased habitat suitability (P> 0.46) were predicted in the coastal region to about 8 km offshore adjacent to the TTR proposed project area (Figure 6-9). Although no Hector's dolphin sightings were recorded along the coastal strip south of Cape Egmont from Opunake to Foxton (possibly due to low observer effort, historical extirpation from habitat, naturally low prevalence, or a combination of these factors), according to model results based on over three thousand sightings of Hector's dolphins across their entire range, the habitat characteristic of certain areas in the coastal region inshore of the proposed TTR mining site provide average to above average habitat suitability for Hector's dolphins (Torres 2013b). This result indicates that if Hector's dolphins were to re-occupy this region there is an average to above average chance a Hector's dolphin would use this coastal habitat.

Hector's dolphins are generalist feeders including surface-schooling fish such as yellow-eyed mullet and kahawai, mid-water fish such as jack mackerels, arrow squid, and a wide variety of benthic species including ahuru and red cod (Miller et al. 2012).

Assessment of impact: Given that modelling suggests that the majority of the STB is unfavourable habitat for Hector's dolphins, the present-day near absence of sightings of Hector's dolphins in the region, the preference of Hector's dolphin for areas of low water clarity, and the likely negligible effects of mining activities on stocks of prey species (see Section 4 above), mining 50 M t per annum is likely to have negligible effects on this species in the near future. This conclusion should be reviewed from time to time, particularly if sightings of Hector's dolphins in the region increase.

