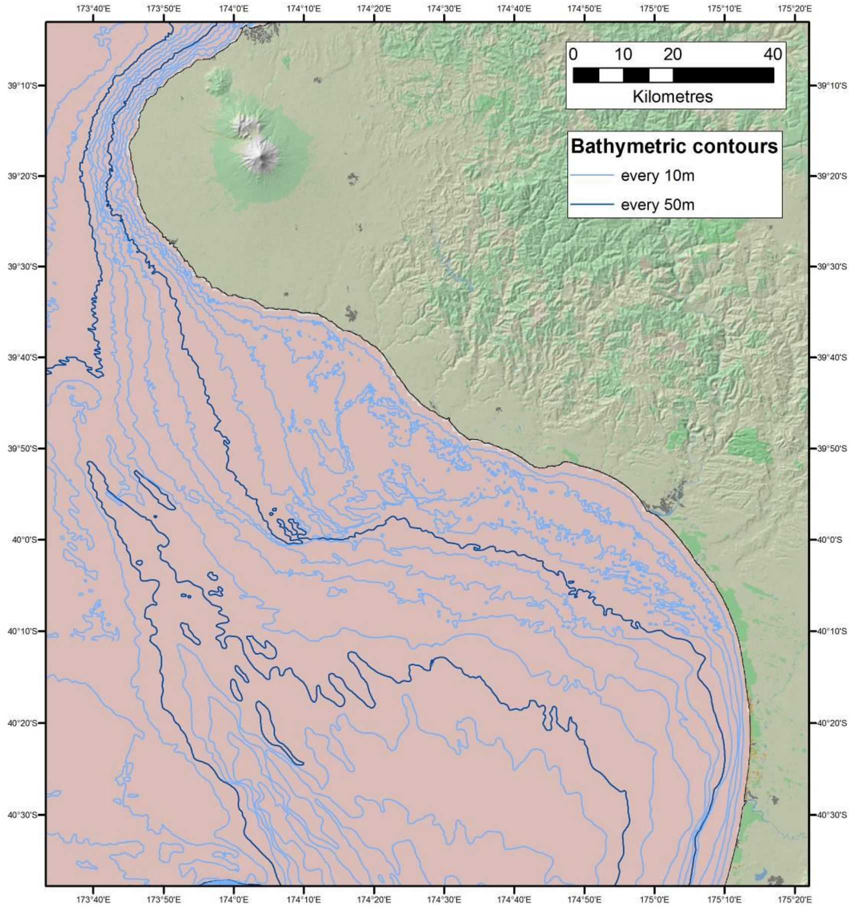
South Taranaki Bight Factual Baseline Environmental Report



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South Taranaki Bight Factual Baseline Environmental Report

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Executive Summary

This report summarises environmental information from the greater South Taranaki Bight (STB) so as to provide the broader context for information pertaining strictly to the areas of iron sands that may be mined at some later date.

The wave climate on the 50 m isobath off the coastline of the STB shows a spatial variation in mean significant wave height from a maximum of approximately 2 m off Cape Egmont, reducing progressively southward. There is a seasonal variation in wave heights, with the highest waves on average occurring in August and September. During storms, significant wave heights of about 8 m can occur, particularly in the winter and early spring. Peak wave periods are most commonly in the range 10-14 seconds.

The orientation of the coast relative to the predominant WSW incident wave direction results in the longshore component of energy being directed predominantly towards the southeast along much of the coast of the STB. It is expected that in the northern part of the Bight, from Opunake to south of the Wanganui River, wave-driven processes will tend to transport sediment along-shore towards the southeast, while along much of the Manawatu coast, northward transport will predominate.

While not quite as strong as tidal flows through Cook Strait proper, tidal currents of up to 0.4 ms^{-1} occur on the relatively shallow waters off Patea. Tidal currents are smaller (with peak speeds less than 0.1 ms^{-1}) in nearshore waters between Wanganui and Foxton. Peak tidal flows throughout the study region are generally aligned coast-parallel with only moderate cross-shore minimum velocities.

Most of the shoreline in the study area is unmodified and near to its natural state. Rivers input the majority of sediment to the Taranaki and Horizons (Whanganui, Manawatu) coast. The Taranaki coast is generally considered sediment starved, but episodic catchment erosion events can inject large quantities of sediment to the coast from a point source. However, there is little information regarding whether there is input of sediment from the offshore region to the littoral zone and the shoreline. Inputed sediments are distributed alongshore or offshore but are eventually transported beyond the STB region.

Variable shorelines dominate the North Taranaki coastline between Stony River and New Plymouth, due to episodic sediment input, especially from the Stony River. There were few survey data for the coastline between Stony River and Oaonui, which show accretion, variable or stable shorelines. Erosion occurs along the cliffs (both volcanic and sedimentary) from Oaonui to Whangaehu, in the centre of the study region, along the STB. There are few data for the Horizons coast, in the south of the study area, but available information suggests the dunes and sand country are prograding, although erosion is identified as a natural hazard for some coastal settlements.

Complex optical conditions are prevalent in the SBT, making the quantification of chlorophyll from remotely sensed ocean colour data extremely difficult. Particulate and dissolved terrigenous material is frequently advected into the region from the Marlborough Sounds, west coast of the South Island and from Cook Strait. Phytoplankton blooms appear to peak in springtime, with an origin off-shore to the west of the study region, and apparent advection of the bloom eastwards through the study region and into Cook Strait. River inputs of terrigenous material along the Taranaki coastline are frequent but sporadic. Resuspension of bottom sediments during storm events can occasionally causes turbid conditions over the the entire region. Apparent median chlorophyll values are relatively high throughout the year all across the study area. No significant decadal trends were observed in apparent chlorophyll concentration.

The limited data set available indicates that the STB is biologically productive in terms of meso (mid-sized) zooplankton. Biomass estimates are among the highest recorded compared to other coastal regions around New Zealand. The mesozooplankton species composition is neritic (nearshore) and is strongly influenced by the physical oceanography of the region, including both the upwelling events off Cape Farewell and the D'Urville current. Although a reasonable amount of mesozooplankton sampling has been done in the STB, it was conducted a number of years ago, using non-standardized techniques. Macrozooplankton are poorly known in the STB.

The available data indicate that the benthic fauna in the STB is generally species poor with a low abundance of benthic organisms in both subtidal and intertidal zones when compared to other coastal areas of New Zealand. Although data are limited, benthic species richness and abundance are particularly low in sandy habitats. This may be to be due the high energy environment and frequent bed resuspension resulting in very mobile sediments, sand inundation of reefs, sand scouring of reef habitats, and sustained high water turbidity in nearshore areas. Species numbers and diversity tend to increase towards the shore, with the highest numbers in the nearshore area.

A productive zone for invertebrates in the southwest of the study area is evident where high wet weights of squid, octopus and decapods (crabs, shrimps etc) have been recorded. This offshore productive zone is most likely due to the influence of the cold, nutrient rich water that originates from the upwelling zone off Cape Farewell and the Kahurangi shoals.

Primary (Section 3) and secondary (Section 4) pelagic productivity is relatively high in the STB region compared to other similar coastal regions but this does not appear to be translated into dense or diverse benthic macrofaunal communities. This may be to be due to the high energy environment of the area.

No nationally endangered or at risk benthic macrofaunal species were found to be present within the area. However, the Department of Conservation describes the Waitotara estuary, Waiinu reef, Waverley Beach, North and South Traps, Whenuakura estuary and Whanganui river estuary, all within the study area, as being "outstanding natural areas".

The STB has a moderately diverse reef fish fauna with only 38 species predicted to occur on reefs within SCUBA diving depth range (30 m) in the region. Two species, black angelfish and common roughy, are predicted to be rare in the region occurring at low abundance at just a few coastal reefs. Six other species have restricted distributions, predicted to occur at <50% of the reef sites in the region. All other twenty-nine species are predicted to be much more widespread and either occur in low abundance throughout the region (14 species), are moderately common over the entire area (13 species), or are abundant widely distributed species (2 species). These model predictions should be treated cautiously as none of the original fish survey came from the region. Moreover, some of the presumed reef areas may in fact be steep-sided sediment waves or shoals.

Fifty-one species of demersal fish occur in the STB. The richness of this assemblage is moderate on a New Zealand wide scale with on average 12-16 species likely to occur within a standard research tow. A few species are very widespread and abundant but most species are common only within a restricted depth range. A few species had a very restricted distribution in the STB. Species with distributions along the South Taranaki coastline that coincide with areas of interest to TTR include anchovy, blue cod, eagle rays, red gurnard, golden mackerel, leather jacket, lemon sole, snapper, rig and trevally.

While the cetacean sightings data must be interpreted with caution, as the distribution of sampling effort is unknown (i.e.data are presence only), it appears that relatively few sightings of cetaceans have been made within the northern and southern Taranaki bights. However, 3 endangered or critically endangered species do occur frequent this area: the Maui's dolphin, killer whale, and southern right whale. The populations of these species are extremely low New Zealand wide.

The SBT supports a relatively modest seabird assemblage, but detailed, systematic and quantitative information on the at-sea distribution of virtually all species is currently lacking. Many of the species occurring in the area are likely to be relatively coastal in their distributions. Such species include blue penguin, shags, gulls and terns, although these latter taxa can extend to more offshore areas. By contrast, and although some species have been observed from and relatively close to the coast, albatross and petrel species tend to be more pelagic and wide-ranging in their distributions and will likely occur anywhere throughout the area. The area does not support large breeding colonies for any species but a number of coastal estuarine sites are of significant value to coastal, shore, wading, and migratory bird species. These include the Waikirikiri Lagoon, and the Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei river estuaries.

Commercial fishing operations within the STB have been dominated in recent years by three main fishing methods, bottom trawling (for a variety of species), midwater trawling (mainly for jack mackerel), and set netting (mainly for rig, blue warehou, and school shark). Together these methods have accounted for 95% of all fishing events recorded with position data, between 1 October 2004 and mid-July 2010. The highest levels of fishing effort (mainly bottom trawling and set netting) were just offshore between New Plymouth and Cape Egmont, and near the 50 m contour between Hawera and Whanganui. Fishing effort of all methods occurred throughout the year, but there was a concentration of midwater trawling effort in early summer.

Information relating to TTR’s additional scientific work undertaken since 2014 has been provided and the conclusions is this report remain valid.

1. Introduction

1.1 Background

Trans-Tasman Resources (TTR) have secured a Property Permit (PP 50 383) to commence prospecting for offshore iron sands along the West Coast, North Island, within the 12 nm territorial sea, along the southern and northern Taranaki bights. The total area of PP 50 383 is 6319 km^2. TTR has a further exploration application under consideration for a licence beyond the 12 nm sea (PP 50 753) in the south Taranaki Bight, which is 2284 km^2 in area.

The granted prospecting licence area (PP 50 383), lying within the 12 nautical mile (M) limit, will be covered by consenting procedures under the Resource Management Act, which is managed three separate regional councils – Auckland Regional Council, Environment Waikato and Taranaki Regional Council. The submitted PP 50 753 licence area (beyond the 12 nm territorial sea) will be managed under the Continental Shelf Act.

1.2 Agreement to carry out a phased biogeophysical study

In an agreement dated 28th April 2010 TTR requested NIWA to undertake phased biogeophysical research in the South Taranaki Bight including the southern section of PP 50 383 and PP 50 753 and the bordering regions. Phase 1 of this work is focused on collation and synthesis of data from existing sources and includes the following elements:

- derivation of wave climate information and tidal patterns for the region from existing models and databases;
- undertaking a geomorphologic analysis of stability and history of adjacent shore;
- characterisation of the ecology of the region including a synthesis of information about rare and endangered species;
- characterisation of the fisheries of the region.

This report contains information pertaining only to Phase 1 of the study. Initial prospecting results from TTR suggest mining targets may be 15 – 30 km off shore in the South Taranaki Bight area (including the Graham Banks shoal). However, this baseline environmental study covers a much greater area (Figure 1.1) so to provide a broader context for information pertaining strictly to the areas that might be mined.

The report is divided into ten sections each containing the methods, results, conclusions and references pertaining to a significant and coherent section of work. The conclusions are drawn together in an overall conclusions section (Section 12).

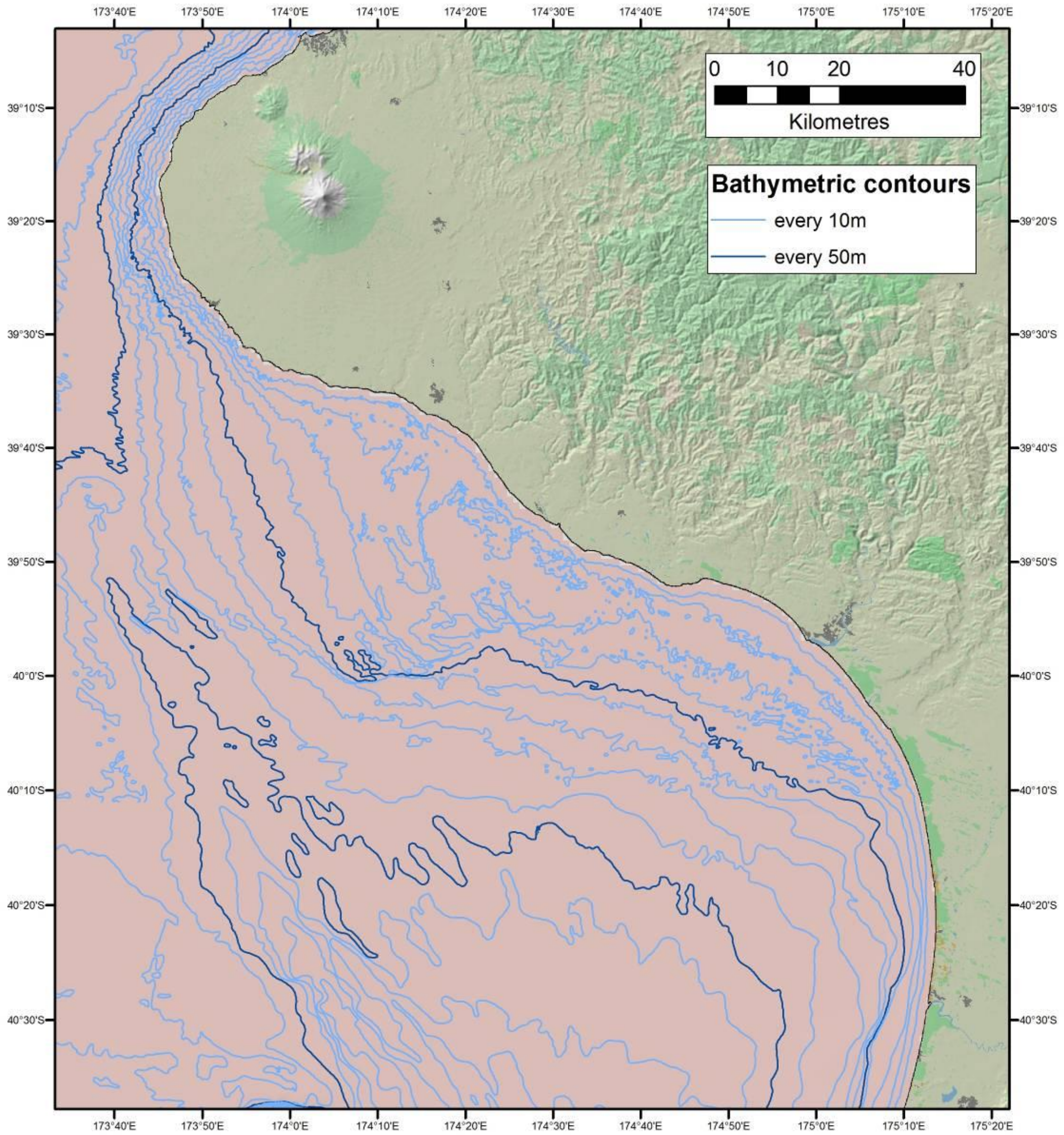

Figure 1.1: Map of the South Taranaki Bight (STB) study area

2. Wave climate and tidal statistics for the South Taranaki Bight

2.1 Methods

2.1.1 Wave hindcast

Numerical modelling can be used to provide wave climate information, supplementing the limited data available from wave buoys and satellite altimeter sources. A 20-year hindcast of wave conditions in the Southwest Pacific and Southern Oceans from 1979 through 1998 has been created (Gorman et al. 2003a, Gorman et al. 2003b). This simulation was based on the WAM wave generation model (Hasselmann et al. 1988), which represents the wave spectral density $S(f,\theta)$, proportional to the energy associated with each wave frequency f and propagation direction θ present in the wave field, at each position in a spatial domain and varying with time through the simulation. The model includes the contributions from various physical processes, including generation by wind stress, propagation, nonlinear interactions, and dissipation by white-capping.

For the New Zealand regional wave hindcast, a rectangular grid was established covering latitudes 78.75°S to 9°S and longitudes 99°E to 220.5°E (139.5°W). Spectra were computed at 16 equally spaced propagation directions and 25 logarithmically spaced frequencies, between f_1 = 0.0417 Hz and f_{25} = 0.4518 Hz. Wind data were sourced from the European Centre for Medium-Range Weather Forecasts (ECMWF). These provide winds at 10 m elevation on a 1.125°×1.125° latitude/longitude grid, at 6-hourly intervals. The same spatial resolution was applied to the wave model grid. The model was run for a 20-year hindcast of the years 1979-1998 inclusive and results were archived at 3-hourly intervals over the entire grid.

In order to obtain wave conditions in the South Taranaki Bight from the hindcast, a set of 43 output locations was first selected on the 50 m isobath (Figure 1). Wave spectra $S(\theta, f)$ were then interpolated from archived hindcast spectra at adjacent grid cells onto each of the selected output locations, using an interpolation procedure (Gorman et al. 2003b) that takes account of the effects of the coastline in blocking wave approach and limiting fetch from the various wave propagation directions.

This provides a 20-year record of wave statistics at each location, including significant wave height, mean and peak wave period, mean and peak wave direction, wave energy flux, as well as the associated wind speed and direction. From these time series, various occurrence statistics can be derived and plotted.

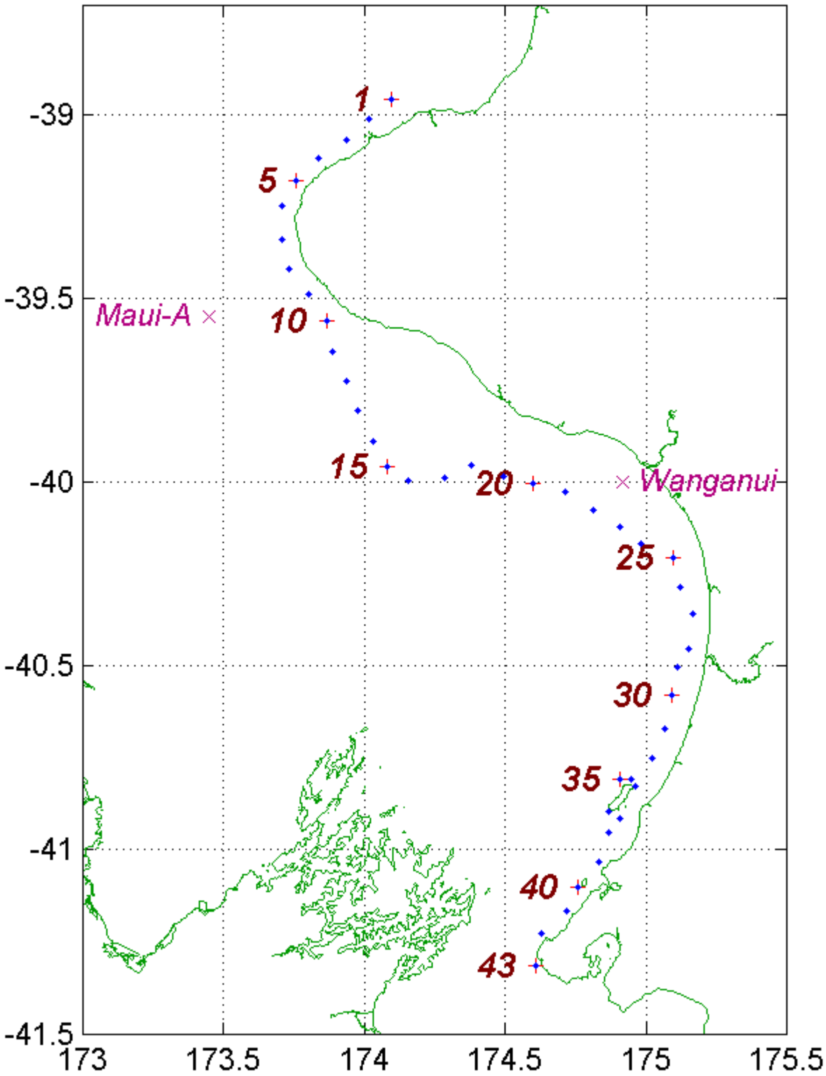

Figure 2.1. Wave hindcast output locations on the 50 m isobath, with every 5th location numbered. The locations of wave buoys (Maui-A, Wanganui) used for verification are also marked.

2.1.2 Spectral wave statistics

The wave statistics presented in this report are derived from the wave spectrum.

Firstly, the full directional spectrum can be integrated over direction to obtain a 1-dimensional frequency spectrum

$$S(f) = \int_0^{2\pi} d\theta \, F(f,\theta) \qquad (1)$$

From this, the peak frequency f_p and corresponding peak period $T_p = 1/f_p$ is identified, at which the maximum value $S(f_p)$ is located. Also, spectral moments

$$M_j = \int_0^{\infty} f^j S(f)\, df \qquad (2)$$

are computed, allowing further statistics to be defined, in particular the significant wave height

$$H_s = 4\sqrt{M_0} \qquad (3)$$

and the (second moment) mean period

$$T_{m02} = \sqrt{M_0 / M_2}\,. \qquad (4)$$

A measure of mean direction

$$\theta_{\boldsymbol{mean}} = \arctan\left(\frac{\boldsymbol{S}_0}{\boldsymbol{C}_0}\right) \qquad (5)$$

can also be derived using directional moments

$$C_0 = \int_0^{\infty} df \int_0^{2\pi} d\theta \, F(f,\theta)\cos\theta\,, \qquad (6)$$

$$S_0 = \int_0^{\infty} df \int_0^{2\pi} d\theta \, F(f,\theta)\sin\theta\,. \qquad (7)$$

Another important quantity is the wave energy flux, representing the net rate at which energy is transferred perpendicular to a unit length of wave front. This can be defined as

$$\vec{P} = \rho g \int_0^{\infty} df \int_0^{2\pi} d\theta \, \vec{C}_g(f,\theta) F(f,\theta) \qquad (8)$$

where $\rho \cong 1025$ kg.m^{-3} is the density of sea water, $g \cong 9.81$ ms^{-2} is the acceleration due to gravity, and $\vec{C}_g(f,\theta)$ is the group velocity for waves of frequency *f* propagating in direction θ.

Note that the group velocity, and hence the wave energy flux, are vector quantities, with both magnitude and direction. We can take averages, or derive occurrence statistics, for either the vector components or the magnitude of the energy flux. In the former case, this could be done by eastward (*x*) or northward (*y*) components, but for nearshore process studies it is also of particular interest to resolve flux vectors into onshore and longshore components, due to their different role in sediment transport studies.

To this end, we require an estimate of the local coastal orientation, relative to which longshore and onshore components can be derived. This has been done by considering the coastline within a certain distance of the relevant output location: in this case we have taken all coastline points at a distance from the output location of less than two times the minimum distance to the coast, and performed a linear regression on these points to obtain a straight line best fit to the local coastline. This is a reasonably robust measure for sites near a relatively straight section of coast, which is generally the case along the South Taranaki coast, although problems may arise where the coastline shows considerable complexity within this range.

It needs to be emphasised that our analysis of wave climate (including the resolution of wave energy flux into onshore and longshore components relative to the coast) is still being applied well offshore at 50 m depth, with no account of how waves are further modified by refraction, bed friction, shoaling and depth-limited breaking before reaching the coast. A more thorough study of nearshore processes, including high resolution nearshore wave modelling, would still be required for a realistic assessment of wave effects on sediment transport. This goes beyond the scope of the present study.

2.1.3 Wave model verification

The wave hindcast has previously been compared with data from wave buoys (Gorman et al. 2003b) and satellite altimeters (Gorman et al. 2003a). For the present study, the most relevant of these results is a comparison with 100 months of data from the Maui-A platform at (39.55°S, 173.45°E) (Figure 2.1). At 120 m water depth, this is somewhat offshore from the region of interest. It was found (Gorman et al. 2003b) that the hindcast underpredicted the measured significant wave height by an average of 0.42 m, with a root-mean-square error of 0.84 m, or 36% of the mean. It was determined that a major contribution to these errors arose from an underestimation of the contribution of waves generated locally by winds from the southeast quadrant blowing across the South Taranaki Bight. Such winds are accelerated by topographic funneling through Cook Strait, an effect which is not adequately resolved in the ECMWF wind fields used.

Wave measurements were also made off Wanganui (Macky 1991)between January 1986 and February 1987. This site (Figure 2.1) is inshore from the output sites used in the present study, in approximately 30 m water depth. While the data are not available for direct comparison, we can compare occurrence statistics for significant wave height obtained over this measurement period with corresponding results from our nearest output location (site 22) over the full 20-year hindcast (Figure 2.2). In this case the hindcast wave heights are greater than the measured wave heights by approximately half a metre. Given the difference in location, one would expect some reduction in wave height between 50 m and 30 m water depth due to bed friction.

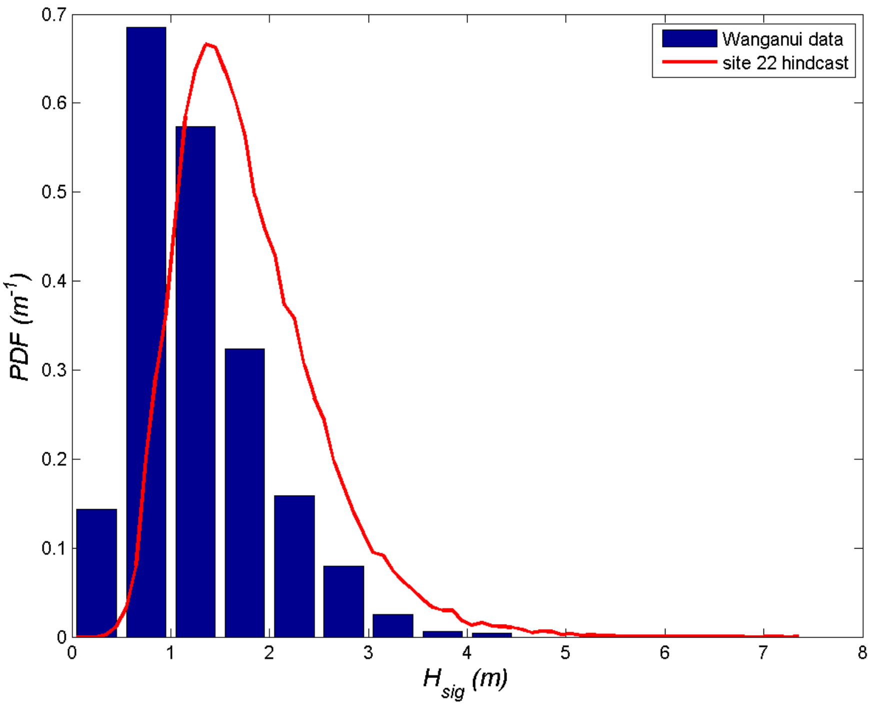

Figure 2.2. **Comparison of probability distribution functions for significant wave height derived from measurements off Wanganui (Macky 1991), and hindcast outputs at site 22.**

2.1.4 Tidal model

NIWA has developed a tidal model that derives major constituents of the tidal variation of sea level and currents, on an unstructured grid covering the full extent of New Zealand's Exclusive Economic Zone (Goring, D. 2001, Goring, D.K. et al. 1997, Walters et al. 2001). This model has been validated against data from 20 sea level gauges, and it was found that, where high quality observations are available, the tidal sea levels are matched to within 0.02 m in amplitude and 7° in phase (Walters et al. 2001).

Tidal constituents from this model were interpolated to a regular latitude/longitude grid covering the Greater Cook Strait region at approximately 1 km resolution. This covers longitudes from 171.47222°E to 174.52778°E in 221 grid cells, and latitudes from 42.01852°S to 39.31481°S in 293 grid cells. Tidal constituents were also interpolated to the same 43 output locations used for wave climate statistics as described above. In this study we use 8 constituents: the semidiurnal constituents M_2, S_2, N_2 and K_2, and the diurnal constituents K_1, O_1, P_1 and Q_1.

For each location, the tidal model describes the tidal variation of sea level η and the eastward and northward components u and v of depth-averaged current as varying with time as a sum of individual constituent motions:

$$\eta(t) = \sum_{n=1}^{N} Z_n \cos(2\pi t / T_n - \phi_n^{(z)}) \tag{9}$$

$$u(t) = \sum_{n=1}^{N} U_n \cos(2\pi t / T_n - \phi_n^{(u)}) \tag{10}$$

$$v(t) = \sum_{n=1}^{N} V_n \cos(2\pi t / T_n - \phi_n^{(v)}) \tag{11}$$

where T_n is the period associated with the n^{th} tidal constituent, while Z_n, U_n, V_n are the corresponding constituent magnitudes, and $\phi_n^{(z)}, \phi_n^{(u)}$ and $\phi_n^{(v)}$ the constituent phases.

For the tidal currents, the motion described above for each constituent results in a current vector rotating through an elliptical path during each tidal period (T_n). The semi major axis of this ellipse represents the greatest current speed (referred to here as the "principal" speed) associated with this constituent, and will be oriented in a certain "principal" direction. Half a tidal cycle later, this current vector will be reversed, flowing with the same speed in the opposite direction. But midway between these two peak flows, the current does not generally reduce to zero, but flows at a minimum speed (the "transverse" speed) in a direction perpendicular to the principal direction.

This describes the motion of a single tidal constituent. The sum of all constituent motions is somewhat more complex. But normally one component, usually M_2, will be the dominant motion, and the net result will be that the current vector traces a somewhat "fuzzier" version of the dominant elliptical pattern, with scatter introduced by the lesser constituents. A "best fit" ellipse can be produced from this net motion, with a defined orientation, principal and transverse speed.

2.2 Results

2.2.1 Wave climate statistics

The 20-year average of significant wave height for all output locations is plotted in Figure 2.2. This shows that the largest wave heights are found off the western end of the Taranaki Peninsula, decreasing further south with increasing shelter from prevailing SW swell. This is also seen in the corresponding average of wave energy flux (Figure 2.3), which is a vector quantity reflecting the magnitude and direction of energy transfer by the waves. This shows relatively strong energy transfer, principally from the WSW, at the northern end of the South Taranaki Bight, while further south, the more southerly energy components become blocked. Note that the magnitude of the (vector) mean energy flux will always be somewhat less than the mean of the magnitude of the energy flux vector.

The orientation of energy flux relative to the coast is also significant, as wave energy reaching the coast at an oblique angle (i.e. not perpendicular to the coast) can drive longshore sediment transport. We would therefore expect that in the northern part of the Bight, from Opunake to south of the Wanganui River, wave-driven processes will tend to transport sediment along the coast towards the southeast, while in much of the Manawatu coast, northward transport will predominate. More detailed study of nearshore processes would, however, be required to quantify these transports.

The monthly mean values of significant wave height and wave energy flux (i.e. averaging data separately for each month over the full 20-year record) are shown in Appendix 1 (Figs. A1.1-A1.24), which also includes Tables (A1.1-A1.8) of monthly mean values for significant wave height, peak and mean wave period, wave energy flux magnitude, and wave energy flux components (east, north, onshore, longshore). These show a seasonal cycle with mean wave heights reaching a maximum in late winter and a minimum in late summer. At site 20, for example, the 20-year mean significant wave height is 1.8 m, but with monthly means varying between 1.4 m in February and 2.1 m in August.

Occurrence distributions for the various wave statistics at selected sites are plotted in Figures 2.5-2.20. These are accumulated over the full 20-year record. Single variable occurrence distributions (as percentage of time that the quantities are in specified ranges) are shown for significant wave height, peak period and mean period. We also show a wave rose, representing the joint occurrence of significant wave height and mean wave direction, the exceedance distribution for significant wave height, and a plot of “downtime”, i.e. the percentage of time in each calendar month that specified thresholds of significant wave height are exceeded. Occurrence distributions are also shown (as probability density functions, plotted on a logarithmic scale) for the magnitude, and the longshore and onshore components, of wave energy flux. Finally, the joint occurrence distribution of energy flux magnitude and direction is plotted in “rose” form.

We see in Figure 2.7(a), for example, that at site 10 (south of Opunake), the highest occurrence of significant wave height is approximately 1.5 m (somewhat below the mean value of 1.9 m), but that the distribution has quite a long tail, up to a maximum of 8.8 m. Peak wave period (usually reflecting the swell component of the spectrum is typically around 12 seconds (Figure 2.7(b)), while the second moment mean period (more influenced by short wind sea) is spread through the range 5-10 seconds (Figure 2.7(c)), with values around 7 seconds predominating. The wave rose (Figure 2.7(d)) shows the predominance of waves from the southwest through westerly sectors. The “downtime” plot shows a strong seasonality in the likelihood of energetic wave conditions: for example, significant wave heights over 3 m occur 10% of the time on a year-round basis (shown by the horizontal red line), but this varies from less than 3% in the summer months, to over 15% in winter.

Wave energy flux at this site (Figure 2.8) shows a high degree of variability, to an even greater extent than significant wave height. While the most common values of flux lie below 10 kW/m, much higher values occur in storms, in which values over 100 kW/m can be obtained. This is predominantly directed onshore, but the longshore component is strongly skewed to negative values, indicating a net component directed towards the southeast.

This is also seen at sites 15 (Figure 2.10(a)) and 20 (Figure 2.12(a)), but further south the predominant long-shore component becomes positive (Figures 2.16(a) and 2.18(a)).

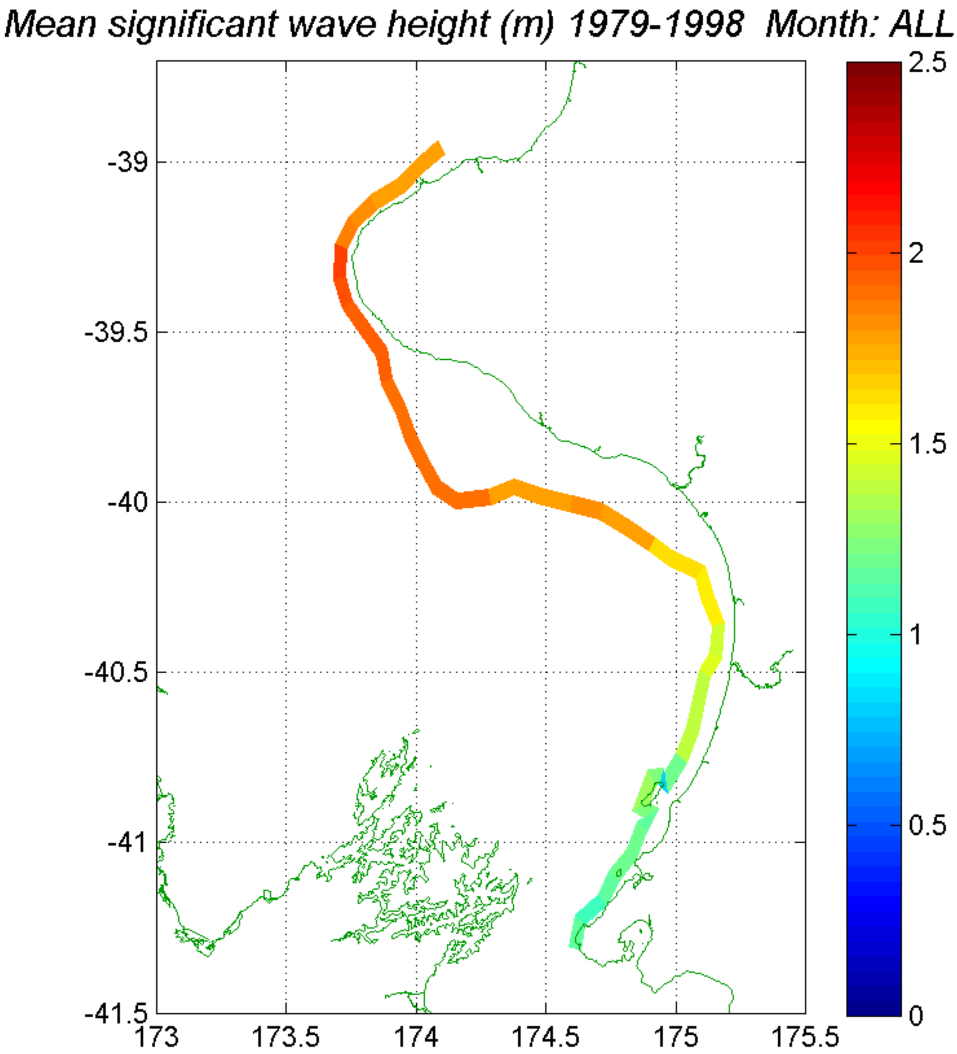

Figure 2.3. Spatial distribution along the 50 m isobath of mean significant wave height, averaged over the full 20-year hindcast record.

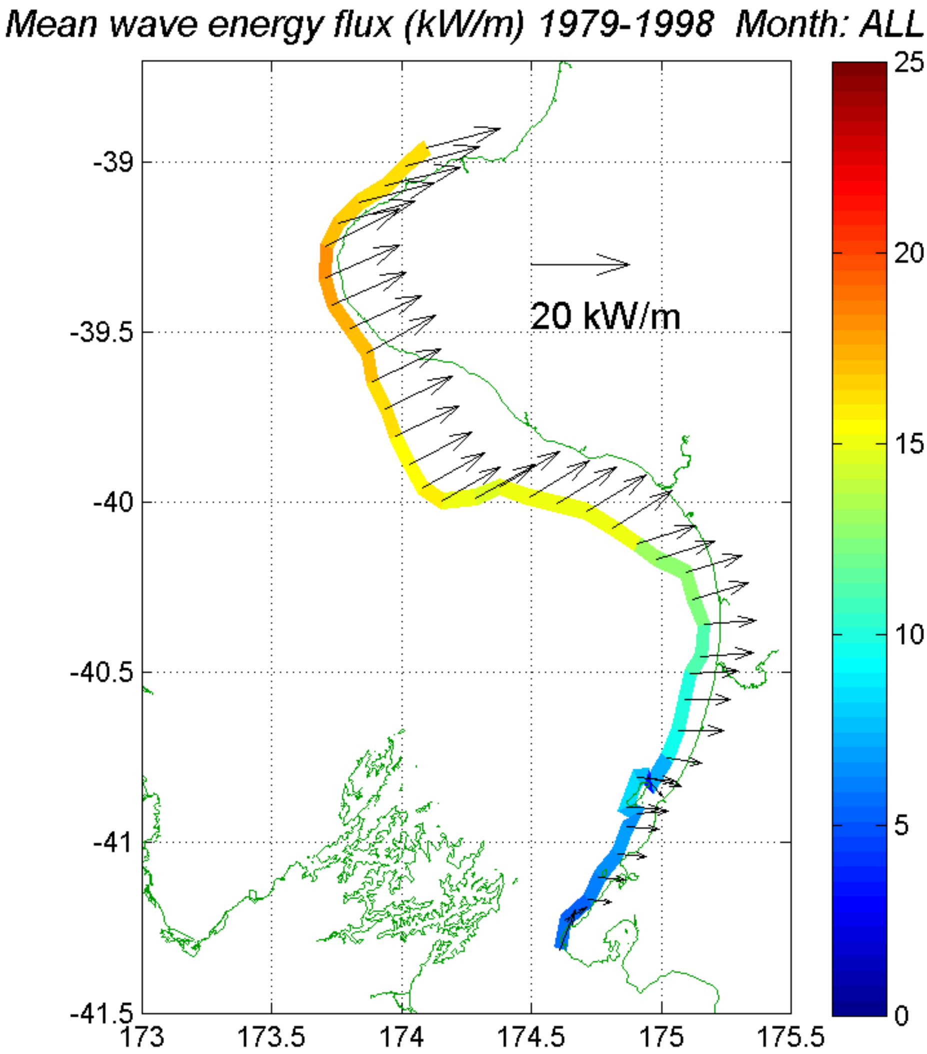

Figure 2.4. Spatial distribution along the 50 m isobath of mean wave energy flux, averaged over the full 20-year hindcast record. The colour scale shows the mean of the magnitude of the energy flux, while the arrows show the vector averaged flux.

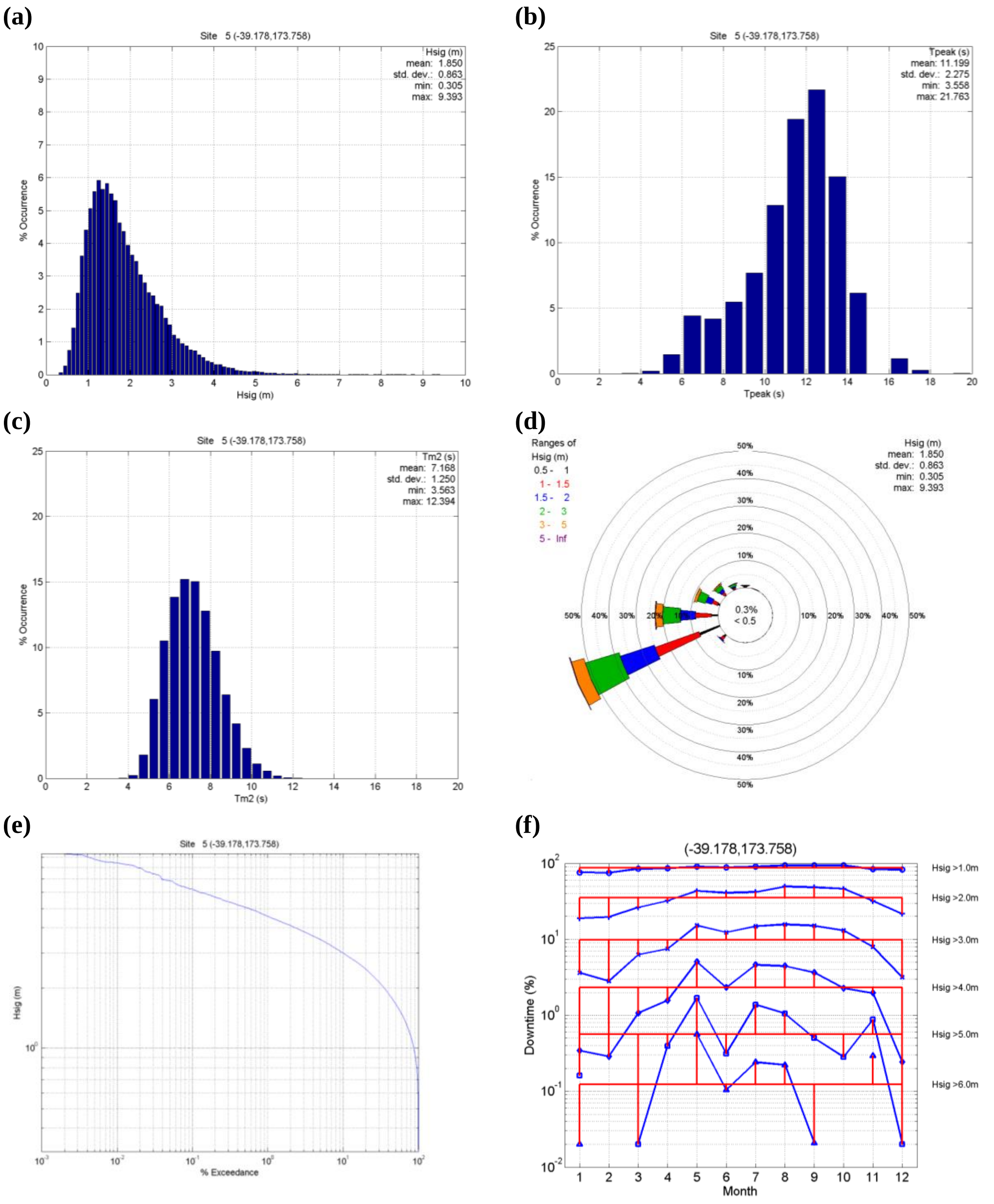

Figure 2.5. **Occurrence statistics for site 5 at (39.176°S, 173.758°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) “downtime” , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

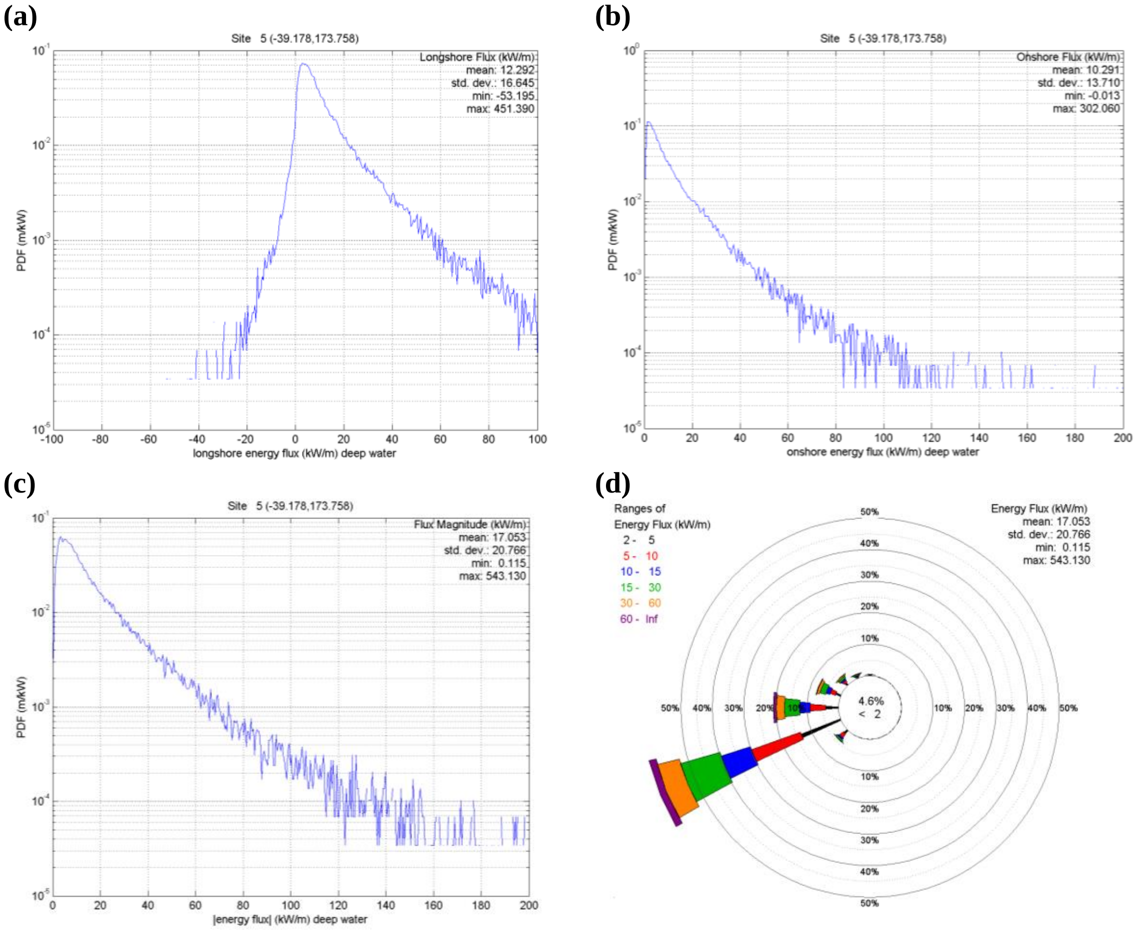

Figure 2.6. **Occurrence statistics for site 5 at (39.176°S, 173.758°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 308°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

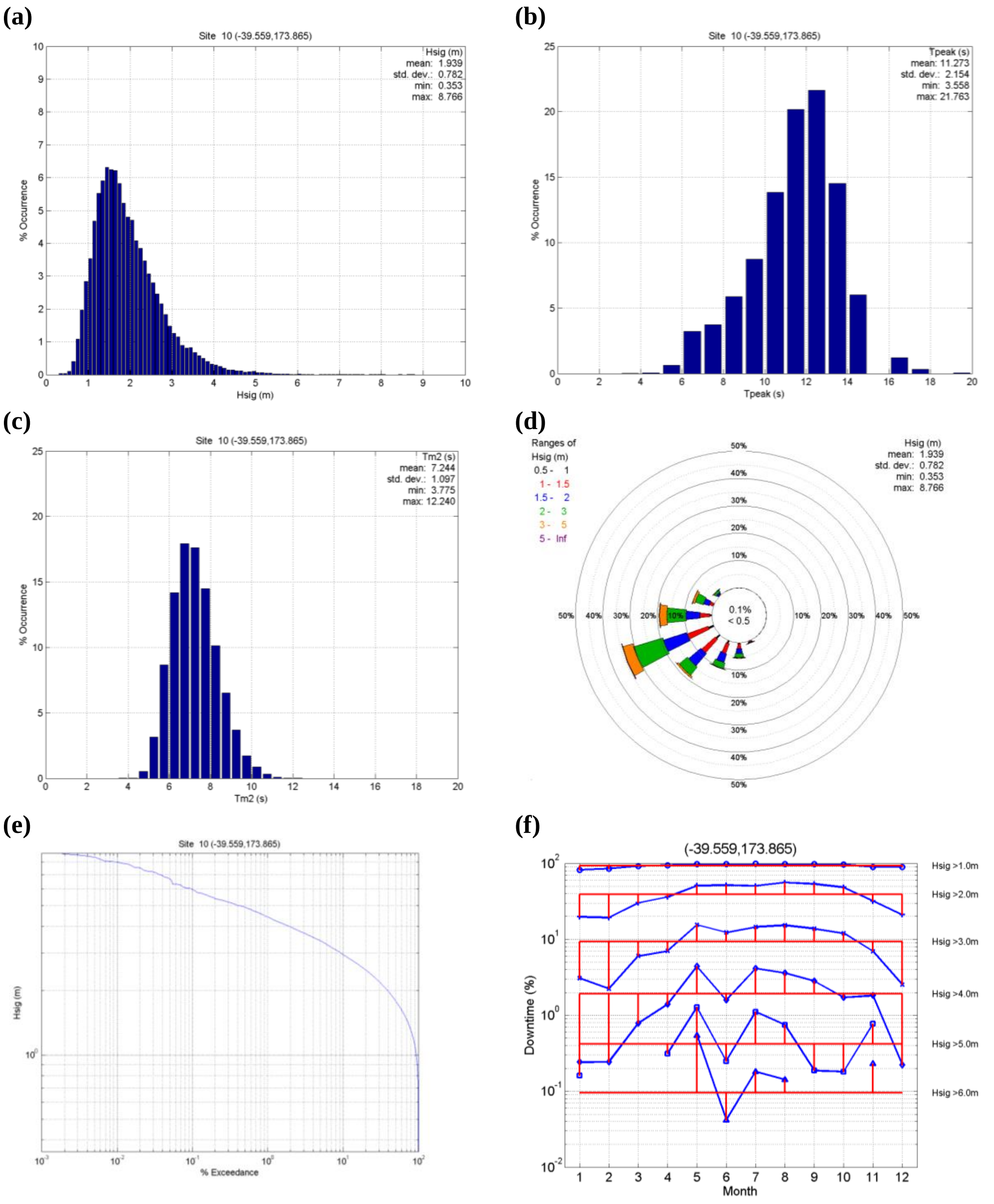

Figure 2.7. **Occurrence statistics for site 10 at (39.559°S, 173.865°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) "downtime" , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