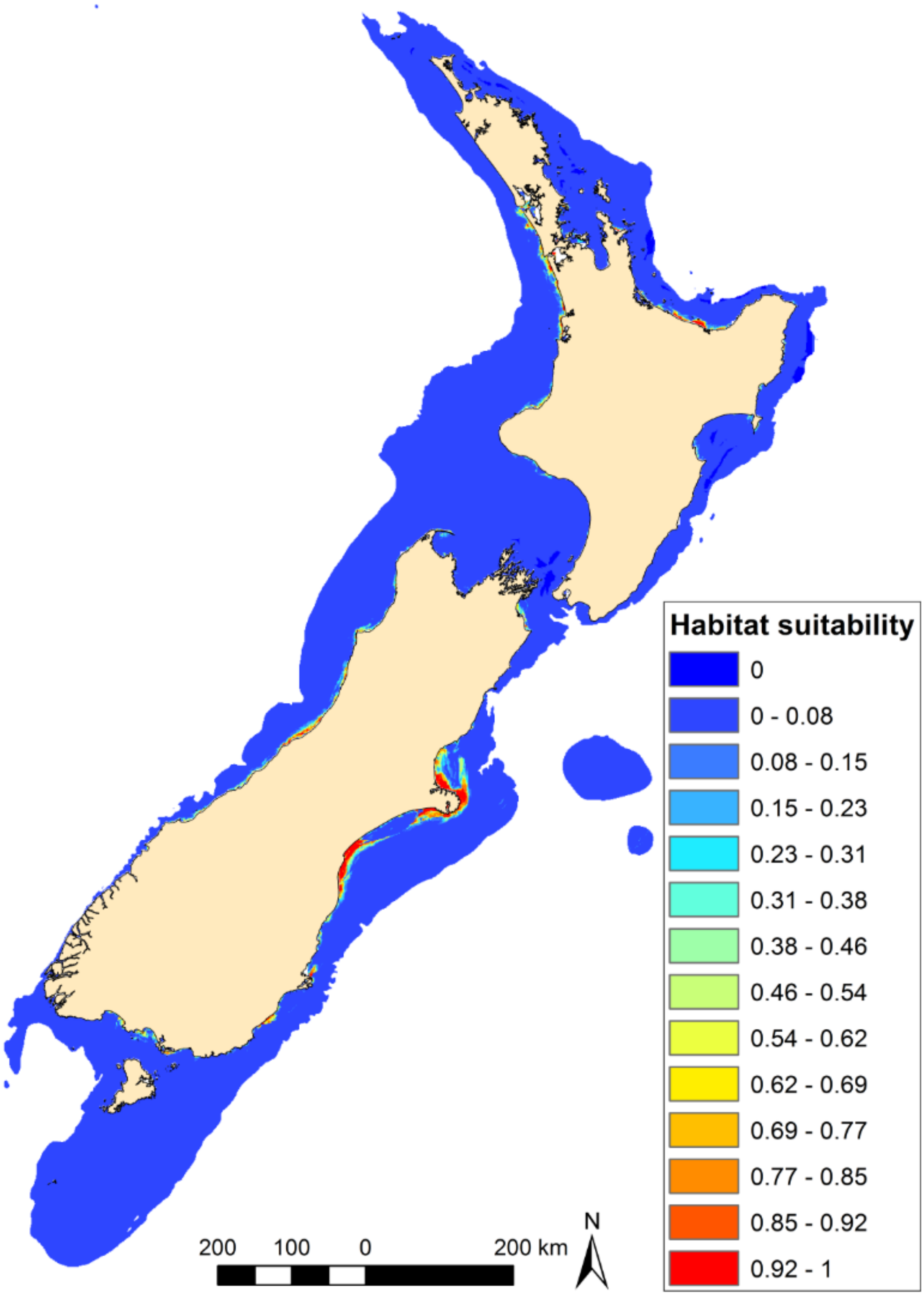


Figure 6-8: Habitat suitability predictions for Hector's dolphins derived from the habitat use model with bias correction. The habitat suitability index is a logistic output from the Maxent model (warm colours showing the highest habitat suitability). Figure from Torres (2013b).

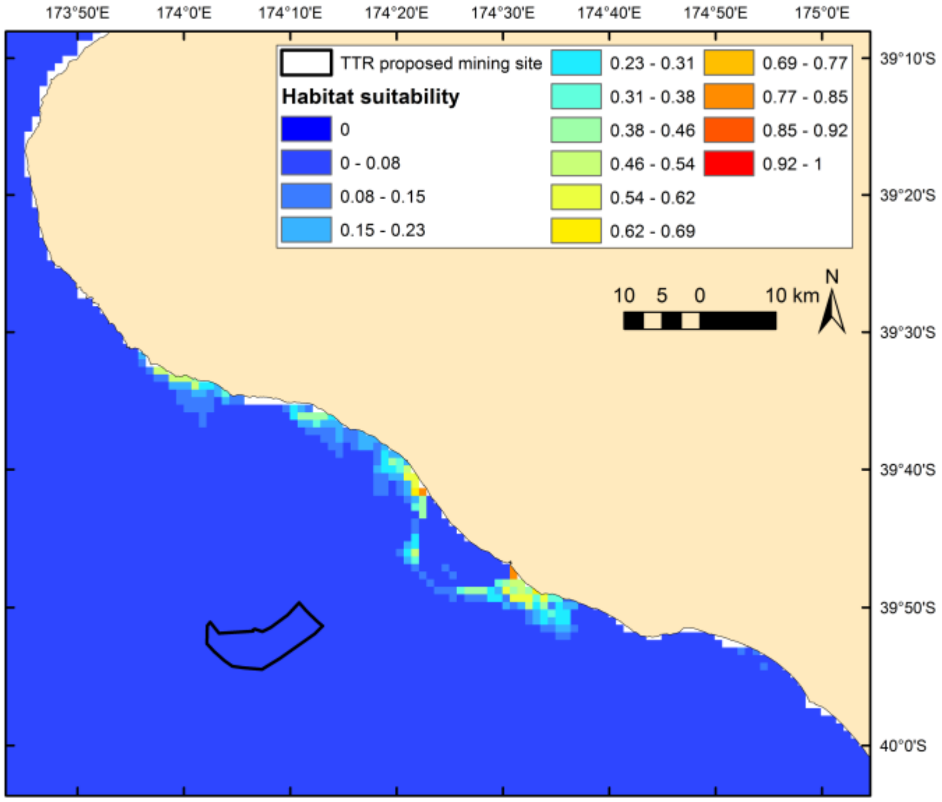


Figure 6-9: Enlargement of prediction of habitat suitability for Hector's dolphin inshore of the TTR proposed project area. TTR proposed project area outlined in black. Predictions derived from the habitat use model with bias correction. The habitat suitability index is a logistic output from the Maxent model (warm colours showing the highest habitat suitability). Figure from Torres (2013b).

6.5 Common dolphin

Common dolphins (*Delphinus* spp.), Figure 6-10, occur around New Zealand (Stockin 2008). In the STB sighting records indicate widespread distribution in the southern and central parts of the region (Figure 6-11). Studies in the Hauraki Gulf and in the Bay of Plenty indicate common dolphins undertake seasonal inshore-offshore movements and were closest inshore in September and farthest offshore by the following April (Neumann and Orams 2005, Stockin 2008). These movements appear associated with sea surface temperature (Neumann 2001).