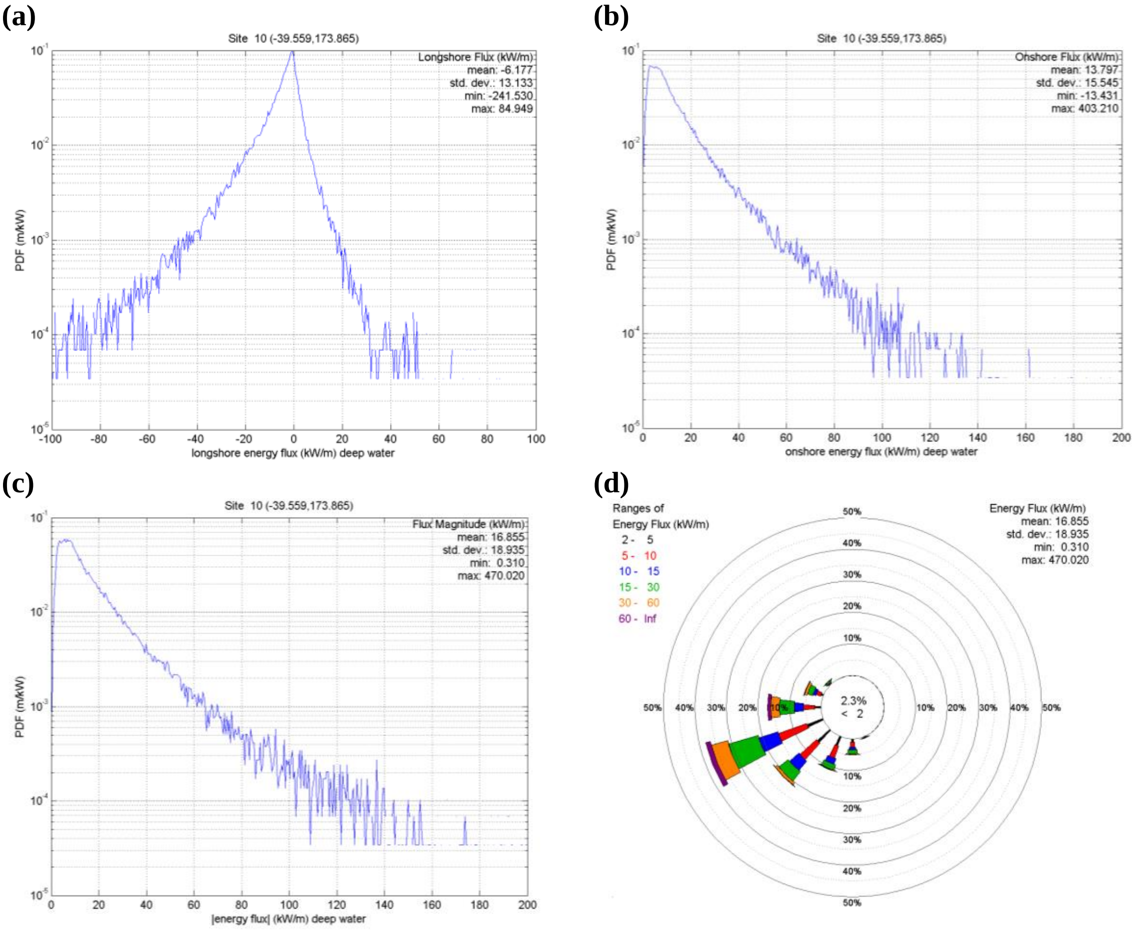

Figure 2.8. **Occurrence statistics for site 10 at (39.559°S, 173.865°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 224°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

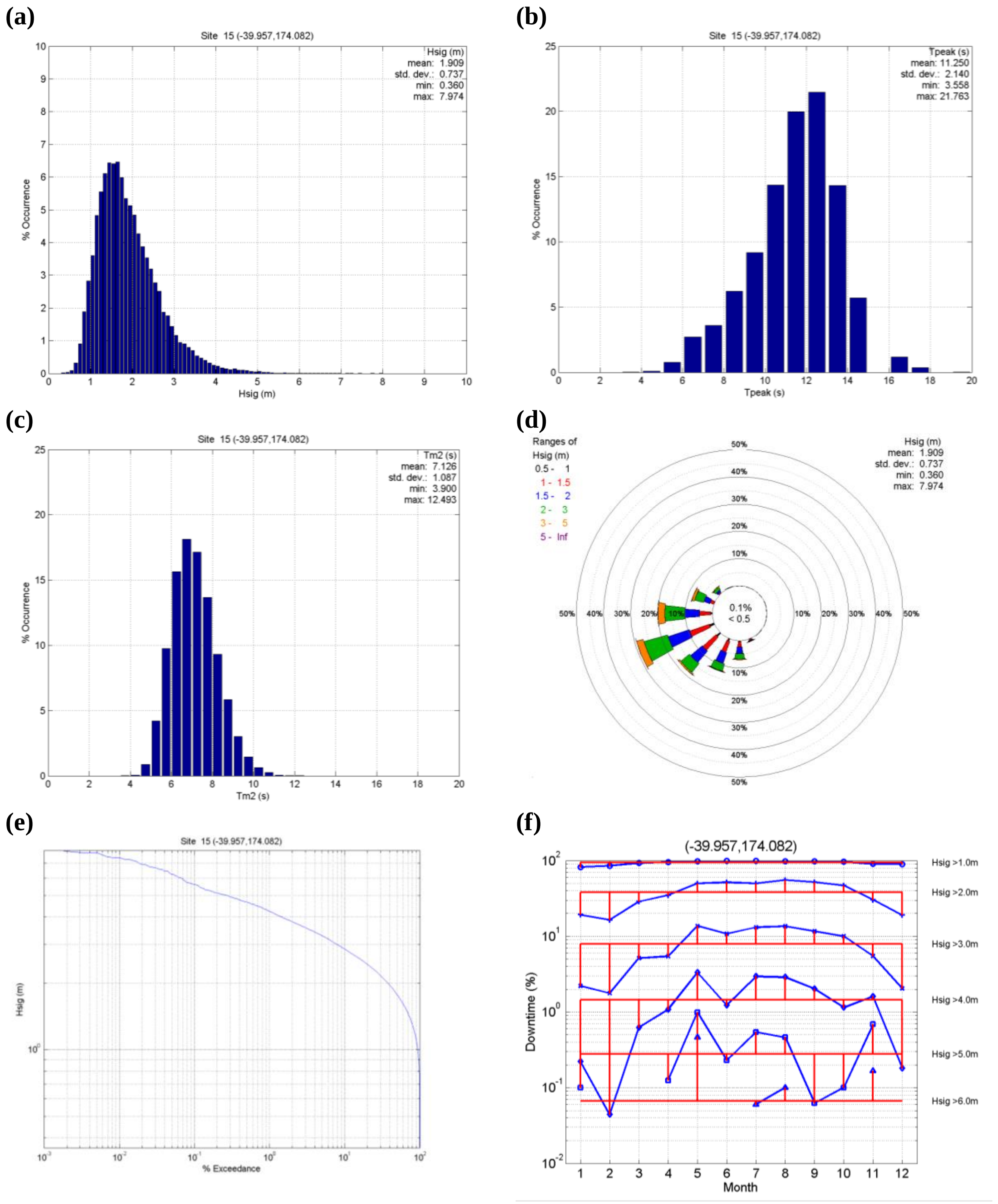

Figure 2.9. **Occurrence statistics for site 15 at (39.957°S, 174.082°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) "downtime" , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

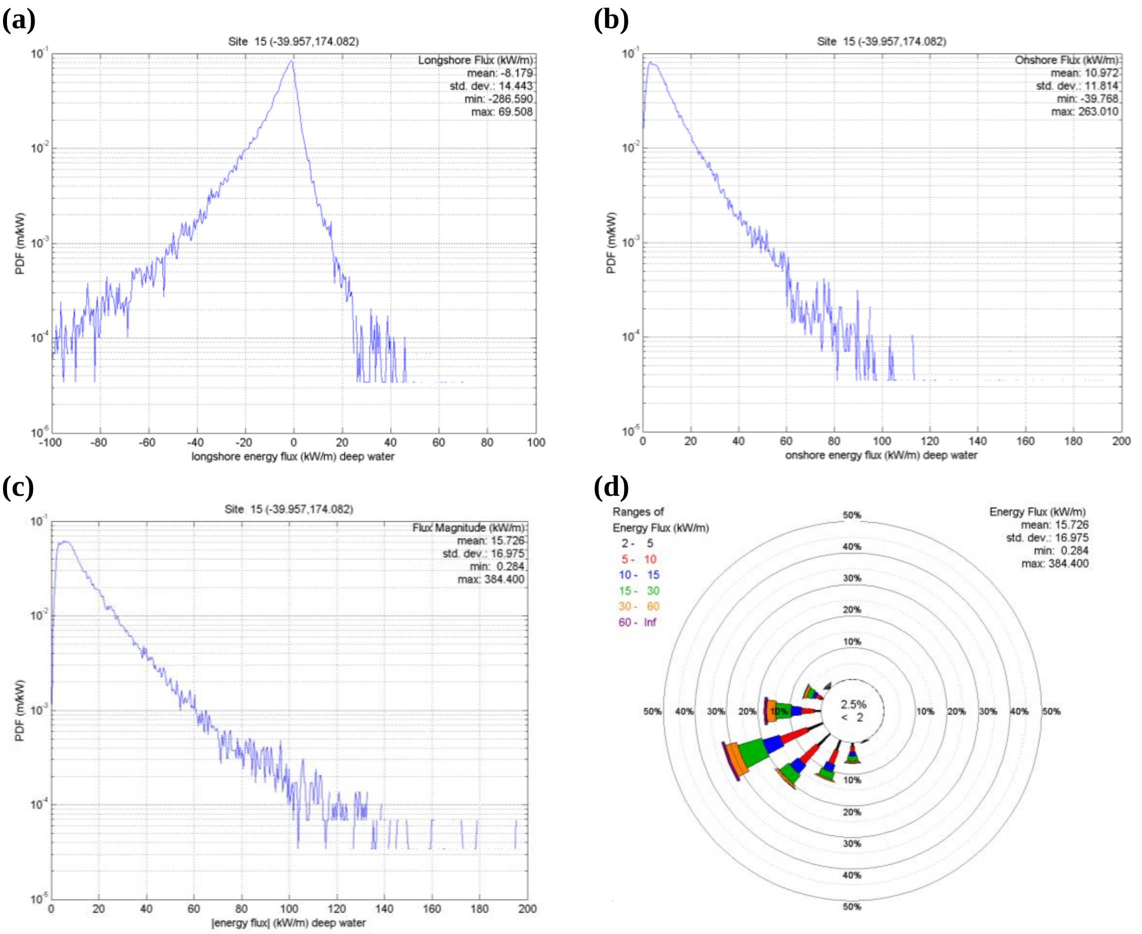

Figure 2.10. **Occurrence statistics for site 15 at (39.957°S, 174.082°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 210°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

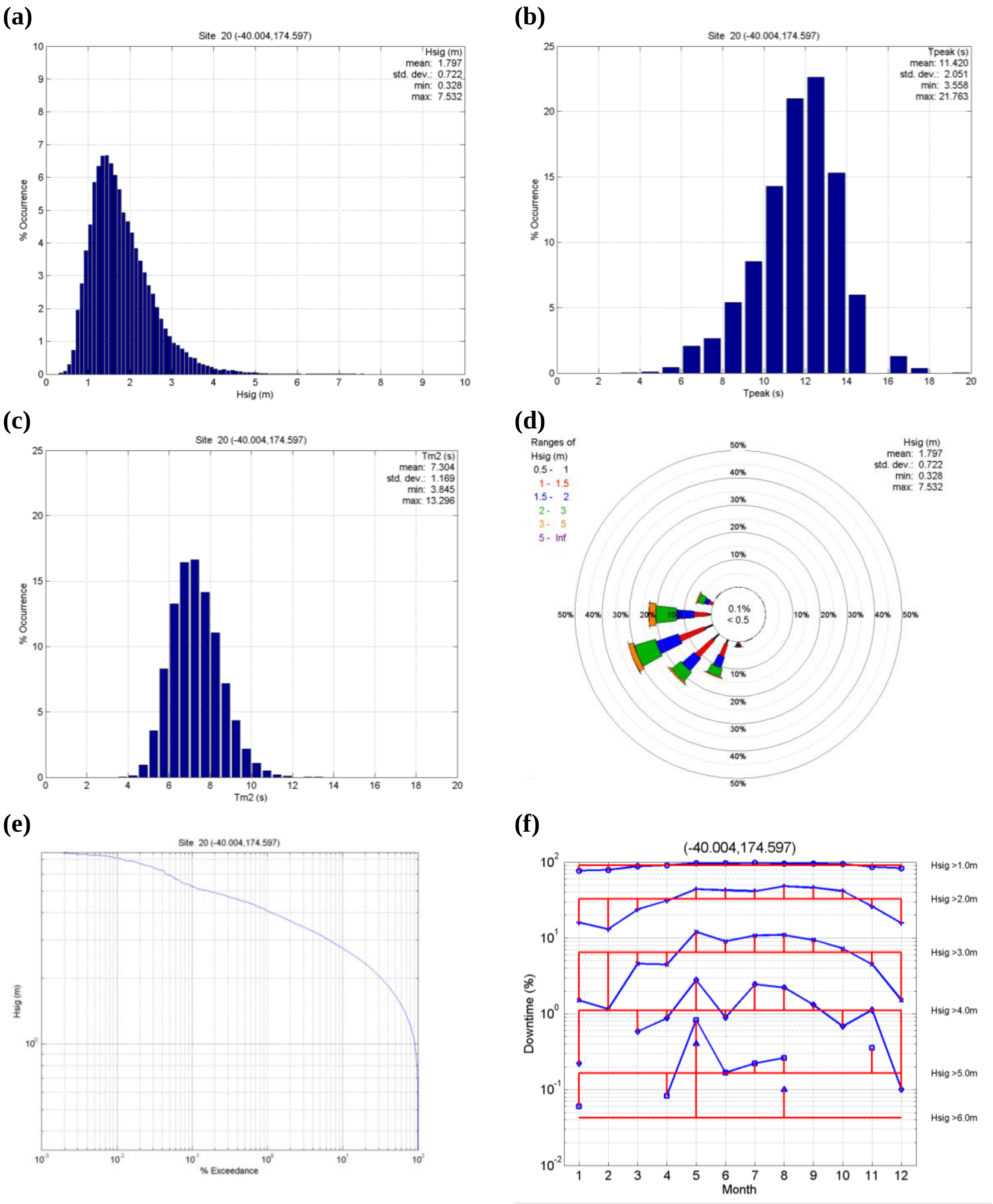

Figure 2.11. **Occurrence statistics for site 20 at (40.004°S, 174.597°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) "downtime" , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

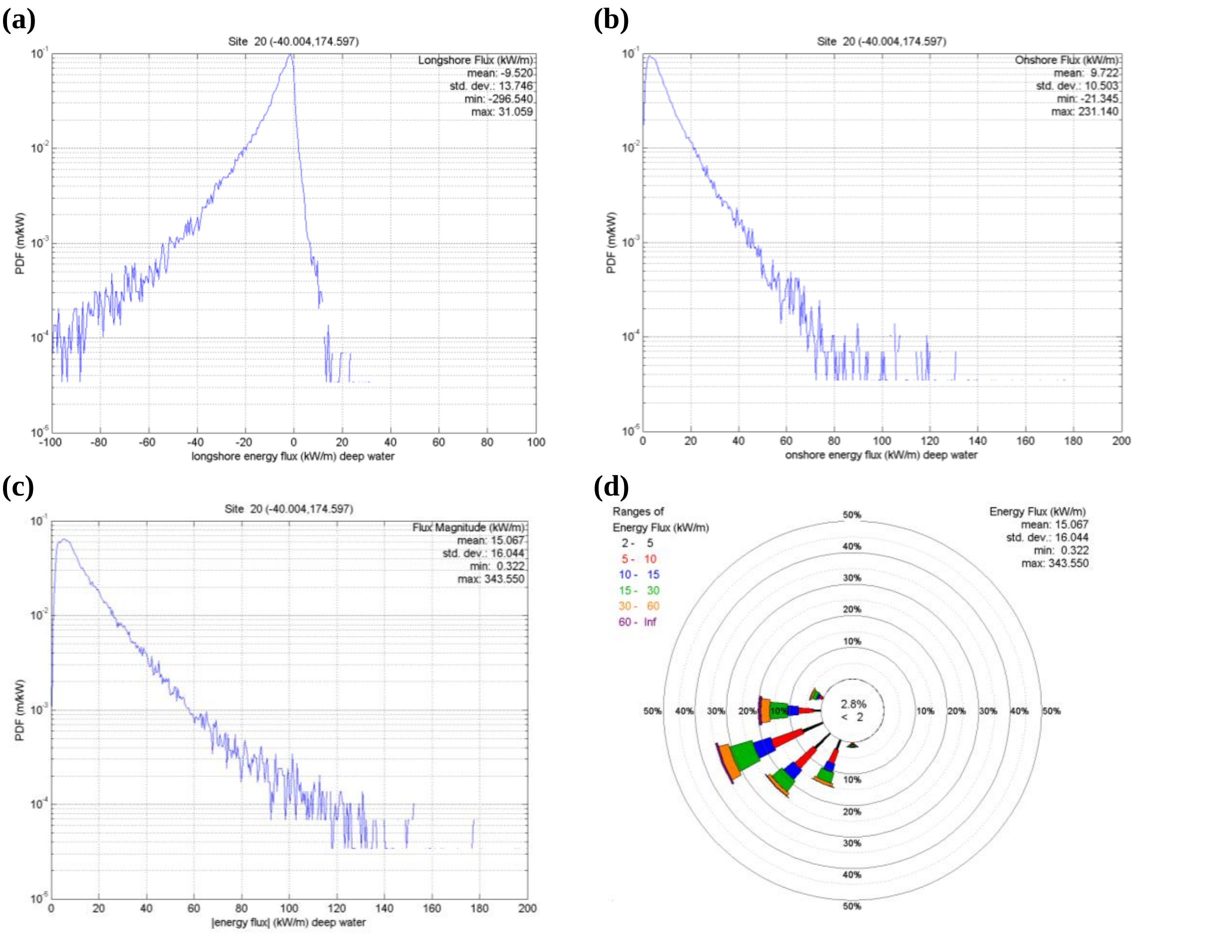

Figure 2.12. **Occurrence statistics for site 20 at (40.004°S, 174.597°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 200°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

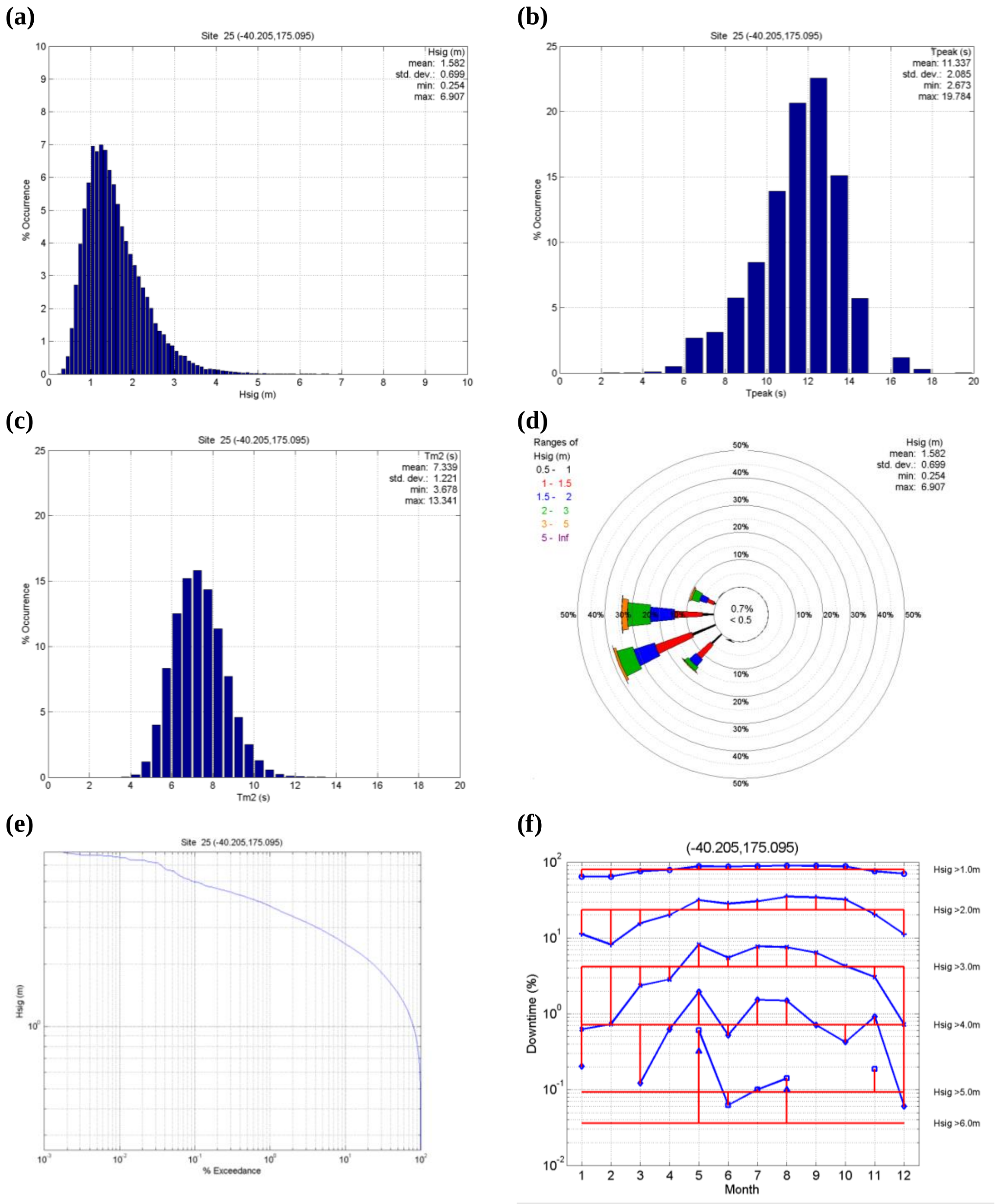

Figure 2.13. **Occurrence statistics for site 25 at (40.205°S, 175.095°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) “downtime” , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

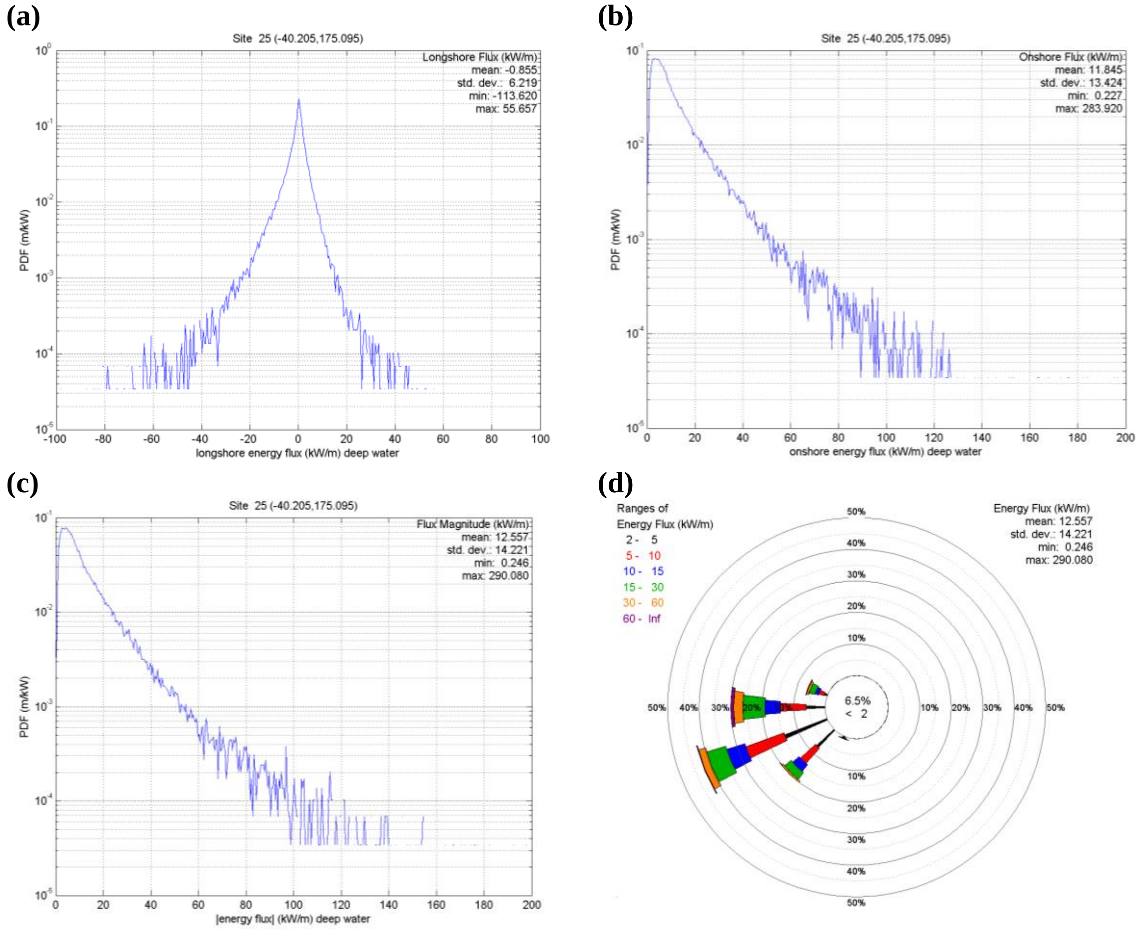

Figure 2.14. **Occurrence statistics for site 25 at (40.205°S, 175.095°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 253°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

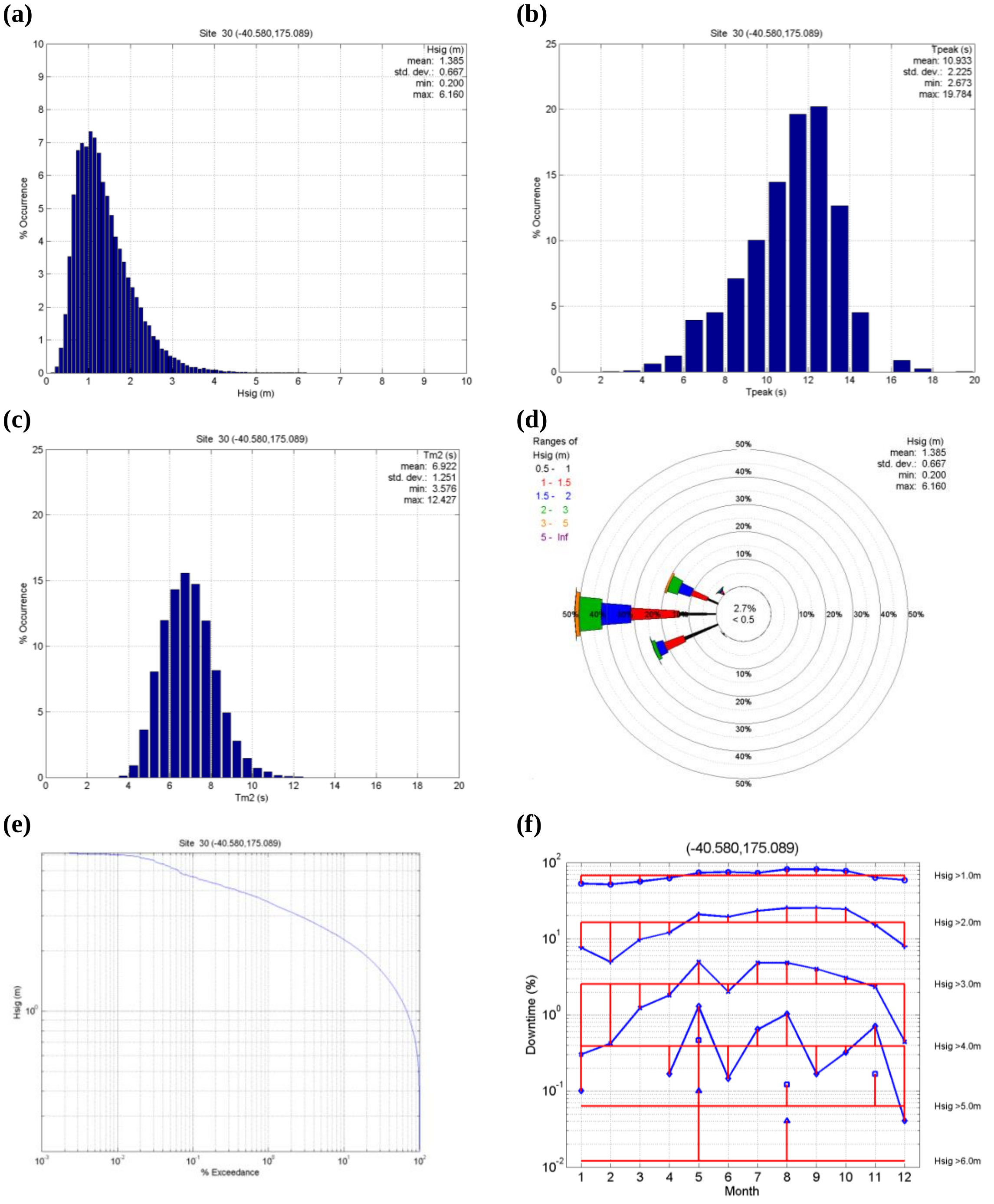

Figure 2.15. **Occurrence statistics for site 30 at (40.580°S, 175.089°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) “downtime” , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

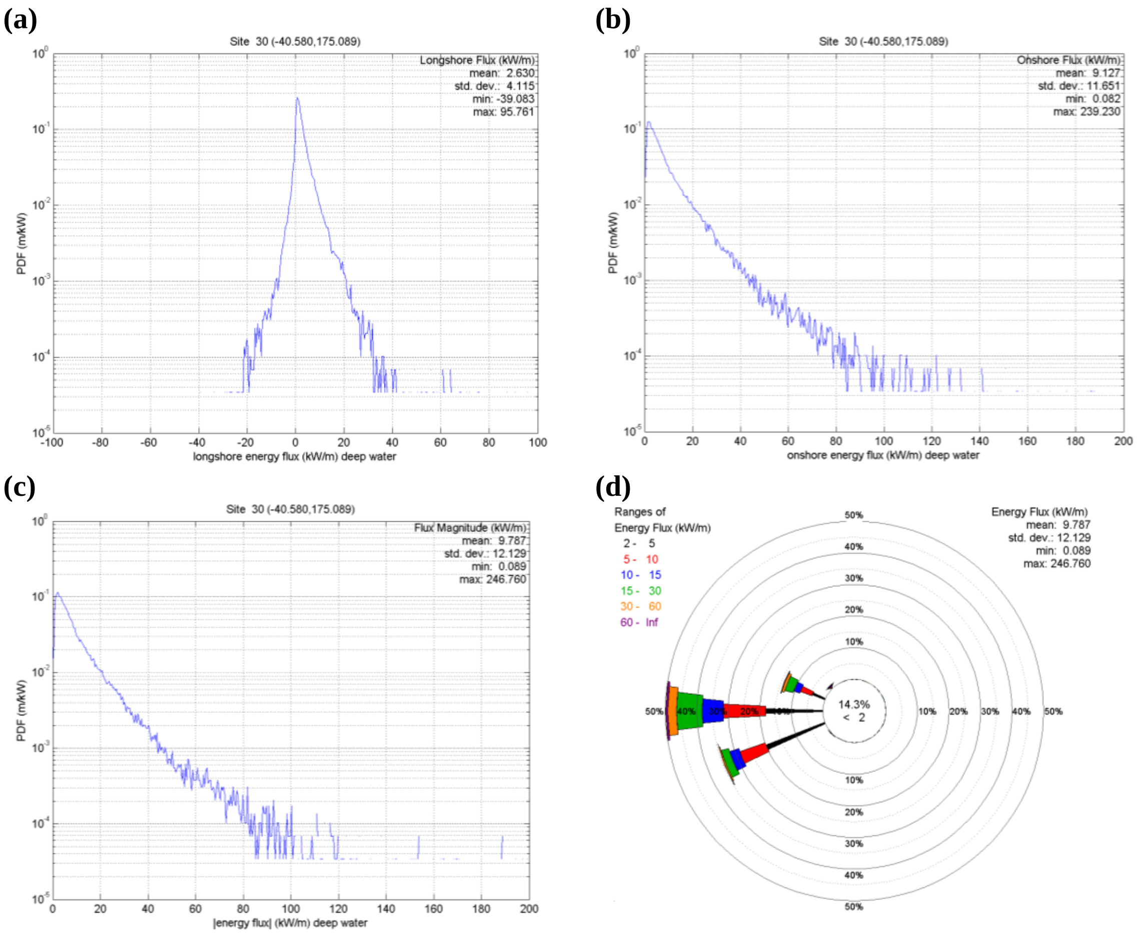

Figure 2.16. **Occurrence statistics for site 30 at (40.580°S, 175.089°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 286°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

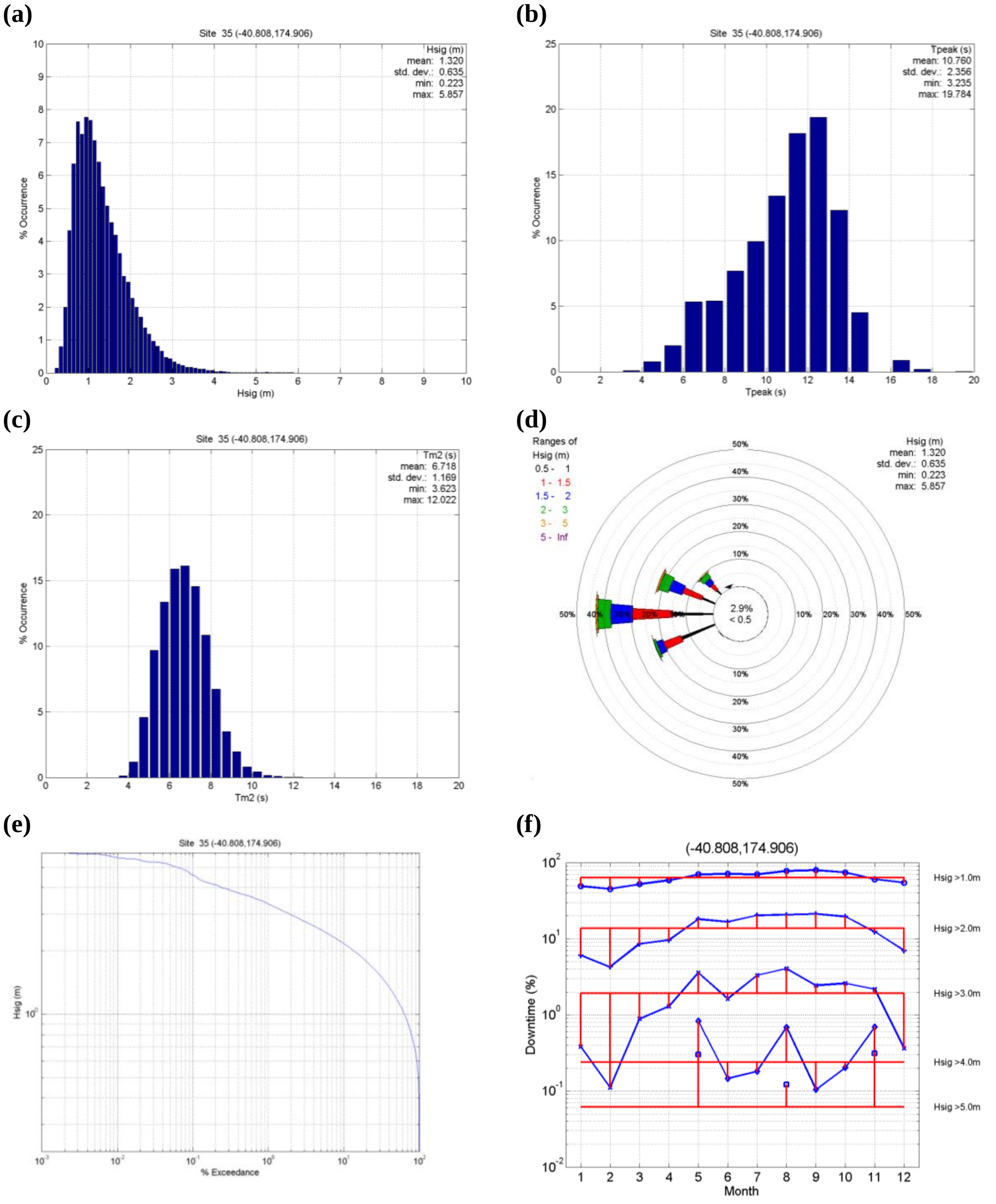

Figure 2.17. **Occurrence statistics for site 35 at (40.808°S, 174.906°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) “downtime” , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

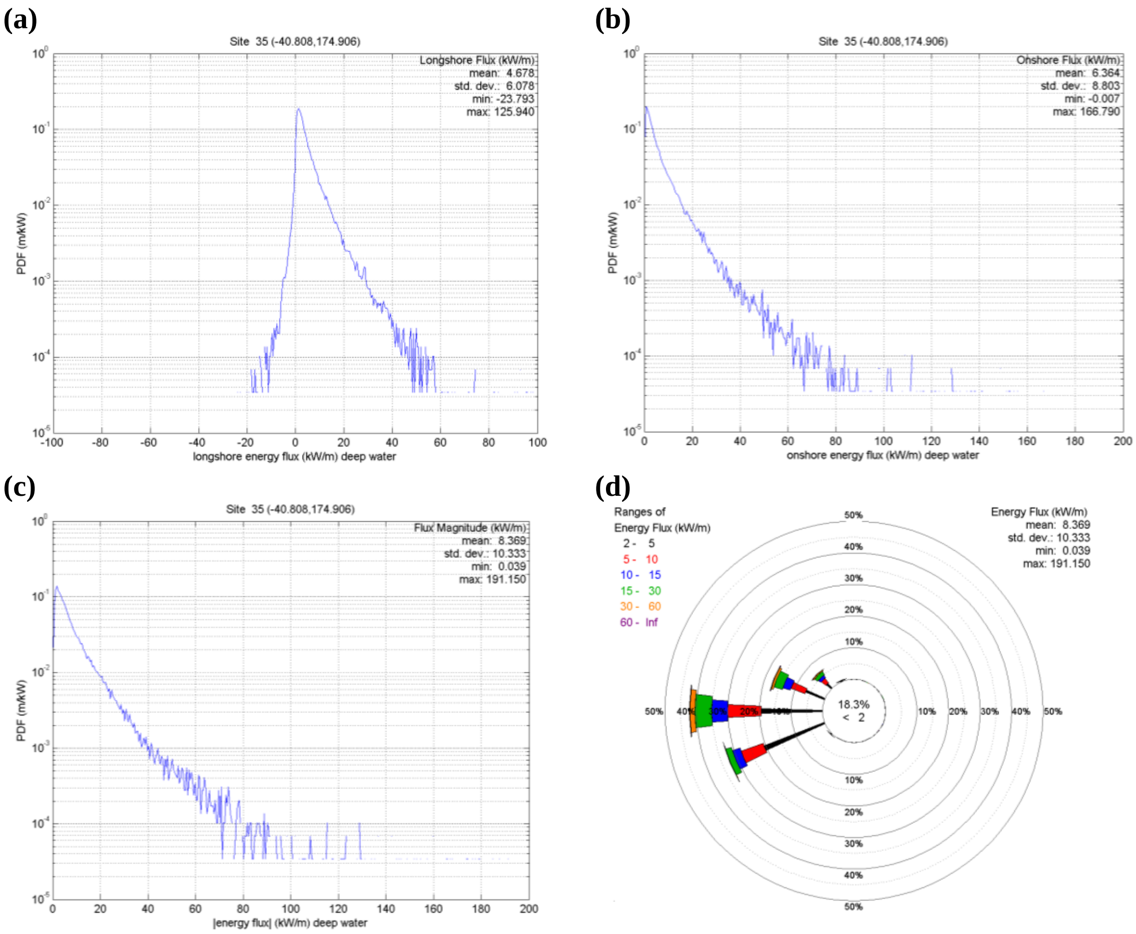

Figure 2.18. **Occurrence statistics for site 35 at (40.808°S, 174.906°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 311°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

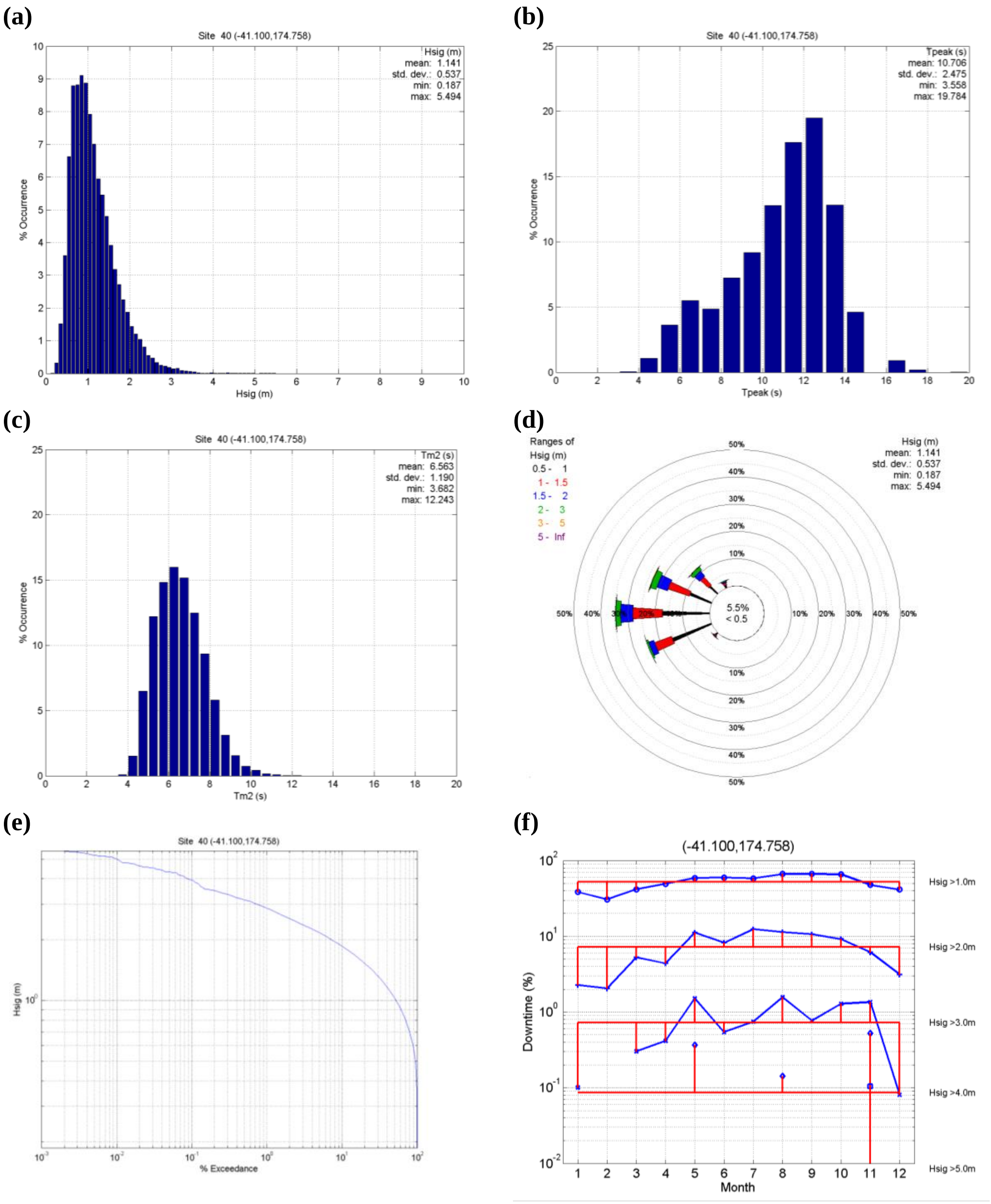

Figure 2.19. **Occurrence statistics for site 40 at (41.100°S, 174.758°E) from the full 1979-1998 hindcast. The first three plots show percentage occurrence for (a) significant wave height, (b) peak wave period, and (c) mean wave period (second moment). Also shown are (d) the wave rose, (e) the wave height exceedance distribution , and (f) "downtime" , i.e. the percentage of time that given significant wave height thresholds are exceeded for each month.**

(a) (b)

(c) (d)

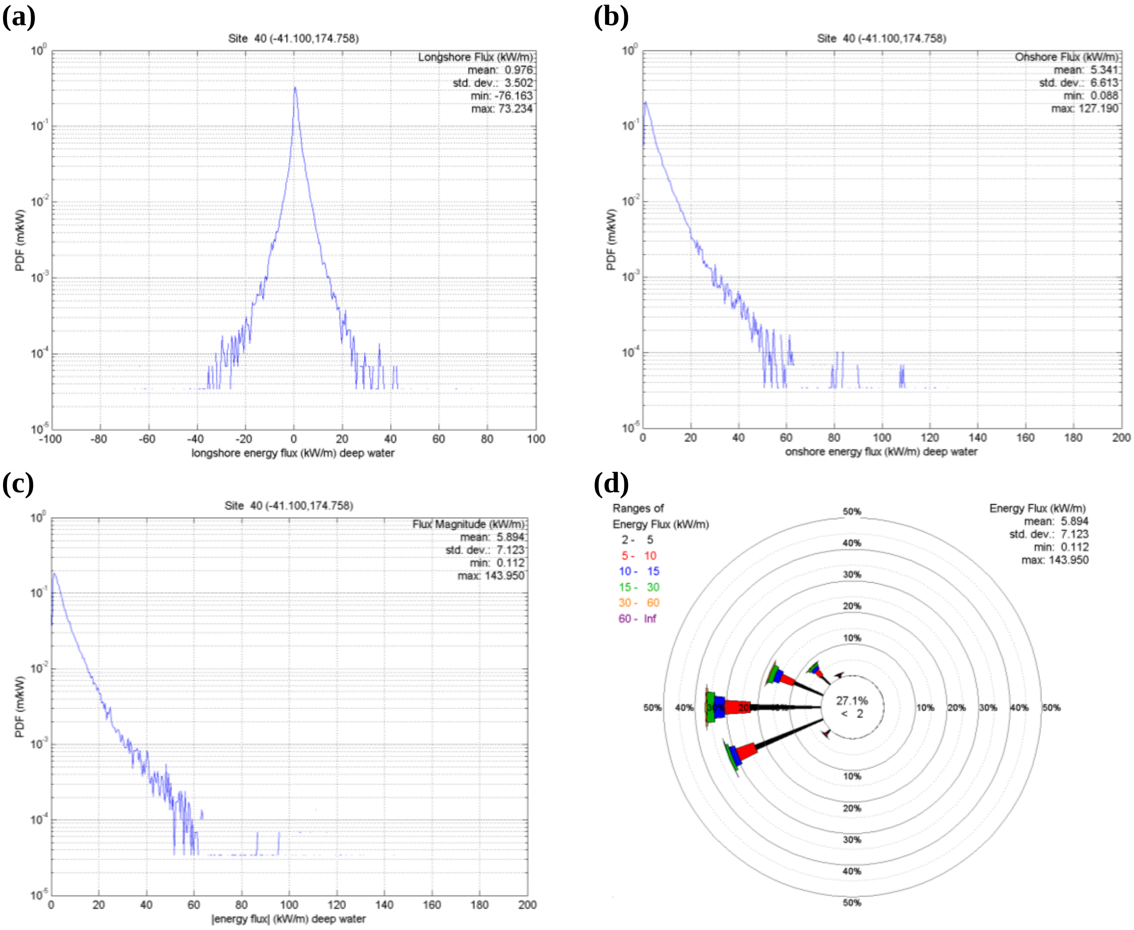

Figure 2.20. **Occurrence statistics for site 40 at (41.100°S, 174.758°E) from the full 1979-1998 hindcast. The first three plots show the probability distribution functions (vertical log scale) for (a) longshore component, (b) onshore component, and (c) magnitude, of the wave energy flux. Note that onshore and longshore directions are defined relative to an estimated shore normal direction of 311°True. The wave rose (d) shows joint occurrence of wave energy flux magnitude and direction. The figure in the centre shows percentage occurrence for wave energy flux less than 2 kW/m (from any direction).**

2.2.2 Tidal sea levels and currents

Cook Strait is a region of strong tidal currents, especially in the Karori Rip off Cape Terawhiti, and between Cape Koamaru and The Brothers on the western side of the Cook Strait, where the dominant M_2 constituent (Figure 2.21(a)) reaches values over 1.7 ms^{-1} (3.3 knots). Currents are somewhat less in waters off the South Taranaki coast, which are the main focus of this study. Here we find that the strongest M_2 currents, up to 0.4 ms^{-1} (0.8 knots), are found in the extensive region of relatively shallow waters off Patea as well as in a more limited nearshore region near Manaia (Figure 2.21(c)). Tidal currents reduce southeast of the Patea Banks, with peak speeds less than 0.1 ms^{-1} in nearshore waters between Wanganui and Foxton. Throughout the study region the principal current direction is generally shore-parallel, with weak cross-shore minimum currents (transverse to the peak current). In the shallow waters off Patea the minimum current is less than 0.1 ms^{-1} (0.2 knots) (Figure 2.21(d)).

Two other semidiurnal components, S_2 and N_2, are both around 20% of the strength of the M_2 component (Figures 2.22, 2.23), while K_2 and the diurnal components are all less than 10% of the M_2 constituent magnitudes (these are not plotted, but tabulated values are available in the Appendix). Hence the net tidal current (Figure 2.24) shows a similar distribution to that seen for the M_2 constituent. Note that Figures 2.21-2.24 use different plotting scales for colour-coded plots of the various constituents.

Appendix 1 contains tables of the tidal constituent amplitudes and phases at all output locations on the 50 m isobath.

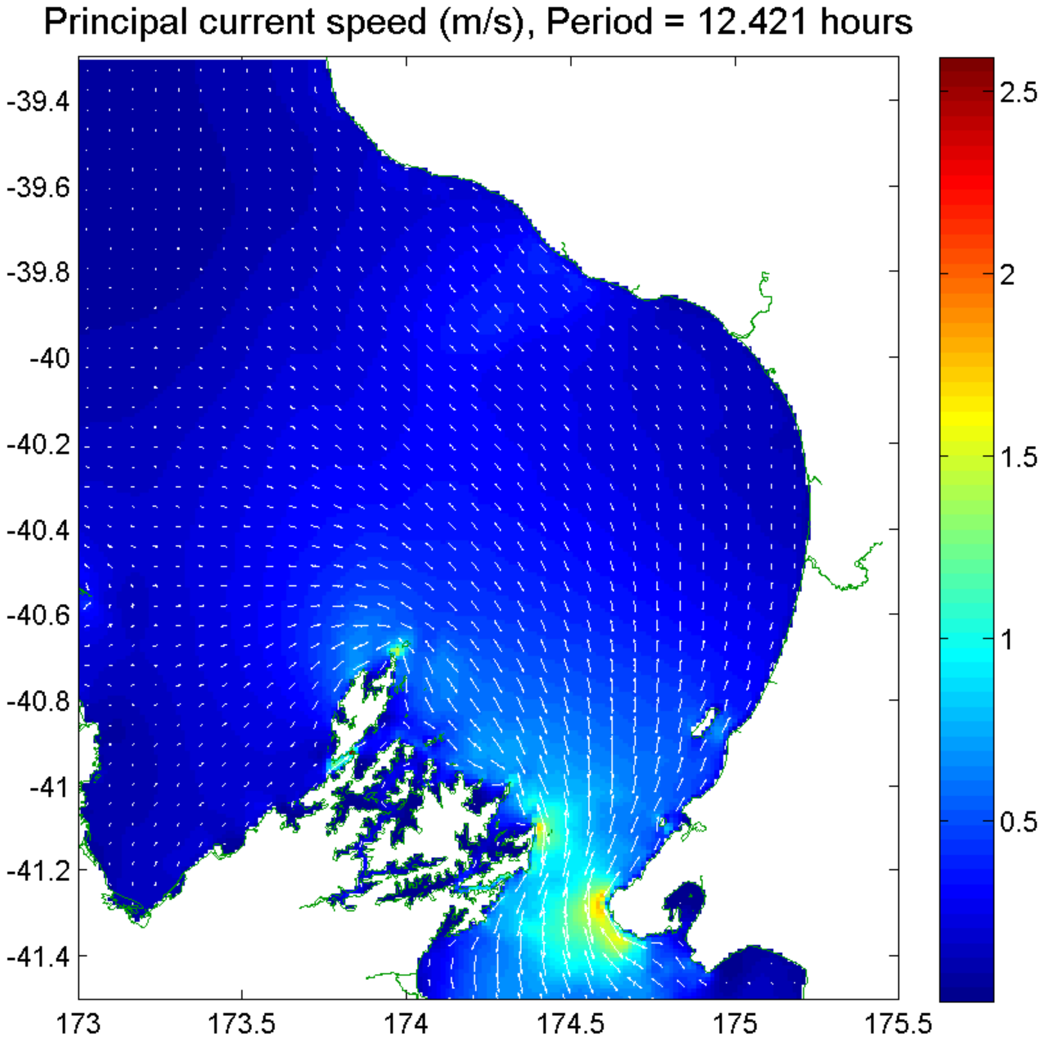

Figure 2.21(a). Peak velocity of the M_2 component of the tidal current. The maximum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

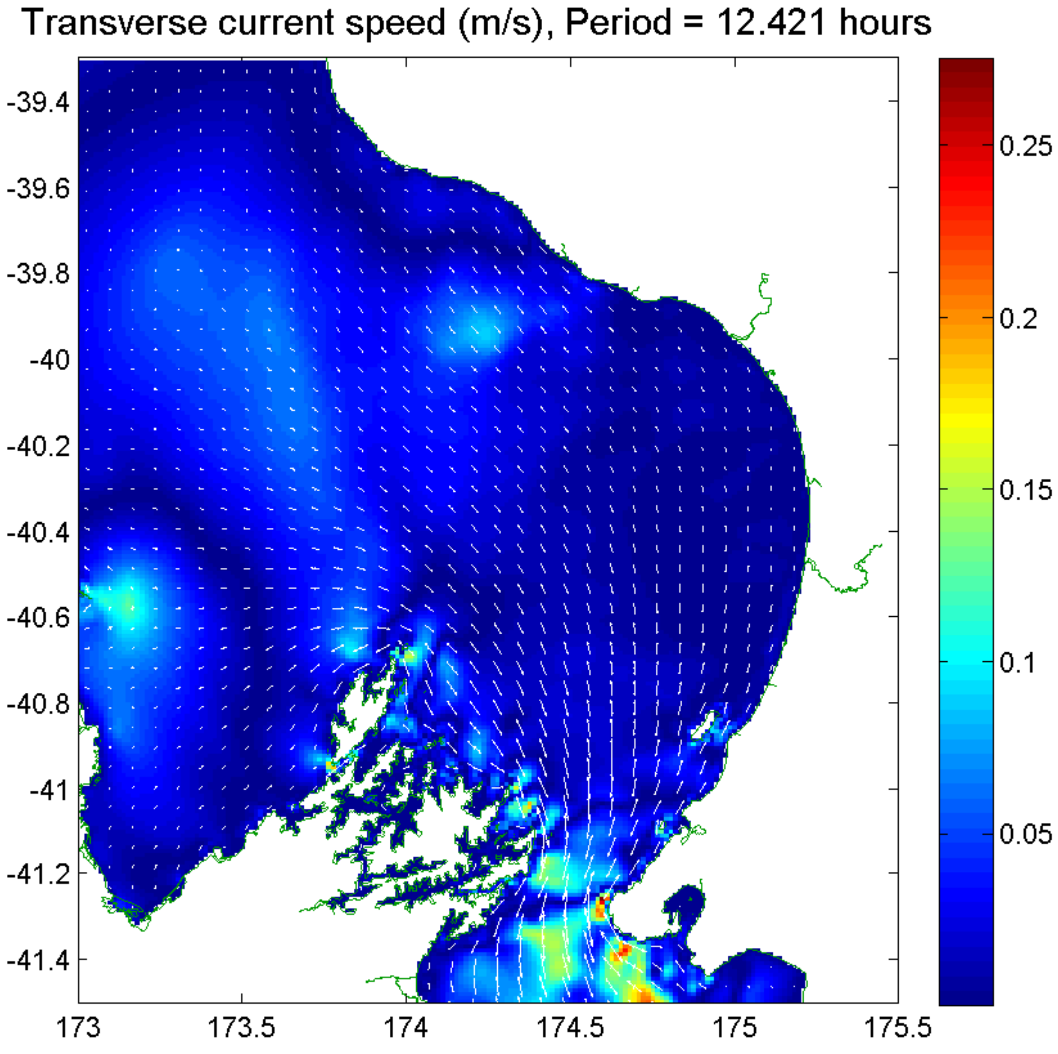

Figure 2.21(b). Minimum velocity of the M_2 component of the tidal current. The minimum speed is shown by the colour, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

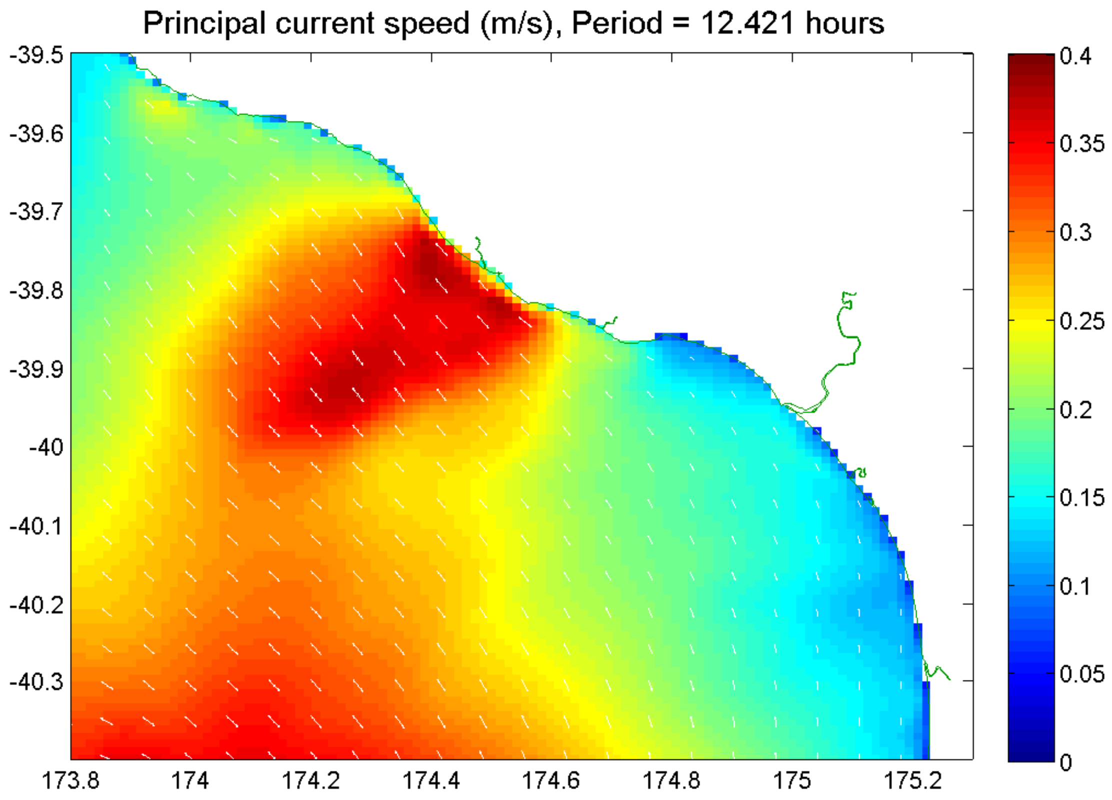

Figure 2.21(c). As for Figure 21(a), with reduced plotting range.

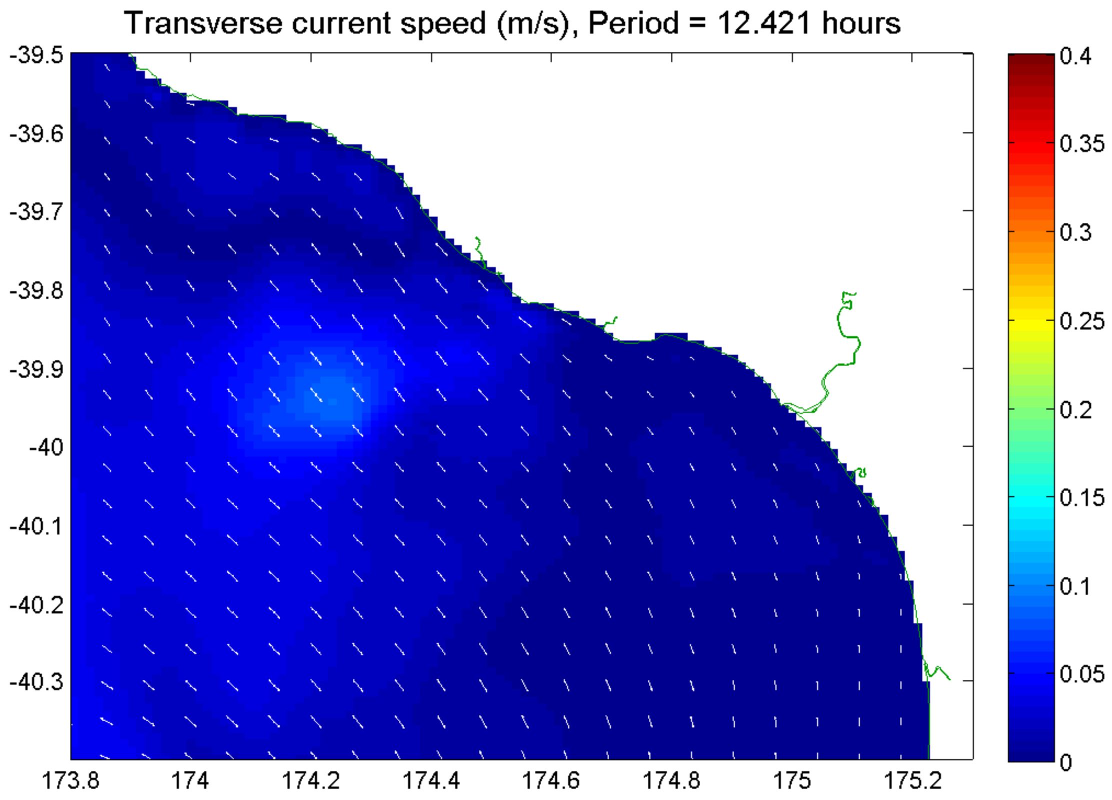

Figure 2.21(d). As for Figure 21(b), with reduced plotting range.

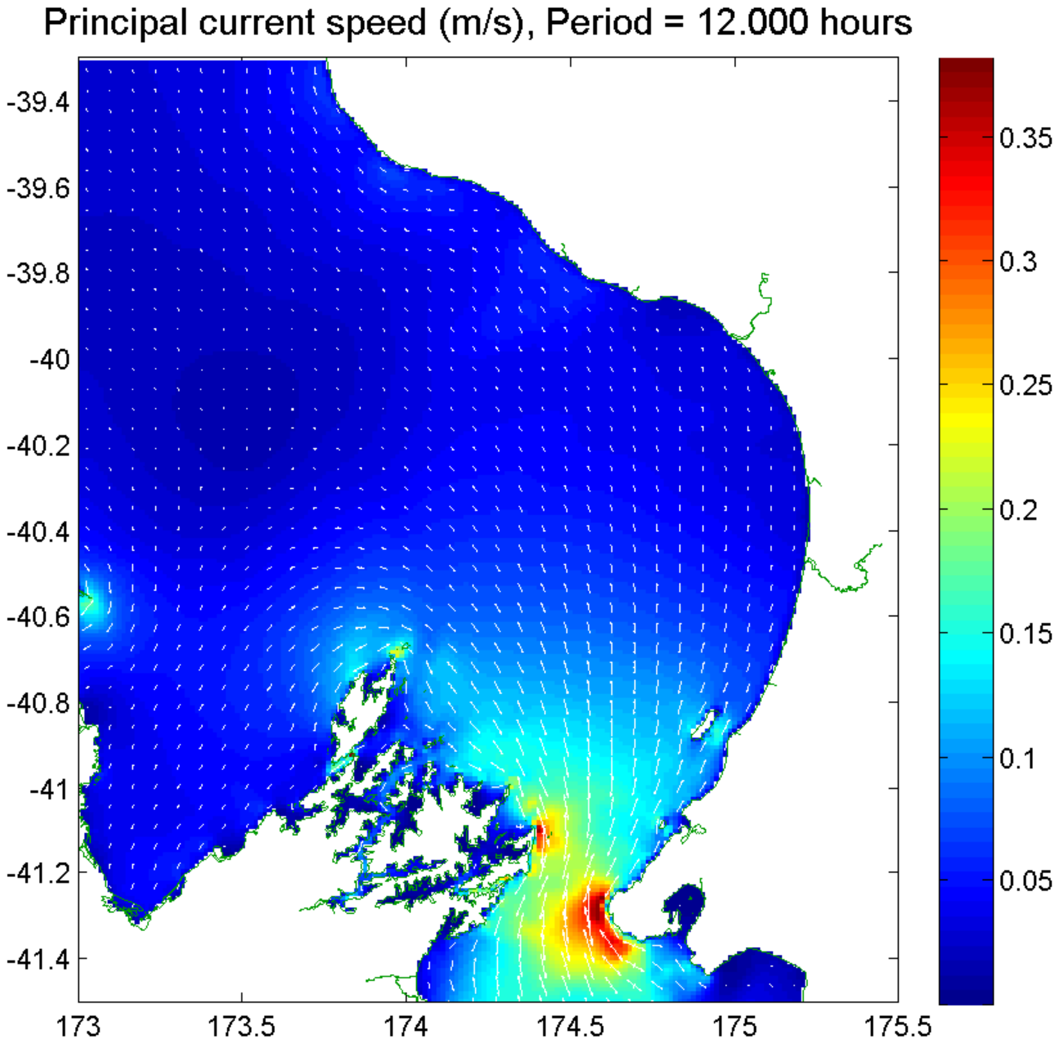

Figure 2.22(a). Peak velocity of the S_2 component of the tidal current. The maximum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

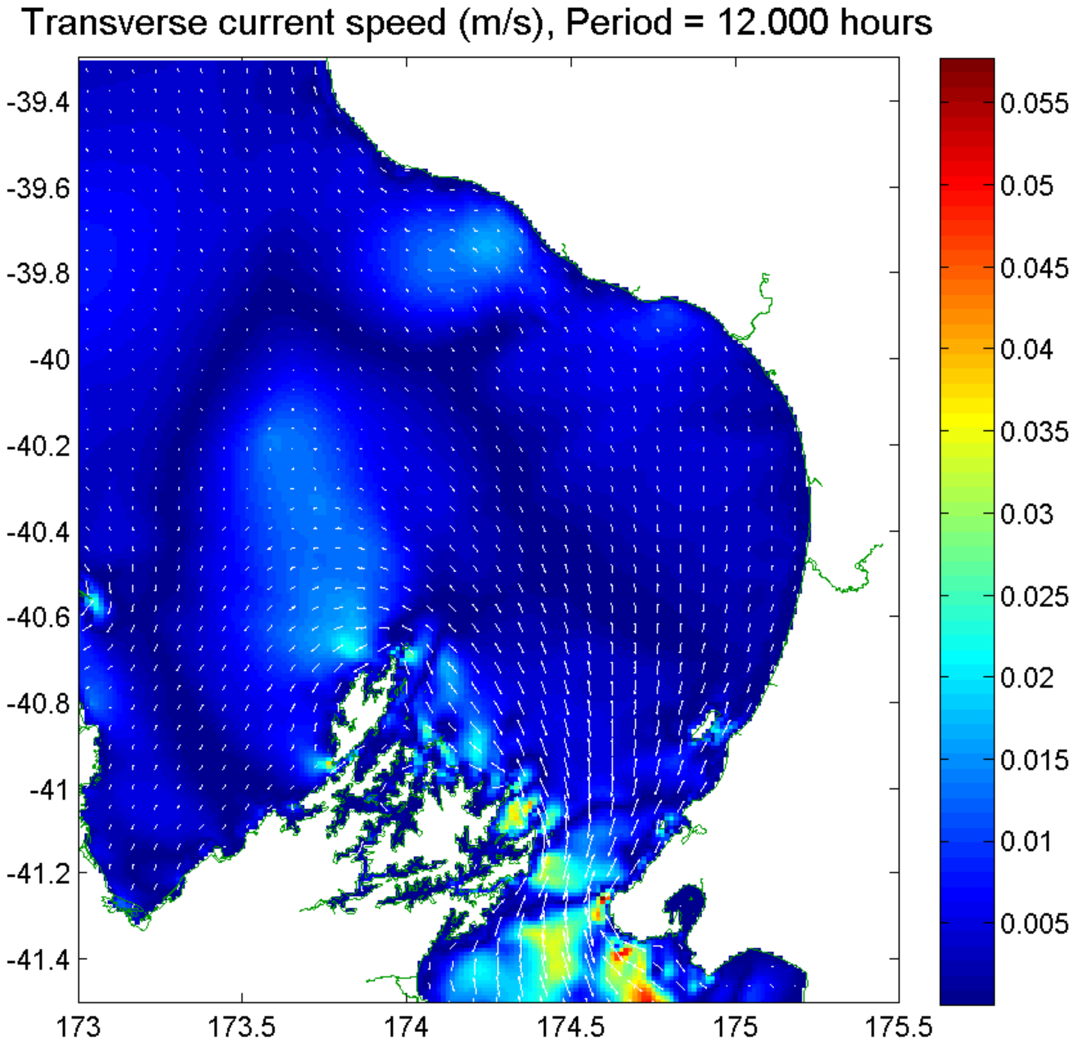

Figure 2.22(b). Minimum velocity of the S_2 component of the tidal current. The minimum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

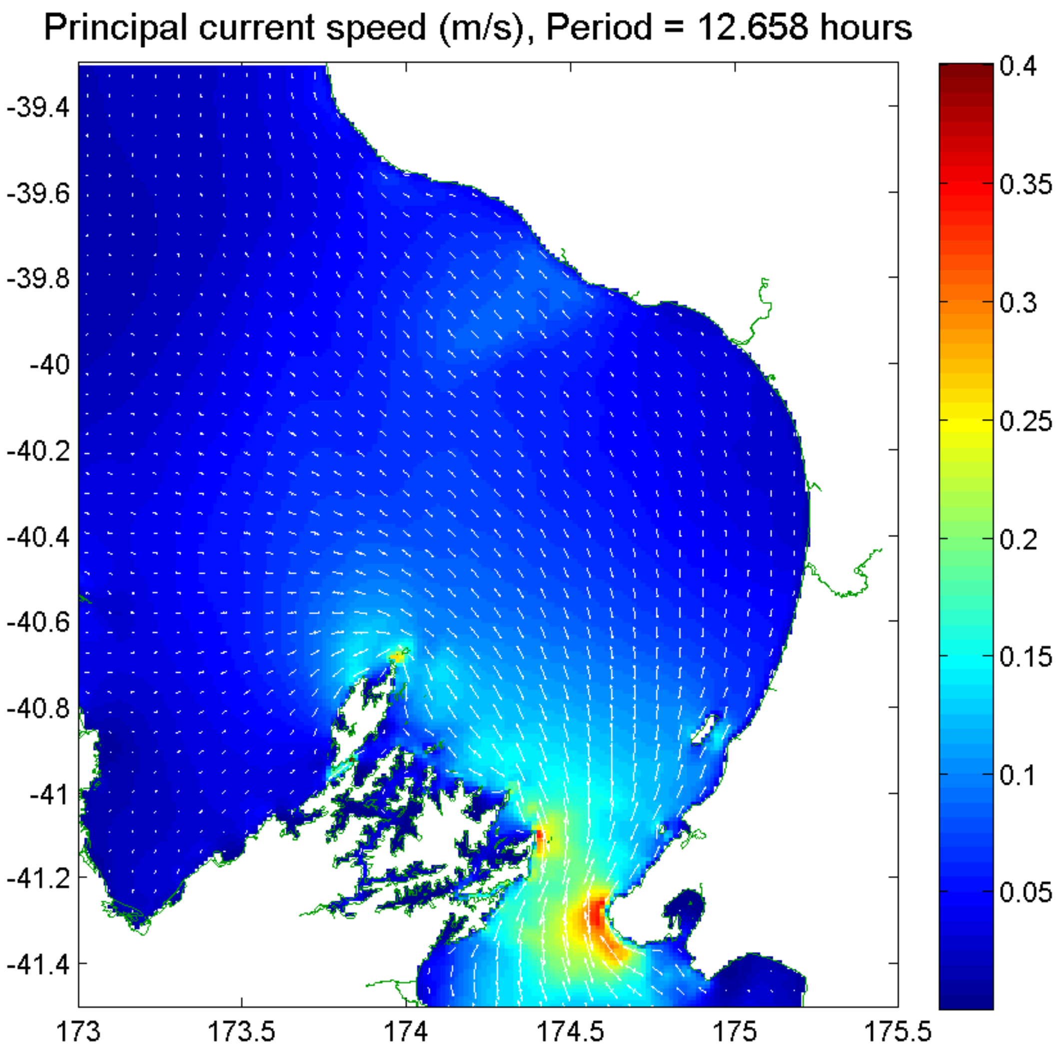

Figure 2.23(a). Peak velocity of the N_2 component of the tidal current. The maximum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

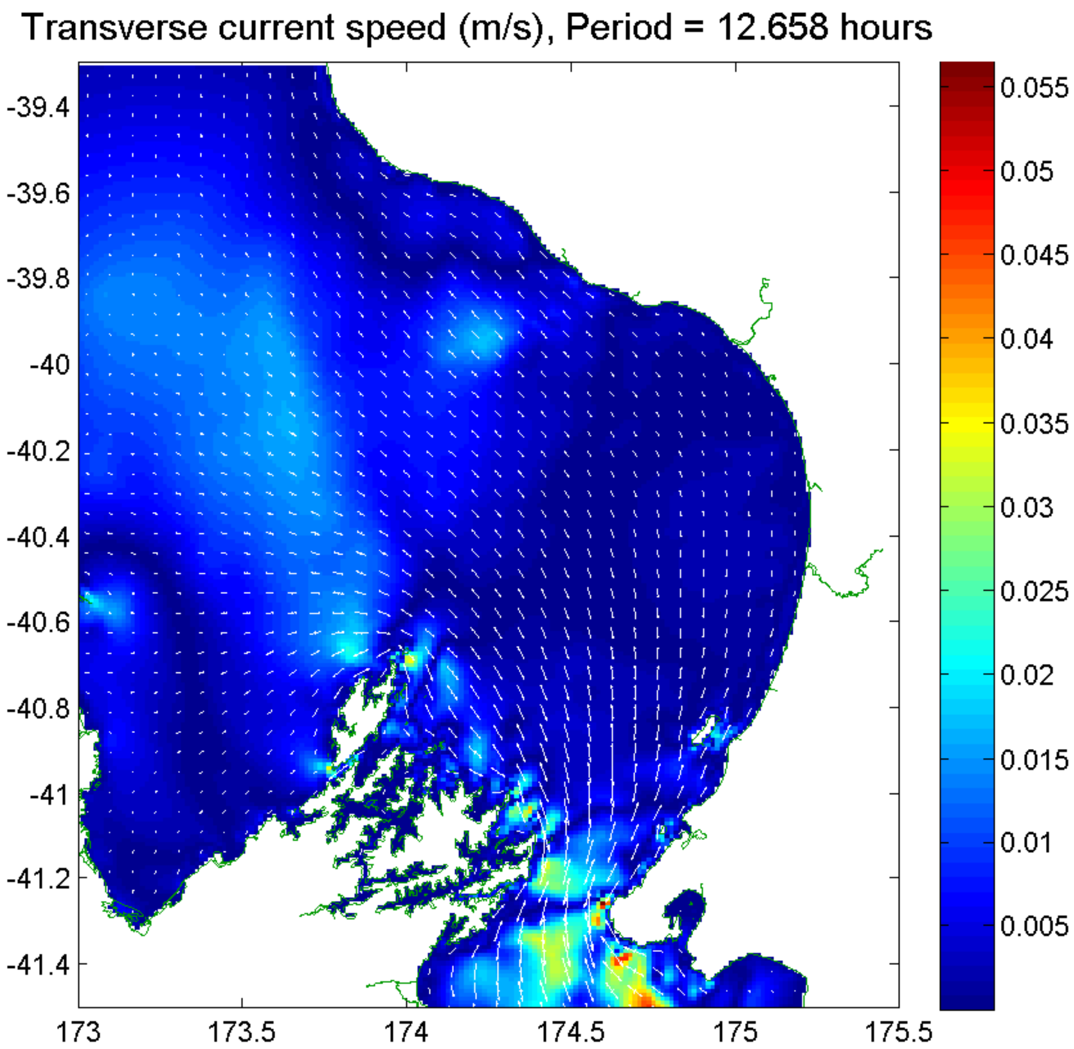

Figure 2.23(b). Minimum velocity of the N_2 component of the tidal current. The minimum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

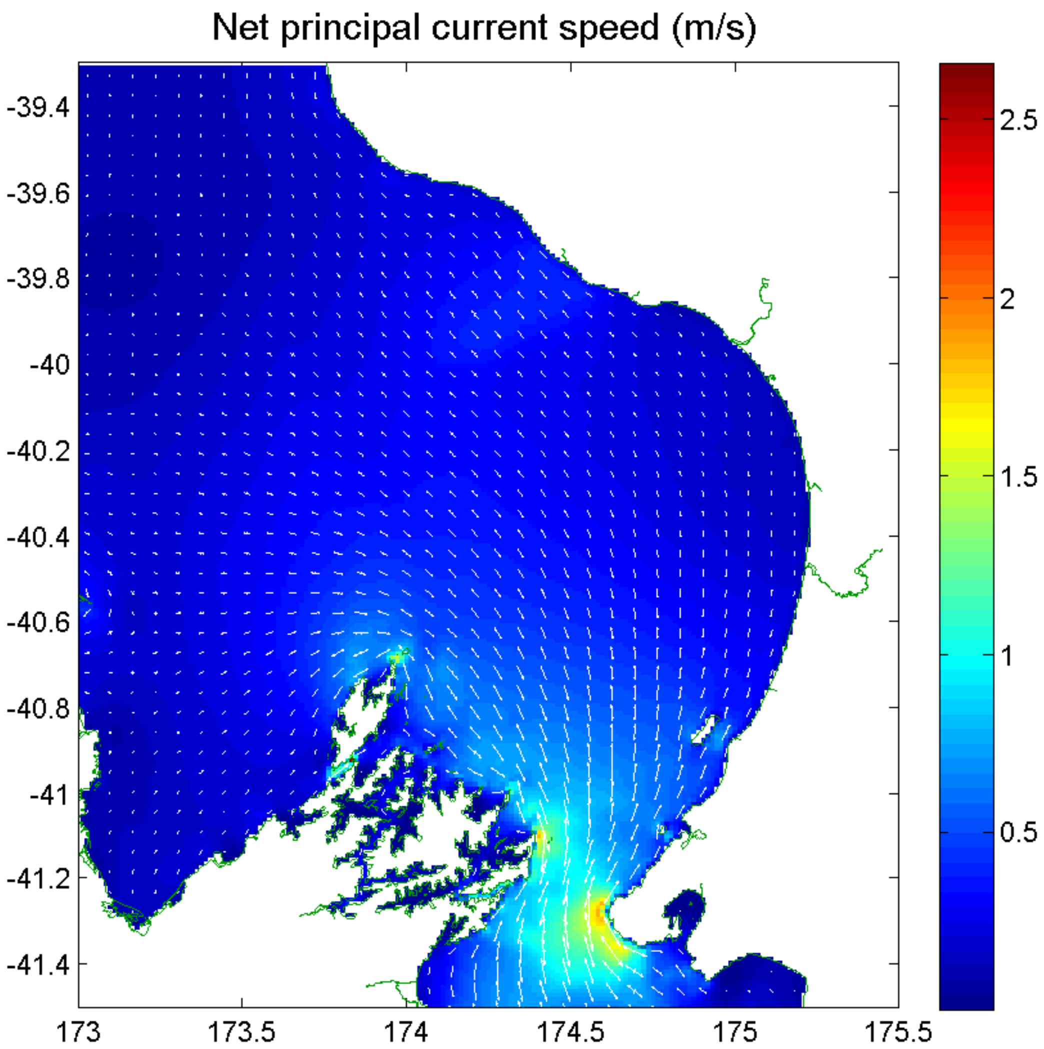

Figure 2.24(a). Peak velocity of the net tidal current. The maximum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

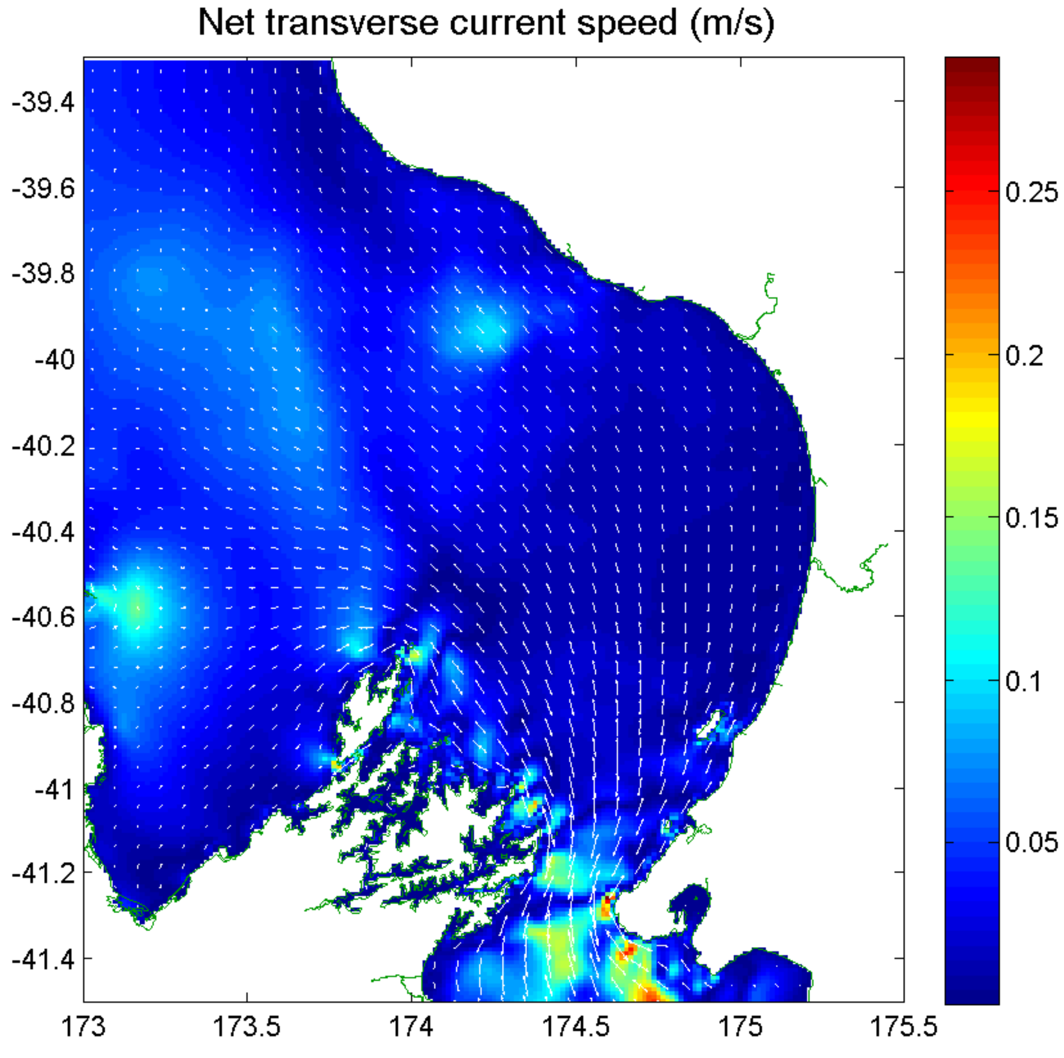

Figure 2.24(b). Minimum velocity of the net tidal current. The minimum speed is shown by the colour scale, while maximum and minimum velocity vectors are shown by the longer and shorter of the crossed arrows, respectively.

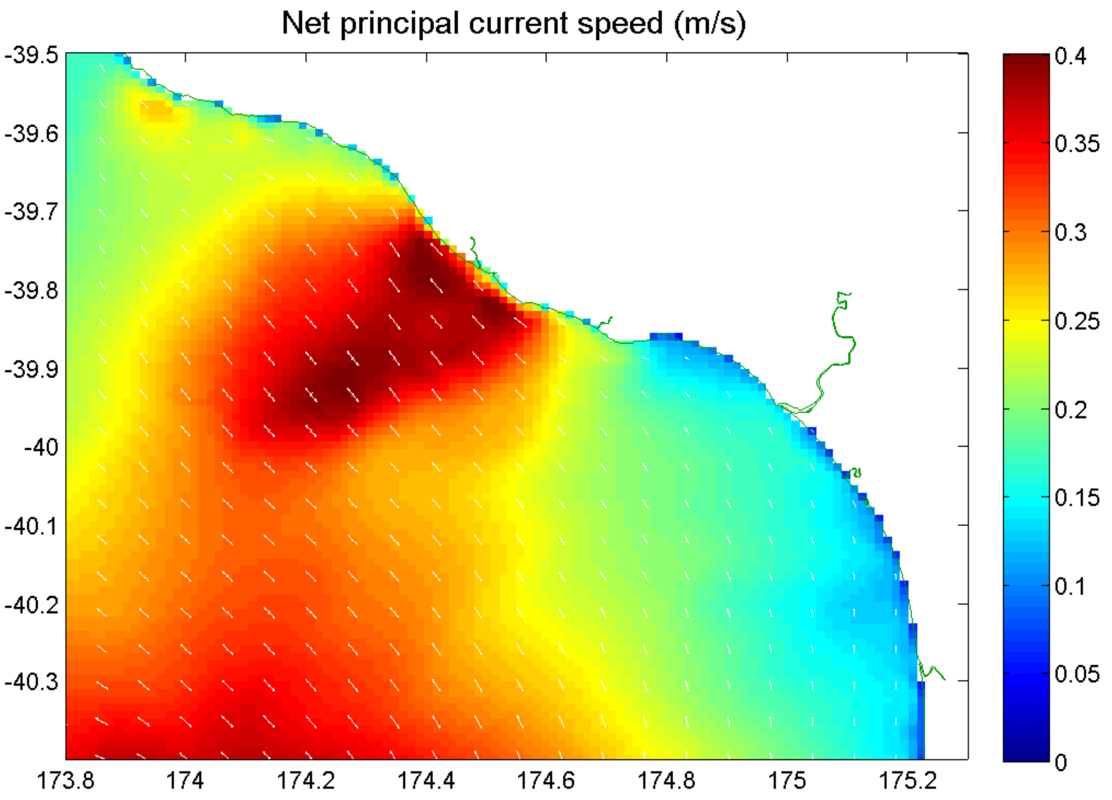

Figure 2.24(c). As for Figure 24(a), with reduced plotting range.

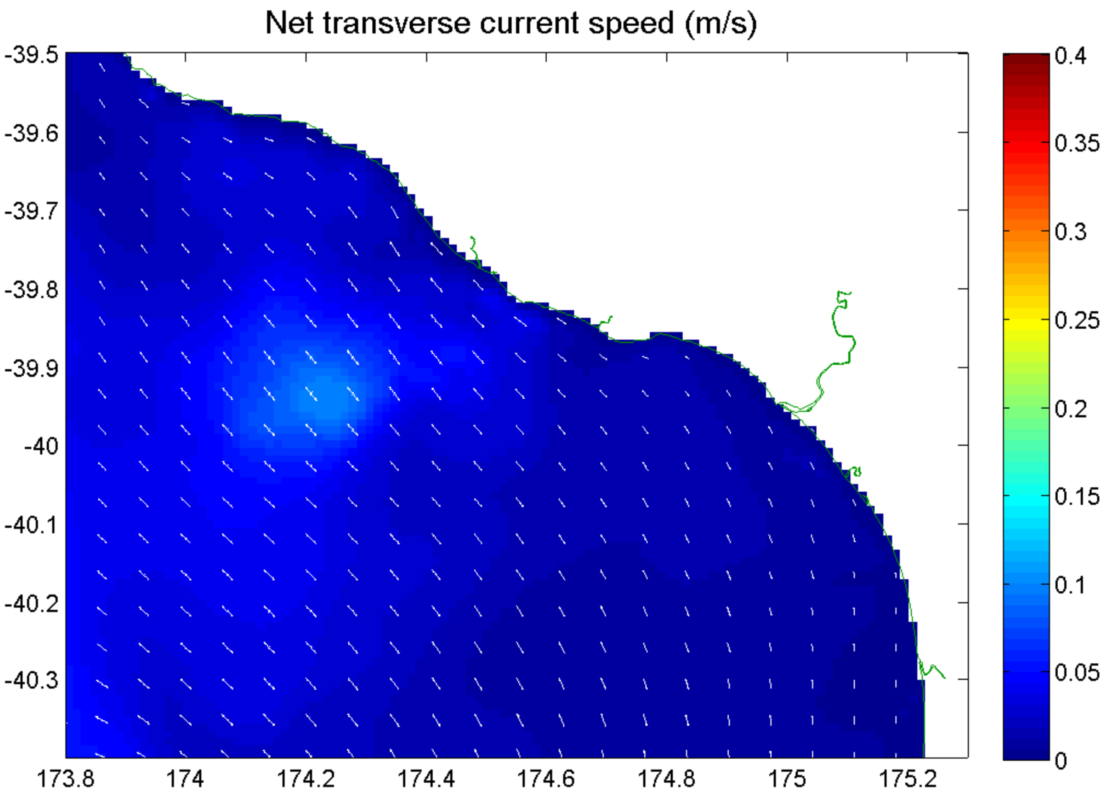

Figure 2.24(d). As for Figure 24(b), with reduced plotting range.

2.3 Conclusions

2.3.1 Wave climate

The wave climate on the 50 m isobath off the coastline of the South Taranaki Bight shows a spatial variation in mean significant wave height from a maximum of approximately 2 m off Cape Egmont, reducing progressively both northward and southward. There is a seasonal variation in wave heights, with the highest waves on average occurring in August and September. In storm conditions, significant wave heights of order 8 m can occur, particularly in the winter and early spring. Peak wave periods are most commonly in the range 10-14 seconds.

Wave energy flux shows high temporal variability, around mean values of 18 kW/m off Cape Egmont, reducing to less than 10 kW/m further south. The orientation of the coast relative to the predominant WSW incident wave direction results in the longshore component of energy being directed predominantly towards the southeast along much of the coast of the South Taranaki Bight. We would therefore expect that in the northern part of the Bight, from Opunake to south of the Wanganui River, wave-driven processes will tend to transport sediment along the coast towards the southeast, while in much of the Manawatu coast, northward transport will predominate.

2.3.2 Tidal currents

While not quite as strong as tidal flows through Cook Strait proper, tidal currents of up to 0.4 ms^{-1} occur on the relatively shallow waters off Patea. Tidal currents are smaller (with peak speeds less than 0.1 ms^{-1}) in nearshore waters between Wanganui and Foxton. Peak tidal flows throughout the study region are generally aligned coast-parallel with only moderate cross-shore minimum velocities.

2.4 References

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3. Shoreline Stability along the South Taranaki Bight

3.1 Background

There are three aims to the shoreline study: (1) to analyse the stability of the shoreline area using existing data; (2) determine how the shoreline has changed in the past and use this as a basis for estimating expected shoreline changes in the future; (3) use these estimates as a basis against which to scale likely impacts of offshore sand extraction on the shoreline.

The shoreline is generally defined as the mean high water spring (MHWS) tide mark, which can be estimated as the seaward boundary of vegetation when survey marks are not available (Gibb 1978). Shorelines are naturally varying landscapes that are influenced principally by; (1) the geology (coast and shore), (2) the climate (wind, waves and rain) and (3) the sediment budget (time averaged terrestrial/river and marine inputs versus sediment transport outputs). These factors interact to modify the shoreline over many timescales including days, weeks, seasons, years, decades and longer. Shorelines can also be influenced by human activities such as planting non-native vegetation, culverting and bridging of streams, walking on dunes, placement of artificial structures such as seawalls and the lowering of the seabed by the removal of boulders (TRC 2009). Existing information about these factors, and shoreline position, have been summarised in this report and the accompanying GIS layers and shapefiles.

A short description of the study area is followed by a summary of the important terrestrial sediment inputs to the shoreline. Nearshore and offshore sediment transport pathways and the factors influencing them are then briefly described. Shoreline data are presented and areas of erosion and accretion are mapped and described. The present understanding of processes affecting shoreline stability in the study area are used as a context within which to estimate future expected shoreline changes. However, climate change considerations would complicate these estimates and are not discussed here. Past and future shoreline changes are used as a basis against which to scale likely offshore sand extraction impacts on the shoreline. Finally, assets (environmental, recreational, historical, cultural, residential and economic) that occur along each section of the shoreline are mentioned.

3.2 Study area

The South Taranaki Bight can refer to the region from Kaupokonui Stream (near Manaia) to Patea River, but it also often refers to the entire lower North Island west coast from Cape Egmont to the Kapiti Coast. In order to consider all potential effects of sand extraction on the shoreline, and put them into a regional context, the shoreline study area extends from New Plymouth in the north to Waikawa Bay in the south.

A strong westerly wave climate directs sediment to the north and south of the Taranaki headland. In the North Taranaki Bight sediment moves in a north-easterly direction along the coast, from approximately Cape Egmont towards New Plymouth and beyond. Sediment transport along this coast is strong and sediments from Taranaki can be found as far north as 90 mile beach in Northland. In the South Taranaki Bight sediment moves in a south-easterly direction along the coast, from approximately Cape Egmont towards the Kapiti Coast.

While the New Plymouth region is not inside the South Taranaki Bight, it is a town with many coastal assets and a highly variable shoreline over space and time with a history of erosion. Changes to sediment supply can have effects many kilometres away, therefore, in order to put the potential effects and results of this study into a regional context, New Plymouth is the northern most boundary of this study. The southern most extent is Waikawa Beach, which lies at the southern boundary of the Horizons Region and the South Taranaki Bight.

3.3 Geology and terrestrial sediment sources

The study region is divided into three sections and the influence of the two distinctive geology types on the shoreline is described. Terrestrial sediment delivery by rivers and characteristic shorelines for each section of coast are summarised.

The Taranaki headland is a ring plain of a lahar deposit originating from the andesitic shield volcano, Mt Taranaki. The lahar deposit extends along the shoreline from just north of New Plymouth to Inaha Stream (near Hawera) in the South Taranaki Bight. Uplift of the ring plain and changes in sea level plus the energetic westerly wave climate have caused parts of the coast to be cliffed, although the cliffs are generally small and erode slowly. Some overlying sedimentary sections that erode more easily and produce higher cliffs are also present. This shoreline consists mainly of cliffs and rocky or bouldered wave cut intertidal platforms with a thin veneer of sand. Rocky seabeds with thin, intermittent sand cover are usual for the subtidal nearshore Taranaki coast, for example around the Maui gas pipeline route near Opunake (McComb 2001 referring to pers obs by McComb) and along a 20 km stretch of the northern Taranaki coast (McComb 2001 referring to unpublished data by McComb).

Terrestrial sediment inputs to this section of shoreline are dominated by erosion of volcanic materials from Mount Taranaki (TRC 2009). There are many small streams, but few rivers, resulting in limited occurrence of sand beaches and dunes at the shore. Stony River was a well documented recent exception when erosion of the upper catchment in 1998 injected substantial sediment to the coastal system. This slug of sediment is being transported north-east along the coastline, temporarily transforming rocky platforms into sandy beaches along the way (Cowie et al 2009, TRC 2009). Waiwhakaiho, Waiongana and Waitara rivers near

New Plymouth supply sediment to north Taranaki beaches but volumes are often insignificant, although recent erosion in the headwaters may alter this (TRC, 2009). River sediment input is also important for Middleton beach at Opunake and changes to river flows in the catchment may have affected sediment supply to the beach, potentially contributing to erosion (Ramsay 2005).

To the south of the influence of the Mt Taranaki ring plain lie younger, softer, marine sediments (e.g., mudstones and sandstones), extending from Inaha Stream (near Hawera) to Whangaehu River (just south of Whanganui). The coast around Whanganui is tectonically active with uplift rates of about 0.25 mm/yr at the shoreline and subsidence offshore (Shand, 2001). High erosion rates along this coast (e.g., near Hawera) have resulted in an almost continuously cliffed coastline (15 – 30 m high), some with sand beaches at their bases. However there are few protective offshore reefs. These sedimentary cliffs tend to erode catastrophically, and groundwater seepage as well as waves lapping at the cliff base at high tide can compound the process. Eroded cliff material at the cliff base protects the cliff until wave action breaks down the material and the process begins again (Cowie et al 2009, TRC 2009). Research by Shand (2001) along this coast showed that sand bars form part of the nearshore sediment budget and provide a natural barrier to shoreline erosion by dissipating wave energy during storm conditions. Terrestrial sediment inputs for this section of shoreline come from erosion of inland sedimentary catchments and are delivered by Patea, Whanganui and Whangaehu Rivers. These river mouths are dynamic due to interactions between episodic inputs of sediment and freshwater, an energetic wave climate and sediment transport.

South of Whangaehu River the coast is dominated by prograding sand dunes and backed by sand country that extends up to 20 km inland. Dunes are dynamic but fragile landforms that naturally undergo periods of growth and erosion due to natural processes of wind, waves and tides. Erosion is generally episodic and occurs during storms, while growth due to wind blown sand is generally slow and occurs over a period of weeks, months or even years. Terrestrial sediment inputs for this section of coast come from three main sources; greywacke from the Tararua and Ruahine ranges, volcanic sediment from the Central Volcanic Plateau and sediment from the Whanganui Basin (Horizons Region Proposed One Plan 2007). Sediments are delivered by the Turakina, Rangitikei and Manawatu Rivers, all of which have estuaries at the river mouth.

3.4 Sediment transport

Sediment transport is a key process influencing shoreline position (and variability) over time. Sediment transport is driven by water movements associated with waves and currents (tidal and non-tidal) that entrain and hold sediment in suspension; processes that depend heavily on grainsize. Sediment transport drives a shoreline sediment budget by transferring sand along the shore, within the surf (littoral) zone, and by importing/exporting sand with deeper offshore areas.

3.4.1 Sediment budget

Sediment can move back and forth along a coastline over days, weeks, months or seasons (gross sediment transport) but net sediment transport refers to the time-averaged difference between sediment input and output.

Inputs (rivers, coastal erosion and other processes transporting sediment from the land to the littoral zone) vary and depend on geology (hard, soft) and topography (steep, flat). Output (sediment transport from the littoral zone to deeper water) depends on geomorphology which depends on wave climate, as does longshore transfer to and from adjacent sections of coast, which can be either a net input or output. If sediment output is greater, there is no shoreline protection, which results in erosion. If sediment input is greater beaches form, which protect the shoreline from erosion. Sediment transfer can occur when there is input, which migrates along the coast creating and removing beaches in the process.

Removal of sediment from the littoral zone will often result in erosion of beaches along the shore, for example sediment trapped within Taranaki Port was dredged and dumped offshore, resulting in a reduction in the amount of sediment available for alongshore littoral sediment transport, which contributed to erosion of nearby beaches (McComb 2001).

In order to fully understand shoreline change (erosion and accretion), two factors need to be understood. The first is the offshore limit of the dune-beach-nearshore bay system. This is often parameterised by the “closure depth”, i.e. the depth at which waves no longer transport sediment. This, however, is generally unknown for this shoreline. The second is the interaction between the beach and the inner shelf.

3.4.2 Influence of tides, wind, waves and grainsize

Taranaki sediment grainsize near New Plymouth is described by McComb (2001) as mostly well-sorted fine sands of andesitic volcanic origin. However, Taranaki sediments contain heavy minerals that affect their entrainment, suspension and advection, but there are no field data from the Taranaki region to quantify how sediment transport is affected (McComb 2001).

Nearshore sediment transport arises from a combination of sediment entrainment (principally through wave action in a wave-dominated environment), net advection of the sediments by the coastal circulation patterns, and subsequent deposition (e.g. Soulsby 1997).

Figures 2.21-2.24 from Section 2 of this report show model outputs of tidal current velocity modelling. Current velocities are generally at a maximum (approximately 18 cm/s) near Patea and south of Kapiti Island.

Tidal currents are generally weak (<10 cm/s) in the New Plymouth region (McComb 2001), which lies outside the tidal model output domain. Tidal currents measured in 5 and 9 m water depth near New Plymouth Power Station were less than 4 cm/s, which is about 4% of the total current variance in the area and were strongly dependent on the east-west component of wind (McComb 2001).

Non-tidal processes also influence nearshore circulation. On an open coast, the nearshore circulation may be driven by wave-induced radiation stresses, and may also have wind-driven components. Continental shelf currents may also induce nearshore current flows, which are in turn influenced by the seabed topography through bathymetric steering and bed friction (McComb 2001).

When waves approach a coastline at an oblique angle, a long-shore current is established flowing parallel to the coastline in the nearshore zone. The current is significant in that it is responsible for net transport of sediment along the coast (TRC 2009) especially under stormy conditions (McComb 2001).

In order to quantify this wave-induced transport, it is necessary to characterise the deep-water wave climate, and also to consider nearshore processes. Offshore waves can change a great deal as they travel shoreward and are influenced by the seabed through shoaling, refraction, diffraction and friction, as well as by sheltering landmasses.