Figure 6-10: Common dolphins near the Marlborough Sounds.

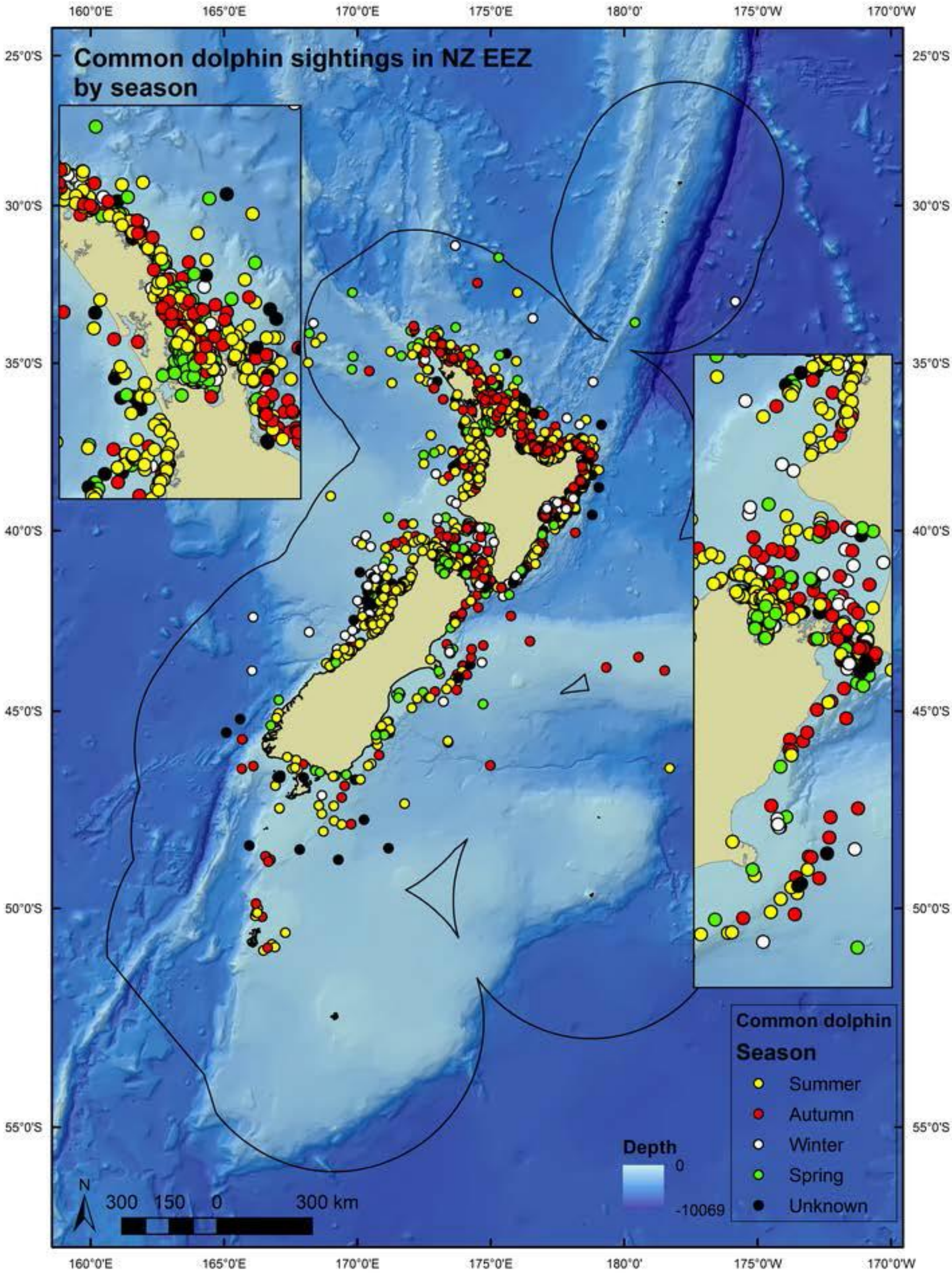


Figure 6-11: Distribution of common dolphin (*Delphinus delphis*) sightings in New Zealand waters between 1970 and 2013. Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct and sightings effort may be spatially biased. Figure from Berkenbusch et al. (2013).

Common dolphin bycatch is strongly associated with the mackerel fishery off the west coast of North Island (Du Fresne et al. 2007) (Figure 6-12). Thompson et al. (2013) estimated that the average rate of death was 2.14 deaths per 100 tows (95% CI 0.8-4.9) with 119 common dolphin captures reported on 4299 observed tows over the 16-year study period from 1995 to 2011. Most captures were of multiple animals with up to nine individuals drowned in a single tow.

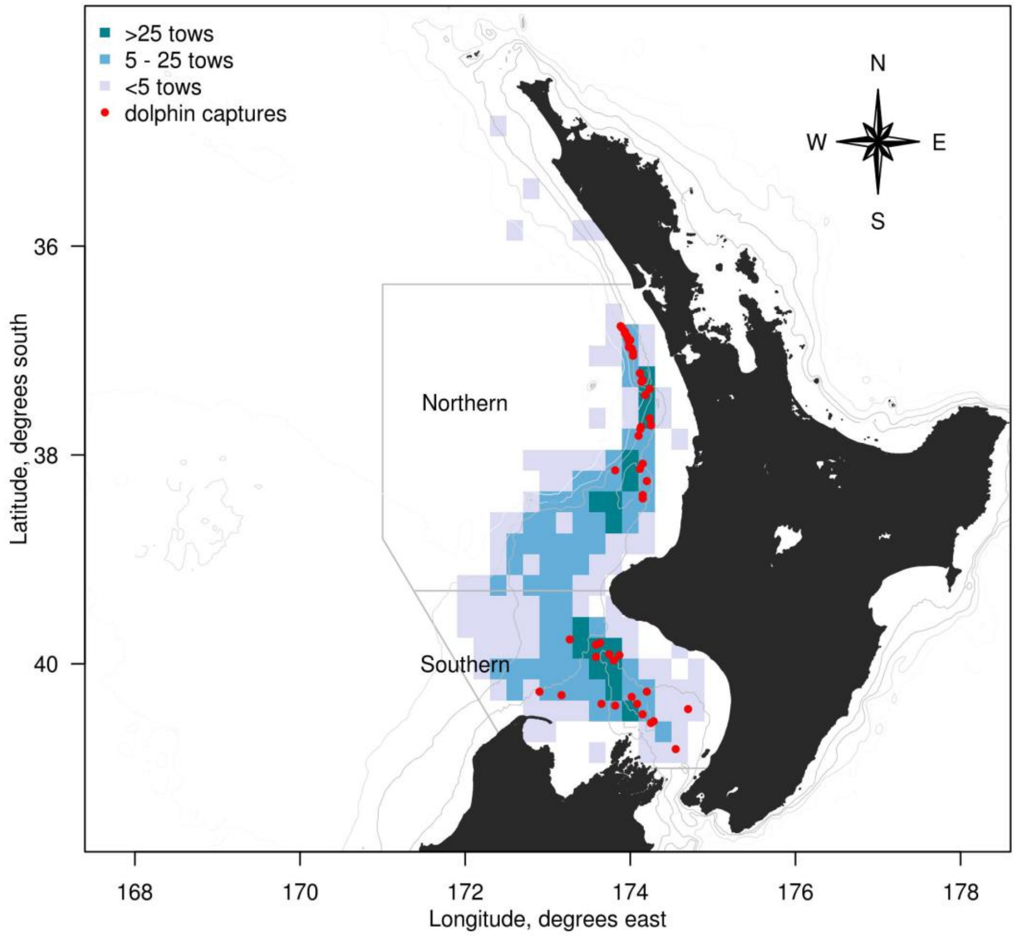


Figure 6-12: Commercial trawl effort and dolphin by-catch in the west coast North Island region, New Zealand. Mean annual trawl effort (number of tows) of the commercial mackerel (*Trachurus* spp. and *Scomber australasicus*) fishery between 1 October 1995 and 30 September 2011, including locations of observed common dolphin (*Delphinus delphis*) captures. Also indicated are the boundaries of the area modelled for estimating common dolphin captures. From Thompson et al. (2013).