While we do not attempt to address nearshore wave processes in the Phase 1 study, the offshore wave climate is discussed in detail in Section 2 of this report. As noted there, New Zealand lacks a long-term systematic wave measurement programme, but one exception is the wave record at the Maui gas platform off the Taranaki coast (Smith et al 2008). Elsewhere in the region, only limited records are available, e.g. from a wave buoy record from a deployment off Whanganui for 1 year (less gaps) (Macky 1991), while Shand (2001) made visual estimates of wave heights in the Whanganui region over 6.3 years and recorded significant wave heights of 1.4 m, with a 5% exceedence of 2.6 m, which compared well with deepwater wave climate statistics of 1.3 and 2.5 m respectively.

Hence wave climate characterisation relies strongly on model studies, as in section 2.2.1 of the present report, of which Figure 2.3 shows modelled mean significant wave height. Waves are largest near Cape Egmont, reducing in size with distance moving north and south of the Cape.

Most wave energy in the South Taranaki Bight comes from large southwest swells from the Southern Ocean and locally generated wind waves that vary in size and direction with season (larger in winter), but can generate 1-2 m seas with 3-7 s periods. Storms from the Tasman Sea which produce large waves from varying directions also contribute wave energy to the coast (TRC 2009).

Due to the shape of the Taranaki headland there is a well defined gradient in the wave energy along the coast due to effects of sheltering, refraction and attenuation, with the most energy is found at the Cape due to its exposed nature and nearby deep bathymetry. Wave energy along the west coast is high, with wave heights up 3 m (TRC 2009). There is less wave energy to the south (TRC 2009).

3.4.3 North Taranaki nearshore sediment transport

North of Cape Egmont, net nearshore sediment transport is in a north-easterly direction along the coast (TRC 2009, Cowie et al 2009, Orpin et al 2009), including around the New Plymouth area (McComb, 2001, McLennan 1982). Due to the strong westerly wave climate on the west coast and the consequent strong northerly sediment longshore drift, sediment from Taranaki can be found on Ninety Mile Beach at the northern end of the North Island (TRC 2009).

McComb (2001) made detailed measurements and models of currents in the Port Taranaki region. Nearshore currents were generally in the eastward direction. Factors influencing nearshore currents included local winds, waves and shelf currents, of which waves caused the greatest increase in current velocity.

Port Taranaki is a sediment trap that collects 128,000 m^3 – 173,000 m^3 of sand per year since 1889 (TRC 2009). Longshore sediment transport potential along beaches such as Fitzroy and East End may be 110,000 – 160,000 m^3/yr but most of the sediment is trapped by the Port and only 40,000 m^3/yr make it to the beaches (TRC 2009).

Sediment dredged from Port Taranaki was dumped in 15-25 m water depth, which may have removed the sediment from the littoral system, although these early investigations were observational and not based on field measurements (McComb, 2001).

3.4.4 South Taranaki nearshore sediment transport

South of Cape Egmont, nearshore sediment transport of ironsand from Mount Taranaki is in a south-easterly direction along the shore within the breaker zone (TRC 2009). Further south the south-east trend continues according to Orpin et al (2009) and Horizons Region Proposed

One Plan (2007). Evidence for this can also be seen in Google Earth images, for example, which show sediment plumes from rivers moving in a south-easterly direction and sediment accretion (erosion) around the upstream (downstream) side of natural and artificial barriers such as river mouths and groynes.

Orpin (2009) described the erosion of nearshore geological features, with terrestrial sand occurring as a thin veneer but with more substantial deposits on offshore geological features. This suggests that the sediment transport direction is generally offshore. They also note that sandy sediments occur as a shore-connected belt around 12-15 km wide that follows the coast.

Research by Shand (2001) also showed a great deal of sand bar movement within the nearshore (surf zone) in the Whanganui region, as a result of episodic high wave energy periods. Transfer of sand between the shallow and deep parts of the surf zone may protect the shoreline from erosion.

It should be noted that the extensive shallow waters around Graham Banks (<10 m) could have strong effect on wave shoaling.

3.4.5 Offshore sediment transport

The continental shelf is broad at the North Taranaki Bight, then narrows around Cape Egmont and broadens again across the South Taranaki and Whanganui Bights. Currents along the west coast are generally weak and unstructured. Circulation consists of three main components which are the ocean-forced currents (West Auckland Current), the wind-driven surface currents and in the Whanganui region, a southeasterly longshore littoral drift.

A desktop study by Orpin et al (2009) includes summaries of the environmental setting (including ocean circulation, waves and sediment transport) and seafloor sediments in the TTR prospecting permit areas.

For the North Taranaki Bight (Stony River to New Plymouth section of coast) the tidal and mean flows are too weak to transport sediment and the majority of sediment transport occurs during storms when waves can resuspend sediments to depths of 40 m (Orpin et al 2009).

Around New Plymouth McComb (2001) found that offshore currents in intermediate water depths (>20 m) have flow patterns that are different to nearshore currents. Offshore currents are strongly bimodal, running at 60° and 250°, which is approximately along the isobaths (50-230°), suggesting currents may be following the coastline. The changes in direction are likely due to regional wind stress.

On the South Taranaki Bight around Whanganui-Manawatu the regular wave climate frequently resuspends mud to ~15 m water depth, while storm event waves may resuspend sediment down to 150 m water depth (Orpin et al 2009).

The South Taranaki Bight continental shelf is complex due to shoals, namely the Patea and Graham Banks, and The Rolling Ground.

In the Whanganui Bight area Orpin et al (2009) reported erosional features such as rock outcrops and ancient buried river valleys in the nearshore (<30 m) and depositional features such as irons and ridges, sand ribbons and sand waves in the offshore (<30 m)areas, but these are likely 9,000-12,000 years old. Smaller active bedforms upon the old depositional bedforms suggest strong oscillatory currents during storms. Sidescan and bottom photos indicate the seabed is undergoing constant modification (Orpin et al 2009).

3.5 The past and present shoreline

3.5.1 Background

The shoreline is generally defined as the mean high water spring (MHWS) tide mark, which can be estimated as the seaward boundary of vegetation when precise survey marks are not available (Gibb 1978). Coastal accretion is defined as ‘the product of deposition of material at the shoreline, leading to a gain of land as the shoreline advances seaward’ (Gibb 1978). Coastal erosion is defined as ‘the process of episodic removal of material at the shoreline leading to a loss of land as the shoreline retreats landward’ (Gibb 1978), which is the result of work by the sea, the wind, migrating river mouths and tidal inlets, coastal landslides and tectonics (TRC 2009). Static shorelines are those where the net erosion rate is less than 0.02 m/year over approximately the last one hundred years (TRC 2009).

Shoreline type depends on the geology, terrestrial/river and marine sediment inputs and sediment transport inputs/outputs. Shorelines found in the study area are cliffs, river mouths, dunes and beaches.

Cliffs tend to be erosive features, although those made of hard volcanic rock tend to erode very slowly, allowing vegetation along the cliff top to persist for many years as is the case in some areas between Stony River and New Plymouth (TRC 2009). Cliffs made of softer sedimentary rock tend to erode faster and more catastrophically, with large sections falling away at once. In this case groundwater seepage as well as waves lapping at the cliff base at high tide can compound the process. Eroded cliff material protects the cliff until wave action breaks down the material and the process begins again (Cowie et al 2009, TRC 2009).

River mouths are generally very dynamic due to interactions between episodic inputs of sediment and freshwater, an energetic wave climate and sediment transport.

Dunes are dynamic but fragile landforms that naturally undergo periods of growth and erosion due to natural processes of wind, waves and tides. Erosion is generally episodic and occurs during storms, while growth due to wind blown sand is generally slow and occurs over a period of weeks, months or even years.

Beaches in the study area can be (a) rocky wave cut intertidal platforms with a thin veneer of sand, (b) steep sand/gravel beaches near river mouths, or at the base of sedimentary cliffs that are episodically supplied with sand due to cliff collapse, or (c) wide and sandy areas backed by dunes and sand country.

3.5.2 Variability

Present day shorelines resulted from sea level stabilising about 5000-6000 years ago. Since then, shorelines have naturally varied over interannual, decadal and interdecadal timescales.

Considering interannual variability, TRC (2009) reports erosion occurs mainly during the winter (May – August) although some autumn and spring storms also contribute to erosion. It is common for east coast beaches to build over the summer months, however there is a lack of beach profile data to confirm that this is also the case for west coast beaches (Ramsay 2005).

Shorelines are complex and vary greatly in just a few kilometres due to interactions between headlands, offshore bars, currents, waves and sediment input. Beaches act differently under similar storm conditions due to local geographic and perhaps bathymetric factors (TRC 2009). Erosion rates differ within short distances due to differences in the geology, coastal orientation (wave attack), sediment supply from rivers and dune management. (TRC 2009).

3.5.3 Coastal erosion hazard assessments

The need for quantitative beach data was recognised in New Zealand in the 1970s after successive years of large storms caused noticeable erosion in coastal areas, which had been built upon in the relatively calm-weather decades beforehand (Hume et al. 1992). The erosion of the 1970s threatened property and prompted studies of beach morphodynamics (e.g., McLennan MSc on Fitzroy beach in 1982) and beach survey programmes (e.g., Gibb 1978, TCC 1988). Before this time there was little perceived need for shoreline monitoring and surveys were generally for navigation and land surveying purposes.

Gibb (1978) calculated rates of coastal erosion and accretion around New Zealand from early European colonisation until the mid to late 1970s using maps, photographs and field measurements.

Coastal erosion hazard assessments done in the 1980s by the Taranaki Catchment Commission showed that the entire Taranaki coastline is eroding at long term average rates of between 0.05 m/year and 1.89 m/year, except at the Patea and Stony (Hangatahua) river mouths where the coast was accreting. Unfortunately, survey benchmarks were lost, meaning present day shoreline position cannot be compared to earlier measurements (TRC 2009).

The Taranaki Regional Council report titled 'Coastal Erosion Information: Inventory and recommendations for state of environment monitoring' (2009) was the first region-wide reassessment since the work in the 1980s. TRC (2009) gives a recent summary of the region's geology, wind and wave climate, sediment transport, geomorphology and historical erosion information. For each section of the coast a description of the geology, geomorphology and assets are given, coastal erosion is estimated from existing data and recommendations for required data are given. This report also states that the coastline is sediment starved and generally eroding, apart from episodic river inputs. Other work has been done at specific locations in the Taranaki region as part of monitoring programmes, subdivisions and coastal development activities (e.g., pipelines) but much of this literature is owned by companies in the form of client reports and not readily available.

Historic aerial photos exist for some areas of the Taranaki Region coast (TRC 2009). However, photos from the mid 1990s are unlikely to be useful for measuring shoreline changes due to their scale (1:27,000) and the associated margin of error. Photos with a scale of 1: 10,000 were taken in 2001 and 2007 which could be used for measuring shoreline change, which was done by Cowie (2009) for the area from Stony River to New Plymouth. Puke Ariki (a museum, library and information centre in New Plymouth) holds an historic collection of oblique coastal photos as well as a photographic catalogue of cliff faces taken in 2003 by Pat Greenfield (Rapanui to Whitecliffs; 11 km).

3.5.4 Methods

Several studies including those described above plus others (e.g., Cowie et al (2009) and Horizons Regional council proposed One Plan 2007 (web ref #4)) used aerial photos, historical maps and charts, surveys, and field measurements (such as beach profiles) to estimate shoreline change rates. Instead of gathering these same photos, maps, charts and beach profiles and recalculating the shoreline changes, this study has used the rates calculated by previous studies and summarised them.

The study region shoreline is divided into sections using changes in shoreline geology as a natural divider. Each shoreline section is briefly described and shoreline rate data are presented and discussed.

Areas with shoreline position or change information are shown in the GIS shapefile called "shoreline state". There are multiple fields in the attribute table indicating the data source, author, publication date and (where available) shoreline change rates and time frames. Shoreline position is indicated by a value of 1 in the appropriate attribute field (erosion, accretion, variable or stable) and rates of change when the information was avaiable. There are also several other fields in the attribute table used to indicate the level of confidence in the data. Survey data by Gibb (1978) are shown as points in the GIS shapefile called "Gibb 1978 survey". The attribute table for the Gibb shapefile contains data including the position, location name, survey dates and rates. Historical shoreline change information is therefore shown in the GIS attribute table in the form of rates (m/year) for each section of the coast where information was available.

A similar shapefile called "sediment transport" shows areas for which there are sediment transport data, however there were few data available.

3.5.5 Shoreline summary for each coastal section

The study region is divided into several sections and the geology, shoreline type and any data and results are summarised.

New Plymouth to Stony River

Features include: Fitzroy Beach, New Plymouth city, Port Taranaki, Paritutu (Back) Beach, Oakura and Stony River

The geology is mostly hard, volcanic rock with some overlying soft, sedimentary rock. The shoreline along this section of coast is highly variable and includes cliffs (lahar and sedimentary), rocky platform beaches with thin veneers of sand, narrow cobble beaches and sediment deposits around stream/river mouths. The lahar cliffs are generally smaller and less erosive than sedimentary ones. Offshore there are hard protective reefs of rock and boulders. In 1988 the TCC reported the Taranaki coast was eroding at 0.05 – 1.89 m per year and the TRC (2009) report describes the coast as an eroding one. However, large sediment inputs from Stony River can cause episodic accretion along the entire section of coast (Cowie et al 2009).

There is a great deal of shoreline related information for New Plymouth, Port Taranaki, Paritutu (Back) beach, Oakura beach and Stony River, which is summarised below.

Most survey information around developed areas (Oakura – New Plymouth) was highly variable. Surveys were done in slightly different locations over many decades, making them hard to compare. Some of the survey results have been assessed by later studies as doubtful. However, much of the variability between surveys may simply be due to the highly dynamic nature of the shoreline. Fluctuating inputs of sediment from the rivers, human intervention and shoreline modification, coastal vegetation, beach orientation and complex nearshore reefs contribute to highly variable shorelines over time (erosive, stable or accreting) along this stretch of coast.

Construction of the Port in 1881 diverted sand from its north-east path up the coast resulting in erosion of the 'downstream' New Plymouth town foreshore. When dredging of the Port began in the 1950, the sand was removed from the littoral cell and dumped in >15 m water depth, resulting in more erosion of the 'downstream' coast. New Plymouth township shoreline was eroding until the seawall was built in 1944. Gibb (1978) reported that Fitzroy Beach was generally eroding at a rate of ~0.5 m/yr from the 1840s to the 1950s, except for one region that accreted slightly (0.05 m/yr). McComb (2001) recommended dredged sand from the Port be placed in shallower water, so that it would remain in the littoral cell and thus be more likely to supply the 'downstream' beaches. Parts of the shoreline around the New Plymouth area are now highly modified by coastal structures (seawalls, roads, bridges) and buildings on the foreshore area that limit the ability of the shore to undergo natural variability.

Paritutu beach (otherwise known as Back beach) is a rocky platform with a thin veneer of sand backed by coastal cliffs that are a mixture of volcanic and sediment rock. The beach is episodically supplied with sand from 'upstream' rivers (TRC 2009). Cowie et al (2009) observed that erosion of the cliffs substantially increased the beach volume during the winter months.

Oakura beach is an intertidal boulder platform with a thin veneer of sand in the lee of an offshore reef, which provides some wave shelter. Gibb (1978) reported accretion in the Oakura area (+0.67 to 0.33 m/year). These surveys may have been made near the Oakura River where they would have been influenced by episodic sediment inputs. An aerial photo survey by McComb (reported in Cowie et al 2009) reported that the beach showed periods of erosion (1970 – 1981) and accretion (1981 – 1986) but that the shoreline has eroded at a mean rate of -0.4 m/yr since 1970. There has also been erosion reported at the Oakura camp ground (TRC 2009). Beach profiles taken in 1997 and 2008 show a similar beach and berm shape but the dune shape varies (Cowie et al 2009). Erosion in this area may have been exacerbated by human activities including planting non-native vegetation, culverting and bridging of streams, walking on dunes, placement of seawalls and the lowering of the seabed by the removal of boulders (TRC 2009).

Gibb (1978) reports accretion at Stony River of +1.53 m/year. Research by Cowie et al (2009 showed a large pulse of sediment from erosion within the Stony River catchment in 1998 was being carried by strong littoral transport along the coast to the north-east. This extra sediment input resulted in large changes to the 'downstream' shoreline. Beach profiles at Stony River, Kaihihi surf beach, Ahu Ahu Beach, Oakura Beach and Paritutu (Back Beach) and aerial photo beach volume estimates showed sandy beaches forming on what was normally a rocky boulder coast, but no accretion rates are given (Cowie et al 2009, TRC 2009). This may be because sediment input is episodic and as the input reduces and the sediment is transported away, the 'downstream' beaches will return to their former state.

Stony River to Cape Egmont

Features include: Bayly Road, Pungarehu Road and Stent Road

The geology is mostly hard (lahar) coastline with some overlying sedimentary geology. The shore is rugged and rocky with several shore types, including a mixture of small cliffs, rocky foreshores and beaches and many ring plain streams. Extensive offshore rocky reefs provide some protection to the shoreline. Sparse shoreline data suggests that cliffs are erosive but stable (TRC 2009) and that sediment deposits around streams are variable. Measurements of accretion at Stent Road and Warea Road by Gibb (1978) were questioned in the 2009 TRC report, and are therefore excluded. A possible explanation for the apparent accretion is that the measurements may have been made near streams that could have had varying sediment input.

Cape Egmont to Mangahume Stream

Features include: Oaonui and Opunake

*T*he geology consists of hard (lahar) and soft (ash bed) rock on this very exposed section of coast. The shoreline is dominated by large sections of beach and cliff, with many small streams, and a pocket beach at Opunake. Data for most of this coastline are sparse. TRC (2009) estimated an erosion rate of -0.8 m/year for Tai Road (Sandy Bay area) using survey lines of the 1918 and 1977 cliff edge. Gibb (1978) also estimated erosion at Tipoka Road (-0.55 m/year) and Waiare stream (-0.91 m/year), but found accretion at Pehu stream (+1.14

m/year) and a stable shoreline at Oaonui. Gibb (1978) also reported accretion at Waitaha (+0.70 m/year) although this may have been at or near a stream.

Middleton beach at Opunake is a rock platform covered by a thin veneer of sand, which is recycled between the dunes, beach and offshore bar (TRC 2009). Ramsay (2005) summarised work by Gibb in 1998 and 2002, reporting that beach erosion has been a problem for some time, causing extensive damage to the frontal dune system and threatening coastal structures. A rock revetment and a subtidal artificial surfing reef have been installed to protect the shoreline. But more recent coastal erosion problems at Middleton Beach may be due (in part) to a landslide in the catchment causing a river to re-route and redirecting sediment from the north of the beach to the south where it is transported away to the south-east (Ramsay 2005). Beach monitoring is required to know whether erosion trends are part of the natural dune advance/retreat cycle, or whether erosion will dominate (Ramsay 2005)

Mangahume Stream to Inaha Stream

Features include: Pihama, Otakeho, Kaupokonui, Manaia and Inaha

This is the final section of the hard, volcanic lahar coast. The shoreline is mostly hard cliffs with numerous ring plain rivers and streams and a few sand dunes near Kaupokonui Stream (which were commented on as unusual in the TRC 2009 report). There is limited access to this section of coast, generally through private land. Measurements by Gibb (1978) show a stable coast at Punehu, Pihama and Glen Road and erosion at Normanby Road (-0.16 m/year), Winks Trig (-0.34 m/year) and Raine Road (-1.11 m/year). TRC (2009) reported a general estimate of cliff regression of -0.1 m/year, which is based on work for Kupe by Maunsell Ltd in 2004, but the location of this estimate is unknown.

There was historical sand extraction of 36,6000 m^3 of gravel between 1945-1960 from Raine Rd (near Ohawe) (TRC 2009).

Inaha Stream to Patea

Features include: Ohawe, Hawera, Karamea, Waingongoro River, Tangahoe River and Manawapou River

The geology transitions from hard volcanic 'lahar' cliffs to soft sedimentary cliffs at Inaha Road. There has been constant tectonic uplift in this area (McGlone et al 1984). The shoreline is almost continuous sedimentary cliff with steep sand/gravel beaches, and some offshore papa reefs, and is incised by three rivers (Waingongoro, Tangahoe and Manawapou).

Erosion of the soft sedimentary cliffs (compounded by groundwater seepage) is evident (TRC 2009), and during catastrophic episodes can lose 1-2 m of shoreline at a time (pers com Kate Giles). Gibb (1978) found that all historic information (field measurements, maps, aerial photos from the late 1800s to mid 1970s) points to erosion, with rates ranging from 0.05 m/yr to 1.1 m/yr. Erosion was recorded at Ohawe (-0.63 m/year) and at two sites in Manawapou (-0.64 m/year and -0.67 m/year) (Gibb 1978). TRC (2009) reports on work by Single in 1996, which used a map from 1871 and aerial photos from 1951, 1972, 1984 and 1993 as well as field measurements in 1996. Long term cliff retreat was calculated at -0.48 m/year (1871 – 1996), but the rate of retreat varied from -0.03 m/year (1951 – 1984) and 0.35 m/year (1984 – 1996). Erosion at Ohawe boat ramp car park between 1984 and 1996 was calculated at -0.58 m/year.

There was gravel extraction Manawapou in 1940 (14,000 m^3) and quarrying of sand and graves from Ohawe beach prior to 1955 and during the 1960s (TRC 2009).

Patea to Waitotara

Features include: Whenuakura River, Waverly, Waipipi and Waitotara River

The geology is soft sedimentary rock and there has been constant tectonic uplift in this area (McGlone et al 1984). The shoreline is dominated by sand beaches backed by dunes and sand country with the exception of cliffs from Waipipi to Caves Beach (TRC 2009). The shoreline around Patea River (and township) is dynamic due to the local wave climate combined with river sediment and freshwater interacting with cyclic sand levels in the estuary. These interactions explain Gibb's 1978 reports of four sections of the Patea shoreline as stable, eroding and accreting (+0.99, +2.05, 0 and -0.85). Patea township has a history of flooding, sand advancing towards the town and erosion. There have been various modifications to the shoreline/river/estuary in response to these threats, including erosion prevention efforts around the gas pipeline that crosses the estuary (planting, rock wall and renourishment). Shoreline changes to the beach and dunes north of the town likely occurred due to modification of the river and estuary for navigation. Cliffs near Waipipi were estimated to be eroding at -0.35 m/year by comparing surveys from 1906 to 2005 (TRC 2009). Ambiguous data meant TRC (2009) was unable to use coastal resource maps prepared by the Department of Lands and Survey in 1983.

There was historic iron sand mining at Waipipi between 1971 – 1989 (TRC 2009) and there is an ironsand pumping station between Patea and Waipipi.

Waitotara to Whangaehu River

Features include: Waiinu, Mowhanau Beach, Kai iwi beach and Whanganui/Wanganui (both spellings are common)

The geology is sedimentary and the coast around Whanganui is tectonically active with uplift rates of about 0.25 mm/yr (Shand, 2001). This shoreline consists of narrow sandy beaches backed by erosive sedimentary cliffs (Horizons Proposed One Plan 2007). TRC (2009) reported erosion at Mowhanau beach of 0.35 – 0.7 m/year, while Gibb (1978) reported erosion between 1940 and 1975 for Kaitoke (-2.0 to -1.6 m/year), Whanganui (-1.43 m/year) and South Whanganui (-2.22 to -5.45 m/year). South Whanganui also had one report of accretion (4.5 m/year) which may be due to river sediment input. Reports by Gibb (1978) of accretion (3.33, 3.70, 9.09, 5.00 and 1.25 m/year) at several points along the beachside suburb of Castlecliff (just north of Whanganui River) may also be due to deposition of river sediments. Shand (2001) reported that jetties built at the mouth of the Whanganui River between 1884 and 1940 caused the shoreline to prograde by ~700 m near the entrance and up to 100 m north of the river, with up to 10 m of progradation between 1990 – 2000. This is in contrast to his measurement of a background regional erosional trend of -0.2 – 0.6 m/yr. Research by Shand (2001) also showed a great deal of sand bar movement within the nearshore (surf zone) in the Whanganui region, as a result of episodic high wave energy periods. Transfer of sand between the shallow and deep parts of the surf zone may protect the shoreline from erosion.

Whangaehu River to Waikawa Beach

Features include: Turakina River, Koitiata, Moana Roa beach (just north of Rangitikei River), Rangitikei River, Tangimoana (up Rangitikei River), Himatangi Beach, Foxton Beach (just north of Manawatu River), Manawatu River, Waitarere, Hokio and Waikawa Beach

The geology is sedimentary. This shoreline consists of sandy beaches backed by dunes and prograding sand country that extends up to 20 km inland due to the prevailing westerly wind blowing sand inland (Horizons proposed One Plan 2007, Harold Barnett pers com, Manawatu District Council SOE 2007, Orpin et al 2009). Beach profile data were collected in the 1970s and 1980s by the TCC but benchmarks were later lost (Harold Barnett pers com). Replacement benchmarks were put in and surveyed by GPS, and will be used for future surveys. The Manawatu District Council State of Environment report (2007) states the 11.5 km of the district coastline (from Tangimoana to Himitanga) is accreting rapidly at 0.5 m/year. Gibb (1978) reported the areas of Foxton, Himatangi, Tangimoana and “Fuslier” wreck were accreting or stable at rates of 0.58 to 0, 4.11 to 0.61, 0.37 and 1.0 m/year respectively, between the mid to late 1800’s and the 1940’s-1970’s. However, erosion has been a problem at Foxton Beach in recent times (Horizons web ref #5). Erosion is also a problem for Himatangi beach township (Manawatu District Council SOE 2007) and the Natural Hazards section of their SOE report lists erosion as a hazard for the district. The shoreline is dynamic around the river mouths, for example Manawatu River mouth moved several hundred metres north in the mid to late 1800s and then several hundred metres south by the early 1960s (Gibb 1978).

3.5.6 Historic sand extraction

The shoreline between Mangahume Stream and Waitotara has had historic sand/gravel extraction. The shoreline in these regions is erosive, which is a hazard to local settlements and assets. There are no data to show shoreline trends in the area before the historic sediment extraction. There appear to be no data to determine whether sediment extraction had an effect on shoreline. The Graham Banks shoals, which are of mining interest, are directly offshore to these areas. Proposed sand extraction may cause concern in these areas if it is perceived that erosion could be exacerbated.

Mangahume Stream to Inaha Stream

Extraction of 36,6000 m^3 of gravel occurred between 1945-1960 from Raine Rd (near Ohawe) (TRC 2009). The coast is hard lahar cliffs with rivers/streams, and a few sand dunes. Gibb (1978) reported the coast was stable to eroding and TRC (2009) reported cliff regression of ~-0.1 m/year.

Inaha Stream to Patea

Gravel extraction occurred at Manawapou in 1940 (14,000 m^3) and quarrying of sand and graves from Ohawe beach prior to 1955 and during the 1960s (TRC 2009). The coast is sedimentary cliffs with steep sand/gravel beaches at their bases that erode catastrophically. Gibb (1978) reported erosion rates of 0.05 m/yr to 1.1 m/year. TRC (2009) reports on work by Single in 1996, which used a map from 1871 and aerial photos from 1951, 1972, 1984 and 1993 as well as field measurements in 1996. Long term cliff retreat was calculated at -0.48 m/year (1871 – 1996), but the rate of retreat varied from -0.03 m/year (1951 – 1984) and 0.35 m/year (1984 – 1996). Erosion at Ohawe boat ramp car park between 1984 and 1996 was calculated at -0.58 m/year.

Patea to Waitotara

Iron sand mining occurred at Waipipi between 1971 – 1989 (TRC 2009). The coast is soft sedimentary rock with sand beaches backed by dunes and sand country. Cliffs near Waipipi were estimated to be eroding at -0.35 m/year by comparing surveys from 1906 to 2005 (TRC 2009).

3.5.7 Shoreline change summary

Figure 3.1 shows a summary of all available shoreline position information (erosion, accretion, variable or stable) along the present day study area shoreline. Areas of erosion and accretion were inferred from existing data found in Regional and District Council reports, consultancy reports, peer reviewed papers and University theses. These existing reports used old surveys, maps, charts and aerial photographs to calculate rates of erosion or accretion. Areas for which there are no data are left blank. In some cases the shoreline states portrayed in Figure 3.1 have been interpreted from sources that have made generalised statements about large sections of the coast, but have provided few or no accompanying data. While the sources are certain to have a good understanding of the shoreline and good reason to make these statements, it is not possible to provide shoreline rates for these sections of coast.

Variable shorelines dominate the North Taranaki coastline between Stony River and New Plymouth, due to episodic sediment input (especially from the Stony River) causing slugs of sediment to travel along the coast causing episodic accretion and erosion as they pass. The cliffs at Paritutu (Back) beach near New Plymouth are erosive, as is the area in front of the seawall along the city of New Plymouth. Port Taranaki is accretional due to dredged trapping of littoral sediments.

The coastline between Stony River and Oaonui has been described as erosive due its exposure to constant wave attack, although it is also suggested that offshore reefs provide some protection and that stable vegetation surveys suggest the cliffs are stable. There were few survey data in this area and they show accretion, variable or stable shorelines; these measurements may have been taken near streams with variable sediment input. Due to conflicting information and a lack of data much of this shoreline has been left blank.

Erosion occurs along the cliffs (both volcanic and sedimentary) from Oaonui to Whangaehu, in the centre of the study region, along the South Taranaki Bight. The river mouths are dynamic and there are some areas with no information. Some accretion was also measured by Gibb (1978) near streams; however it is likely these features are variable in the long term.

Accretion occurs predominantly along the south of the study area, where dunes and sand country dominate the shoreline. There are some variable areas around river mouths and erosion has occurred at Foxton beach. Himatangi beach has also experienced erosion but conflicting information also suggested the area is accreting, therefore it has been defined as variable.

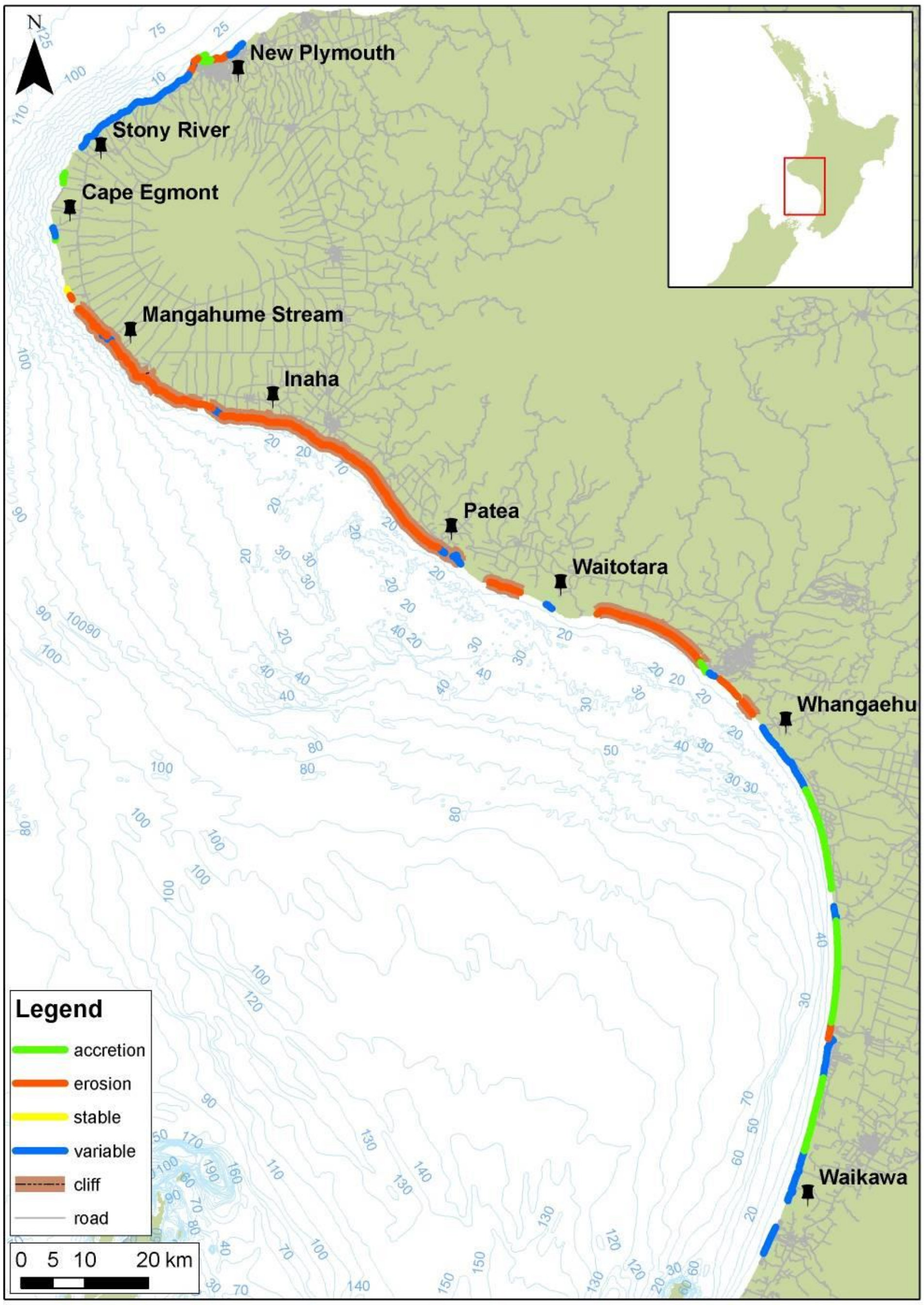

Figure 3.1: Summary of all available shoreline position information (erosion, accretion, variable or stable) along the present day study area shoreline.

While Gibb made some measurements of stable shores in 1978, later data have suggested that those areas were either erosive or variable. The only section of shoreline defined as stable in this study is the beach near Oaonui, for which there is no further information after measurements by Gibb in 1978.

3.6 Assets

Shoreline areas of value in the Taranaki region include natural landscapes such as cliffs and beaches, as well as estuaries with internationally recognised ecological importance (e.g., Manawatu estuary has RAMSAR recognition), popular recreation areas such as beaches and high quality surfing breaks, cultural and/or historical features such as traditional Maori canoe launching ramps, man made assets (e.g. roads, structures, buildings and navigation areas), residential areas (cities, towns, settlements, pa sites and subdivisions) and economically valuable land (e.g., pipelines, camping grounds, farms, waste water treatment plants and commercial areas) (Table 3.1). While this table is not an exhaustive list of assests, it provides an indication some of the types amenities found along the shoreline study area.

Taranaki Regional Council produced a report titled 'Inventory of coastal areas of local or regional significance in the Taranaki Region' (2004) which summarises information from South Taranaki District Council, New Plymouth District Council, Department of Conservation and Taranaki Regional Council on coastal areas of significant scenic, amenity, recreational, cultural, historical or ecological value, but it is not an exhaustive list. Assets include significant coastal areas, significant natural areas, regionally significant landscapes, outstanding natural features, notable trees, heritage items, wahi tapu, archaeological sites, significant habitats of marine life or bird life, significant or unmodified natural character, or regionally important amenity values. The list is provided in Table 3.2.

The Horizons Regional Council has identified its entire west coast shoreline (from Waitotara River in the north to Waikawa Beach in the south) as a "regionally important landscape" in Schedule F of the Regional Plan (Horizons web site #2) and most of the rivers are protection zones. Reasons cited are ecological value, particularly the Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei river estuaries as habitats for indigenous fauna and migratory birds as well as for recreational value, cultural significance to tangata whenua and scientific value (Horizons web site #2). Manawatu Estuary, at the mouth of the Manawatu River near Foxton, is the largest estuary in the lower North Island of New Zealand, and is an important site in the lifecycle of many indigenous and migratory bird and fish species. In recognition of the ecological importance of the site, it was declared a Wetland of International Importance under the Ramsar Convention in July 2005 (Horizons Regional Council website #1).

Table 3.1. Some of the types of assets found in each section of the shoreline study.

Shoreline section	Assets
New Plymouth to Stony River	Fitzroy Beach and suburb New Plymouth city foreshore Port Taranaki Paritutu (Back) beach and suburb Sugarloaf marine reserve Oakura town, beach and camp ground Farm and residential land Subdivisions Recreational beaches High quality surf breaks Recreational facilities (e.g, boat ramps) Artificial structures (e.g., roads, bridges, seawalls)
Stony River to Cape Egmont	This whole section of coast is identified as highly valued for recreation (including high quality surf breaks) Several coastal residences between Bayly Road and Pungarehu Road Many new subdivisions at popular surfing breaks (Puniho Road, Porikapa Road, Stent Road and Bayly Road) Cape Egmont Boat Club Bayly Road Boat Ramp (historical maori turanga waka - maori canoe ramp) Waikirikiri Komene Lagoon (Significan Natural Area) Warea Redoubt
Cape Egmont to Mangahume Stream	Many new subdivisons at Tai Road, Arawhata Road, Tipoka Road, Opunake and Mangahume Stream House for Karen Opunake Waster Water Treatment Plant Opunake beach camp Boat ramp Maui gas pipe line near Oaonui Middleton Bay popular recreational beach, boatramp and artificial surfing reef High quality surfing breaks (e.g., Opunake and Mangahume Stream)
Mangahume Stream to Inaha Stream	New subdivisions along South Road between Waiteika Road and Opunake - set back 200 m Kaupokonui Beach settlement Private land only access to numerous surfbreaks
Inaha Stream to Patea	Te Tangatapu Reserve at Ohawe (important to Nga Ruahine-Rangi iwi) Origin Energy pipeline and pipeline corridor close to the coast Ohawe village and beach Ohawe boatramp and boulder groynes Oeo marae Fonterra wastewater outfall and seawall Golf course near Hawera near cliff Manawapou River redoubts Manaia wastewater treatment plant Wellsites between Manutahi road and Patea Fossils in sedimentary cliffs
Patea to Waitotara	Waverly/Caves Beach settlement Waipipi subdivision Gas pipelines acress Patea estuary Artificial strucutures for navigation and coastal protection of Patea River and estuary Patea township
Waitotara to Whangaehu River	Artificial strucutures for navigation and coastal protection of Whanganui River and estuary This coastline is identified as a regionally important landscape in Schedule F of the Horizons Regional Plan Whanganui township Whanganui airport Manawatu River and Estuary (Wetland of International Importance) Wai-inu Beach settlement Mowhanau Beach Kai iwi beach Popular surf breaks (e.g., Castlecliff)
Whangaehu River to Waikawa Beach	This coastline is identified as a regionally important landscape in Schedule F of the Horizons Regional Plan Turakina River Koitiata settlement Moana Roa beach settlement (just north of Rangitikei River) Rangitikei River Tangimoana settlement (up Rangitikei River) Himatangi Beach settlement Foxton Beach town (just north of Manawatu River) Manawatu estuary Wetland of International Importance Manawatu River Waitarere settlement Hokio settlement Waikawa Beach settlement

Table 3.2. Taranaki Regional Council 'Inventory of coastal areas of local or regional significance in the Taranaki Region'.

Number	Site name	Page No.
1	Mokau-Mohakatino (Epiha Reef)	16
2	Mohakatino Estuary	18
3	Te Kawau Pa	20
4	Te Puia	22
5	Rapanui	24
6	Tongaporutu Estuary	26
7	Tongaporutu Coast	28
8	Whitecliffs (Parininihi)	30
9	Pariokariwa Reef and Opourapa Island	32
10	Pukearuhe	34
11	Waiiti Beach	36
12	Mimi Estuary	38
13	Urenui Estuary and Beach	40
14	Onaero Estuary and Beach	42
15	Buchanans Bay	44
16	Motunui	46
17	Waitara Estuary	48
18	Waitara, Waiongana and Airedale Reefs	50
19	Waiongana Estuary	52
20	Bell Block Beach and Waipu Lagoons	54
21	Waiwhakaiho Estuary	56
22	Fitzroy Beach	58
23	East End Beach	60
24	New Plymouth Foreshore	62
25	Kaweroa Park	64
26	Ngamotu Beach	66
27	Sugar Loaf Islands Marine Protected Area	68

3.7 Discussion

3.7.1 What is the shoreline likely to do in the future, based on past information?

Information collected in this study on historical shorelines can show conceptually how shorelines have changed in the past and therefore what can be expected in the future, to provide a basis against which to scale the likely impacts of offshore extraction on the beaches.

However, there is a great deal of temporal variability, which estimates of 'future' shorelines need to allow for. Beach and dune volumes around New Zealand are likely linked to the interannual El Nino – La Nina and Interdecadal Pacific Oscillation (IPO) climate cycles, as these cycles tend to influence the prevailing wind conditions which in turn control erosion and accretion (Ramsay, 2005, Bryan et al 2008). While links between climate cycles and erosion/accretion have been observed on east coast beaches, it is uncertain whether west coast beaches follow the same patterns due to a lack of long-term beach profile records (Ramsay 2005, Bryan et al 2008). Slugs of sediment from rivers travelling along the coast causing accretion and then erosion as they pass makes it difficult to determine whether shoreline variability is due to climate trends (Bryan et al 2008) or long term erosion.

Climate trends are not the same as climate change. Effects of climate change on shoreline stability are too complex to predict (TRC 2009). They are likely to exacerbate coastal erosion but the influences will be complex involving inter-connections between winds (extreme storms, prevailing wind), waves (extreme storms, prevailing sea), sea-level variability (seasonal, interannual, interdecadal) and sea level rise, tide range, rainfall and river flow (extreme storm, base flow), storms/cyclones (frequency, intensity, track, surge), ocean and coastal currents and sediment supply to the coast (TRC 2009). Effects of climate change are not considered in this section on likely future shoreline changes.

The shorelines in this study are naturally varying landscapes that are influenced principally by; (1) the geology (coast and shore), (2) the climate (wind, waves and rain) and (3) the sediment budget (terrestrial/river and marine inputs versus sediment transport outputs). These factors interact to modify the shoreline over days, weeks, seasons, years, decades and longer. Shorelines can also be influenced by human activities. Based on the information gathered in this study, each section of shoreline can be expected to behave in the same way in the future as it has in the past.

The volcanic cliffs in the north of the region will erode slowly due to their hard nature and protection from wave attack by offshore reefs. Rocky intertidal platform and boulder beaches will vary between being covered in a thin veneer of sand to being steep beaches, depending on episodic terrestrial inputs from rivers. River mouths will continue to be dynamic due to interactions between waves and river inputs of sediment and freshwater. Further south, sedimentary cliffs will erode quickly and catastrophically due to their soft nature, exacerbated by groundwater seepage. They will be periodically protected by eroded cliff material until it is broken down and washed away. In the south of the study area, the beaches, dunes and sand country will continue to prograde due to terrestrial sediment input being blown back inland by the predominant westerly wind.

3.8 Conclusions

Information collected in this study gives a conceptual understanding of how shorelines have changed in the past and how they will change in the future.

Shorelines are naturally varying landscapes that are influenced principally by; (1) the geology (coast and shore), (2) the climate (wind, waves and rain) and (3) the sediment budget (terrestrial/river and marine inputs versus sediment transport outputs). These factors interact to modify the shoreline over days, weeks, seasons, years, decades and longer. Shorelines can also be influenced by human activities such as planning non-native vegetation, culverting and bridging of streams, walking on dunes, placement of artificial structures such as seawalls and the lowering of the seabed by the removal of boulders (TRC 2009). Existing information about these factors, and shoreline position, have been summarised in this report and the accompanying GIS layers and shapefiles.

Rivers input the majority of sediment to the Taranaki and Horizons coast (Cowie, 2009, McComb 2001, TRC 2009, Horizons Proposed One Plan 2007). Sediment type and quantity delivered to the coast depends on the erodability of the catchment which depends on geology (rock type), topography (steepness), rainfall frequency and intensity, and the stream/river network that deliver the sediment to the coast. Erosion of hard volcanic cliffs input little sediment to the budget, but catastrophic erosion of sedimentary cliffs can substantially increase beach volume at the cliff base until it is broken down by wave action and transported away. The Taranaki coast is generally sediment starved (TRC 2009), but episodic catchment erosion events can inject large quantities of sediment to the coast from a point source such as Stony River (Cowie 2009). These sediments become part of the sediment budget and are distributed alongshore or offshore by sediment transport but are eventually transported beyond the study area. There are few data for the Horizons coast, but available information suggests the dunes and sand country are prograding, although erosion is identified as a natural hazard for some coastal settlements (e.g., Foxton and Himatangi).

Shoreline survey data are limited for the ~260 km of shoreline from New Plymouth to Waikawa Beach and for much of the coast there are no data. Most shoreline data in the Taranaki region were from areas that were developed or had assets, such as Patea, Opunake, Stony River, Oakura, Paritutu (Back) beach and the New Plymouth city and port region. Most shoreline interest in Horizons region has been around the Whanganui, Rangitikei and Manawatu Rivers, as well as settlements with erosion issues. While this shoreline is a highly valued, there are presently little data, although newly installed benchmarks will become useful for future shoreline surveys.

Existing shoreline studies that used aerial photos, historical maps and charts, and field measurements (such as beach profiles) to estimate shoreline change rates were summarised and mapped in GIS. The study region was divided into sections using changes in shoreline geology as a natural divider and described.

The Northern Taranaki coastline is generally hard volcanic rock that is slowing eroding due to wave attack. Intertidal rocky platform beaches are often covered by a thin veneer of sand, but can receive large episodic inputs of sediment from ring plain rivers, turning them into steep sand/gravel beaches until the sediment is eventually transported away. The South Taranaki Bight is dominated by eroding volcanic and sedimentary cliffs and dynamic river mouths. South of Whangaehu River the shoreline is dominated by dunes, backed by sand country, which are likely prograding due to wind blown sand. Rivers and estuaries also feature in this area and cause the shoreline to move back and forth over long time periods.

3.9 Summary

Most of the shoreline in the study area is unmodified and in its natural state. Apart from the areas that have been modified, it's likely the shoreline will continue to do what it has done in the past because the processes are driven by geology and climate cycles. Climate change effects on the factors influencing shoreline change are not included.

There is a general understanding of nearshore and offshore sediment transport in the study area, with sediment predominantly pushed by the strong westerly wave climate along the coast from Cape Egmont to the northeast in the direction of New Plymouth, and southeast in the direction of Whanganui. However, there is little information regarding sediment whether there is input from the offshore region to the littoral zone and the shoreline.

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4. Ocean primary productivity in the South Taranaki Bight

4.1 Background

The Taranaki Bight is a dynamic area influenced by river outflow from the Bight's catchments, advection of material from the northern South Island, wind-resuspension of sediments and strong currents through Cook Strait. The optical conditions are complicated by these inputs of diverse coloured material. Water colour is determined by a highly variable mixture of land-derived dissolved substances, inorganic sediments from rivers and the sea-floor, bottom-reflectance in shallow waters and by phytoplankton blooms. This places the region into the optical class of Case II waters. Atmospheric correction of ocean colour data in this region is spurious because red light is scattered back out of the water by sediments, rendering the 'black pixel approximation' void (Gordon & Wang, 1994; Gordon et al., 1997; Pinkerton et al., 2006). Similarly, the standard algorithms for deriving chlorophyll concentration, which rely on the assumption that chlorophyll and other phytoplankton-related substances dominate the determination of water colour, do not perform well in optically complex waters. There are currently no universal algorithms for handling such conditions. In the absence of in situ data to provide ground-truthing, the best use of ocean colour data in this region is to calculate surface chlorophyll conditions in the usual manner, as though the water were less complex, and to supplement this information with 'true colour' composites of the water-leaving radiance data to provide insight into the performance of the chlorophyll algorithm.

4.2 Methods

4.2.1 True colour imagery

NIWAs existing true colour image repository was used for this study:- Remotely sensed data from the MODIS-Aqua instrument were obtained from the Level 1 and Atmosphere Archive Distribution System at Goddard Space Flight Centre, NASA (http://ladsweb.nascom.nasa.gov). Top-of-atmosphere radiances from red, blue and green wavebands were combined, with minimal atmospheric correction, into true colour composites, using the NASA freeware package SeaDAS, with a spatial resolution of 1 x 1 km. Subscenes of the study area were examined individually. 290 cloud-free images of the Taranaki Bight were available for the period 2002 to 2007. Based on the visual interpretation of these scenes, 10 sites were chosen for examination of chlorophyll concentration time-series.

4.2.2 Chlorophyll concentration

NIWA's existing archive of Global Area Coverage SeaWiFS data was used for this study. Remotely sensed radiance data from the NASA sensor SeaWiFS were obtained for the period 1997 to 2007, from the NASA Ocean Color Website (http://oceancolor.gsfc.nasa.gov/ Level 1 browser). The standard atmospheric correction and chlorophyll algorithms were applied (O' Reilly et al., 1998) to produce daily estimates of chlorophyll concentration with a spatial resolution of 4 x 4 km. Non-zero values were extracted into a time series for each of the ten Taranaki Bight sample sites selected using the true colour imagery. Seasonal minimum, maximum and median chlorophyll values were calculated for each site.

4.3 Results

4.3.1 Characteristics of the study region observed in true colour imagery

Under certain conditions, phytoplankton blooms are identifiable in the true colour imagery. Blooms of the calcifying prymnesiophyte *Emiliania huxleyi* appear initially as a normal phytoplankton bloom, with strong absorption in the blue and red regions of the spectrum. During the growth phase, all blooms cause the water to darken and sometimes to take on a green hue. This phase can be confused with the presence of coloured, dissolved organic matter (CDOM), high concentrations of which are generally associated with land run-off (high molecular weight humic substances). When the growth phase of *E. huxleyi* ends, the cells release millions of calcite platelets which accumulated around the cells during the growth phase. These platelets scatter very efficiently and give the water a milky appearance. Strong, spectrally neutral scattering enhances the ambient water colour - pure water appears turquoise, whereas water with a strong CDOM or chlorophyll component appears green. This phase of the bloom can be confused with strong sediment loading, and vice versa. The time sequence of dark water to bright water, together with the long residence times of calcite platelets compared to inorganic sediments, so that the water colour retains a memory of mixing events visible in the finely-structured trail of platelets, means that *E. huxleyi* blooms can be identified with some confidence from true colour imagery alone. *E. huxleyi* blooms appear to be an annual event in this region. Figure 1 illustrates four cases where such blooms intrude into the Taranaki Bight area and throughout Cook Strait. It is possible that these blooms begin in the Tasman Sea and are carried through Cook Strait, seeding similar blooms along the northern Chatham Rise. *E. huxleyi* blooms generally occur during spring and summer in the study area.

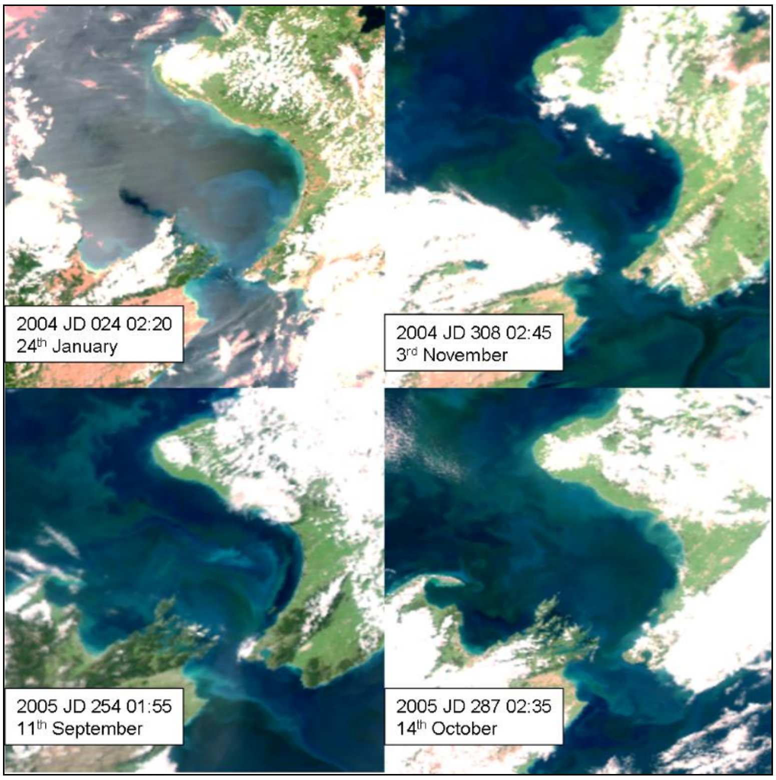

Figure 4.1. Blooms of *Emiliania huxleyi* occuring in the Taranaki Bight and Cook Strait area area visualised using MODIS –Aqua true colour imagery.