A study of common dolphins that examined the stomach contents of by-caught or stranded animals, including ten from the northern and southern Taranaki bights, found that their diet comprised a diverse range of fish and cephalopod species, with the prevalent prey arrow squid, Jack mackerel, and anchovy (Meynier et al. 2008). The authors suggested that the mixed prey composition in the diet of common dolphins by-caught inshore and offshore may be due to inshore/offshore movements of common dolphin on a diel (day/night) basis. In the STB anchovy occur only in waters of less than about 50 m depth while yellowtail jack mackerel, *Trachurus novaezelandiae*, is widespread and greenback jack mackerel (*T. declivis*) is most abundant offshore in waters deeper than 50 m (MacDiarmid et al. 2013).

Assessment of impact: Common dolphins have a wide distribution and wide ranging movements around New Zealand. The area of distribution of Jack mackerels, their common prey species, in JMA7 is 171 times the size of the area potentially impacted by the proposed mining activities. Any displacement of common dolphins, or decrease in prey abundance or availability due to proposed mining is highly likely to have negligible effects on the status of the common dolphin population in the STB.

6.6 Pilot whales

Berkenbush et al. (2013) reviewed the available information for pilot whales in New Zealand waters. Two species, long-finned and short-finned pilot whales (*Globicephala melas* and *Globicephala macrorhynchus*) occur in New Zealand waters (Taylor et al. 2008, 2011). Short-finned pilot whale prefer warm temperate to tropical waters, while long-finned pilot whales are prevalent in cold-temperate waters (Olson 2009) but there is some area of overlap in New Zealand waters (Berkenbush et al. 2013). Sightings are common around the entire coast in all seasons but there are no records of winter sightings in the STB (Figure 6-13).

Although there are no global or New Zealand abundance data or population trends available for long- or short-finned pilot whales, both species are considered relatively common and abundant and are not presently threatened (Berkenbusch et al. 2013). Pilot whales have a long lifespan and delayed maturity (Olsen 2009, Berkenbusch et al. 2013).

The diet of pilot whales is dominated by squid, but may include some fish species (Olson 2009). Both species are known to forage at depth, reaching several hundred metres but long-finned pilot whale may also follow prey into coastal areas and continental shelf waters in summer and autumn (Taylor et al. 2008, Berkenbusch et al. 2013).

New Zealand fisheries observer records for the 20 year period between October 1992 and September 2012 include bycatch data of 27 long-finned pilot whale mostly in trawl fisheries but also from long-line and set-net fisheries (Berkenbusch et al. 2013). The observer coverage was low (6% in the trawl fisheries) thus total deaths of pilot whales can be expected to be much higher over the observed period (Berkenbusch et al. 2013).

Assessment of impact: Pilot whales have a wide distribution and wide ranging movements around New Zealand, but the area of SSC elevated above 2 mg/l due to mining 50 M t per annum is relatively small (see Table 2-1). Any displacement, or decrease in prey abundance or availability due to mining activities is highly likely to have negligible effects on the status of the pilot whale populations.

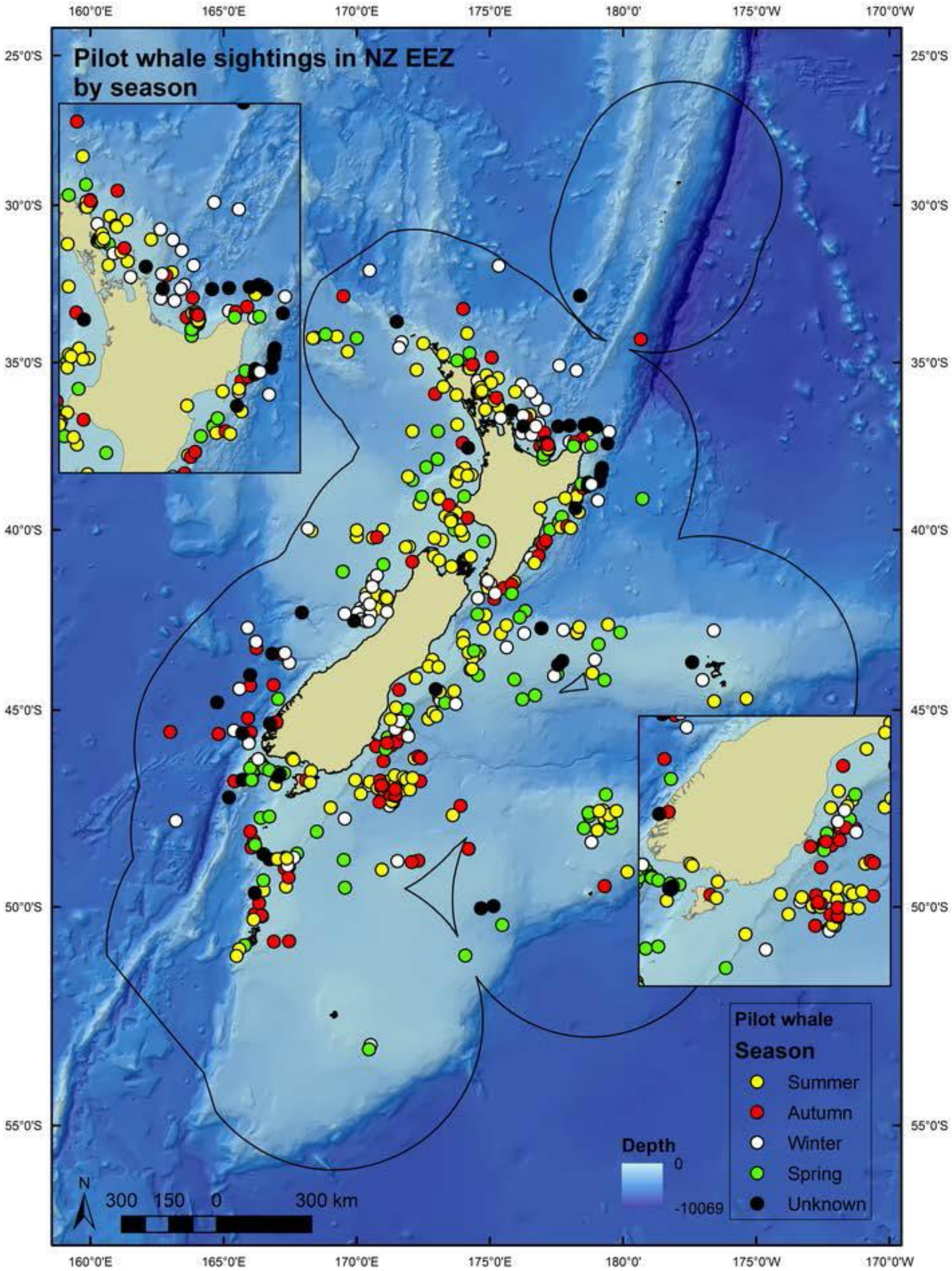


Figure 6-13: Distribution of pilot whale (*Globicephala* sp.) sightings in New Zealand waters between 1970 and 2013. Reported sightings are from a variety of sources and need to be considered indicative only, as identifications may not be correct and sightings effort may be spatially biased. Figure from Berkenbusch et al. (2013).

6.7 New Zealand fur seal

New Zealand fur seals *Arctocephalus forsteri* are distributed around New Zealand, the southern coastline of Australia and Australasian temperate and subantarctic islands (Goldsworthy et al. 2003; Harcourt 2005). Numbers in New Zealand have increased and their breeding distribution has expanded northward through recent decades after extirpation attributable to Polynesian subsistence hunting (Smith 2005) followed by European commercial sealing in the late 18th and early 19th centuries (Lalas & Bradshaw 2001; Ling 2002; Richards 2003). Fur seals were last officially culled in New Zealand in 1946 although they did not receive full protection until the passing of the New Zealand Marine Mammals Protection Act in 1978 (Lalas & Bradshaw 2001). The most recent population estimate in the New Zealand region is c. 100 000 individuals in 1992 (Harcourt 2005). Breeding colonies in close proximity to the STB occur at the Sugar Loaf Islands off New Plymouth, on Stevens Island in the Marlborough Sounds, at Separation Point and Tonga Island in Able Tasman National Park, and at Pillar Point and Archway Island near the base of Durville Spit (Figure 6-14).