In each of the cases shown in Figure 4.1, the phytoplankton signature, which most likely dominates the colour in the central study region, is augmented by dark and bright hues along the coastlines. These peripheral features indicate CDOM and sediment resuspension and/or sediment delivered by rivers in the Taranaki Bight, Golden Bay and Marlborough Sounds. Figure 4.2 illustrates six cases when these influences, together with wind-driven resuspension of bottom sediments throughout the study region, are particularly strong, making the standard chlorophyll product highly unreliable. These non-phytoplankton events are typically short-lived, disappearing within a few days.

Periods of relative calm are observed infrequently in this region, either because the area is indeed predominantly turbulent, or because calm periods are associated with cloud cover which precludes optical remote sensing. Figure 4.3 illustrates three instances of relative calm, with minimal sediment suspension in the Cook Strait, little evidence of river plumes and only a faint absorption signal (phytoplankton or CDOM) to the south of the study area. All instances of dark 'calm' water were found in early autumn for this study area.

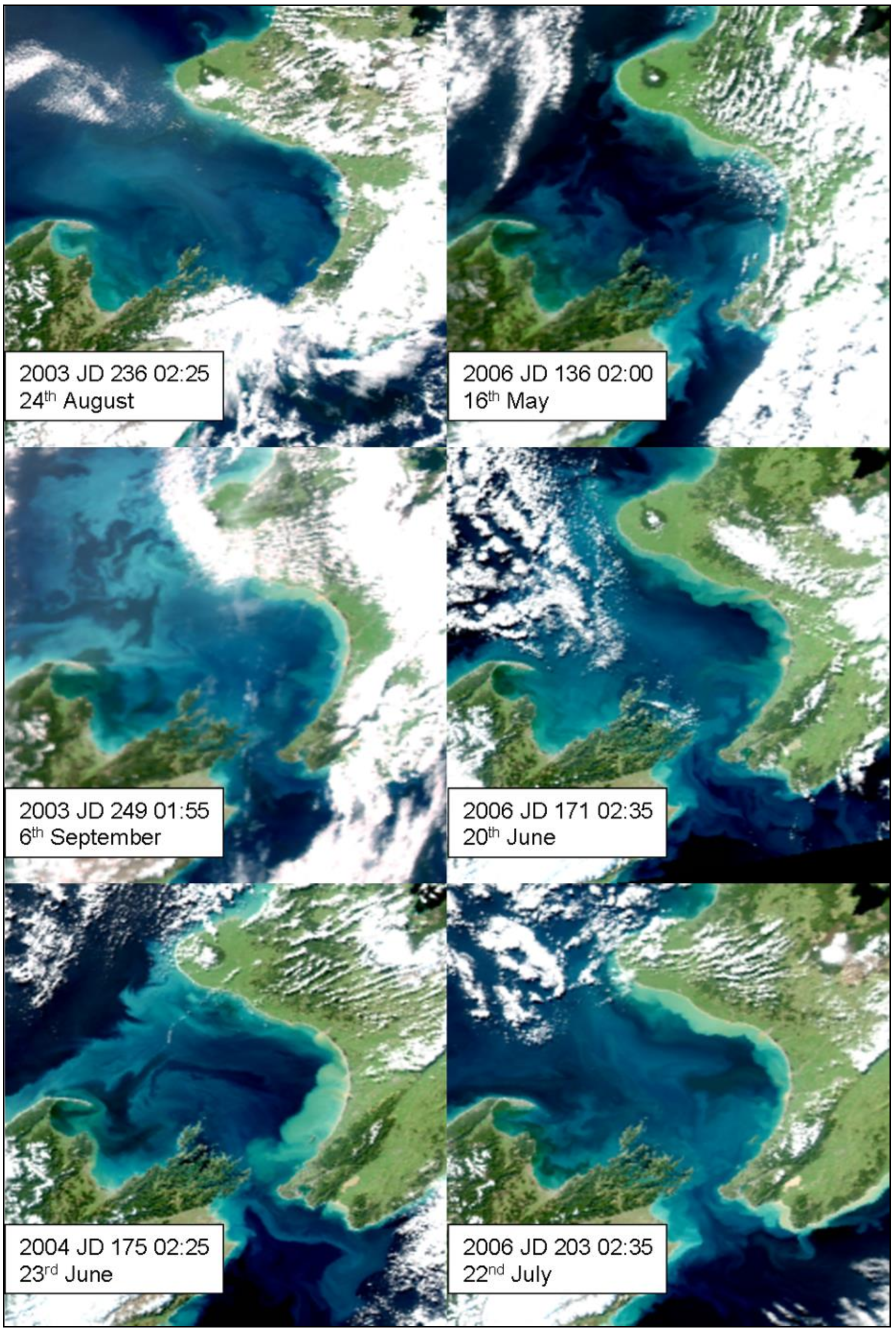

Figure 4.2. Instances of extreme turbidity in the study area area (MODIS –Aqua). Sediments from river plumes and from wind-driven resuspension brighten the water by scattering; terrigenous humic substances absorb strongly at blue wavelengths; phytoplankton cells contribute to both absorption and scattering.

Figure 4.3. Examples of optically 'calm' periods in the South Taranaki Bight and adjacent areas (MODIS –Aqua imagery).

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4.3.2 Climatology of the standard chlorophyll product

The monthly climatology of satellite-derived surface chlorophyll concentrations derived using SeaWiFS must be interpreted with caution, because the examination of true colour imagery indicates that the likelihood that chlorophyll is overestimated, because of high sediment and CDOM loading, is high. Figures 4.4a and 4.4b show the median monthly chlorophyll values (left-hand column), together with the minimum, maximum and standard deviation. Note that the colour scale is maximised for each variable, but remains constant within a variable across months, to ease comparison.

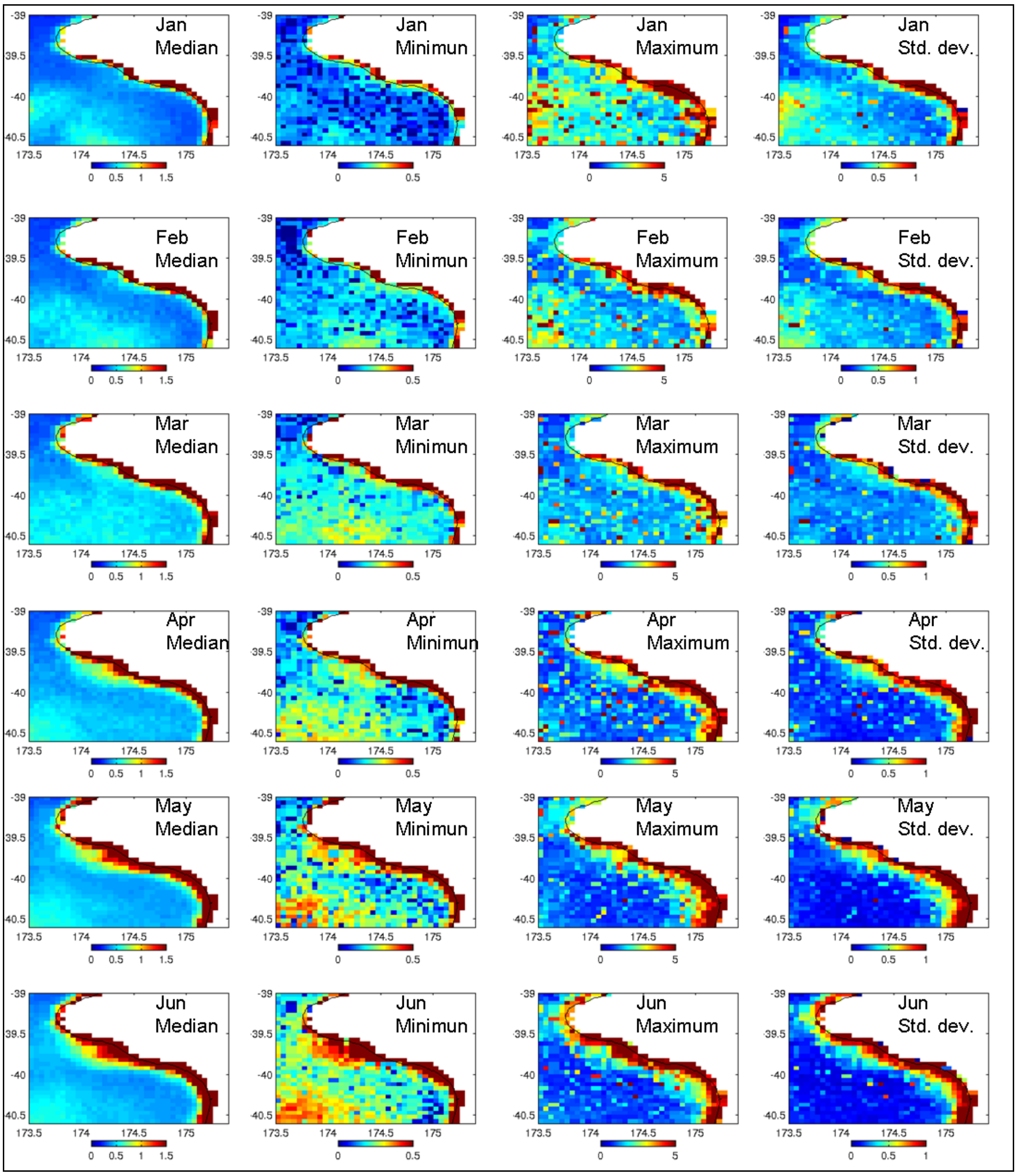

Figure 4.4a. Chlorophyll climatology, January to June (SeaWiFS imagery). Refer to the text for caveats as to the accuracy of these data.

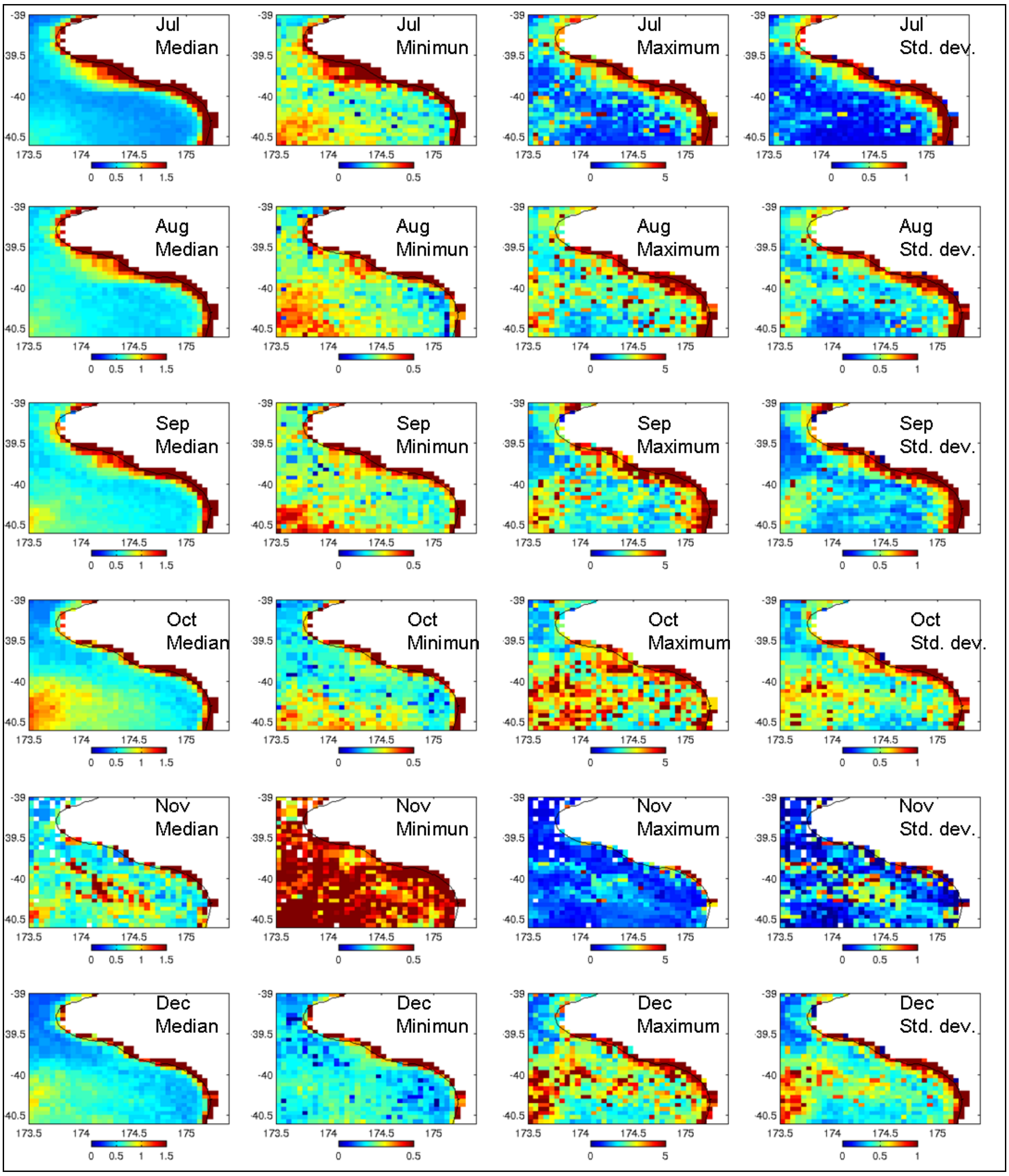

Figure 4.4b. Chlorophyll climatology, July to December. Refer to the text for caveats as to the accuracy of these data (SeaWiFS imagery).

Chlorophyll values along the coast of the study region were exceptionally high and are certainly over-estimated because of river plumes and sediment resuspension. These values were lowest from October to February. The maximum distance off-shore at which coastal sediments were detected occurred in May-June. The range of values remained high throughout the year, as did the standard deviation, indicating that the coastal physical forcings are not strongly seasonal.

Off-shore, at the south-west edge of the study region, chlorophyll values peaked in October, and maintained 'bloom' conditions (chlorophyll concentration > 1 mg m^{-3}) from September to December. These values are realistic and are likely to be within the estimated error of the satellite algorithm (± 33 %).

Between the coast and the off-shore, deeper water, along the Taranaki shelf-edge, a band of relatively clear water is observed. Chlorophyll concentrations tend not to reach bloom levels, and the highest values are observed between August and November. Without in situ corroborating evidence, it is difficult to determine whether this represents moderate, early spring growth or aliasing by terrigenous materials.

In order to examine the temporal development of chlorophyll concentration more closely, and to test for inter-annual variability, ten sites were chosen in a grid across the study region. Figure 4.5 shows the site locations.

The exact locations are:

N: North of the Bight: 38.90 °S, 173.90 °E

D1: Deep water 1: 39.35 °S, 173.50 °E

D2: Deep water 2: 39.65 °S, 173.50 °E

T: Central Taranaki Bight: 39.90 °S, 174.05 °E

G1: Golden Bay 1: 40.35 °S, 173.70 °E

G2: Golden Bay 2: 40.35 °S, 174.25 °E

C: Cook Strait: 40.50 °S, 174.85 °E

R1: River/resuspension 1: 39.65 °S, 174.20 °E

R2: River/resuspension 2: 40.00 °S, 174.90 °E

R3: River/resuspension 3: 40.50 °S, 175.15 °E

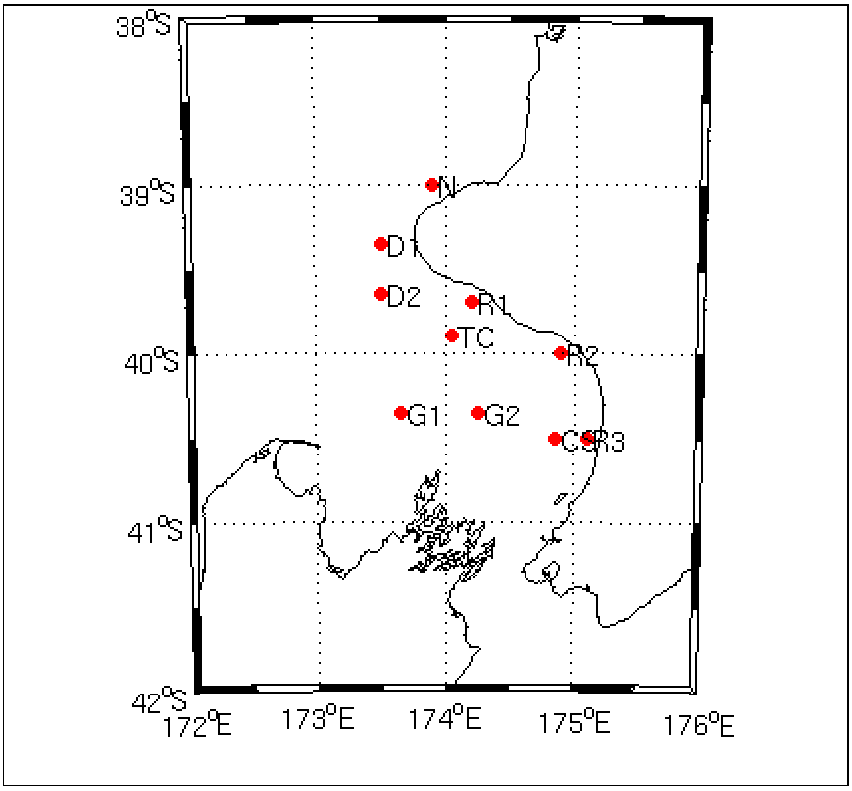

Figure 4.5. Study sites chosen for examination of chlorophyll time-seies.

Time series of chlorophyll at specific locations in the study area

Chlorophyll statistics and the seasonal chlorophyll dynamics for each of the chosen sites are summarised in Table 4.1. Low seasonal variability is observed at the deeper sites N, D1, D2 and T. Chlorophyll peaks during both winter and spring at these locations, suggesting a winter influence of terrigenous substances and a spring phytoplankton bloom. To the south, sites G1, G2 and C are characterised by a single chlorophyll peak during spring, reaffirming the likelihood that the seasonal chlorophyll dynamics are representative of phytoplankton growth. Site G1 sustained the highest median spring chlorophyll values. However, high median chlorophyll values (≥ 0.37 mg m^{-3}) at these sites throughout the year suggest ongoing aliasing by CDOM and/or sediments. Advection of water from around Golden Bay and upwelled off the west coast of the South Island may affect stations G1, G2 and C. At each of the near-shore sites, R1-3, chlorophyll peaks in winter, suggesting that river plumes and wind-driven sediment resuspension dominate the optical properties at these locations, and that any phytoplankton activity in this zone is masked by sediment scattering.

Site	Spring			Summer			Autumn			Winter		
	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max
N	0.39	0.12	2.1	0.24	0.12	1.36	0.28	0.02	1.4	0.41	0.16	2.8
D1	0.48	0.18	1.6	0.28	0.08	1.5	0.33	0.08	2.5	0.46	0.12	4.4
D2	0.48	0.21	1.7	0.34	0.12	2.5	0.41	0.02	2.2	0.47	0.26	1.8
T	0.60	0.08	6.0	0.39	0.08	2.7	0.52	0.00	1.5	0.64	0.26	2.4
G1	0.95	0.24	3.3	0.54	0.06	32	0.55	0.20	10	0.57	0.31	3.9
G2	0.65	0.33	3.9	0.50	0.11	2.0	0.48	0.22	1.5	0.48	0.26	1.8
C	0.56	0.26	8.4	0.37	0.13	3.0	0.45	0.00	3.8	0.41	0.25	1.8
R1	0.68	0.29	3.2	0.43	0.15	3.0	0.89	0.27	2.9	1.3	0.41	4.8
R2	0.85	0.14	5.7	0.51	0.12	10	1.2	0.21	6.4	1.3	0.28	9.2
R3	0.66	0.23	5.5	0.37	0.07	6.5	0.71	0.15	5.7	0.81	0.03	5.7

Table 4.1. Summary of seasonal chlorophyll statistics for the ten study sites

In the absence of in situ validation data, there are several ways to improve our understanding of how reliable these values are. Two factors that are considered here are the specific functioning of the chlorophyll algorithm and a further look at the true colour imagery at each site.

The chlorophyll algorithm functions by detecting the difference between reflectance of blue light, which is absorbed by chlorophyll, and green light, which is not. Higher chlorophyll concentrations absorb more blue light, causing a shift in the reflectance spectrum towards the green. The chlorophyll algorithm therefore selects the highest radiometric signal of the blue wavebands (443 nm, 490 nm and 510 nm) and calculates the ratio of this value with the green reflectance (555 nm). Contamination of the signal by absorbing CDOM or scattering sediments causes an overestimate of chlorophyll concentration and a more rapid transition to greener wavelengths. Frequent use of the 510 nm waveband is therefore an indicator for either sustained, very high chlorophyll concentrations or high concentrations of CDOM and inorganic particulates. Table 4.2 shows the colour waveband usage for each of the sites.

Station	No. instances of peak reflectance occurring in a given blue waveband:			Total No. non-zero chl values
	443 nm	490 nm	510 nm	
N	420	268	3	691
D1	352	319	7	678
D2	346	353	6	705
T	223	501	16	740
G1	185	652	80	917
G2	233	639	27	899
C	306	554	21	881
R1	92	514	104	710
R2	104	483	183	770
R3	147	514	97	758

Table 4.2: Summary of frequencies with which each of the blue SeaWiFS wavebands was dominant for each of the chosen stations.

A clear difference is found between the near-shore river/resuspension stations R1-3, which are often very green, and the northerly stations for which the reflectance spectrum seldom peaked in the 510 nm waveband. The chlorophyll algorithm is most likely to be reliable at stations N, D1 and D2, which each have low instances of reflectance peaks at 510 nm and also more frequent reflectance peaks at 443 nm than at 490 nm.

True colour imagery - features at each site

North of the Bight (site N, 38.90 °S, 173.90 °E):

Station N often appears relatively clear. Occasional instances of river plume/near-shore sediment resuspension are observed (upper two panels, Figure 4.6). Another feature is the appearance of blue water off Cape Egmont despite more turbid waters off-shore (Figure 4.6, lower panel, also Figure 4.1, lower left panel). This spatial signature is typical of upwelling, with minimal river influence and relatively clear water. These chlorophyll estimates are likely to be within an error range of ± 33% (Franz et al., 2007).

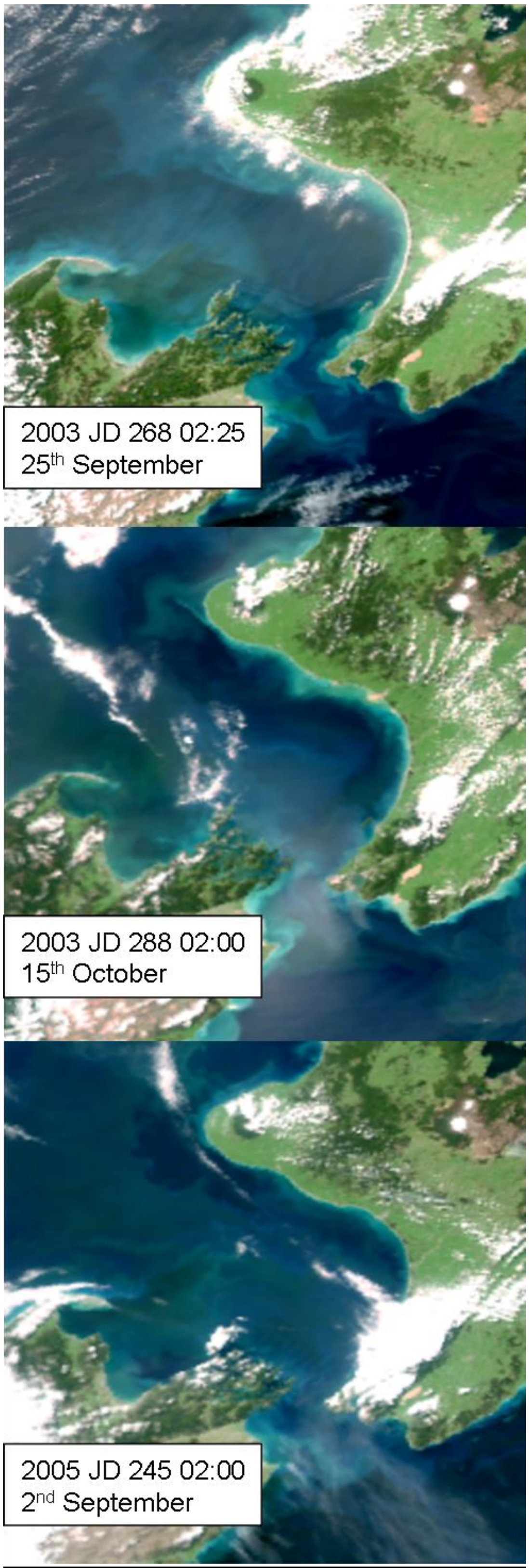

Figure 4.6. Notable features at site N. Upper panel: northward advection of sediments from the South Taranaki Bight (SeaWiFS). Middle panel: southerly advection of sediments from the North Taranaki Bight. Lower panel: possible upwelling off Cape Egmont.

Deep water to the northwest of the region (sites D1, 39.35 °S, 173.50 °E and D2, 39.65 °S, 173.50 °E):

The deeper sites to the west of the study region appear to be influenced by terrigenous substances mainly during winter/spring (e.g. Figure 4.6, upper panel). The spring phytoplankton bloom is evident at these sites in Figure 1. Relatively clear water with regular influence of phytoplankton blooms centred off-shore are seen. Chlorophyll estimates are likely to be within an error range of ± 33%.

Central Taranaki Bight (site T, 39.90 °S, 174.05 °E):

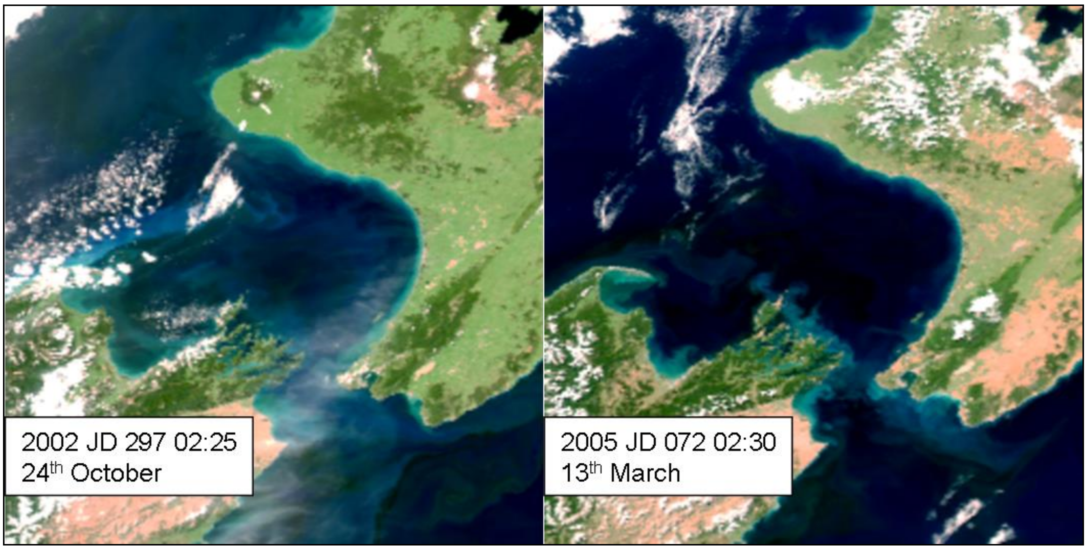

Figure 4.7. Features observed at site TC (SeaWiFS).

Site TC appears to be located in a transition zone between the turbid, near-shore coastal environment and the more variable region off-shore. Figure 4.7 demonstrates that the site can be affected by advected particulates from the west coast of the South Island (left panel, Figure 4.7) and from Marlborough Sounds and Cook Strait (Figure 8). At other times, this entire central zone appears relatively clear (right panel, Figure 4.7). The fidelity of the satellite chlorophyll estimates at this site is likely to vary throughout the year.

Golden Bay (sites G1, 40.35 °S, 173.70 °E and G2, 40.35 °S, 174.25 °E):

Sites G1 and G2 are located in the central Cook Strait, closest to the South Island. Advection of dissolved and particulate terrigenous material from the south is frequently observed (Figure 4.8). Chlorophyll estimates are likely to be compromised by absorbing dissolved substances and scattering inorganic particulates for much of the year at these sites.

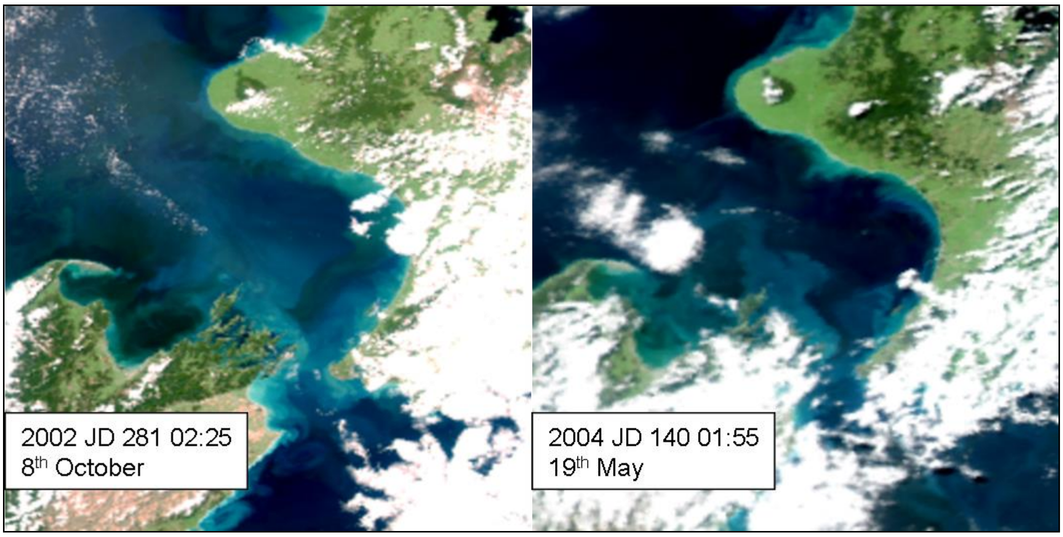

Figure 4.8. Features observed at sites G1, G2 and C (SeaWiFS).

Cook Strait (site C, 40.50 °S, 174.85 °E):

Site CS appears to be influenced strongly by currents flowing through the Cook Strait, advecting resuspended sediments, phytoplankton and dissolved terrigenous substances. Chlorophyll estimates are likely to be compromised by absorbing dissolved substances and scattering inorganic particulates for much of the year at this site.

Shoreline with river inflow (sites R1, 39.65 °S, 174.20 °E, R2, 40.00 °S, 174.90 °E and R3, 40.50 °S, 175.15 °E):

Sediment-laden river plumes are observed sporadically along the coastline, sometimes constrained near-shore, sometimes extending past the 50 m depth contour. These plumes are sometimes observed for many rivers at the same time (Figure 4.9, upper panels) and sometimes for one or two rivers only (Figure 4.9, lower right panel). Resuspension of bottom sediments by wind-mixing is also likely, and again may appear across the entire coastline (Figure 4.9, upper panels) or segregated zonally (e.g. in north and south segments, Figure 4.9, middle-left panel, or confined to the south Figure 4.9, middle-right panel). Chlorophyll estimates are likely to be compromised by scattering inorganic particulates for most of the year at these sites.

Figure 4.9. Near-shore features in the South Taranaki Bight (SeaWiFS).

Inter-annual variability in chlorophyll at selected sites.

The entire time-series of chlorophyll for each of the ten selected sites is shown in Figures 4.10 to 4.13.

These figures demonstrate firstly the spread in chlorophyll values at each site. Sites N, D1 and D2 exhibit the least scatter in chlorophyll values, consistent with less frequent inputs of terrigenous material than is observed elsewhere. The greatest degree of scatter is observed at the near-shore sites R1-3, and at the southerly site G1 (Figure 4.11).

Where there is a strong seasonal cycle with peaks in spring and possibly also autumn it is a good indication that phytoplankton is dominating the optical signal. This signature is most pronounced at sites TC, G1, G2 (Figure 4.11), CS (Figure 4.12) and D2 (Figure 4.13).

Inter-annual variability in optical properties may reflect climatic conditions, such as high rainfall years affecting the amount and frequency of river sediment inputs, or changes in off-shore stratification, driven by upwelling, circulation and cloud shadowing processes, affecting phytoplankton bloom dynamics. Inter-annual variability is observed to some degree across the study region. The most noticeable inter-annual features are:

- Near-shore site R1 exhibits a relative lull in peak chlorophyll (probably aliased by inorganic sediment) values during the period 2002 - 2005 (Figure 4.10);

- High peak values at sites R2 and R3 appear to cycle more frequently than at R1, with maxima during 1999, 2002, 2005, 2007 (Figure 4.10);

- A relative lull in peak values is observed at sites G1 and G2 during the period 1999 to 2002 (Figure 4.11).

- There is no significant temporal trend in chlorophyll values at any of the sites. In other words no detectable response to long-term climatic change is found in the Case I chlorophyll product.

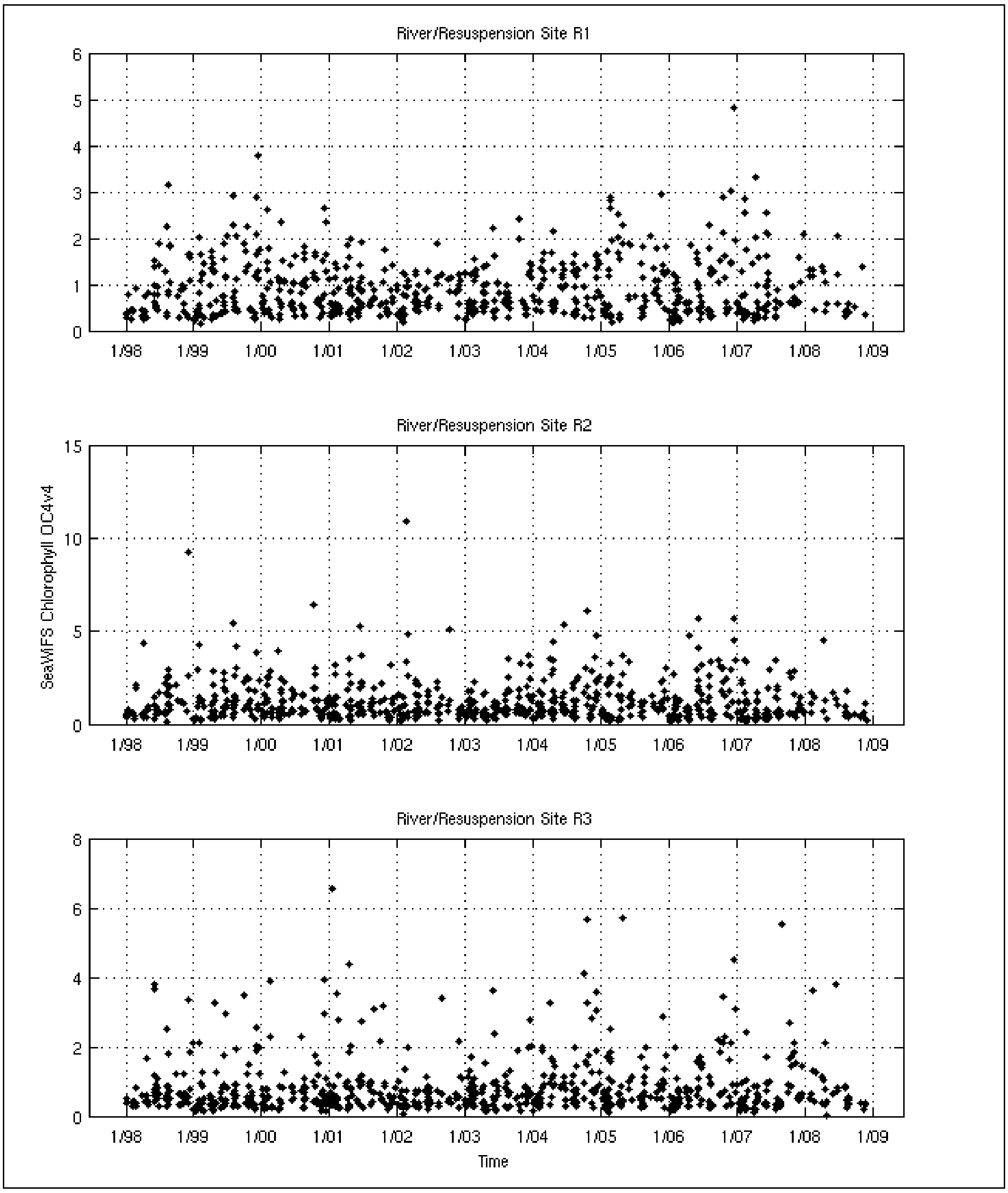

Figure 4.10. Chlorophyll time-series for coastal sites R1, R2 and R3 (derived from SeaWiFS).

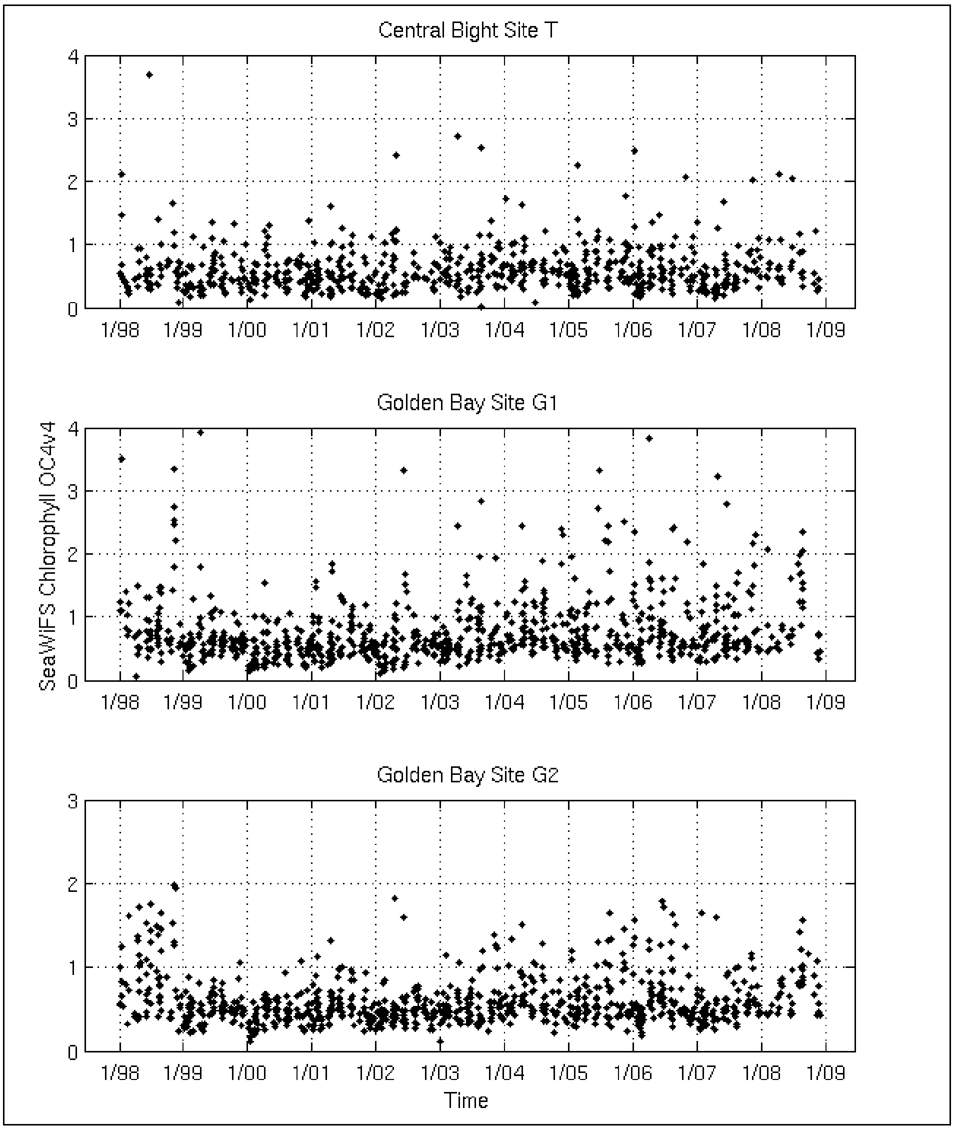

Figure 4.11. Chlorophyll time-series for mid-Bight site T and southerly sites G1, G2 (derived from SeaWiFS).

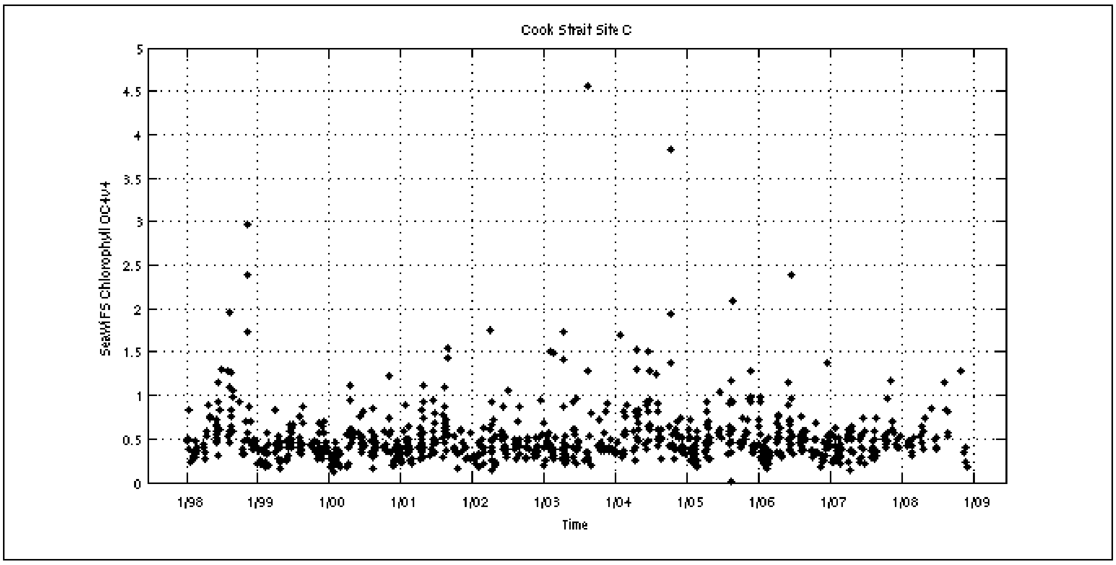

Figure 4.12. Chlorophyll time-series for the Cook Strait site C (derived from SeaWiFS).

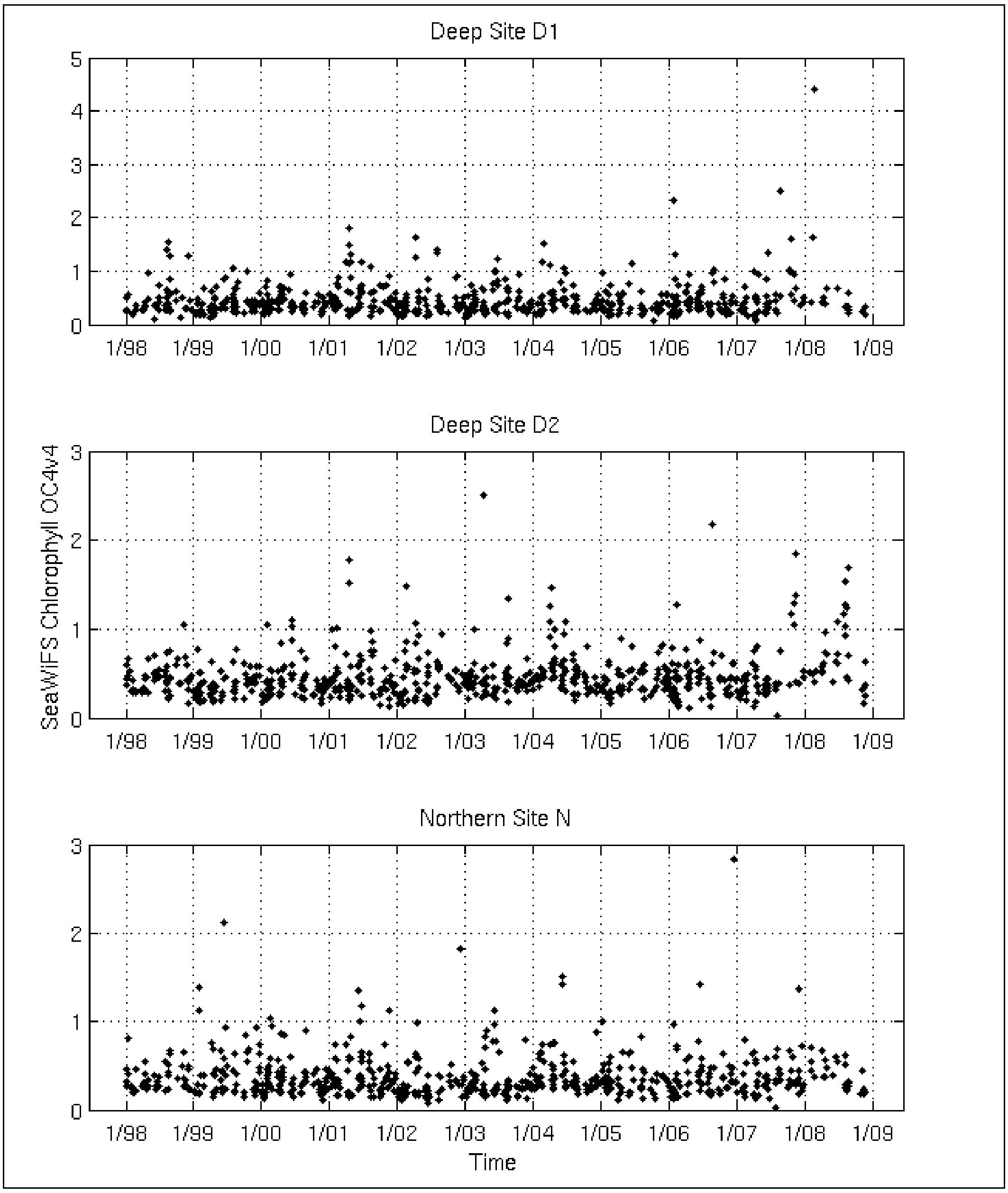

Figure 4.13. Chlorophyll time-series for northerly sites N, D1 and D2 (derived from SeaWiFS).

4.4 Conclusions

Complex optical conditions are prevalent in the South and North Taranaki Bight, making the quantification of chlorophyll from remotely sensed ocean colour data extremely difficult. Particulate and dissolved terrigenous material is frequently advected into the region from the Marlborough Sounds, west coast of the South Island and from Cook Strait. Phytoplankton blooms appear to peak in springtime, with an origin off-shore to the west of the study region, and apparent advection of the bloom through the study region and into Cook Strait. River inputs of terrigenous material along the Taranaki coastline are frequent but sporadic. Massive resuspension of bottom sediments, presumably wind-driven, occasionally causes the entire region to appear bright and turbid. Chlorophyll values at those sites deemed to be least compromised by terrigenous inputs (sites N, D1, D2) range from 0.02 to 4.4 mg m^{-3}, with blooms occurring regularly during October, and no significant autumn bloom. Apparent median chlorophyll values are relatively high throughout the year all across the study area, with an overall range of 0.02 to 32 and median 0.57 mg m^{-3}. This compares to values typically < 0.1 mg m^{-3} in clear blue waters. No significant decadal trends were observed in apparent chlorophyll concentration.

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5. Zooplankton of the South Taranaki Bight

5.1 Introduction and scope

A reasonable amount of mesozooplankton (0.2-20 mm) sampling has been conducted in the South Taranaki Bight (STB) (see Figure 5.1). This work has focused on measurements of mesozooplankton species composition and, less frequently, biomass estimates, in the upper water column. Very little depth-stratified sampling was done, and the entire water column was not routinely sampled. Most of the mesozooplankton samples were collected in summer and autumn, thus no conclusions on zooplankton seasonal patterns can be drawn from the data. Considering all samples taken, a wide variety of net types and mesh sizes were used (*i.e.*, 65 µm 100 µm, 200 µm, 280 µm, 560 µm). This complicates the data and limits the overall conclusions that can be made.

Although a small amount of macrozooplankton (>20 mm) sampling was done in Cook Strait, on euphausiids (Bartle 1976) and chaetognaths (Nairn 1975), the samples were collected outside of the current study area (*i.e.*, Taranaki Bight (TB) iron sands, roughly bounded by 39°10′S, 40°30′S, 173°40′E and 175°20′E, see Figure 5.1). Two studies reported on the distribution of the euphausiid *Nyctiphanes australis* in Cook Strait (Bradford and Chapman 1988; James and Wilkinson 1988) and some of the sampled stations fall within the area of the TB iron sands. Biomass of *N. australis* was elevated in STB, as compared to the rest of Cook Strait (reaching 150 mg m^{-3} wet mass, Bradford and Chapman 1988). It is unclear whether the *N. australis* population is resident in STB, or whether it is advected into the region as part of the Cape Farewell upwelling (see below). Since there are few other data on macrozooplankton, the rest of this review will focus on mesozooplankton.

5.2 Mesozooplankton occurrence

5.2.1 Background and physical environment

The bulk of the mesozooplankton research was done in the 1970s and 80s as part of the "Maui Development Environmental Study", to learn more about the physical, chemical, and biological oceanography of the greater Cook Strait region, as it related to the Maui-A oil platform that began production in 1979 (Battaerd 1983; background provided by Bowman et al. 1982). These and other studies indicated that the ecology of STB zooplankton was strongly influenced by the upwelling events that persist off Kahurangi Shoals and Cape Farewell, at the northwestern corner of the South Island (Battaerd 1983; Foster and Battaerd 1985; Bradford and Chapman 1988; James and Wilkinson 1988; Bradford et al. 1993).

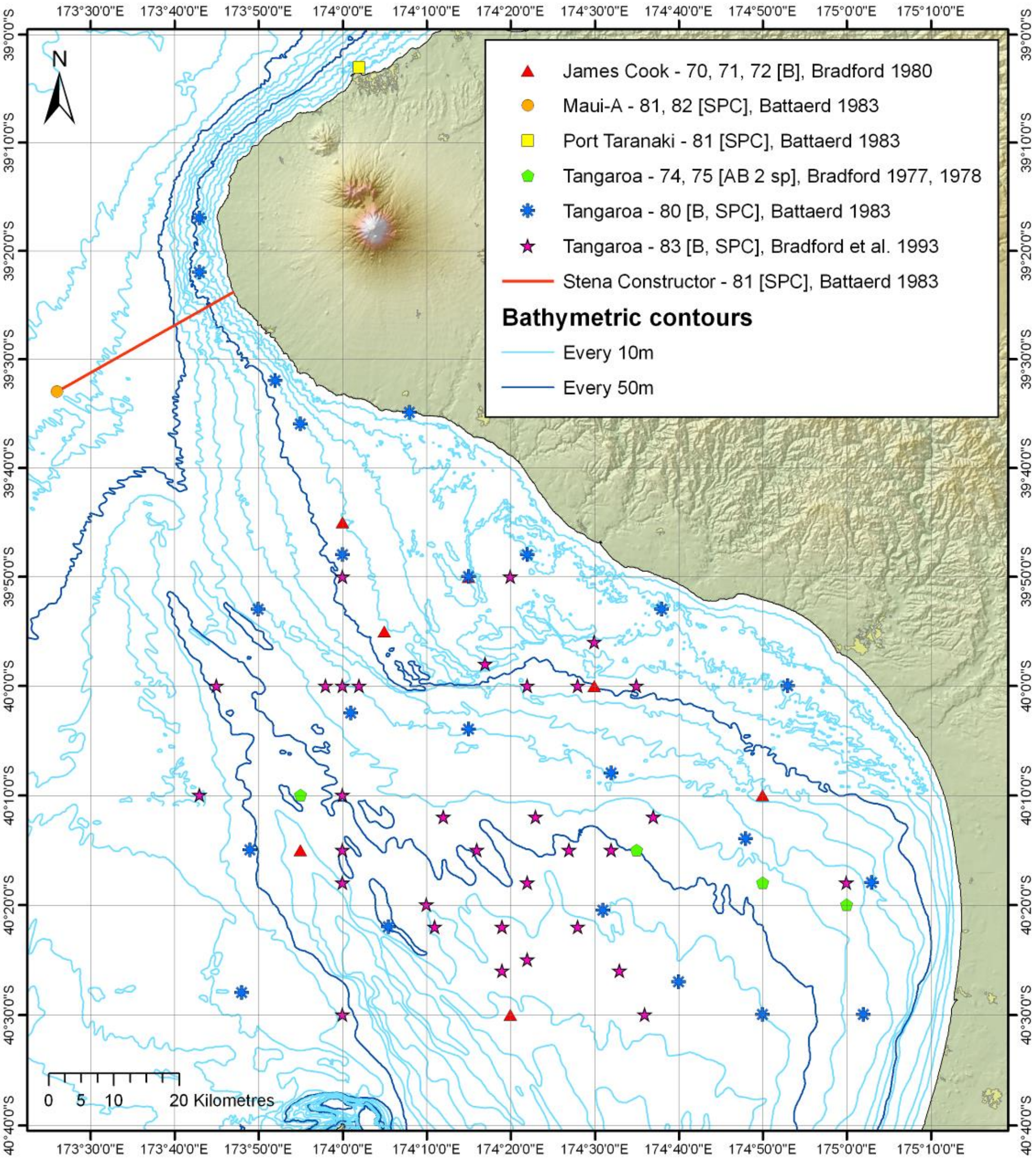

Figure 5.1. Locations in the South Taranaki Bight where mesozooplankton sampling has been conducted. The legend shows the scientific voyages during which samples were collected. The vessel or location is followed by the year of sampling and the reference. Codes refer to the types of samples that were collected where B=biomass, SPC=species composition, and AB 2 sp=abundance data for 2 individual copepod species. A total of 10 stations were sampled at Port Taranaki, but the resolution was too fine to show individual stations on a map of this size. Along the transect from Oaonui to the Maui-A gas platform (*Stena Contructor*), a total of 23 stations were sampled.

Cold-core eddies are released from the upwelling zone off Cape Farewell and meander northward, toward the western approaches to Cook Strait or toward Cape Egmont, depending on local winds (Bowman et al. 1983). This upwelling event is persistent and results in an area of enhanced biological productivity (Bowman et al. 1983). Plankton become entrained in the eddies and move northeastward into STB; copepods are thought to reproduce here, which promotes large aggregations of euphausiids and squid (Bowman et al. 1982). The D'Urville current, that travels eastward through Cook Strait, also influences the movement of the meandering eddies (Bowman et al. 1982).

5.2.2 Biomass

Mesozooplankton biomass has not been extensively measured in the STB and the number of published studies is few. Biomass measurements were taken in the STB aboard the *James Cook* in 1970, 1971, and 1972, and were found to be elevated here (values exceeding 300 mg m^{-3}), as compared to other near-shore regions around New Zealand (Bradford and Roberts 1978; Bradford 1980). Similar levels of mesozooplankton biomass were found during *Tangaroa* voyages in the STB in 1980 (280-400 mg m^{-3}; Battaerd 1983) and 1983 (200 to >300 mg m^{-3}; Bradford et al. 1993).

5.2.3 Species composition

The mesozooplankton community in STB is neritic (near-shore) in origin, and there is very little oceanic influence evident in the species present (Battaerd 1983). The STB zooplankton production and populations appear to result from transport meanders originating at the upwelling zone around Cape Farewell (Battaerd 1983). The dominant species found at all sampling sites (Maui-A platform, STB proper, Port Taranaki) were the *Oithona similis* (reaching 15,000 m^{-3}) and *Paracalanus indicus* (reaching 1200 m^{-3}), both of which are considered neritic copepod species (Battaerd 1983; Foster and Battaerd 1985). Other species and groups that were frequently abundant were copepod nauplii, and the copepods *Microsetella rosea*, *Clausocalanus* spp., *Acartia ensifera*, *Corycaeus aucklandicus*, *Euterpina acutifrons*, and *Temora turbinata* (Battaerd 1983). Gelatinous zooplankton such as appendicularians (*e.g.*, *Oikopleura* spp.) and salps (*e.g.*, *Thalia democratica*) were also episodically dominant. Bradford (1977; 1978) performed a detailed analysis of the coastal distribution of *T. turbinata* and *Centropages aucklandicus* and found relatively low numbers in the STB (2-46 m^{-3} and 0-0.6 m^{-3}, respectively). *T. turbinata* prefers semi-enclosed, semi-tropical embayments with little or no water exchange, while *Centropages aucklandicus* is more abundant in the colder waters surrounding the South Island (<19°C; Bradford 1977; 1978). The neritic fauna observed in the STB region can be subdivided into "coast" and "shelf" groups (Battaerd 1983). The coastal group, which is characterised by species such as *Corycaeus aucklandicus*, *T. turbinata* and *E. acutifrons*, was found in the STB proper.

Around the Cape Egmont coast and at the Maui-A platform, the shelf fauna was more evident, being characterized by occurrences of oceanic species, although not in great numbers (*e.g.*, *Acartia danae*, *Calanus minor*).

5.3 Conclusions

The limited data set available indicates that the STB is biologically productive in terms of mesozooplankton. Biomass estimates are among the highest recorded, when other coastal regions around New Zealand are considered. The STB may represent a breeding ground for zooplankton, which in turn promotes aggregations of larger, mobile, predatory species, particularly squid. The mesozooplankton species composition is neritic (near-shore) and is strongly influenced by the physical oceanography of the region, including both the upwelling events off Cape Farewell and the D'Urville current.

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6. Benthic macrofauna and macroalgae of the South Taranaki Bight

6.1 Introduction

This section of the report describes what is known on the benthic macrofauna and macroalgae of the South Taranaki Bight study area. A variety of databases held by NIWA and Te Papa were used to identify benthic macrofaunal and macroalgal records. Information was also available from existing reports describing the study area.

6.2 The *Trawl* database

NIWA's *Trawl* database contains records of all biological samples collected during fisheries research trawl surveys using NIWA vessels (for example see Stevens et al. 2009). Data are recorded as wet weight of each taxonomic group or species per trawl together with a location, making this one of few fully quantitative datasets available. Data were available from 248 locations from 25 research voyages within the study area.

Squid (mostly *Notodarus sloanii* and *N. gouldi*) was the dominant invertebrate group recorded, both in distribution and size of catch (Figure 6.1a). The wet weight of squid caught in the south western part of the study area in the 50-100 m depth range, was up to 960 kg per trawl. Octopus (*Pinnoctopus cordiformis*) also had a wide distribution with wet weights of up to 8 kg. The largest catches of octopus were in the 50-100 m depth range, mostly in the same location as the largest catches of squid (Figures 6.1a and b).

Two species of crab were recorded within the study area; the paddle crab (*Ovalipes catharus*) and the more abundant hairy red swimming crab (*Nectocarcinus antarcticus*). Neither species was widely distributed, being caught in low numbers and only in depths greater than 100 m. The most abundant decapod group was the shrimps; *Chlorotocus novaezealandiae* and species in the family Crangonidae. These were also recorded only in a few locations and in depths of around 100 m or greater (Figure 6.1b).

There are relatively few samples shallower than 50 m within the study area within the *trawl* database, but it is interesting to note that squid and octopus were the only taxonomic groups recorded in this depth range.

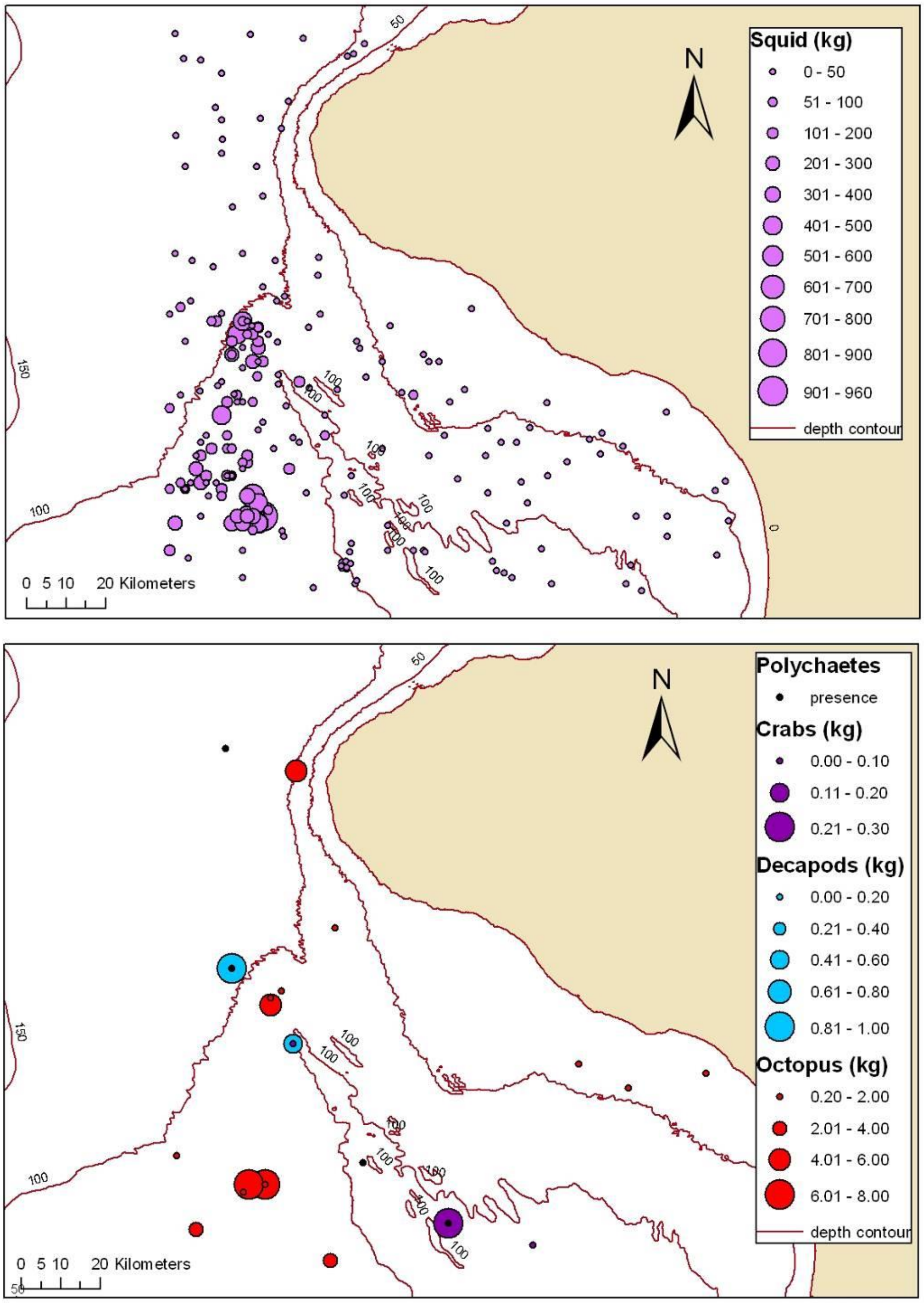


Figure 6.1. Invertebrate data from *Trawl* database: a) location and wet weight per trawl of squid catches on scientific voyages; b) location and wet weight of crabs, non-crab decapods (mostly shrimps), octopods and the presence of polychates and other crustaceans recorded on scientific voyages.

6.3 NIWA's *Specify* database

NIWA's *Specify* database is a collation of benthic invertebrate specimens collected from New Zealand science programmes from 1950 to the present. Data consist of taxonomic identification, location, depth, and research voyage details. It should be noted, however, that these are qualitative rather than quantitative data. Generally only a subset of specimens sampled at each site are recorded into *Specify*, often only "voucher" specimens or specimens of particular interest (i.e. new records for a site). Older surveys are also less well represented in the database than more recent ones. Despite these limitations, the database contains much useful information.

Specify contained 209 records (presence only) of benthic macrofaual invertebrates from the South Taranaki Bight area (Figure 6.2). Arthropoda was the dominant phylum with 53 species records, followed by the Cnidarian with 21 species, Echinodermata with 12 species, Annelida with 4 species, Brachiopoda with 3 species, Mollusca with 3 species, Porifera with 2 species and Chordata (ascidians) with 1 species. Although these data record presence only, the total of 209 individual records (representing 99 different species) from 93 scientific voyages could be indicative of a relatively low benthic macrofaunal diversity.

Within the 0 to 50 m depth range, the general area proposed for sand extraction, there were 98 records from a total of 40 different species; 3 Annelids, 21 arthropods, 1 brachiopod, 11 cnidarians, 3 echinoderms and 1 mollusc (Table 6.1). Again, this is a relatively small species list.

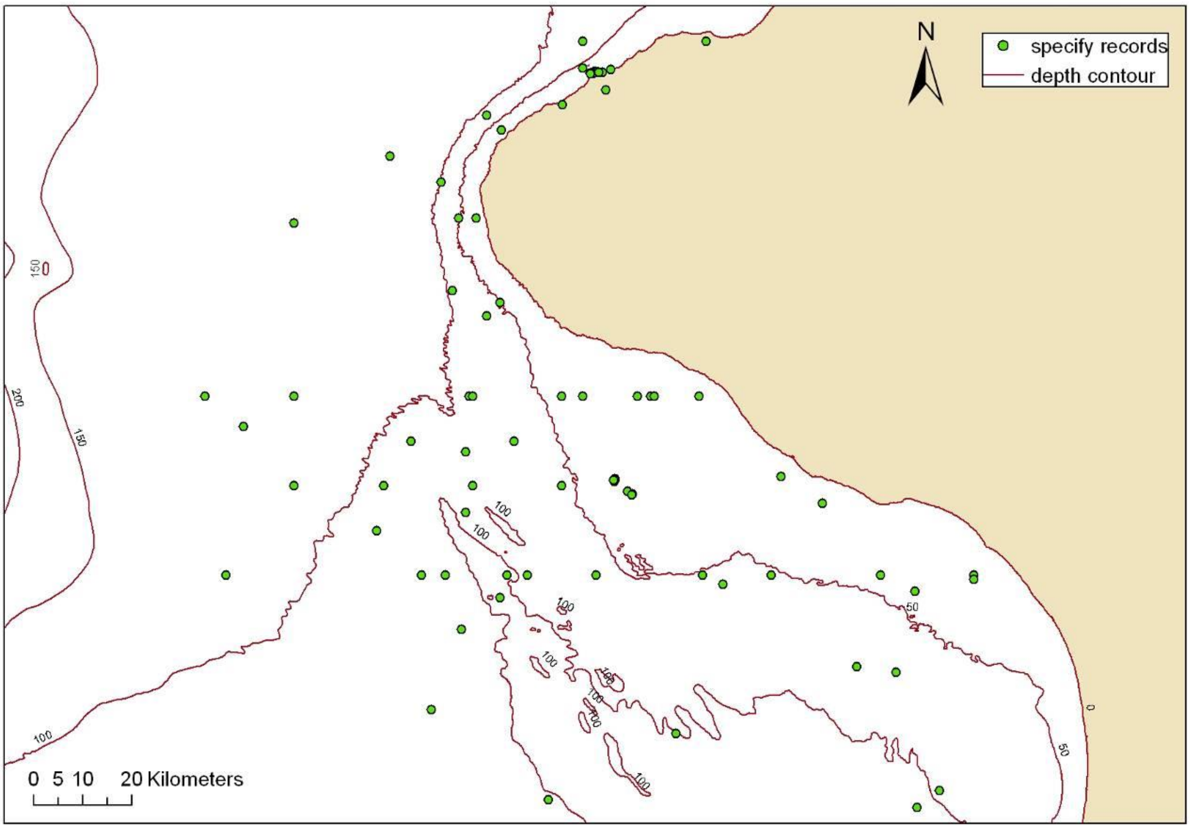


Figure 6.2. Location of all invertebrate records within the study area from the NIWA *Specify* database.

Table 6.1. Taxonomic list of benthic invertebrate records in *Specify* from the 0-50m depth range within the South Taranaki Bight.

Phylum	Class	Order	Family	Genus	Species
Annelida	Polychaeta	Phyllodocida	Syllidae	Clavisyllis	alternata
		Sabellida	Sabellidae	Megalomma	suspiciens
		(blank)	(blank)	(blank)	(blank)
Arthropoda	Malacostraca	Cumacea	(blank)	(blank)	(blank)
		Decapoda	Crangonidae	Pontophilus	australis
			Diogenidae	Paguristes	setosus
			Leucosiidae	Dittosa	cheesmani
			Paguridae	Lophopagurus	laurentae
			(blank)	(blank)	(blank)
		Isopoda	Chaetiliidae	Macrochiridothea	uncinata
			Cirolanidae	Pseudaega	secunda
					(blank)
			Joeropsididae	Joeropsis	(blank)
			Pseudidotheidae	Pseudidotea	richardsoni
					(blank)
			Sphaeromatidae	Cassidinopsis	admirabilis
				Dynamenopsis	varicolor
				Exosphaeroma	montis
				Isocladus	(blank)
	Maxillopoda	Sessilia	Archaeobalanidae	Austrominius	modestus
			Balanidae	Balanus	amphitrite
			Chthamalidae	Chamaesipho	brunnea
					columna
			Tetraclitidae	Epopella	plicata
Brachiopoda	Articulata	Terebratulida	Terebratellidae	Calloria	inconspicua
Cnidaria	Anthozoa	Zoanthidea	Parazoanthidae	(blank)	(blank)
			Zoanthidae	(blank)	(blank)
	Hydrozoa	Leptothecata	Aglaopheniidae	Lytocarpia	vulgaris
			Lafoeidae	Cryptolaria	exserta
			Plumulariidae	Nemertesia	ciliata
					elongata
				Plumularia	insignis
			Sertulariidae	Amphisbetia	bispinosa
					fasciculata
				Crateritheca	insignis
				Stereotheca	elongata
Echinodermata	Asteroidea	Forcipulatida	Zoroasteridae	Zoroaster	spinulosus
		Paxillosida	Astropectinidae	Astropecten	polyacanthus
	Echinoidea	Cidaroida	Cidaridae	Prionocidaris	australis
Mollusca	Bivalvia	Mytiloida	Mytilidae	Xenostrobus	pulex

6.4 National datasets

Data for taxonomic groups with good national coverage were exported from OBIS (Ocean Biogeographic Information System) as well as Mollusc and Algal data from the Museum of New Zealand Te Papa Tongarewa's database system (KEmu). In total there were 1129 mollusc records, 269 algal records, 246 polychaete records, 97 brozoan records, 47 echinoderm records, 34 arthropod records and 1 sponge record within the study area. These data are qualitative rather than quantitative, as many datasets have been collected over time through a combination of detailed surveys and opportunistic collection of interest by scientists and members of the public. As a result they can only be used here as presence-only data and can not be taken as an indication that these, or other, taxa do not exist in other parts of the study area for which no records exist.

There were 404 different species recorded within the study area across all 6 groups. Within the 1129 mollusc records there were 166 gastropod species, 85 bivalve species, 11 scaphopod (limpet) species and 3 polyplacophora species (chitons) (Figure 6.3).

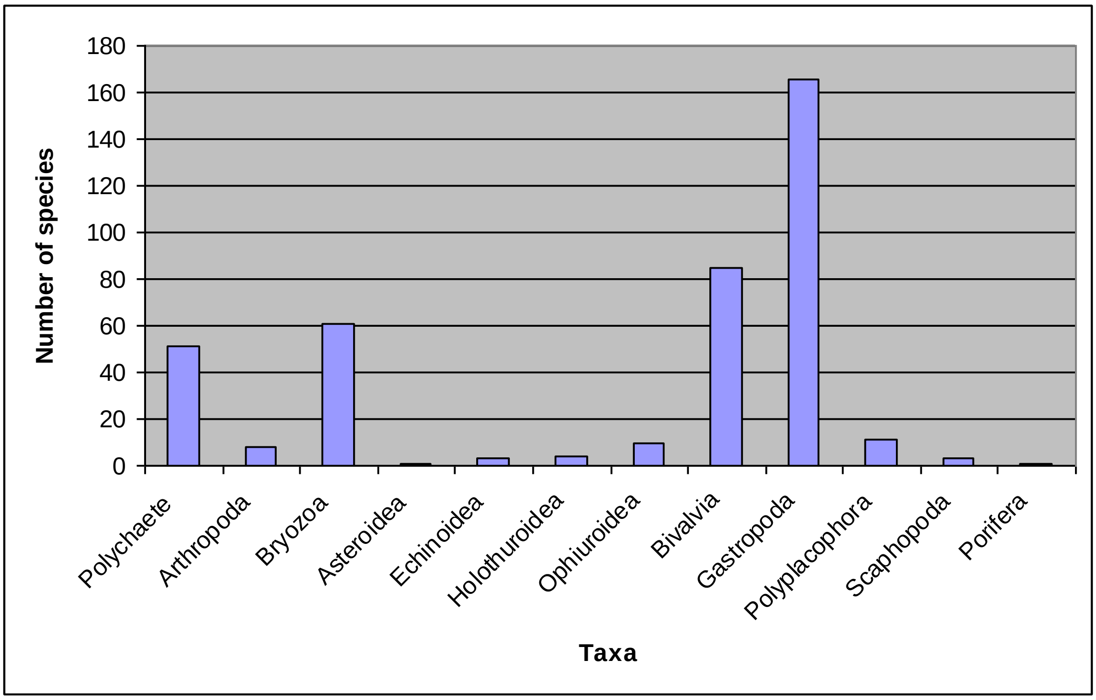


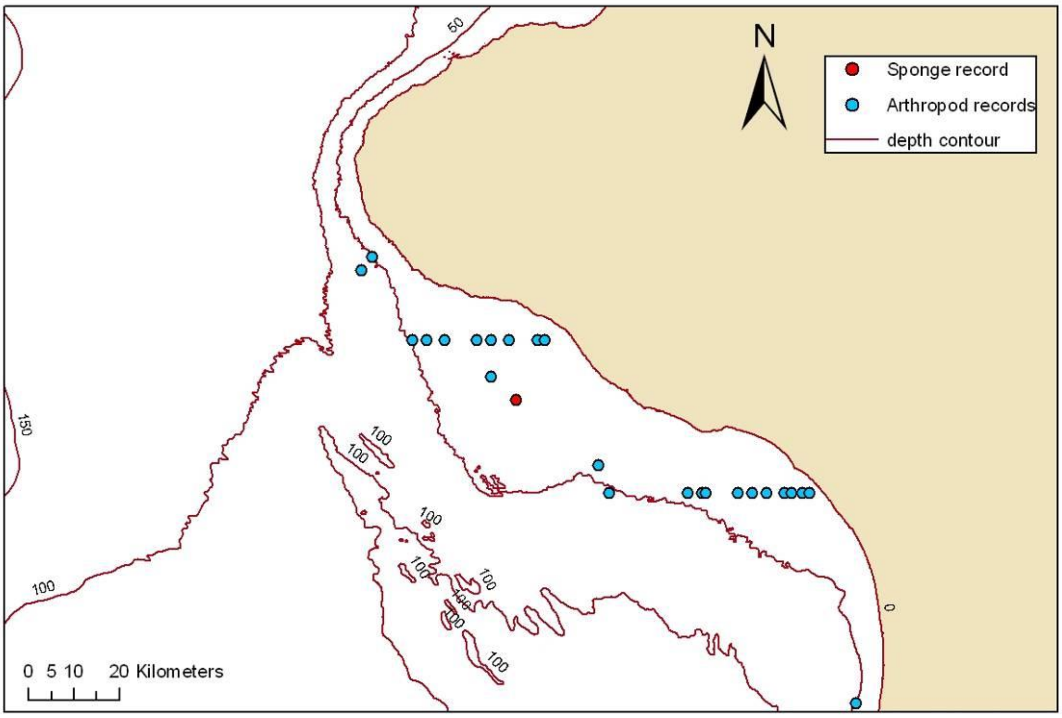
Figure 6.3. Number of species per taxonomic group recorded in the study area. Note that these data are qualitative and direct comparisons between taxonomic groups should be made with caution due to differences in sampling effort between groups.

The arthropod, echinoderm and polychaete records are reasonably well distributed in the near-shore (less than 50 m depth) area of the South Taranaki Bight but with very few records in depths of greater than 50 m (Figures 6.4 and 6.5). Algal records are almost all in the intertidal/very shallow subtidal zone. The few bryozoan records are subtidal but are aggregated in the south east corner of the study area. The mollusc records are more widely distributed, although again there are large areas for which there are no data.

None of the species recorded in the study area are included within the Department of Conservation's NZ Threatened Species Classification System as being at risk or threatened marine species.

Beaumont et al. (2008) used these data to map the environmental values around the New Zealand coastline. When data from the South Taranaki Bight study area are compared with data from the New Zealand coastline as a whole a few trends stand out. Firstly, most taxa have been poorly sampled within the study area compared to many coastal areas of New Zealand. Beaumont et al. (2008) made estimates of species richness of each taxonomic group for each area, taking into account sampling effort. Most taxonomic groups had lower than average (for New Zealand) species richness within the study area, although there did appear to be a higher species richness for algae in the area south of the Whanganui river and for the echinoderms in the area around Cape Egmont in the far north of the study area. Interestingly, the bryozoa had a lower than average species richness in the northern half of the study area but a higher than average species richness between Hawera and Whanganui.

A measure of the distinctness of the species composition was also derived for each taxonomic group (see Beaumont et al. 2008 for details). The measure of distinctness is calculated using a resemblance matrix generated using the Sorenson's index on presence/absence transformed data within PRIMER software (Clarke and Warwick, 2001). The polychaetes and molluscs had a high value and the arthropods and echinoderms had medium values within the South Taranaki Bight area. This indicates that the species compositions of these taxonomic groups from within the study area are quite similar to many other communities around the New Zealand coastline. However, interestingly the bryozoa and algae had low values for species composition, which means that these communties may be distinct from those in other areas around New Zealand.



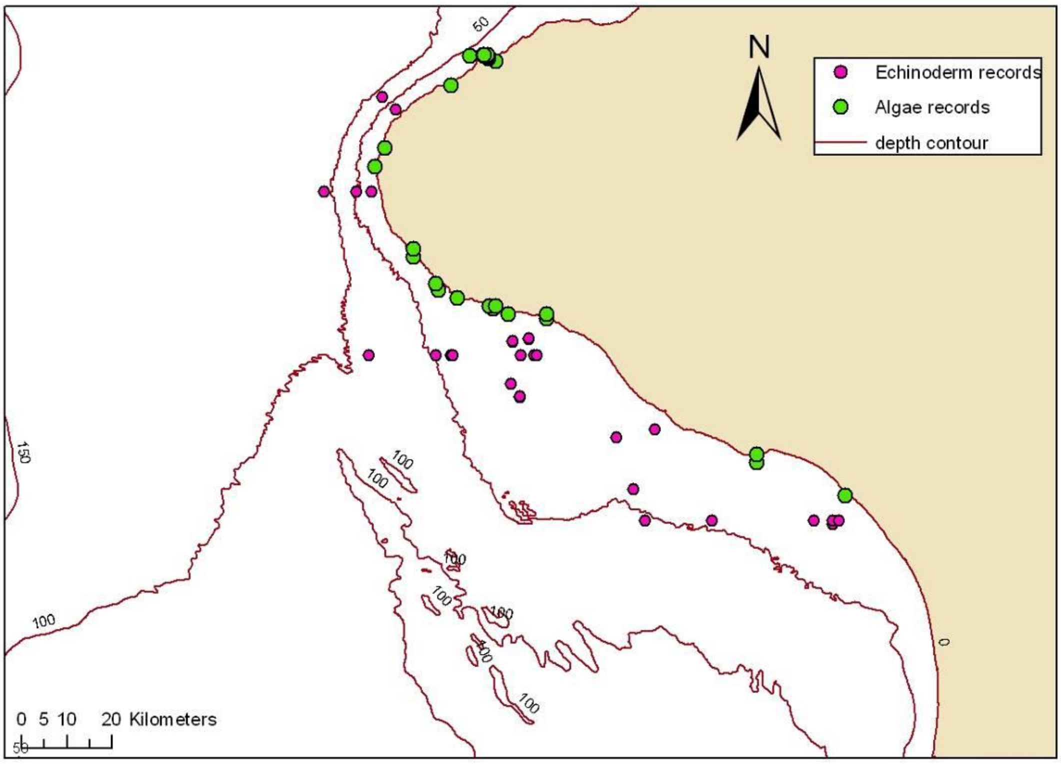


Figure 6.4. The study area showing a) location of sponge and arthropod records within the study area., b) location of echinoderm and algae records

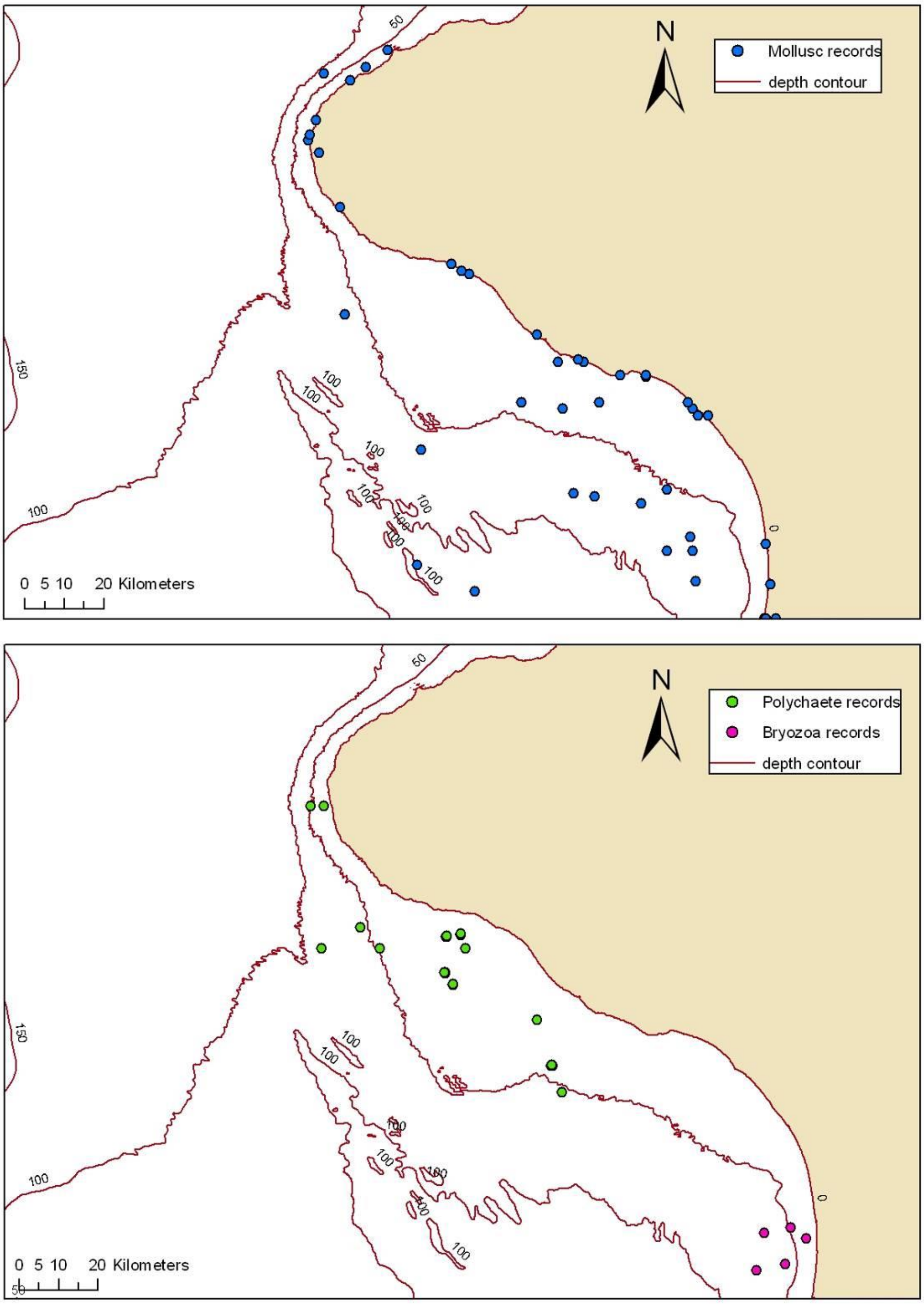


Figure 6.5. The study area showing a) location of mollusc records in the study area, b) location of polychaete and bryozoan records in the study area.

6.5 Other sources of information

A number of reports were written in the late 1970s and early1980s by the University of Auckland for Shell BP and Todd Oil Services in relation to the MAUI platform off the coast of Taranaki. Many of these describe aspects of the biology of marine species in relation to oil dispersants or the biological fouling of the platform structures. However, the report series includes a report on intertidal micromolluscs (and chitons) of the Taranaki coast, and reports on the sponges, barnacles, understone faunas and the bryozoans of the Maui shores (Willan 1980, Bergquist 1979, Foster 1978, Foster 1978b, Gordon 1980). These reports were written as baseline assessments of the shoreline area and as such are mostly descriptive with little perspective on how the fauna of these shores compares with other areas. However, a common theme among these reports is that the coastline is an exposed boulder shore formed of laharic breccia boulders which makes sampling difficult. Many of the boulders are described as being mobile, although in the lower mid-shore the boulders are "fused" by coralline algae.

Bergquist (1979) describes the sponges as constituting a "surprisingly small component of the upper mid and mid shore under boulder fauna". However only rocks of turnable size were inspected within the survey and it is noted that these could be more subject to movement or scouring during wave action than the larger boulders which the author comments would certainly shelter encrusting sponges. This is a view repeated amongst many of the reports for different taxa. Interestingly, Bergquist concludes that the sponge fauna is not particularly rich but suggests that from the species present in the study area that it is necessary to infer considerable mixing of northern and southern elements.

In 2006 the Department of Conservation (DOC) published a report describing the South Taranaki-Whanganui marine area (DOC 2006) using information gathered from the literature as well as from local coastline users through workshops, interviews and questionnaires. The geology of the study area is interesting, with volcanic rock north of Hawera and sedimentary rock with uplifted terraces and highly erodible cliffs in the southern half of the area. In addition, the biology is described as being of low species richness due to a rugged high energy physical environment.

The study area as a whole is an exposed area of coastline with high energy. Much of the seabed of the study area is sandy which is described within the DOC report as having a low diversity and abundance of infaunal species (in comparison to stable reefs). The Graham sand bank is apparently "pure sand" with little living on/in it. Page et al. (1992) identified just 64 infaunal species from sand habitats after sampling with an Anchor dredge, with a mean of just 8 to 15 species recorded per site. It was also noted that the large surface macrobenthic fauna was sparse on all four of the 40 m video transects that were undertaken in the area.

To the south of Hawera, the Papa Rock coast, the seabed is described as having a gentle gradient, reaching approximately 50 m depth at around 12 miles offshore. The area is dominated by sand bars, sand waves, drowned sand dunes and offshore sand bars. Rock reefs extend offshore (to 0.5 km) in the Waverly and Waitotara areas, with rock ledges and gutters. These reefs extend to approximately 8-20 m depth.

Approximately 6 km offshore from Patea there are two adjoining underwater pinnacles, the North and South traps. These are an unusual feature of the sandy coastline and reports from divers suggest that these reef structures support a wide and varied fish, invertebrate and algal community. The Department of Conservation (DOC 2006) suggests that these rocky areas (the sedimentary rock platforms as well as the North and South Traps) appear to be biologically significant for the South Taranaki coast due to the provision of habitat for encrusting and sessile fauna. However, there are little data available for this section of the coast.

To the north of Hawera, on the volcanic coast, large boulder-platform reefs extend, at a low gradient, up to several kilometres offshore. These reefs are described as providing habitat for species such as paua and crayfish, as well as some canopy forming algae, although it is noted that the marine life becomes less abundant beyond the edge of the volcanic debris as the substrate becomes mainly mudstone (DOC 2006). Molluscs are noted as being the dominant mobile species on reefs. Sea urchins are also present but it is noted that they are less dense than other areas of New Zealand with similar habitat structure. It is speculated that this may be due to the large wave height and sediment movement in the nearshore areas within the study area.

6.6 Benthic-pelagic coupling

Primary (Section 3) and secondary (Section 4) pelagic productivity is relatively high in the STB region compared to other similar coastal regions but this does not appear to be translated into dense or diverse benthic macrofaunal communities. This may be to be due to the high energy environment of the area. The available information indicates that the STB region is an energetic area of high wave activity, especially in the north-west of the region and with high current strengths especially over the area of Graham Shoals off Patea (Section 2). In depths less than ~50m this proably results in very mobile sediments, sand inundation of reefs, sand scouring of reef habitats, and high water turbidity in nearshore areas that limits macroalgal production. It may be that much of the unused primary pelagic production and detritus from secondary pelagic production is is consumed by microfauna including bacteria.

6.7 Summary

The available data indicate that in the STB the benthic fauna and flora is generally species poor with a low abundance of organisms in both subtidal and intertidal zones when compared to other coastal areas of New Zealand. This may be to be due to the high energy environment area resulting in very mobile sediments, sand inundation of reefs, sand scouring of reef habitats, and high water turbidity in nearshore areas (DOC 2006). Species numbers and diversity tend to increase towards the shore, with the highest numbers in the nearshore area (Haggitt et al. 2004 in DOC 2006). A species list compiled from all sources is provided in Table 2.

Analysis of data from NIWA's *Trawl* database showed a productive zone in the southwest of the study area where high wet weights of squid, octopus and decapods have been recorded. This offshore productive zone is most likely due to the influence of the cold, nutrient rich water that originates from the upwelling zone off Cape Farewell and the Kahurangi shoals (DOC 2006 and see also Sections 4 and 5). This may explain the rich fishery within the study area (DOC 2006 and section 11) despite the generally low benthic species richness and abundances reported.

In comparison to much of the New Zealand coastline there are few data available on the macrofauna of the South Taranaki Bight and therefore any characterisation based on these data should be treated with caution. However, inspection of a variety of datasets within this study suggests generally low species richness across most taxonomic groups within the area. Analysis of data from the study area with national datasets (Beaumont et al. 2008) did however highlight some potentially interesting community compositions within the bryozoan and algal taxonomic groups.

From the available information, species richness and abundance are particularly low in the sandy habitat within the study area. Coupling of the macrobenthos to the productive pelagic environment appears weak. Benthic macrofaunal communities of the South Taranaki Bight, particularly those inshore and close to sand beds, are often exposed to naturally high levels of disturbance from high wave energy and mobile sediments, including sand scour. No nationally endangered or at risk benthic macrofaunal species were found to be present within the area. However, the Department of Conservation (DOC 2006) describes the Waitotara estuary, Waiinu reef, Waverley Beach, North and South Traps, Whenuakura estuary and Whanganui river estuary, all within the study area, as being "outstanding natural areas".

Table 6.2. A taxonomic list of specimens recorded from the South Taranaki Bight area.

Phylum	Class	Order	Family	Genus	Species	Determination
Annelida	Polychaeta	Phyllodocida	Pilargidae	Synelmis	knoxi	Synelmis knoxi
			Syllidae	Clavisyllis	alternata	Clavisyllis alternata
		Sabellida	Sabellidae	Megalomma	suspiciens	Megalomma suspiciens
		(blank)	(blank)	(blank)	(blank)	Polychaeta
Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	Ampelisca	(blank)	Ampelisca
			Corophiidae	Cerapus	(blank)	Cerapus
				(blank)	(blank)	Corophiidae
			Lysianassidae	(blank)	(blank)	Lysianassidae
			Phoxocephalidae	Torridoharpinia	hurleyi	Torridoharpinia hurleyi
				(blank)	(blank)	Phoxocephalidae
			(blank)	(blank)	(blank)	Amphipoda
		Cumacea	Bodotriidae	Cyclaspis	(blank)	Cyclaspis
			(blank)	(blank)	(blank)	Cumacea
		Decapoda	Crangonidae	Pontocaris	lacazei	Pontocaris lacazei
				Pontophilus	australis	Pontophilus australis
			Diogenidae	Paguristes	pilosus	Paguristes pilosus
					setosus	Paguristes setosus
			Leucosiidae	Dittosa	cheesmani	Dittosa cheesmani
				Ebalia	(blank)	Ebalia
			Majidae	Leptomithrax	garricki	Leptomithrax garricki
					longimanus	Leptomithrax longimanus
				Thacanophrys	filholi	Thacanophrys filholi
			Paguridae	Diacanthurus	rubricatus	Diacanthurus rubricatus
				Lophopagurus	cookii	Lophopagurus cookii
					laurentae	Lophopagurus laurentae
					thompsoni	Lophopagurus thompsoni
			Pandalidae	Chlorotocus	novaezealandiae	Chlorotocus novaezealandiae

		Portunidae	Nectocarcinus	antarcticus	Nectocarcinus antarcticus
		(blank)	(blank)	(blank)	Anomura
		(blank)	(blank)	(blank)	Brachyura
		(blank)	(blank)	(blank)	Decapoda
	Isopoda	Chaetiliidae	Macrochiridothea	uncinata	Macrochiridothea uncinata
		Cirolanidae	Pseudaega	secunda	Pseudaega secunda
				(blank)	Pseudaega
		Gnathiidae	(blank)	(blank)	Gnathiidae
		Joeropsididae	Joeropsis	(blank)	Joeropsis
		Pseudidotheidae	Pseudidotea	richardsoni	Pseudidotea richardsoni
				(blank)	Pseudidotea
		Sphaeromatidae	Cassidinopsis	admirabilis	Cassidinopsis admirabilis
			Dynamenopsis	varicolor	Dynamenopsis varicolor
			Exosphaeroma	montis	Exosphaeroma montis
			Isocladus	(blank)	Isocladus
			(blank)	(blank)	Sphaeromatidae
Malacostraca	Stomatopoda	(blank)	(blank)	(blank)	Stomatopoda
	Tanaidacea	Apseudidae	Apseudes	(blank)	Apseudes
		Colletteidae	Libanius	monokanthus	Libanius monokanthus
		Tanaidae	Zeuxo	phytalensis	Zeuxo phytalensis
		Typhlotanaidae	Typhlotanais	longisetosus	Typhlotanais longisetosus
		(blank)	(blank)	(blank)	Tanaidacea
Maxillopoda	Calanoida	Calanidae	(blank)	(blank)	Calanidae
		Eucalanidae	(blank)	(blank)	Eucalanidae
	Sessilia	Archaeobalanidae	Austrominius	modestus	Austrominius modestus
		Balanidae	Balanus	amphitrite	Balanus amphitrite
		Chthamalidae	Chamaesipho	brunnea	Chamaesipho brunnea
				columna	Chamaesipho columna
		Tetraclitidae	Epopella	plicata	Epopella plicata

	Pycnogonida	Pantopoda	Ammotheidae	Cilunculus	sewelli	Cilunculus sewelli
Brachiopoda	Articulata	Terebratulida	Terebratellidae	Calloria	inconspicua	Calloria inconspicua
				Neothyris	compressa	Neothyris compressa
					lenticularis	Neothyris lenticularis
Chordata	Ascidiacea	(blank)	(blank)	(blank)	(blank)	Ascidiacea [Tunicates]
Cnidaria	Anthozoa	Zoanthidea	Parazoanthidae	(blank)	(blank)	Parazoanthidae
			Zoanthidae	(blank)	(blank)	Zoanthidae
	Hydrozoa	Anthoathecata	Pandeidae	(blank)	(blank)	Pandeidae
		Filifera	Clavidae	Turritopsis	nutricula	Turritopsis nutricula
		Hydroida	(blank)	(blank)	(blank)	Hydroida
		Leptothecata	Aglaopheniidae	Lytocarpia	vulgaris	Lytocarpia vulgaris
			Haleciidae	Halecium	beanii	Halecium beanii
				Hydrodendron	armata	Hydrodendron armata
			Lafoeidae	Cryptolaria	exserta	Cryptolaria exserta
					prima	Cryptolaria prima
			Plumulariidae	Nemertesia	ciliata	Nemertesia ciliata
					elongata	Nemertesia elongata
				Plumularia	insignis	Plumularia insignis
			Sertulariidae	Amphisbetia	bispinosa	Amphisbetia bispinosa
					fasciculata	Amphisbetia fasciculata
				Crateritheca	insignis	Crateritheca insignis
				Salacia	bicalycula	Salacia bicalycula
				Stereotheca	elongata	Stereotheca elongata
				Symplectoscyphus	johnstoni	Symplectoscyphus johnstoni
			Syntheciidae	Synthecium	subventricosum	Synthecium subventricosum
		Trachymedusae	Rhopalonematidae	Aglaura	hemistoma	Aglaura hemistoma
Echinodermata	Asteroidea	Forcipulatida	Zoroasteridae	Zoroaster	spinulosus	Zoroaster spinulosus
		Paxillosida	Astropectinidae	Astropecten	polyacanthus	Astropecten polyacanthus
			Luidiidae	Luidia	neozelanica	Luidia neozelanica

		Valvatida	Odontasteridae	Acodontaster	capitatus	Acodontaster capitatus
	Echinoidea	Cidaroida	Cidaridae	Goniocidaris	corona	Goniocidaris corona
				Prionocidaris	australis	Prionocidaris australis
	Holothuroidea	Dendrochirotida	Phyllophoridae	Neothyonidium	armatum	Neothyonidium armatum
				Pentadactyla	longidentis	Pentadactyla longidentis
		Molpadiida	Caudinidae	Paracaudina	chilensis	Paracaudina chilensis
			Molpadiidae	Heteromolpadia	pikei	Heteromolpadia pikei
		(blank)	(blank)	(blank)	(blank)	Holothuroidea
	Ophiuroidea	Ophiurida	Ophiuridae	Ophiozonoida	(blank)	Ophiozonoida
Mollusca	Bivalvia	Mytiloida	Mytilidae	Xenostrobus	pulex	Xenostrobus pulex
	Cephalopoda	Octopoda	Ocythoidae	Ocythoe	tuberculata	Ocythoe tuberculata
	Gastropoda	(blank)	(blank)	(blank)	(blank)	Gastropoda
Porifera	Demospongiae	Astrophorida	(blank)	(blank)	(blank)	Astrophorida
	(blank)	(blank)	(blank)	(blank)	(blank)	Porifera

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7. Reef associated fish of the South Taranaki Bight

7.1 Introduction

A variety of marine fish species are commonly associated with rocky reef or ‘reef-like’ structures such as wharf piles and oil platforms. Some species occur only on reefs while others occur across a variety of marine habitats, including reefs. Many species support important customary, recreational and/or commercial fisheries. Reef structures on the south Taranaki coastline are often of low relief, and may be subject to occasional burial and exposure dependent on the wave climate, currents and sediment availability. In the context of iron-sand mining, reef habitat and the associated fish community may be vulnerable. We know of no reeef focused surveys of fish in the region. Thus, in this section we use the results of Smith (2008) who estimated expected reef fish abundance in the region from surveys conducted elsewhere, together with a set of environmental and geographical predictors.

7.2 Methods

The predicted distributions and relative abundance of fishes on shallow subtidal reefs around New Zealand were obtained from models produced by Smith (2008). The Department of Conservation kindly provided access to these model results. The predictions were produced by applying boosted regression tree (BRT) regression to dive surveys of fishes, using environmental and geographic variables as predictors. The fish count data consisted of relative abundance recorded by divers on a 5-level abundance scale (0 = absent; 1 = 1; 2 = 2-10; 3 = 11-100; 4 = >100 individuals of a species observed per dive) at 467 sites throughout New Zealand. However the distribution of sites was not uniform, with none of the sites surveyed from along the south Taranaki coast. The closest were at the Sugar Loaf Islands off New Plymouth, at Kapiti Island north of Wellington and in the Marlborough Sounds.

The 15 environmental variables consisted of a range of measures available at high spatial resolution including temperature, salinity, dissolved organic matter, tidal current, wind fetch, distance from coast and several variables defining the characteristics of each dive. BRTs were used to predict the abundance of each species in a 1 km^2 grid for 9,605 grid squares having shallow (< 50 m depth) rocky reefs. The most important variable for explaining variation in fish abundance was sea surface temperature, followed by average fetch and salinity. On average, 64% of the variation in reef fish abundance was explained by the models (Smith 2008).

The model predictions produced by Smith (2008) for each fish species were re-plotted in a Geographical Information System for the region covered by the present study (see Figure 1.1 for map of study region). These predicted distribution maps provide an easily interpreted, visual summary of the parts of the study area inhabited by each species, and its relative abundance (at a coarse level) in the inhabited areas.

7.3 Results

Just 37 of the 72 species of New Zealand reef fish modelled by Smith (2008) are predicted to occur in the region (Table 7.1). Some species such as common roughy, common conger eel and trevally occur very infrequently and on average are likely to observed only once over 2-5 one-hour dives (Table 7.1). Other species such as spectacled triple fin and butterfly perch are very abundant and between 11-100 are likely to be observed during a single one hour dive on reefs along this coastline. Other common species include marble fish, leatherjackets, butterfish, parore, tarakihi, red moki, scarlet wrasse, banded wrasse and all the other species of triplefins.

The distribution and abundance of the thirty-seven reef fishes occurring in the region are provided in Appendix 2. Two species, black angelfish (Fig 7.1) and common roughy (Fig 7.2), are truly rare in the region, predicted to occur on just a few small reef areas. Six other species such as common conger eel (Figure 7.3) (see Table 7.1) have a restricted distribution, occurring at fewer than 50% of the reef areas. All other species are widespread and either occur in low abundance throughout the region (e.g sea perch; Figure 7.4), are moderately common over the entire area (e.g. blue cod, Figure 7.5), or are abundant widely distributed species (e.g. butterfly perch; Figure 7.6).