In summer and autumn New Zealand fur seals typically forage offshore at night over the edge of the continental shelf and over the continental slope (Harcourt et al. 1995; Harcourt & Davis 1997; Harcourt et al. 2001, 2002), though in winter they may forage in inshore waters (Harcourt et al. 2002). Dietary studies of New Zealand fur seals were conducted at rookeries in Nelson-Marlborough, west coast South Island, Otago Peninsula, Kaikoura, Banks Peninsula, and the Snares Islands (Baird 2011). Summaries of these studies by Harcourt (2001) and Boren (2010), indicate some dietary differences between New Zealand fur seal populations in different regions. The main prey species in the Otago region are arrow squid, *Nototodarus sloanii* and Maori octopus, *Macroctopus maorum* and a variety of pelagic and demersal teleost fishes ranging in size from lanternfish (Myctophidae) at 1–10 g to barracouta (*Thyrsites atun*) at 2–3 kg (Street 1964; Fea et al. 1999: Harcourt et al. 2002; Harcourt 2005; Lalas 2009). At Kaikoura lanternfish were important in the diet, whereas at Cape Foulwind, ahuru (*Auchenoceros punctatus*), anchovy (*Engraulis australis*), and silverside (*Argentina elongata*) were important at different times of the year (Carey 1992). Lanternfish as well as hoki were preyed upon by fur seals near Cook Strait (Dix 1993). At Tonga Island in Tasman Bay the main species identified from New Zealand fur seal scats and regurgitates were arrow squid, anchovy, pilchard, and jack mackerel (Willis et al. 2008). The absence of myctophids in these samples probably reflects the distance of this colony from the shelf edge and slope.

Baird (2011) reviewed the available information on movement of this species. Most tracking data are available for lactating females as they must return to the colony from foraging trips to suckle their pups enabling tracking devices and data to be reliably retrieved. Sinclair & Wilson (1994) fitted radio transmitters to 15 females from Cape Foulwind on the South Island (see Figure 6-14). The mean minimum distance travelled by females during foraging trips was 100.8 km (range 48.4–157.7 km), with animals travelling twice as far during daytime than at night, when they are likely to be feeding. This would put the proposed iron sand mining area within the foraging range of lactating females from the nearest colonies on Stephens Island and on the Sugar Loaf Islands (Figure 6-14).

Torres (2012) reviewed the available at-sea sightings of New Zealand fur seals in the STB. Thirty-five animals were sighted with no seasonal trend in distribution. Sighted animals were generally distributed inshore at water depths of less than 100 m with seven sightings made in the area potentially affected by the proposed iron sand mining activities and sediment plume. Seven additional animals were sighted in this area during aerial surveys for marine mammals during 2011-2013 (Martin Cawthorn Associated Ltd 2013).