Table 7.1. Modelled reef fish species predicted to occur on south Taranaki reefs arranged by increasing order of abundance. Specifically, 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100).

Common Name	***Genus species***	**Maximum abundance on reefs within SCUBA range**	**Distribution within region**
Common roughy	*Paratrachichthys trailli*	0.2	Rare
Common conger eel	*Conger verreauxi*	0.3	Restricted
Trevally	*Pseudocaranx dentex*	0.4	Restricted
Kingfish	*Seriola lalandi*	0.5	Widespread
Goatfish	*Upeneichthys lineatus*	0.6	Widespread
Black angelfish	*Parma alboscapularis*	0.6	Rare
Sea perch	*Helicolenus percoides*	0.6	Widespread
Slender roughy	*Optivus elongatus*	0.8	Widespread
Common triplefin	*Forsterygion lapillum*	0.8	Restricted
Blue moki	*Latridopsis ciliaris*	0.9	Restricted
Scaly-headed triplefin	*Karalepis stewarti*	1.1	Widespread
Blue dot triplefin	*Notoclinops caerulepunctus*	1.1	Widespread
Porae	*Nemadactylus douglasii*	1.2	Widespread
Yaldwyn's triplefin	*Notoclinops yaldwyni*	1.4	Widespread
Rock cod	*Lotella rhacinus*	1.5	Widespread
Red pigfish	*Bodianus unimaculatus*	1.6	Restricted
Southern bastard cod	*Pseudophycis barbata*	1.6	Widespread
Blue cod	*Parapercis colias*	1.8	Widespread
Tarakihi	*Nemadactylus macropterus*	1.9	Restricted
Spotty	*Notolabrus celidotus*	1.9	Widespread
Dwarf scorpionfish	*Scorpaena papillosus*	1.9	Widespread

Red-banded perch	*Hypoplectrodes huntii*	1.9	Widespread
Marblefish	*Aplodactylus arctidens*	2	Widespread
Leatherjacket	*Parika scaber*	2	Widespread
Sweep	*Scorpis lineolatus*	2.1	Widespread
Butterfish	*Odax pullus*	2.1	Widespread
Variable triplefin	*Forsterygion varium*	2.1	Widespread
Parore	*Girella tricuspidata*	2.2	Widespread
Blue-eyed triplefin	*Notoclinops segmentatus*	2.2	Widespread
Red moki	*Cheilodactylus spectabilis*	2.6	Widespread
Scarlet wrasse	*Pseudolabrus miles*	2.6	Widespread
Oblique-swimming triplefin	*Obliquichthys maryannae*	2.6	Widespread
Banded triplefin	*Forsterygion malcolmi*	2.7	Widespread
Banded wrasse	*Notolabrus fucicola*	2.8	Widespread
Yellow-black triplefin	*Forsterygion flavonigrum*	2.9	Widespread
Spectacled triplefin	*Ruanoho whero*	3	Widespread
Butterfly perch	*Caesioperca lepidoptera*	3.7	Widespread

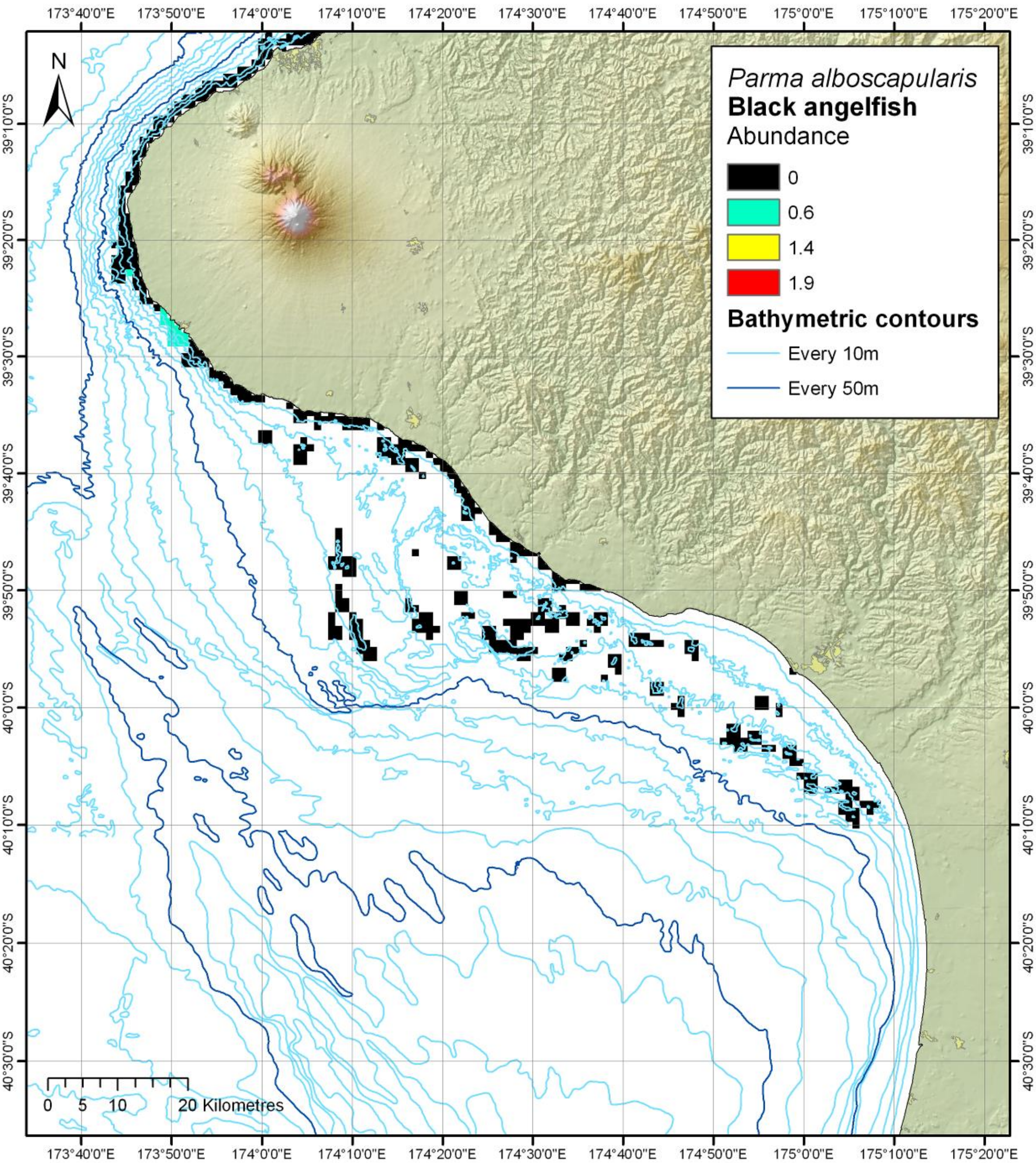

Figure 7.1. Distribution and abundance of black angelfish in the South Taranaki Bight. Note on the scale 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100). Model out provided courtesy of the Department of Conservation.

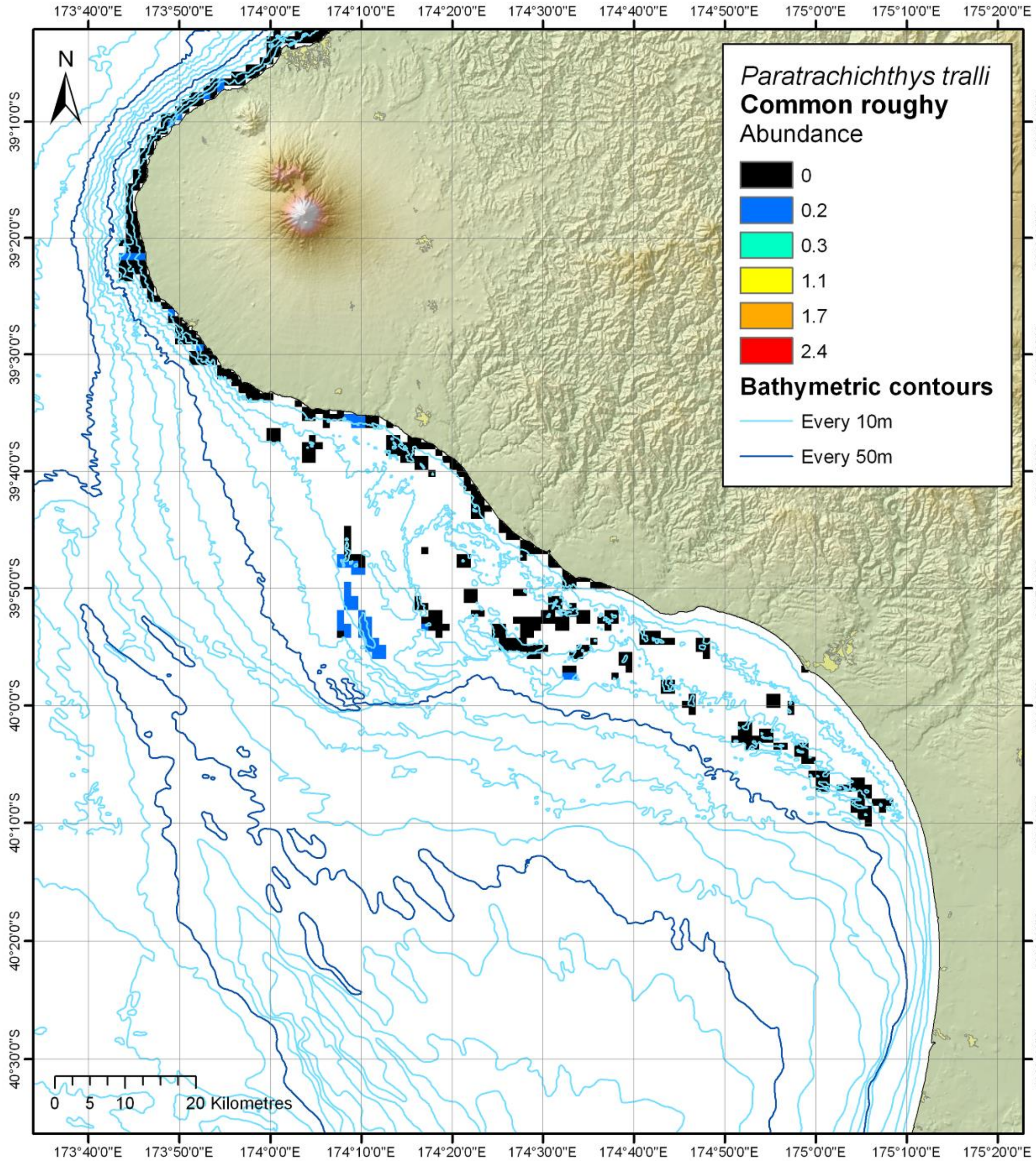

Figure 7.2. Distribution and abundance of common roughy in the South Taranaki Bight. Note on the scale 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100). Model out provided courtesy of the Department of Conservation.

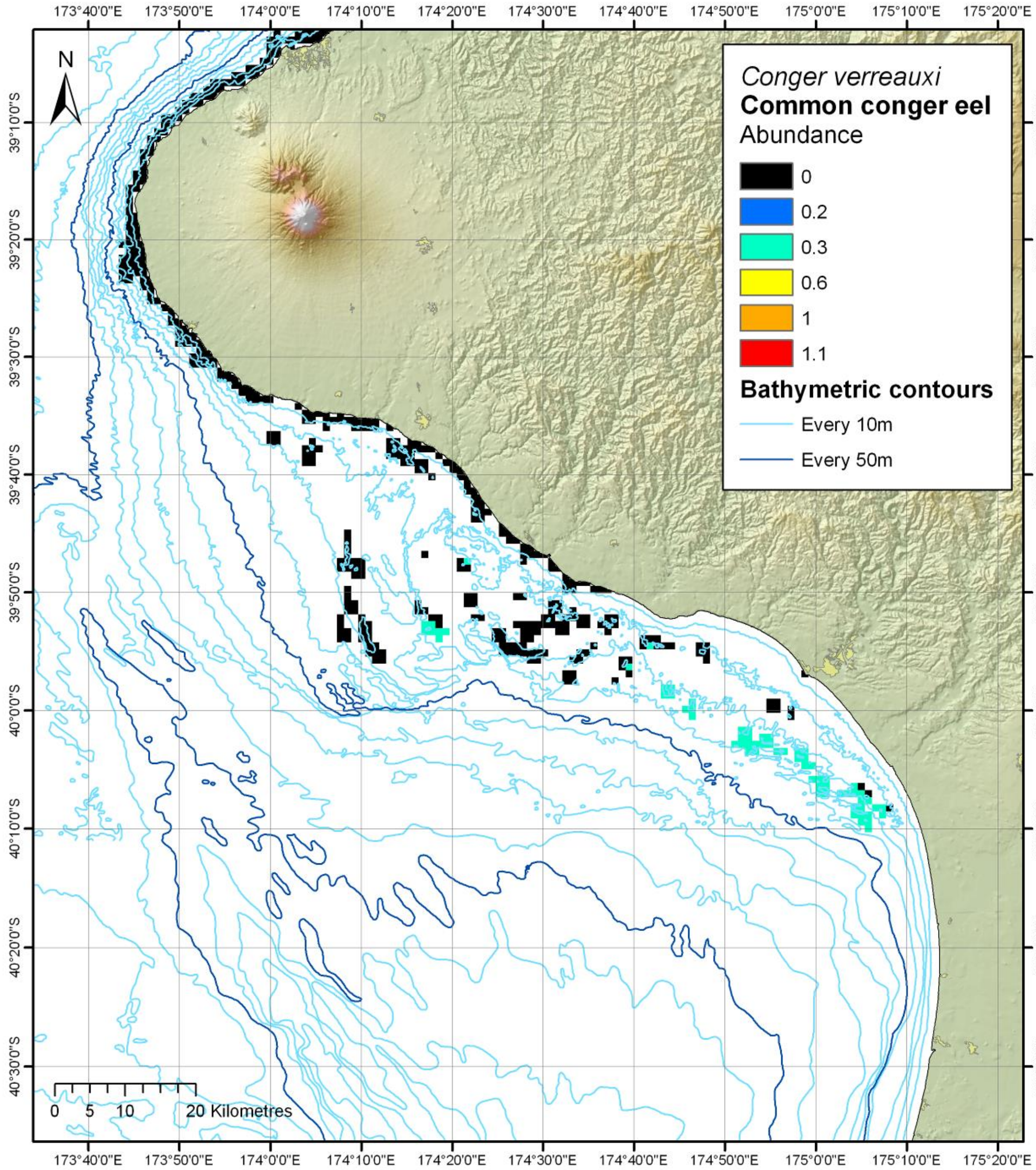

Figure 7.3. Distribution and abundance of common conger eel in the South Taranaki Bight. Note on the scale 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100). Model out provided courtesy of the Department of Conservation.

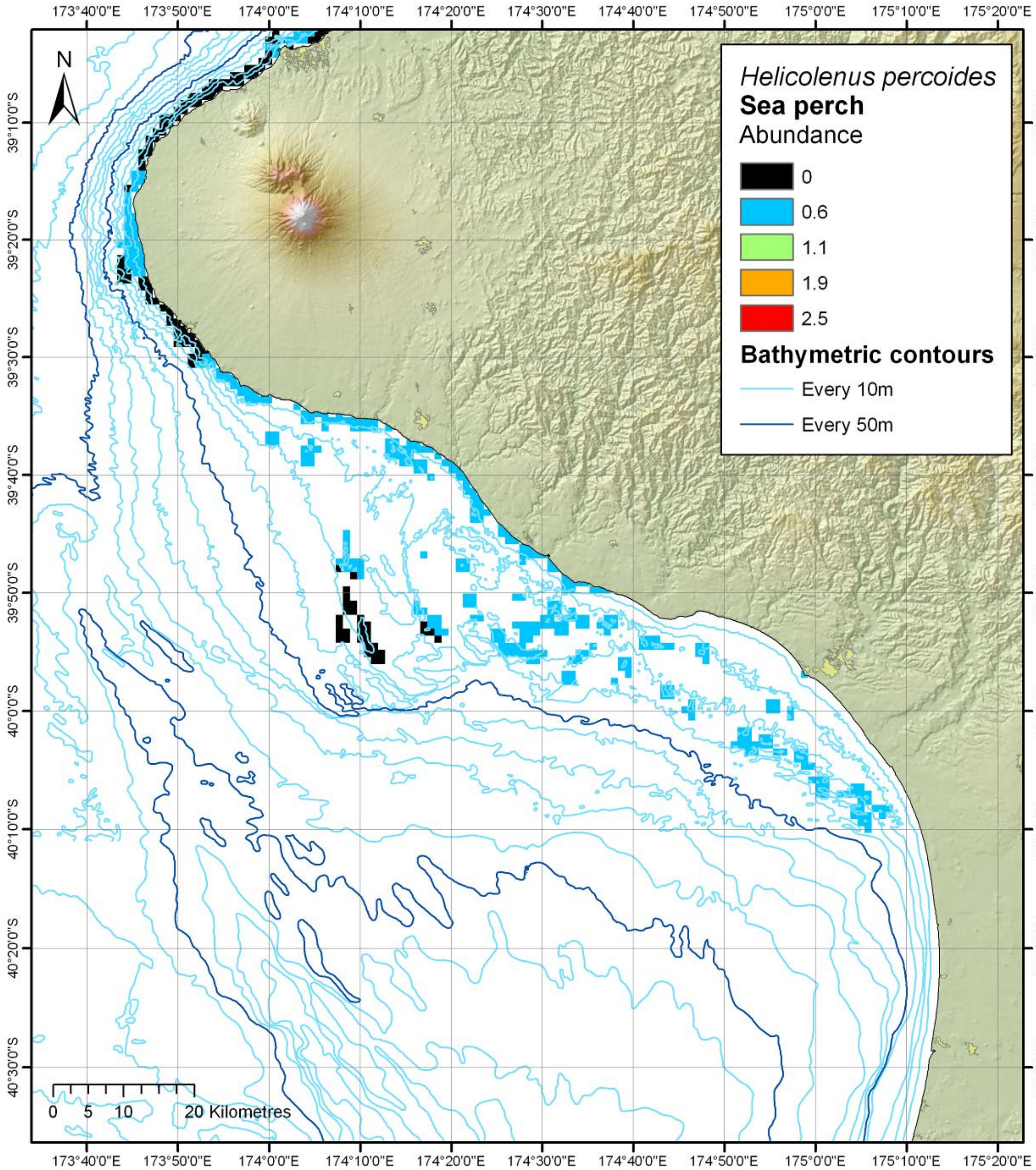

Figure 7.4. Distribution and abundance of sea perch in the South Taranaki Bight. Note on the scale 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100). Model out provided courtesy of the Department of Conservation.

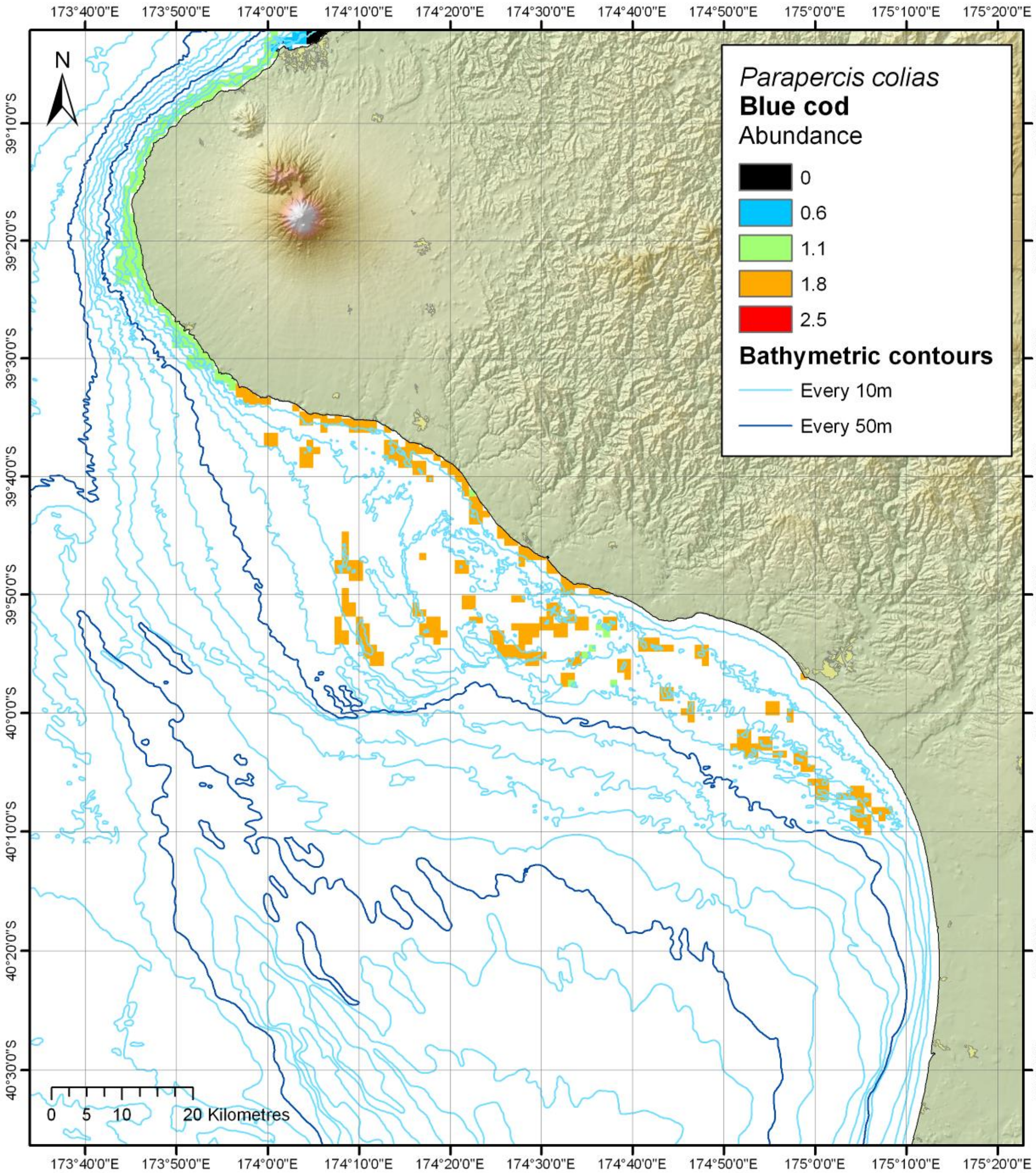

Figure 7.5. Distribution and abundance of blue cod in the South Taranaki Bight. Note on the scale 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100). Model out provided courtesy of the Department of Conservation.

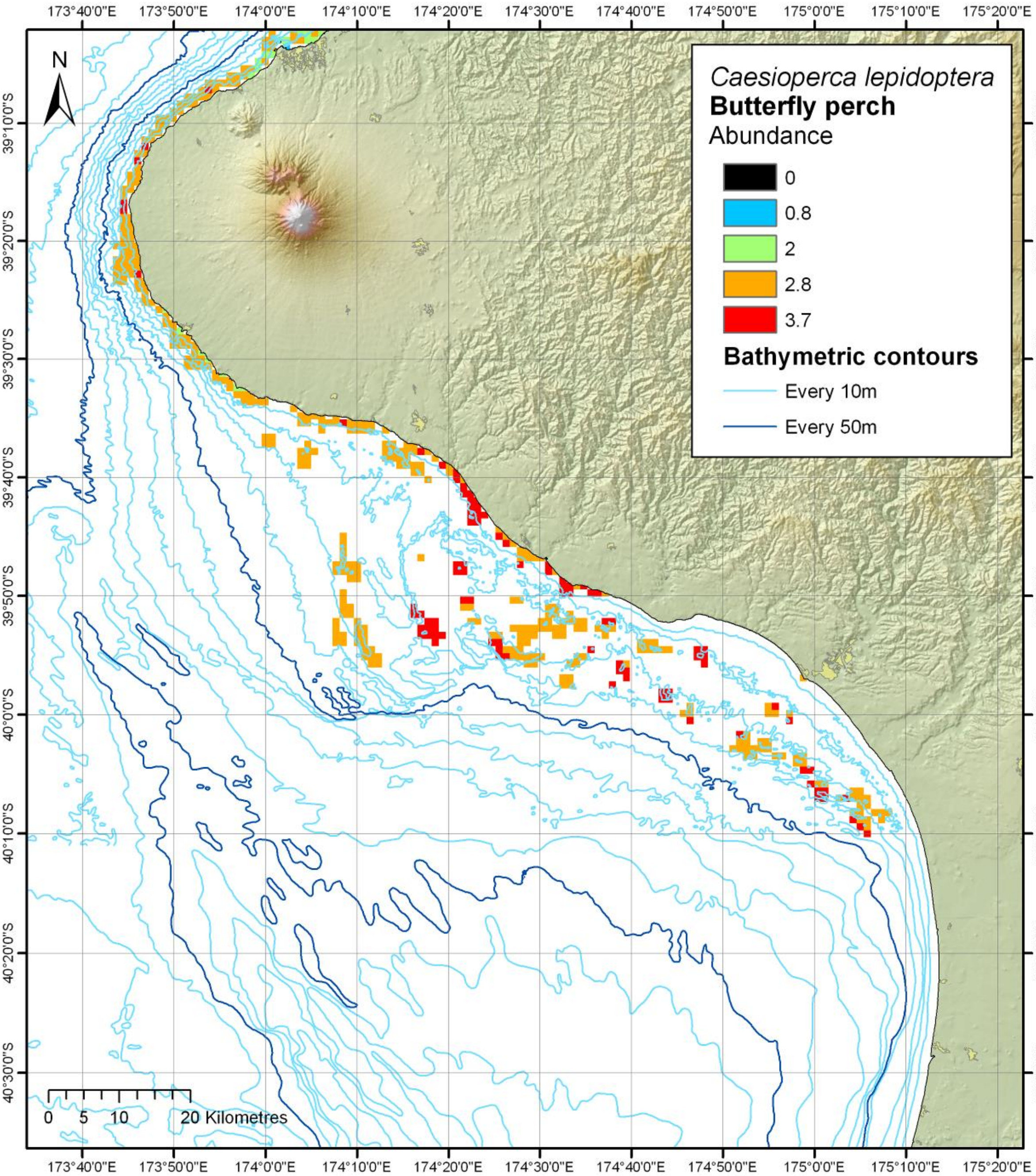

Figure 7.6. Distribution and abundance of butterfly perch in the South Taranaki Bight. Note on the scale 1 = single (1 individual seen per 1 hr dive), 2 = few (2 – 10), 3 = many (11 – 100) and 4 = abundant (> 100). Model out provided courtesy of the Department of Conservation.

7.4 Conclusions

The South Taranaki Bight has a moderately diverse reef fish fauna with only 38 of the 72 species modelled by Smith (2008) New Zealand wide predicted to occur on reefs within SCUBA diving depth range in the region. Two species, black angelfish and common roughy, are predicted to be rare in the region occurring at low abundance on just a few coastal reefs. Six other species have restricted predicted distributions occurring at <50% of the reef sites in the region. All other twenty-nine species are predicted to be much more widespread and either occur in low abundance throughout the region (14 species), are moderately common over the entire area (13 species), or are abundant widely distributed species (2 species).

Despite their elegance and potential utility, Smith (2008) pointed out that his reef fish abundance predictions have a number of limitations. These include problems with counting fishes underwater (e.g. some species are attracted to divers and others are repelled), depth limitations (most dives were to less than 30 m depth), coarse spatial resolution (1 km^2) relative to the scale of habitat variation known to affect reef fish abundance (a few metres to tens of metres), and use of surrogate variables that may be inappropriate for reef fishes (e.g. wind fetch instead of wave exposure). In addition, none of the reef sites surveyed around New Zealand that generated the original data used by Smith (2008) were from along the south Taranaki coast. Thus, these predictions need to be interpreted cautiously. For example, the parore is a fish with a north-eastern North Island centre of distribution and is rarely found as far south as Cook Strait (Ayling 1982), but the modelling predicts it to be moderately abundant in the STB region.

Many of the reef fish are predicted to occur on the off-shore shoals as well as on coastal rocky reefs. In Smith's (2008) study, all seabed features with abrupt changes in vertical relief were assumed to be reef structures, but this may not always be the case. In some cases large sand waves may have been interpreted as reefs and the modelled predictions of reef fish abundance applied to these areas.

7.5 References

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8. Demersal fish abundance and distribution in the South Taranaki Bight

8.1 Introduction

Demersal (bottom associated) fish occur over a variety habitats in the South Taranaki Bight (SBT) region, including sandy habitats. Many species support important commercial, recreational and/or customary fisheries. Mining iron sands may directly or indirectly affect these fish or their habitat. In this section we sumarise the information pertaining to the distribution and abundance of these demersal fish species. There have been many research trawl surveys around New Zealand that have sought to determine their distribution and abundance. Rather than providing the raw information from these surveys for the SBT region we present the predicted distributions and catch levels from statistical models describing the relationships between environment and catch as recorded in data from 21,000 research trawls sampling demersal waters throughout New Zealand's EEZ from 1979-1997 (Leathwick et al. 2006).

8.2 Methods

The biological data layers contained in this section describe the predicted distributions of 51 demersal fish species occurring in the region (Table 8.1). All layers were produced from statistical models describing the relationships between environment and catch as recorded in data from research trawls from only three vessels; RVs James Cook, Kaharoa and Tangaroa. These predictions were derived using a statistical implementation of Boosted Regression Trees (BRT), a recently developed technique that uses stochastic gradient boosting to fit a model (Friedman et al. 2000), enabling sophisticated regression analyses of complex responses, optimised for high predictive performance (Elith et al. 2006; Leathwick et al. 2006). This method differs from conventional regression in that, rather than fitting a single "best" model, it fits an ensemble or "committee" of simple regression tree models that are then combined to form predictions.

Two statistical models were fitted for each species and combined to predict spatial variation in standardised catch; the first described the probability of a catch from presence/absence transformed data from all trawls; the second described the amount of fish caught conditional on a catch occurring, and used log-transformed catch data from only those trawls in which the species were caught. These models were then used to predict both the probability of capture and catch (kg/trawl) under standardised trawl conditions. Predictions were made for all 1 km grid cells. Grids are defined within the Clarke 1866 Mercator projection, i.e. the same projection as used for Marine Environments Classification (MEC) (Snelder *et al.* 2007). Further details of the modelling methods are provided in Leathwick et al. (2006).

Table 8.1. Species codes for 51 demersal fish species, and their equivalent common and scientific names.

Code	Common name	Scientific name
ANC	Anchovy	*Engraulis australis*
BAR	Barracouta	*Thyrsites atun*
BCO	Blue cod	*Parapercis colias*
BRA	Short-tailed black ray	*Dasyatis brevicaudata*
CAR	Carpet shark	*Cephaloscyllium isabellum*
CBE	Crested bellowsfish	*Notopogon lillei*
CUC	Cucumber fish	*Chlorophthalmus nigripinnis*
EGR	Eagle ray	*Myliobatis tenuicaudatus*
ELE	Elephant fish	*Callorhinchus milii*
EMA	Blue mackerel	*Scomber australasicus*
ESO	N.Z. sole	*Peltorhamphus novaezeelandiae*
FRO	Frostfish	*Lepidopus caudatus*
GSP	Pale ghost shark	*Hydrolagus bemisi*
GUR	Gurnard	*Chelidonichthys kumu*
HAK	Hake	*Merluccius australis*
HAP	Hapuku	*Polyprion oxygeneios*
HOK	Hoki	*Macruronus novaezelandiae*
JDO	John dory	*Zeus faber*
JMD	Horse mackerel	*Trachurus declivis*
JMM	Murphys mackerel	*Trachurus symmertricus murphyi*
JMN	Golden mackerel	*Trachurus novaezelandiae*
KAH	Kahawai	*Arripis trutta*
KIN	Kingfish	*Seriola lalandi*
LEA	Leatherjacket	*Parika scaber*
LIN	Ling	*Genypterus blacodes*
LSO	Lemon sole	*Pelotretis flavilatus*
NSD	Northern spiny dogfish	*Squalus griffini*
PCO	Ahuru	*Auchenoceros punctatus*
POP	Porcupine fish	*Allomycterus jaculiferus*
RBM	Rays bream	*Brama brama*
RBT	Redbait	*Emmelichthys nitidus*
RCO	Red cod	*Pseudophycis bachus*
RMU	Red mullet	*Upeneichthys lineatus*
SCG	Scaly gurnard	*Lepidotrigla brachyoptera*
SCH	School shark	*Galeorhinus galeus*
SDO	Silver dory	*Cyttus novaezealandiae*
SFL	Sand flounder	*Phombosolea plebeia*
SKI	Gemfish	*Rexea solandri*
SNA	Snapper	*Pagrus auratus*
SPD	Spiny dogfish	*Squalus acanthias*
SPE	Sea perch	*Helicolenus spp.*
SPO	Rig	*Mustelus lenticulatus*
SPZ	Spotted stargazer	*Genyagnus monopterygius*
SSI	Silverside	*Argentina elongata*
STY	Spotty	*Notolabrus celidotus*
SWA	Silver warehou	*Seriolella punctata*
TAR	Tarakihi	*Nemadactylus macropterus*
TRE	Trevally	*Pseudocaranx dentex*
WAR	Common warehou	*Seriolella brama*
WIT	Witch	*Arnoglossus scapha*
YBF	Yellow-belly flounder	*Rhombosolea leporina*

Environmental predictors used in this analysis (shown in Table 8.2) were based on those used by Leathwick et al. (2006) with modifications as follows. Estimates of sea floor water temperature and salinity were derived from the World Oceans Atlas (Boyer et al. 2005) as described in Pinkerton et al. (2005). Estimates of suspended particulate matter and dissolved organic matter were derived from a case-2 analysis of satellite imagery (Pinkerton & Richardson 2005), and for consistency, estimates of chlorophyll-*a* concentrations (a proxy for micro-algal biomass) were also derived from a case-2 analysis.

Table 8.2. Environmental and trawl variables used in predicting the distribution of demersal fish species across New Zealand's Exclusive Economic Zone.

Variable	Details
AvgDepth	Average depth (m)
Temperature	Estimated temperature at the sea floor (^{o}C)
Salinity	Estimated salinity at the seafloor (psu)
ChlaCase2	Chlorophyll-a concentration – derived from case-2 algorithm (ppm)
SSTGrad	Sea surface temperature spatial gradient (^{o}C km^{-1})
TidalCurr	Depth averaged tidal currents (ms^{-1})
Slope	Sea-floor slope (^{o})
SusPartMat	Suspended particulate matter (approximate to g m^{-3})
OrbVel	Wave-induced orbital velocity at the seafloor (m s^{-1})
DisOrgMat	Dissolved organic matter (dimensionless index)
CodendSize	Mesh-size of the trawl cod-end (mm)
Distance	Trawl distance (nm)
Pentade	Year of trawling grouped in five-year intervals
Speed	Trawl speed (kn.)

8.3 Results

8.3.1 Predicted fish distributions

The modelled distributions (probability of occurrence (%) in trawl catches) of the demersal fish species occurring in the South Taranaki Bight region are provided as maps (on a 1-km grid) in Appendix 3, and the main depth ranges of the modelled predictions for each species are summarised in Table 8.3. The distribution of leatherjackets is shown as an example in Figure 8.1. They are particularly common inshore on shallow reefs and in 20-50m along the whole South Taranaki Bight and also in Tasman Bay. There are similar distinct distributions for many of the species.

Table 8.3. Main depth ranges for the predicted catch rates, by species. Note that several species are not included in this table: for hake the predicted distribution was mainly concentrated in patches in 20–100 m in Tasman Bay and in Cook Strait; Murphy's mackerel was common only on the southern flanks of Cook Strait.

Depth range	Species
< 50 m	anchovy, elephant fish, eagle ray, kahawai, kingfish, leather jacket, lemon sole, New Zealand sole, ahuru, sand flounder, snapper, spotted stargazer, spotty, short-tailed black ray, yellow-bellied flounder, red mullet, trevally, common warehou
< 100 m	blue cod, blue mackerel, cucumberfish, red gurnard, john dory, kingfish, porcupine fish,
< 150 m	golden mackerel, rig, scaly gurnard
< 200 m	Barracouta, ling, red cod, spiny dogfish, school shark, tarakihi
> 50-200 m	carpet shark, frostfish, hapuku, horse (greenback jack) mackerel and witch.
100–150 m	Gemfish, Murphy's mackerel, mirror dory, crested bellowsfish, redbait, and seal shark.
100–200 m	hapuku, horse mackerel, common warehou, northern spiny dogfish, ray's bream, sea perch, silverside, spiny dogfish,
150-200 m	bluenose, crested bellowsfish, gemfish, hoki, pale ghost shark, capro dory, silver warehou and silver dory

For some species there are well-defined concentrations of higher predicted catch rates within the broad depth ranges given in Table 8.3; for example, leather jackets, golden mackerel, eagle rays and blue cod. Some species were particularly common through the whole region, particularly baracoutta, carpet sharks, gurnard, school shark, spiny dogfish and tarakihi.

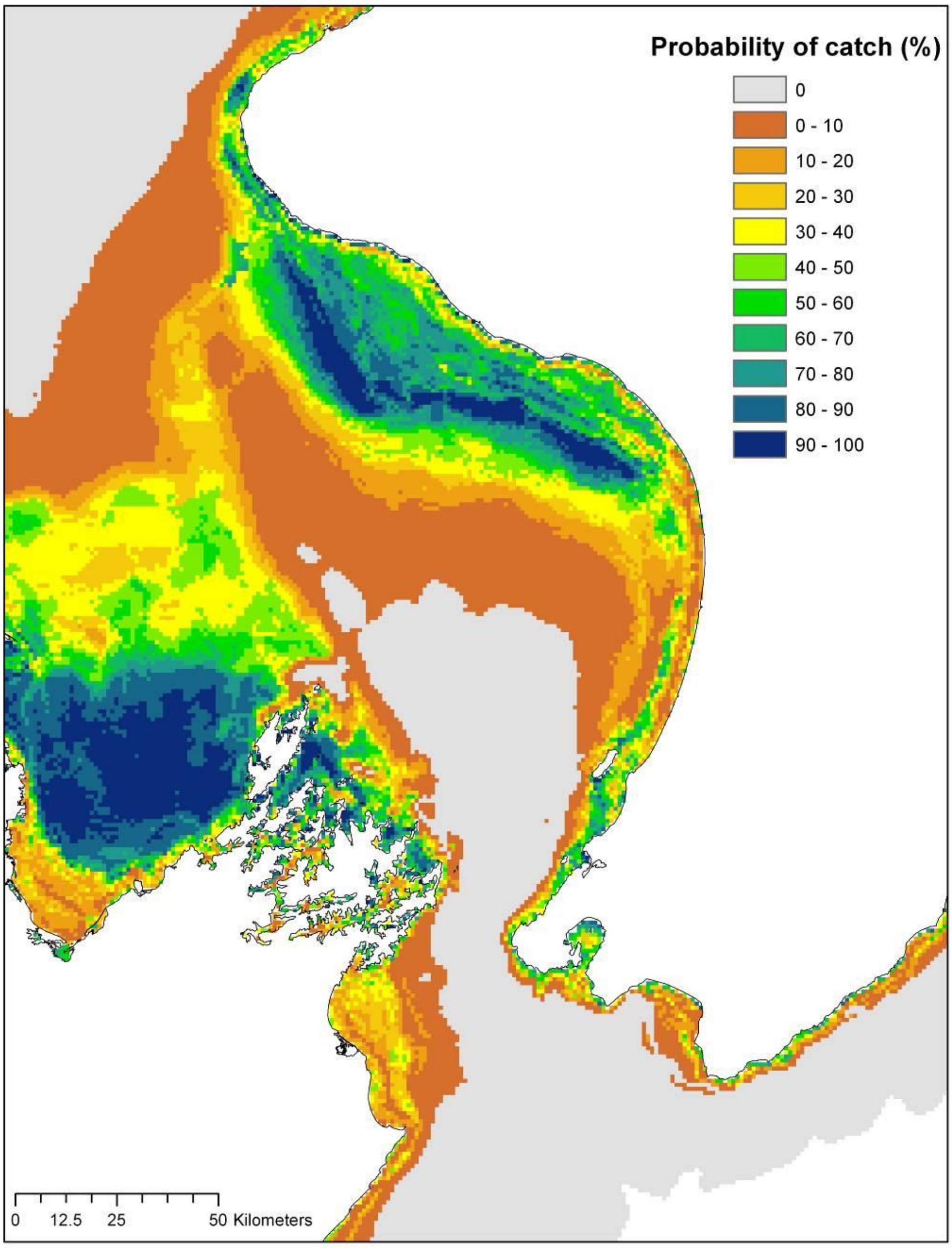

Figure 8.1. Probability of occurrence (%) of leatherjackets (*Parika scaber*) in a demersal trawl in the South Taranaki Bight region

Species such as elephant fish, New Zealand sole, kahawai, kingfish, ahuru, pilchard, sand flounder, snapper, rig, spotted stargazer, spotty, trevally, short-tailed black ray, and yellow-bellied flounder showed distinct inshore distributions.

Species with main distributions along the South Taranaki coastline that coincide with areas of interest to TTR include anchovy, blue cod, eagle rays, gurnard, golden mackerel, leather jacket, lemon sole, snapper, rig and trevally.

8.3.2 Predicted fish catch rates

Maps of the predicted maximum catch rates (kg per trawl) for each species are provided in Appendix 4. The catch of leather jackets is provided (Figure 8.2) for comparison with Figure 8.1. In the South Taranaki Bight north of Cook Strait catch rates varied widely between species, with about 10 species having less than 10 kg per trawl (Table 8.4). Generally the distributions of these catches were very patchy, though some exceptions include some shark species, soles, orange perch, redbait, and witch. Those species with higher maximum catch rates were more likely to have widespread distributions within their predicted depth ranges, but the concentration of higher catch rates was not necessarily uniform throughout their predicted range (e.g. barracouta, golden mackerel, and snapper). Barracouta, school shark and spiny dogfish were abundant throughout the region.

Table 8.4. Distribution of maximum predicted catch rates (kg per trawl), by species.

Catch rate (kg per trawl)	Species
< 5	anchovy, ahuru, short-tailed black ray, crested bellowsfish, hake, blue mackerel, pale ghost shark, silverside, spotted stargazer
5–10	witch
10–50	blue cod, cucumber fish, elephant fish, kingfish, New Zealand sole, lemon sole, ling, porcupine fish, ray's bream, red bait, red mullet, scaly gurnard, spotty, yellow-bellied flounder
50–100	carpet shark, gemfish, john dory, kahawai, , northern spiny dogfish, sea perch, silver warehou, common warehou
100–500	eagle ray, frostfish, hapuku, horse mackerel, Murphy's mackerel, golden mackerel, Red gurnard, sand flounder, silver dory, snapper, rig, tarakihi, trevally,
500–1,000	red cod, school shark
1000-10,000	leather jacket, spiny dogfish, barracouta, hoki

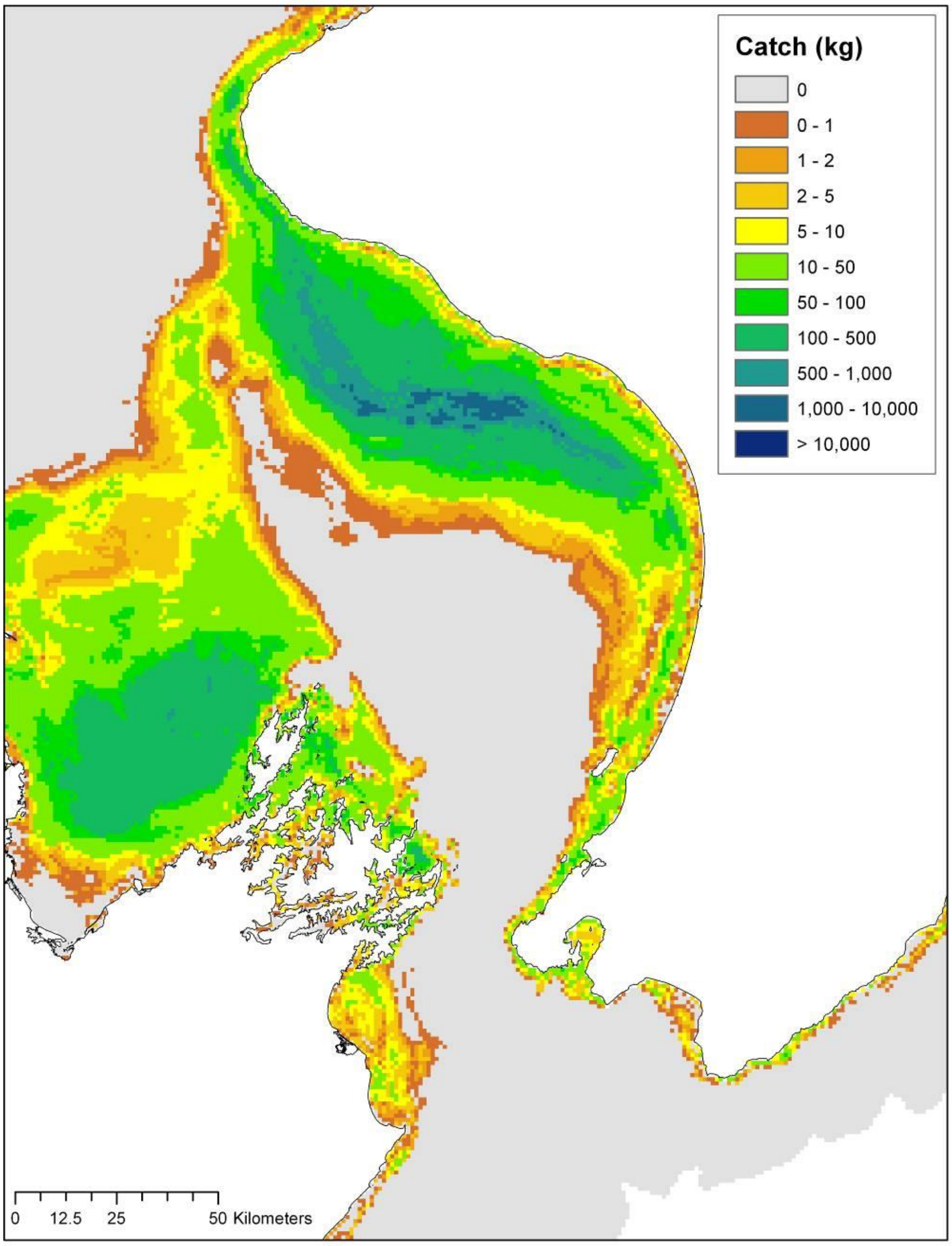

Figure 8.2. Predicted catch (kg) of leatherjackets (*Parika scaber*) in a demersal trawl in the South Taranaki Bight region

8.3.3 Demersal fish species richness

Leathwick et al (2006) indicate that over a broad region of the South Taranaki Bight demersal fish species richness is predicted to be a moderate 12-16 species per standard research bottom trawl with slightly lower richness (8-12 species) in depths <50m off Patea and slightly higher richness (16-20 species) inshore in the south-east of the region north of Kapiti Island towards Whanganui. This compares with the northern flank of the Chatham Rise and continental slopes along the north-eastern flank of South Island and south-eastern flank of North Island that have predicted richness in excess of 20 species per tow. Leathwick et al (2006) also note that generally species richness also increased with increasing chlorphyll *a* concentrations. Thus areas in the region subject to upwelling, such as north of Farewell Spit, may support more diverse demersal fish assemblages.

8.3.4 Data gaps

A good representation of research trawls (666 trawls; 3% of the NZ EEZ total) ranging in depth from 4-1410 m appears within the region of interest. In general, there is good spatial coverage throughout the region although the trawls did span 26 years from 1979 to 2006.

Although effort from trawl surveys throughout the EEZ is included in the modelling, there are seasonal distribution biases that could confound the predictions, given that some species migrate. Use of predictors describing trawl distance, cod-end mesh size and trawl speed contributed substantially to the analysis outcome, with the first of these variables explaining nearly 25% of the variation (Leathwick et al 2006).

The study area is a wide shelf area with a variable environment, particularly towards Farewell Spit and Cook Strait. Factors such as water clarity and catchability rates may vary with time of year, time of day, depth, and latitude or local area, and the environment is frequently influenced by the flow of oceanic water and upwellings through Cook Strait and north of Farewell Spit (see sections 4.2.1 and 4.2.2). The effects of these environmental changes may define the presence or absence of a species.

8.4 Conclusions

Fifty-one species of demersal fish occur in the region. The richness of this assemblage is moderate on a New Zealand wide scale with on average 12-16 species likely to occur within a standard research tow. A few species are very widespread and abundant but most species are common only within a restricted depth range. A few species had a very restricted distribution in the region.

Species with main distributions along the South Taranaki coastline that coincide with areas of interest to TTR include anchovy, blue cod, eagle rays, red gurnard, golden mackerel, leather jacket, lemon sole, snapper, rig and trevally.

Depth, temperature, and salinity are the main predictors of demersal fish species abundance (Leathwick et al. 2006).

The modelling is performed on data collected over many years so that inter-annual variations or trends in demersal fish abundance and distributions have been ignored.

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9. Whales and dolphins of the South Taranaki Bight

9.1 Methods

Two datasets of opportunistic sightings of cetacean species were used to describe their distribution patterns along the southern and northern Taranaki bights within the 12 nm territorial sea of New Zealand: (1) The Department of Conservation (DOC) cetacean sightings data, and (2) a dataset compiled by Martin Cawthorn of incidental cetacean sightings by transiting cargo ships. These are presence data, not presence/absence data i.e. the absence of a sighting record within part of a region does not mean the species never occurs there. Thus these data must be interpreted cautiously when drawing conclusions about the use of the region by particular cetacean species.

Cetaceans are highly mobile and dynamic animals which travel quickly between areas in search of prey and preferred habitat. Therefore, this examination of the distribution of cetaceans was conducted at 2 scales: (1) within the South Taranaki Bight (STB) region, and (2) within a 25 km buffer area adjacent to the STB region. This second area provides increased information about species distribution immediately beyond the STB region.

9.2 Results

9.2.1 Overview

In summation, these two datasets provide 64 records of 13 different cetacean species sighted between February 1980 and December 2007 within the STB region, and 123 records of 15 different cetacean species sighted between February 1980 and March 2008 within the 25 km buffer area (Figure 9.1, Tables 9.1 and 9.2). Within this dataset there are sighting records of three Nationally Critical or Endangered species: Killer whale (*Orcinus orca*), Maui's dolphin (*Cephalorhynchus hectori maui*), and Southern right whale (*Eubalaena australis*). Seasonal variation in the number of cetacean sightings is apparent within this dataset. There is a peak in sightings during summer months (Dec – Feb), followed by Spring (Sep - Nov) and Winter (Jun - Aug) months, with the least number of sightings during Autumn (Mar – May) (Figure 9.2, Tables 9.1 & 9.2).

Cautious interpretation of these datasets is warranted due to a lack of information on observation effort and absence data. However, apparent trends in spatial and temporal distribution patterns of these cetacean species are described below.