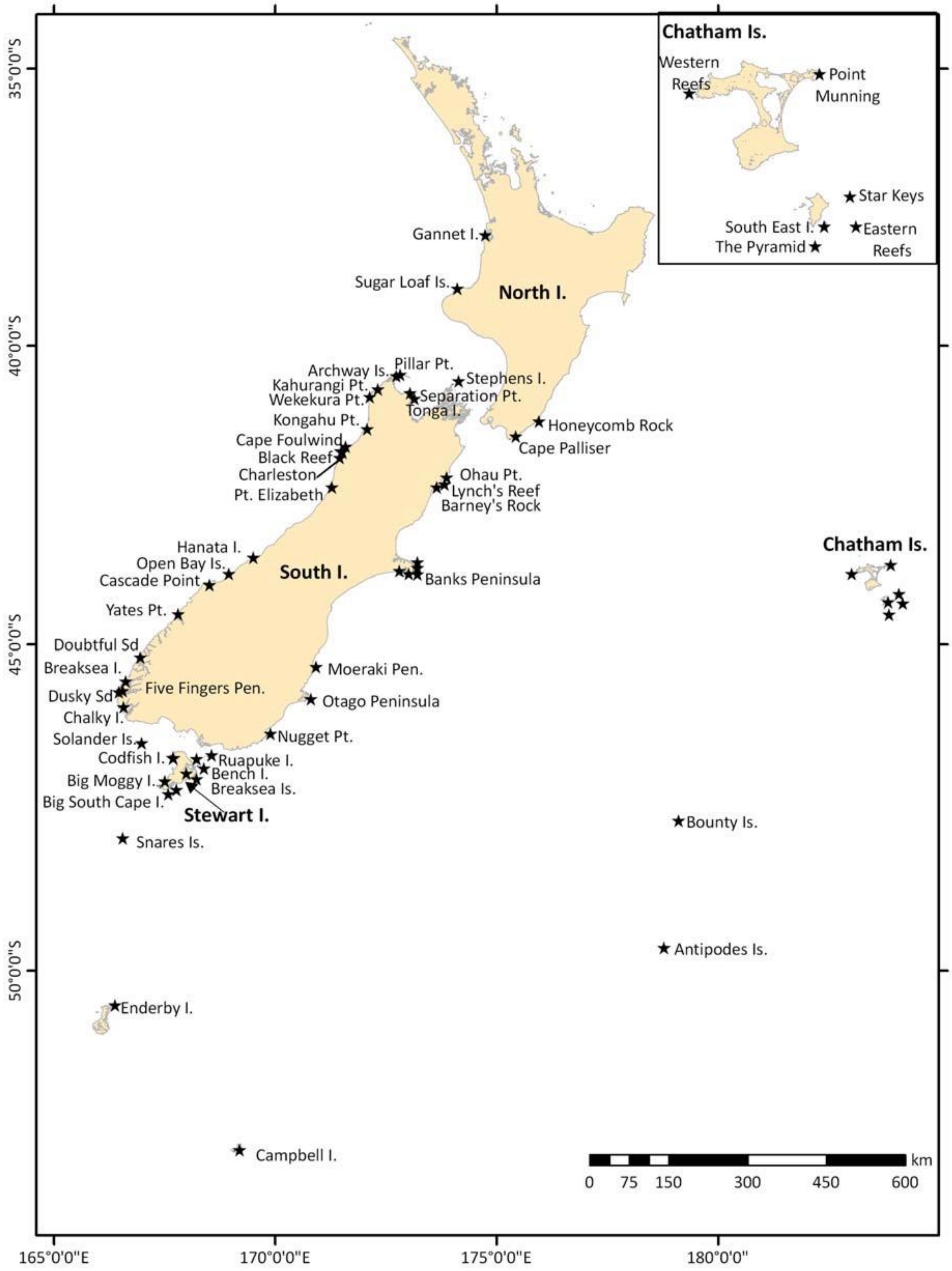


Figure 6-14: Locations of the main New Zealand fur seal rookeries. The map was prepared based on information at http://www.nabis.govt.nz. From Baird (2011).

Assessment of Impact: Following historical extirpation around the mainland, New Zealand fur seals are rapidly recovering their former range, including the STB. They feed on a variable range of squid and pelagic fish species depending on local availability. The proposed mining activities are within foraging range of the closest breeding colonies on Stephens Island and on the Sugar Loaf Islands. Lactating females are the most at risk to threats as their foraging range is restricted because they must return to their colony to suckle their pups at frequent intervals. If lactating females from Stephens Island and the Sugar Loaf Islands forage a mean maximum distance of 100 km from their rookery (as Sinclair & Wilson, 1994 found at Cape Foulwind), they would be displaced from, or experience a decrease in prey abundance or availability over <1% of their foraging area due to overlap with the area of SSC elevated above 2 mg/l due to mining 50 M t per annum. This is a negligible impact according to the criteria provided in Table 2-2. As males and non-lactating females are not obliged to return to shore at frequent intervals and potentially forage over much greater areas, the impact of the proposed mining activities will also be negligible on these animals.

7 Discussion

This review of the spatial and foraging ecology of the key fauna occurring in the STB has identified that for all zooplankton, seabird, and marine mammal species, and most fish species, there should be negligible effects of mining 50 M t per annum according to the criteria outlined in Table 2-2. This is principally because the scale of the mined area and the elevated SSC are small compared to the area used by the populations of these species. Consequently they would be displaced from, or experience a decrease in prey abundance or availability over a very small part of their distribution. For coastal kaimoana species, the proposed mining activity should not add significantly to the levels of suspended sediments currently experienced inshore in frequently turbid waters.

One species, eagle ray, may be affected to a moderate extent. Although the area potentially impacted by mining 50 M t per annum comprises less than 1% of the area of distribution of eagle ray in FMA8, about 8% of its core area of distribution (>50% occurrence) overlaps with the area of SSC elevated above 3 mg/l. Using this threshold a minor to moderate proportion of the stock could be affected by mining through displacement of fish, or decrease in prey abundance or availability. During summer and autumn eagle rays tend to concentrate inshore in water less than 10 m deep where background SSC may reach over 100 mg/l (Hadfield and Macdonald 2015). This suggests that eagle rays may be tolerant to SSC higher than the threshold of 3 mg/l used to assess the impact of SSC elevated by the proposed mining activities.

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