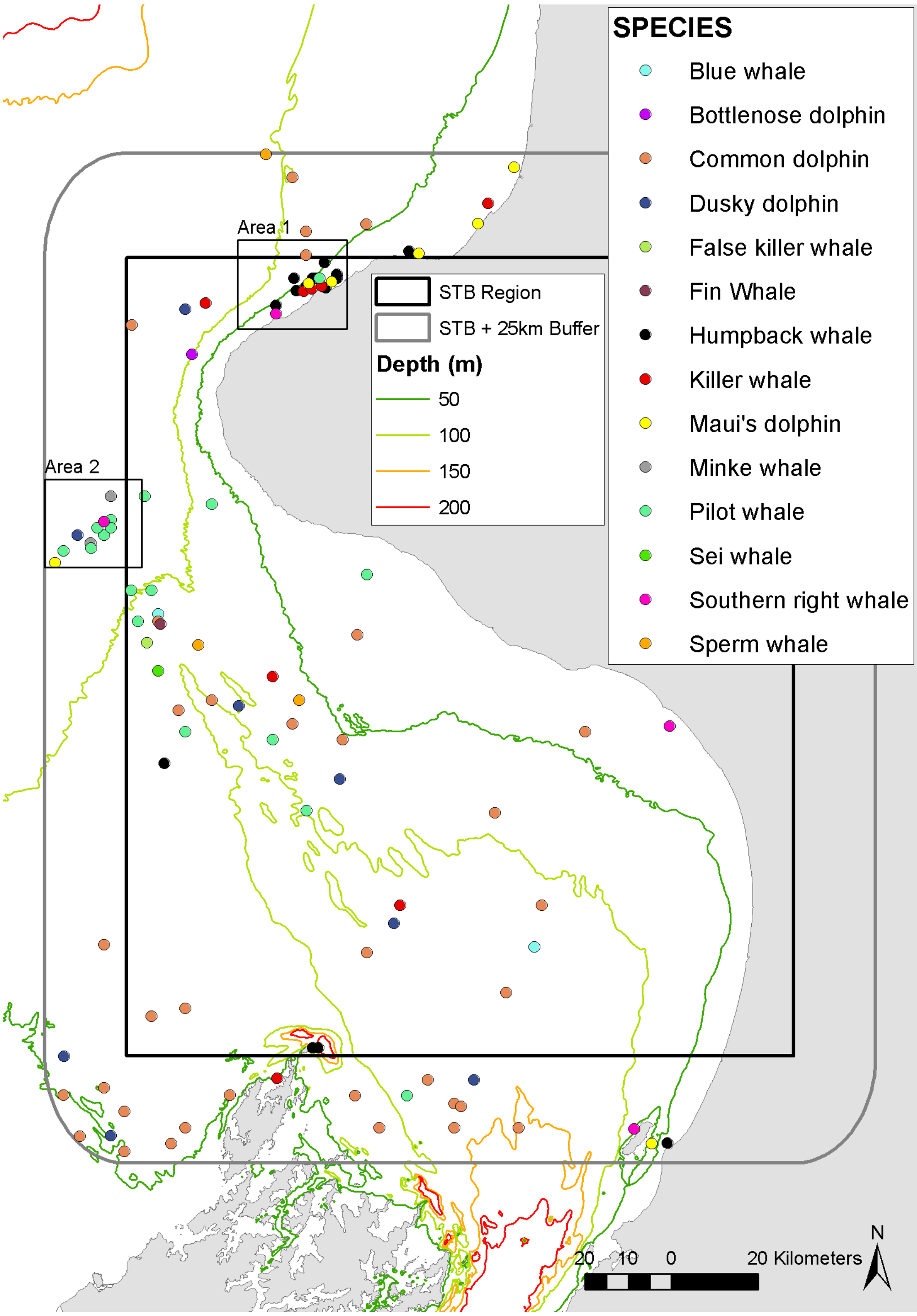

Figure 9.1. Distribution of sighting locations, by species, from DOC and Cawthorn datasets of all cetaceans within the southern and northern Taranaki Bights, within the STB region and the 25 km buffer zone. Area 1 and Area 2 demarcate two areas of sighting concentrations (enlarged in Figs. 3 and 4, respectively). Data provided courtesy of DoC and Martin Cawthorn.

Table 9.1. Sighting records by season from DOC and Cawthorn datasets of 13 cetacean species observed along the southern and northern Taranaki bights. Listed alphabetically. Summer: Dec, Jan, Feb; Autumn: Mar, Apr, May; Winter: Jun, Jul, Aug; Spring: Sep, Oct, Nov. Data provided courtesy of DoC and Martin Cawthorn.

Species	Threat Classification	Spring	Autumn	Summer	Winter	Unknown	Total
Blue whale (*Balaenoptera musculus*)	Migrant			1		1	2
Bottlenose dolphin (*Tursiops truncatus*)	Range restricted			1			1
Common dolphin (*Delphinus* spp.)	Not threatened	2	2	5	5	1	15
Dusky dolphin (*Lagenorhynchus obscurus*)	Not threatened	1	3				4
False killer whale (*Pseudorca crassidens*)	Not threatened			1			1
Fin whale (*Balaenoptera physalus*)	Migrant			1			1
Humpback whale (*Megaptera novaeangliae*)	Migrant	3		2	10		15
Killer whale (*Orcinus orca*)	Nationally critical			3		3	6
Maui's dolphin *Cephalorhynchus hectori maui*)	Nationally critical			2			2
Pilot whale (*Globicephala* spp.)	Not threatened	5	1	6			12
Sei whale (*Balaenoptera borealis*)	Migrant			1			1
Southern right whale (*Eubalaena australis*)	Nationally endangered	1			1		2
Sperm whale (*Physeter macrocephalus*)	Migrant			2			2
Total		12	6	25	16	5	64

Table 9.2. Sighting records by season from DOC and Cawthorn datasets of 13 cetacean species observed along the southern and northern Taranaki bights within the 25 km buffer area. Listed alphabetically. Summer: Dec, Jan, Feb; Autumn: Mar, Apr, May; Winter: Jun, Jul, Aug; Spring: Sep, Oct, Nov. Data provided courtesy of DoC and MAF-BNZ.

Species	Listing	Spring	Summer	Autumn	Winter	Unknown	Total
Blue whale (*Balaenoptera musculus*)	Migrant	4	1			1	6
Bottlenose dolphin (*Tursiops truncatus*)	Range restricted		1				1
Common dolphin (*Delphinus* spp.)	Not threatened	6	7	11	10	2	36
Dusky dolphin (*Lagenorhynchus obscurus*)	Not threatened	1	2	4	1		8
False killer whale (*Pseudorca crassidens*)	Not threatened		1				1
Fin whale (*Balaenoptera physalus*)	Migrant		1				1
Humpback whale (*Megaptera novaeangliae*)	Migrant	4	3		10		17
Killer whale (*Orcinus orca*)	Nationally critical		4		1	3	8
Maui's dolphin (*Cephalorhynchus hectori maui*)	Nationally critical		4		2	1	7
Minke whal (*Balaenoptera bonaerensis*)	Migrant	2					2
Pilot whale (*Globicephala* spp.)	Not threatened	8	17	2			27
Sei whale (*Balaenoptera borealis*)	Migrant		1				1
Southern right whale (*Eubalaena australis*)	Nationally endangered	2	2		1		5
Sperm whale (*Physeter macrocephalus*)	Migrant	1	2				3
Total		28	46	17	25	7	123

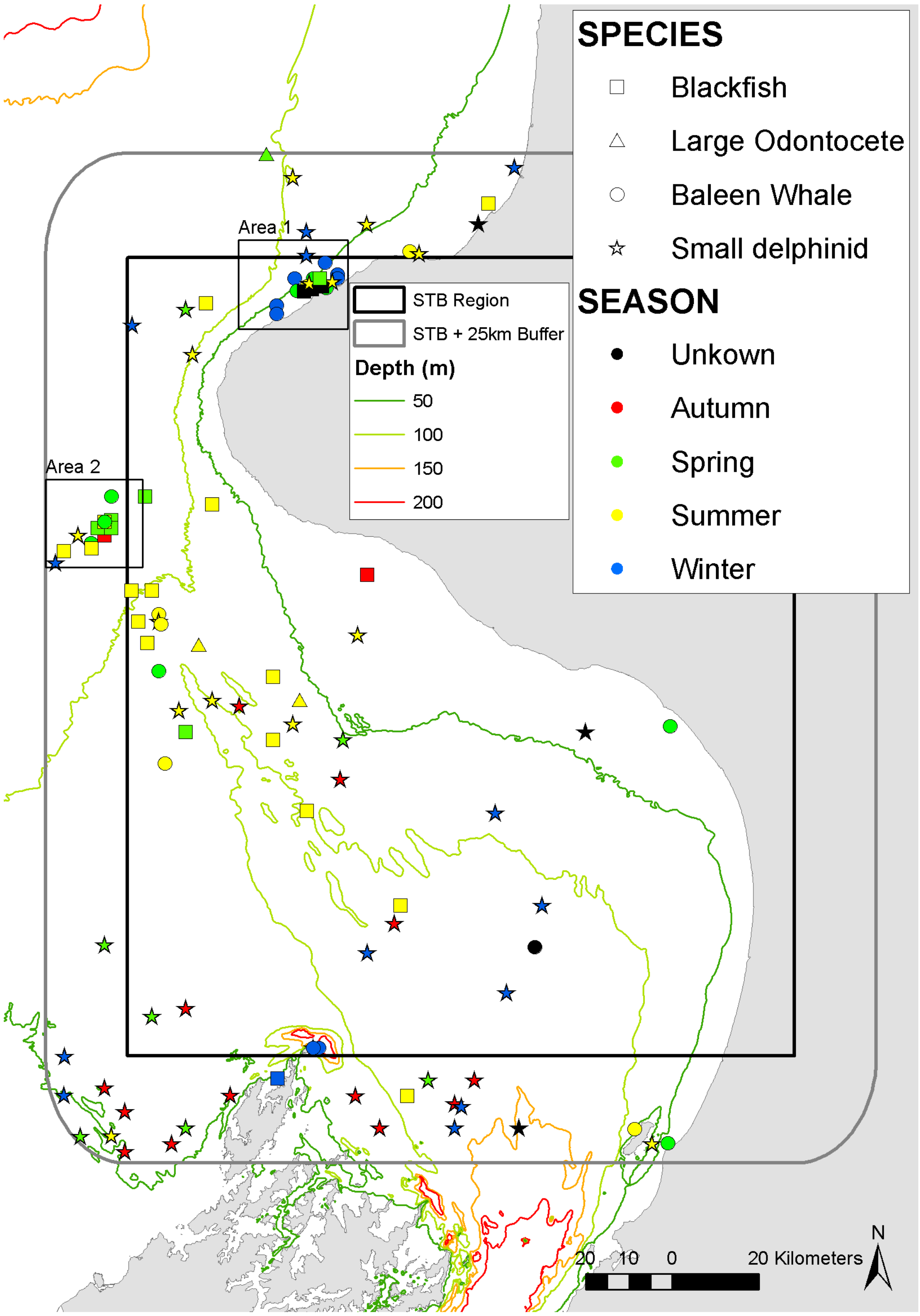

Figure 9.2. Seasonal distribution of sightings from DOC and Cawthorn datasets of all cetaceans symbolized by species group within the southern and northern Taranaki Bights, and the 25 km buffer zone. Data provided courtesy of DoC and Martin Cawthorn.

Two concentrations of cetacean sightings are evident: (Area 1) in the northern region of the study area near the coast of New Plymouth, and (Area 2) in the western region beyond the 100 m isobath (Figure 9.1). Both may result from high densities of human observers related to port and oil platform activities respectively. It is important to note that within Area 1 there are sightings of two species listed as Nationally Critical (Maui's dolphin and Killer whale) and one species listed as Nationally Endangered (Southern Right Whale) (Figure 9.3). Additionally, within Area 2 there is one sighting of Maui's dolphin and one sighting of Southern right whale (Figure 9.4).

Additionally, DOC and MFish reports and published literature on cetacean distributions around New Zealand were used as data sources and references. Overall, data on the distribution and ecology of the following cetacean species (with the possible exceptions of common dolphins, bottlenose dolphins, and Maui's dolphin) throughout New Zealand, including the southern and northern Taranaki bights, is scarce. Therefore, a systematic survey for cetaceans in this region would profoundly advance our understanding of cetacean habitat use patterns and improve our ability to conserve and manage these iconic marine megafauna.

9.2.2 Toothed whales and dolphins (Odontoceti)

Sightings of all odontocetes (toothed whales and dolphins) in the southern and northern Taranaki bights are depicted in Figure 9.5. While the small delphinids are scattered throughout the area, the blackfish species (pilot whales, false killer whales, killer whales) appear to concentrate near the 100 m isobaths in the southern bight, as well as in Area 1. The sightings of large odontocetes (sperm whales) are also near the 100m isobath and occur only in spring and summer months.

Bottlenose dolphin (*Tursiops truncatus*)

Bottlenose dolphins are regarded as range restricted in New Zealand. A northern population is isolated from other populations and concentrated in the Bay of Islands with year-round movements along the east coast of Northland and into the Hauraki Gulf (Constantine et al. 2003). However, some individuals were found to range as far away as Manukau Harbour, indicating that all of these animals are not yearly residents but may move seasonally along the NZ coast (Childerhouse 2005). These dolphins represent the 'coastal' population of bottlenose dolphins. The singular sighting of a group of bottlenose dolphins within the STB region was of an estimated 100 individuals during the summer of 1986. The large size of this group, and that it was made in a depth of approximately 100 m indicates that these bottlenose dolphins were of the 'offshore' population. Offshore bottlenose dolphins tend to travel more widely and in larger groups then the 'coastal' populations.

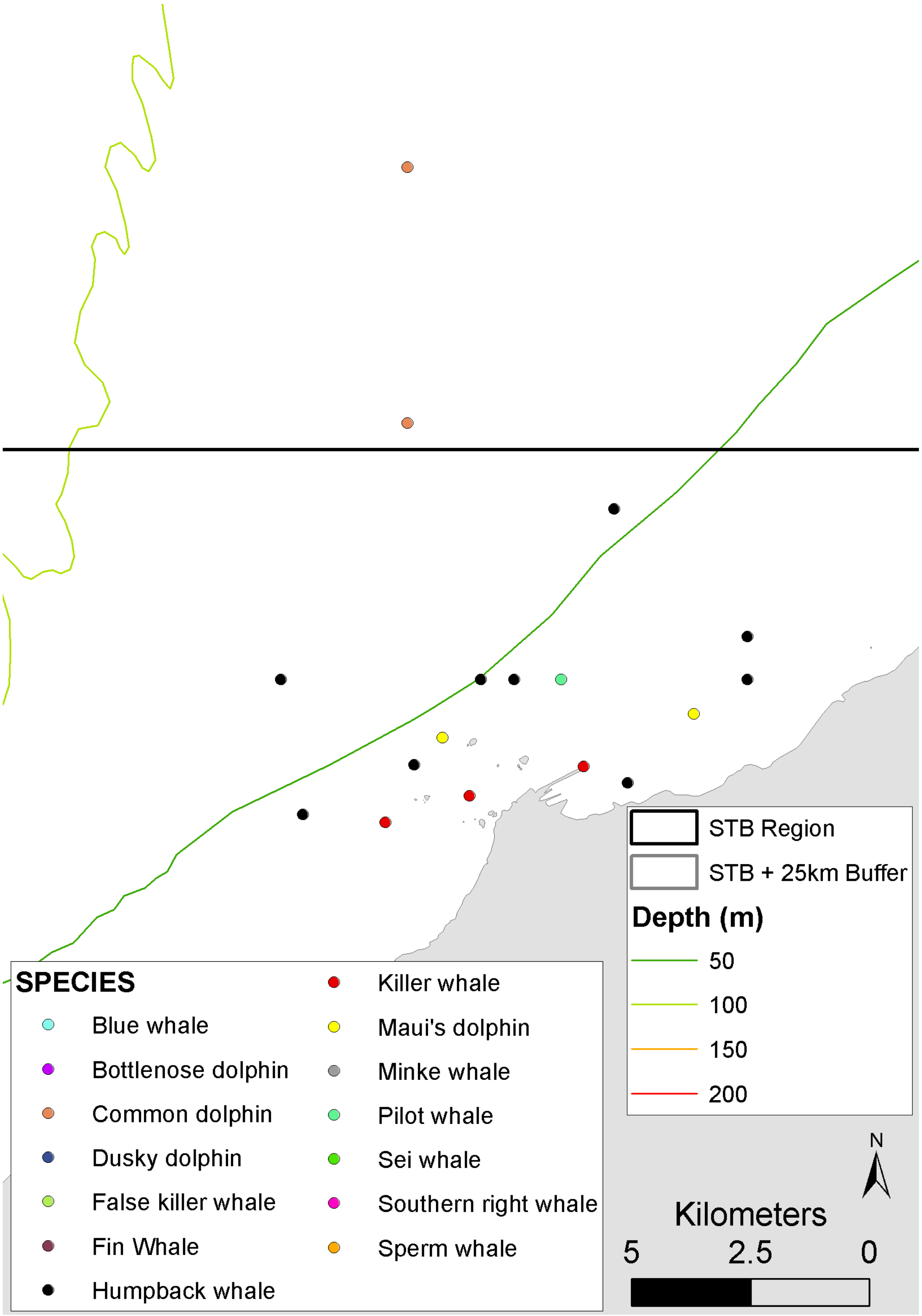

Figure 9.3. Distribution of sighting locations, by species, from DOC and Cawthorn dataset, of all cetaceans within Area 1, an area of sightings concentration within the northern Taranaki Bight (see Figure 9.1). Data provided courtesy of DoC and Martin Cawthorn.

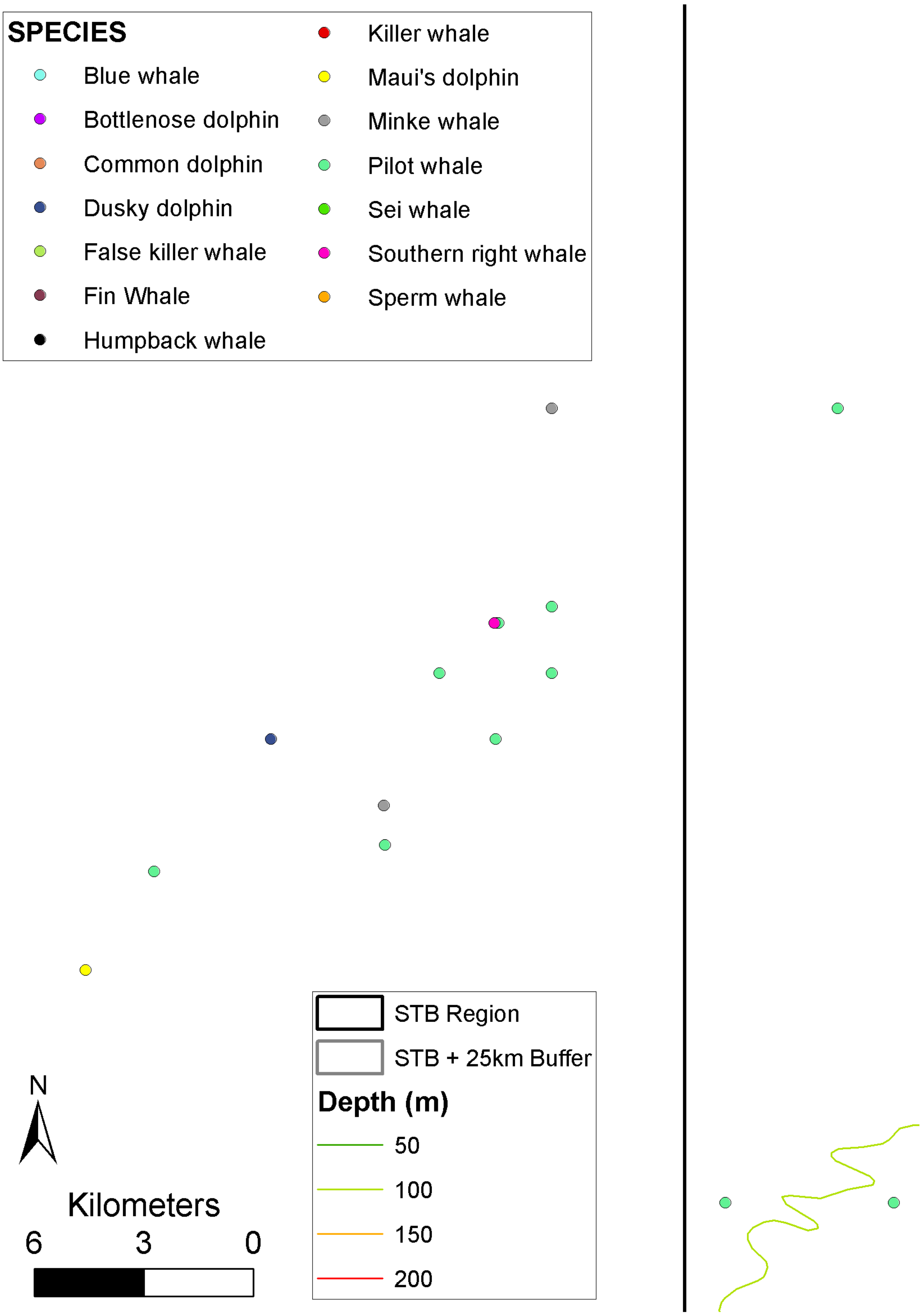

Figure 9.4. Distribution of sighting locations, by species, from DOC and Cawthorn datasets, of all cetaceans within Area 2, an area of sightings concentration in the western part of the South Taranaki Bight (see Figure 9.1). Data provided courtesy of DoC and Martin Cawthorn.

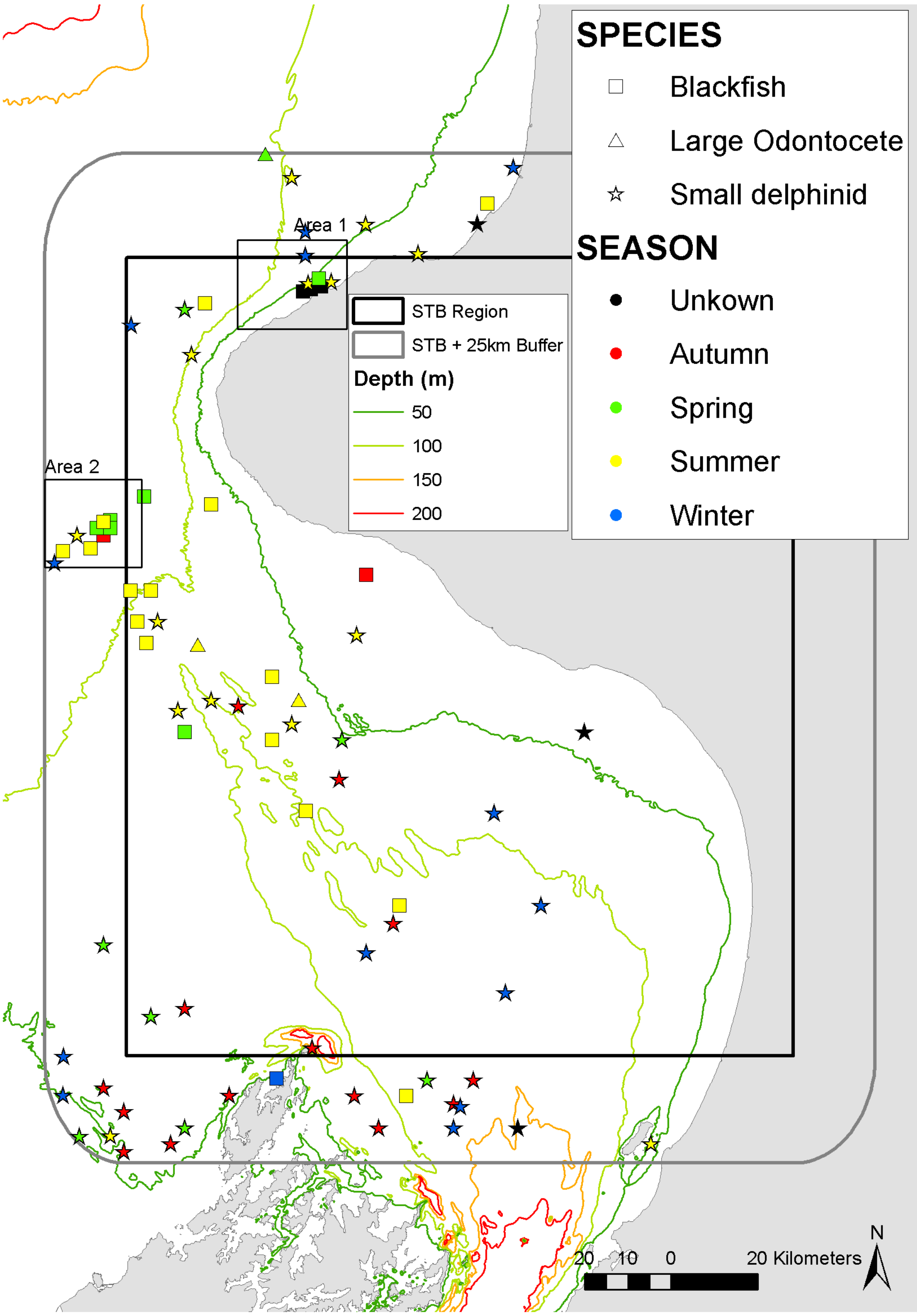

Figure 9.5. Seasonal distribution from DOC and Cawthorn datasets of all sightings of odontocets (toothed whales and dolphins) symbolized by season within the southern and northern Taranaki Bights. Data provided courtesy of DoC and Martin Cawthorn.

Common dolphin (*Delphinus* spp.)

The DOC and Cawthorn datasets include 36 sightings of common dolphins within the northern and southern Taranaki Bights and in the 25km buffer area (Figure 9.6). The sightings show a relatively seasonal distribution with all autumn and spring (except 1) sightings in the southern area (north of the Marlborough sounds). Winter and summer sightings of common dolphins are distributed throughout the STB region and the 25km buffered area. A study of common dolphins that examined the stomach contents of by-caught or stranded animals, including 10 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 suggest that the mixed prey composition in the diet of common dolphins by-caught in waters further offshore may be due to inshore/offshore movements of common dolphin on a diel basis.

No other studies of common dolphin ecology have been conducted within in the Taranaki bights. However, common dolphins are far ranging and distributed in other areas around the North Island. Therefore, we can derive information on their ecology from studies in other parts of the island. Over a 12 month study in the Bay of Islands region, Constantine and Baker (1997) determined the mean depth at sightings of common dolphins to be 80 m with a range of 6-141 m. This study also documented that during late spring and summer common dolphins were found in deeper waters outside the inner Bay of Islands and during the late autumn and winter months they were frequently found inside the bay. These patterns are consistent with the general ecology of common dolphins that are typically found in warmer temperate or tropical waters and principally offshore (Shirihai 2002).

Dusky dolphin (Lagenorhynchus obscurus)

Dusky dolphins are regarded as not threatened in New Zealand (Suisted & Neale 2004). Between 1980 and 1989, eight sightings of dusky dolphins in the 25 km buffered area of the northern and southern Taranaki bights were recorded. Four sightings of dusky dolphins were recorded within the STB region, with three of these occurring in autumn months (one in spring). Sightings were generally in waters near the 100 m isobath (Figure 9.1). Dusky dolphins tends to inhabit cooler waters in more southerly latitudes, and this species occurs off most of the South Island, the lower part of the North Island (Wursig et al. 2007). There are historical sightings reported in the Taranaki/Wanganui region, and it is possible that they still frequent this area (Wursig et al. 2007). A population of dusky dolphins is known to inhabit Admiralty Bay, Marlborough Sounds between April–July (Wursig et al. 2007). Because dusky dolphins travel and disperse over distances greater than 100 km it is possible that the sightings of dusky dolphins in the northern and southern Taranaki bights are from the Admiralty population.

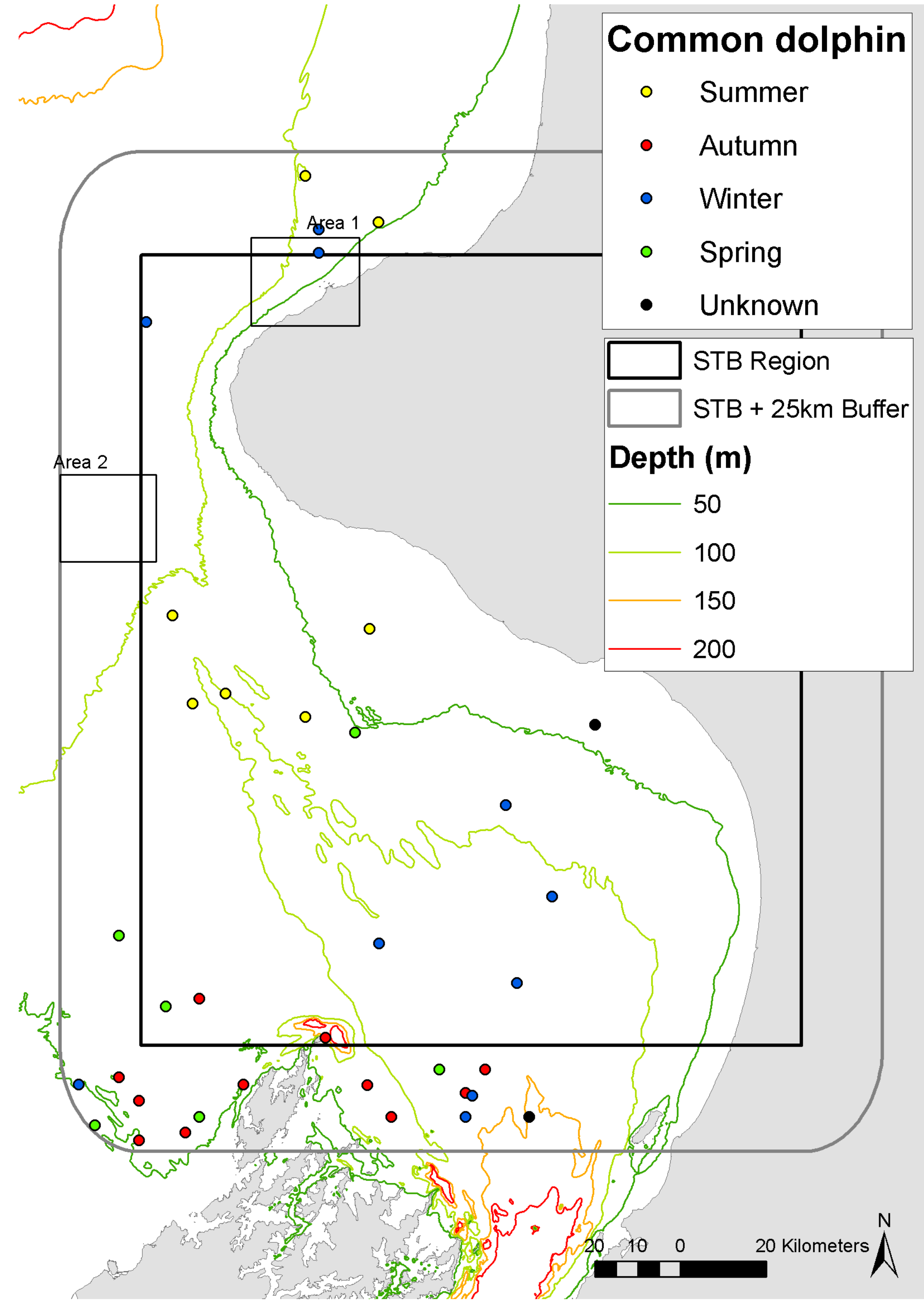

Figure 9.6. Seasonal distribution from DOC and Cawthorn datasets of all sightings of Common dolphins (*Delphinus* spp.) symbolized by season within the southern and northern Taranaki Bights. Data provided courtesy of DoC and Martin Cawthorn.

False killer whale (*Pseudorca crassidens*)

Only one sighting of a false killer whale group of seven individuals during the summer of 2007 was recorded within the STB region. This sighting was made in water greater then 100m deep. Like pilot whales, a similar species also within the Blackfish group, false killer whales typically occur in deep water habitats (200 -2000 m, Shirihai 2002).

Killer whale (*Orcinus orca*)

Killer whales are classified as a nationally critical threatened species in New Zealand waters (Suisted & Neale 2004). Between 1980 and 2005, 8 sightings of killer whales were recorded within the 25 km buffer area (consisting of 41 individuals), and 3 within the STB region (consisting of 17 individuals). Three of the eight sightings in the 25 km buffer area have an ‘unknown’ season, but the other sightings were predominantly during the summer months (1 in winter) (Table 9.1). The entire New Zealand killer whale population is small (mean = 119 ± 24 SE) with broad distribution patterns around both North and South islands (Visser 2000). Killer whales may be transiting through this habitat or use this habitat to forage for prey including fish, other marine mammals, and sharks and rays.

Maui’s dolphin (Cephalorhynchus hectori maui)

Hector’s dolphin, and its subspecies the Maui’s dolphin, are endemic and iconic species of New Zealand. Due to small population sizes, limited genetic exchange, and threats from fisheries and habitat destruction, the Hector’s dolphin is listed as Nationally Endangered and the Maui’s dolphin is listed as Nationally Critical (Suisted & Neale 2004).

Pichler et al. (2002, 1998) used mitochondrial DNA analysis to determine that Hector’s dolphin population in New Zealand is composed of four sub-populations, due to little or no female dispersal: North Island, East Coast South Island, West Coast South Island, and South Coast South Island. The North Island subpopulation of Hector's Dolphin was subsequently recognized as a subspecies, *C. h. maui* (Baker et al. 2002). Therefore, the seven sightings of Hector’s/Maui’s dolphins within the 25 km buffer area are assumed to be the sub-species Maui’s dolphin. It is possible, however, that the southernmost sighting, inshore of Kapiti Island, is part of the Clifford Bay (northern SI) Hectors dolphin population.

The population size of Maui's dolphin is estimated to be 111 (c.v. 0.44) (Slooten et al. 2005). The geographic range of Maui's dolphin extends from the north at Maunganui Bluff to at least New Plymouth in the south, with highest densities between the Manukau Harbour and Port Waikato (Slooten et al. 2005). Ferreira and Roberts (2003) found no sightings of Maui's dolphins between New Plymouth and Paraparamu in their aerial surveys conducted between December and March of the 2000/01 and 2001/02 summers.

Hector's and Maui's dolphins inhabit a wide range of water temperatures (surface temperature 6.3-22°C) and water turbidity (<10 cm to >15 m) (Slooten & Dawson 1994). Additionally, Hector's and Maui's dolphins appear to alter their distribution patterns seasonally: during the summer months dolphins (frequently with calves) they occupy shallow and turbid waters; in winter months the dolphins tend to move offshore with greater distribution throughout their depth range (Slooten et al. 2005, Slooten et al. 2006). These changes in distribution patterns may reflect changes in the distribution patterns of their prey. Hector's dolphins appear to feed mostly in small groups. The dolphins feed opportunistically, both at the bottom and throughout the water column, and take a wide variety of species.

The seven sightings of Maui's dolphin from the DOC and Cawthorn datasets within the 25km buffered TTR area reflect this seasonal distribution pattern: all summer sightings are close to shore, while 1 winter sighting is also close to shore while a second sighting was recorded approximately 25 km from shore and in waters greater then 100 m deep (Figure 9.7).

Pilot whale (*Globicephala* spp.)

There are two species of pilot whale that are both found in NZ waters: long-finned pilot whales (*Globicephala melas*) and short-finned pilot whale (*Globicephala macrorhynchus*). Short-finned pilot whales tend to be in warmer waters then long-finned pilot whales but their habitats do overlap. Both species are a poorly known migrant species in New Zealand waters (Suisted & Neale 2004). It is unknown to which species group the sightings of pilot whales within the STB region belong to, but their ecology is very similar so can be considered jointly here. Pilot whales feed on fish and squid, prefer deeper water and are highly sociable, often occurring in large groups (Shirihai 2002). A total of 655 individuals were estimated at the 27 sightings in the 25 km buffer area, and 289 individuals at the 12 sightings in the STB region. The majority of pilot whale sightings were in waters with depths greater then 100 m (Figure 9.8). There is a concentration of pilot whale sightings within Area 2 (Figure 9.4). No sightings were made in winter months, only two sightings in autumn, and the rest were made in spring and summer months. Strandings of long-finned pilot whales occur throughout the coastlines of New Zealand, with peaks in stranding events in spring and summer months (O'Callaghan et al. 2001).

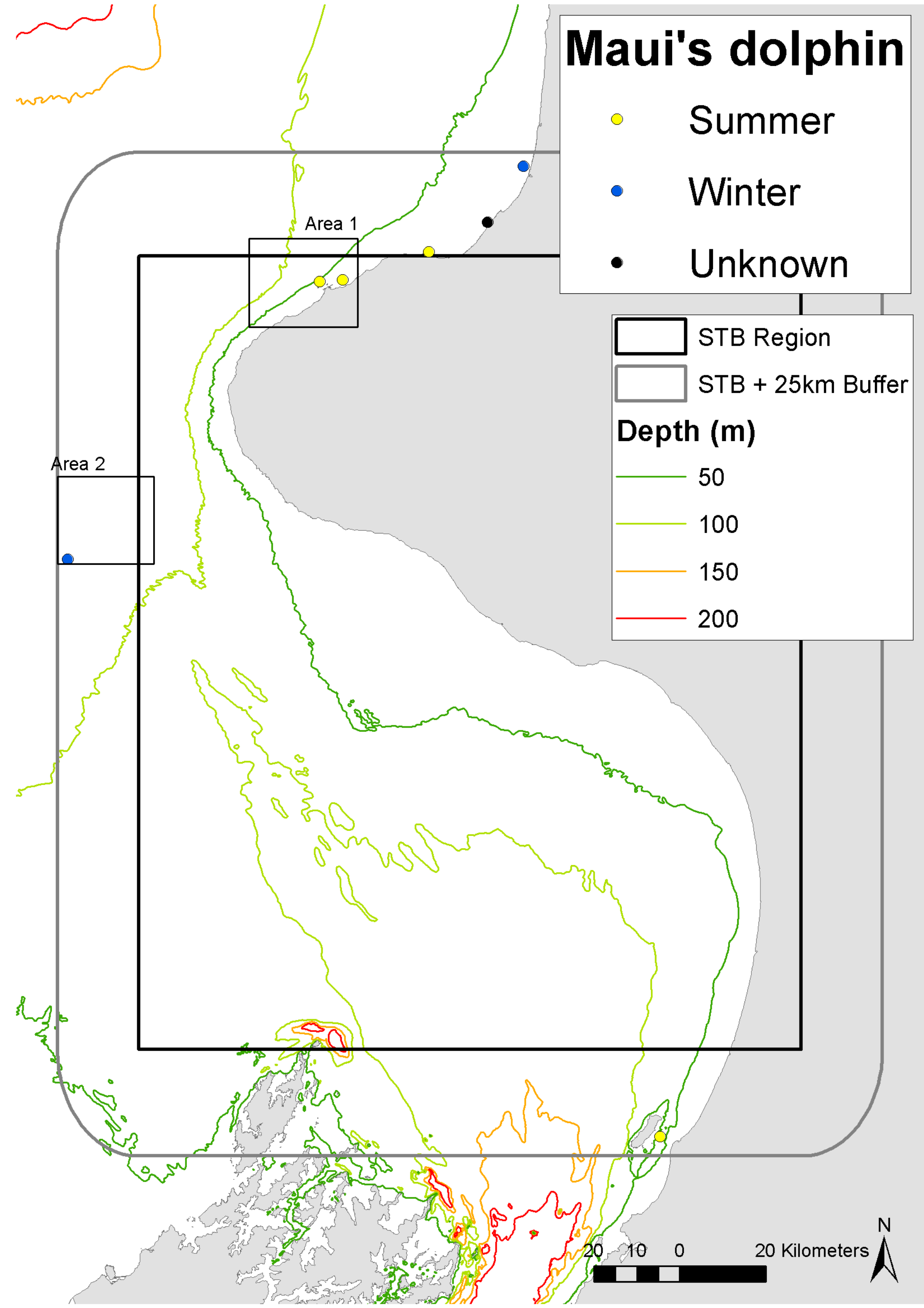

Figure 9.7. Seasonal distribution from DOC and Cawthorn datasets of all sightings of Mauis's dolphins (*Cephalorhynchus hectori maui*) symbolized by season within the southern and northern Taranaki Bights. Data provided courtesy of DoC and Martin Cawthorn.

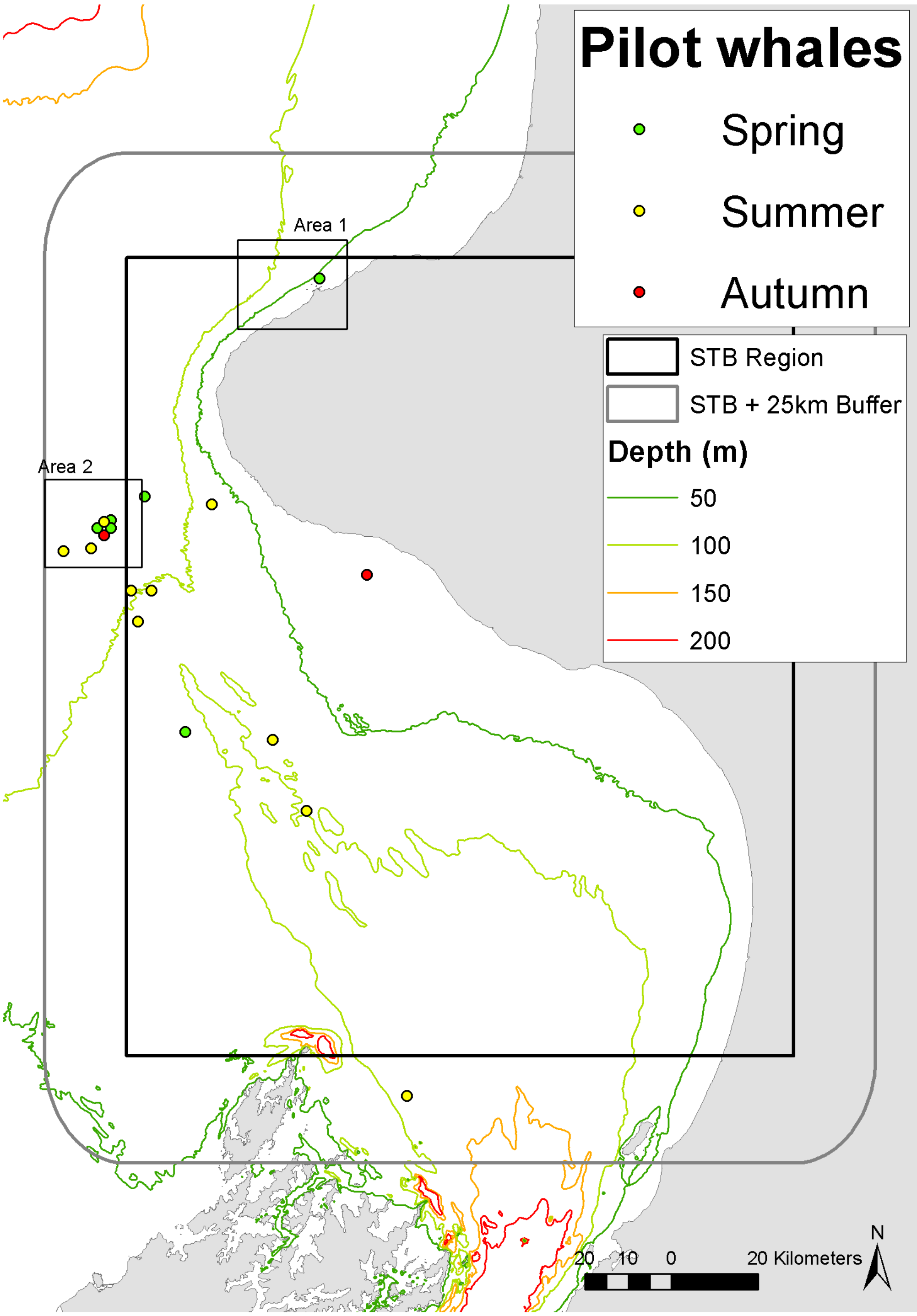

Figure 9.8. Seasonal distribution from DOC and Cawthorn datasets of all sightings of Pilot whales (*Globicephala* spp.) symbolized by season within the southern and northern Taranaki Bights. Data provided courtesy of DoC and Martin Cawthorn.

Sperm whale (Physeter macrocephalus)

Two sightings of sperm whales were made during spring months within the STB region, and 1 additional sighting in the 25k m buffer area during spring. All sightings were recorded near the 100 m isobath. Sperm whales are typically found in areas where the continental shelf drops off dramatically (Shirihai 2002) as these tend to be productive foraging habitats for target prey items such as squid.

9.2.3 Baleen whales (Mysticeti)

Thirty-two sightings of baleen whales were recorded in the DOC and Cawthorn datasets within the 25 km buffer area. No sightings were made in autumn, and the greatest diversity of species were sighted in spring and summer months (Table 9.3). The seasonal distribution of baleen whales is patchy (Figure 9.9). During the spring months, a concentration of sightings was made in Area 2 (Figs. 9.4 & 9.9). In summer months, sightings of baleen whales were made in the offshore region of the southern Taranaki bight near the 100 m isobath. A concentration of sightings of baleen whales is also in Area 1 (Figs. 9.3 & 9.9) in all seasons but autumn. One species of baleen whale sighted within the STB region, the southern right whale, is listed as Nationally Endangered. All other baleen whales recorded in the northern and southern Taranaki bights are listed as Migrants.

Blue whale (Balaenoptera musculus)

Due to extensive whaling effort, there are estimated to be fewer than 2,000 blue whales in the southern hemisphere (Shirihai 2002). During their migration between the summer feeding grounds in the Antarctic and the equatorial waters where they spend the winter, blue whales are believed to pass the New Zealand coast (Shirihai 2002). Six sightings of blue whales have been recorded within the 25km buffer area, none within the STB region. Four of these sightings occurred during spring months and all within Area 2. (Table 9.3, Figs. 9.4 & 9.9). All sightings of Blue whales occurred in waters close to 100 m in depth.

Fin whale (Balaenoptera physalus)

Fin whales perform long seasonal migrations and are typically found in deep offshore waters (Shirihai 2002). Only one sighting of a Fin whale was recorded in the DOC and Cawthorn datasets within the STB region or 25 km buffered TTR area. This sighting in 2007 occurred during the summer season, included 3 individuals and was close to Area 2 in waters of approximately 100 m (Figure 9).

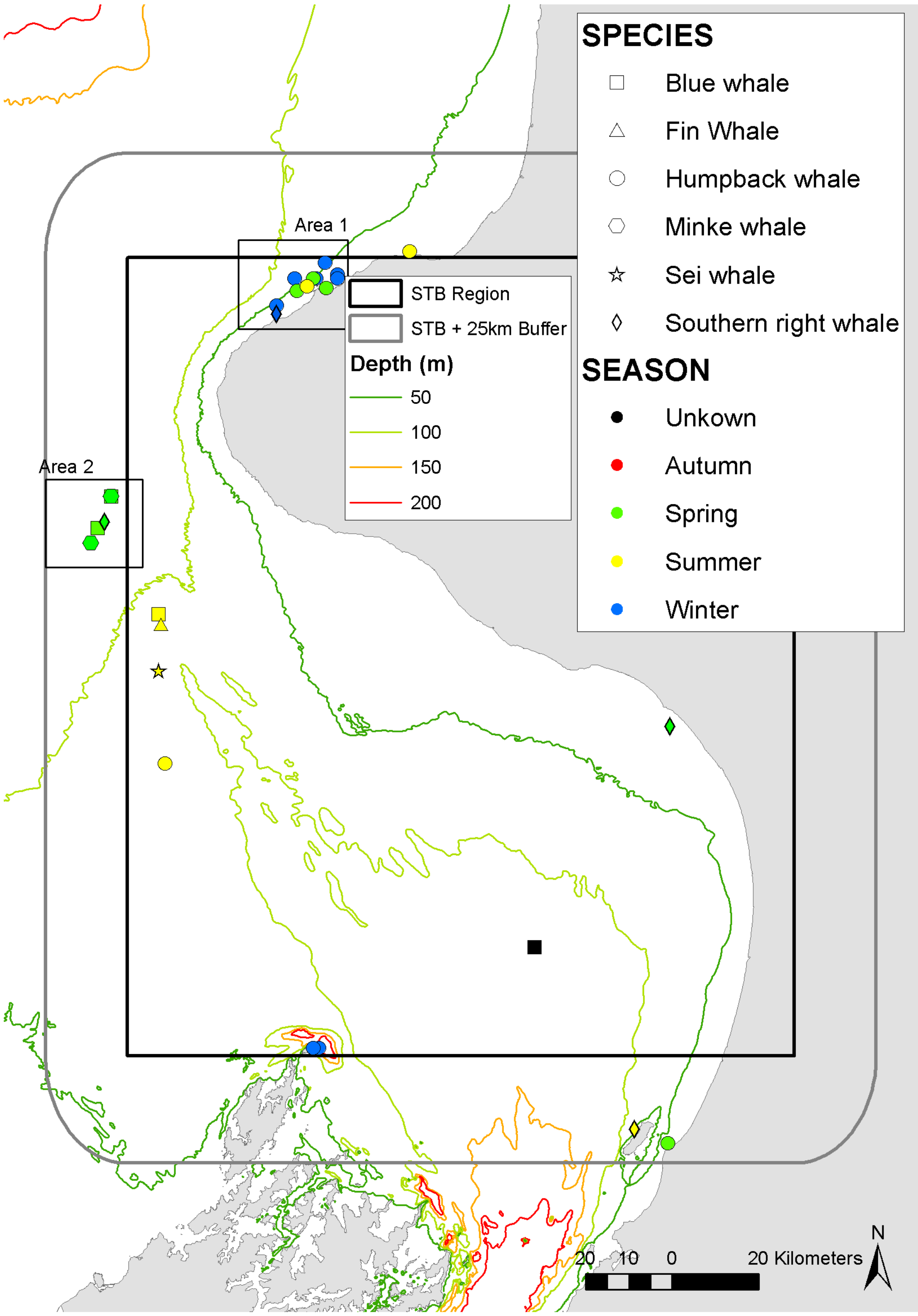

Figure 9.9. Seasonal distribution from DOC and Cawthorn datasets of all sightings of mysticets (baleen whales) symbolized by season within the North and South Taranaki Bights. Data provided courtesy of DoC and Martin Cawthorn.

Table 9.3 Sighting records by season from DOC and Cawthorn datasets of 6 baleen whales species observed along the North and South Taranaki Bights. Listed alphabetically. Summer: Dec, Jan, Feb; Autumn: Mar, Apr, May; Winter: Jun, Jul, Aug; Spring: Sep, Oct, Nov. Data provided courtesy of DoC and Martin Cawthorn.

Species	Listing	Spring	Summer	Autumn	Winter	Unknown	Total
Blue whale (Balaenoptera musculus)	Migrant	4	1			1	6
Fin whale (Balaenoptera physalus)	Migrant		1				1
Humpback whale (Megaptera novaeangliae)	Migrant	4	3		10		17
Minke whale (Balaenoptera bonaerensis)	Migrant	2					2
Sei whale (Balaenoptera borealis)	Migrant		1				1
Southern right whale (Eubalaena australis)	Nationally endangered	2	1		1		4
Total		12	7	0	11	1	31

Humpback whale (Megaptera novaeangliae)

Humpback whales in the southern hemisphere were reduced by the whaling industry from about 120,000 animals to just 15,000 today, but the population is currently recovering (Suisted & Neale 2004). Humpback whales travel along the New Zealand coast between May and December as they migrate between their summer feeding grounds in the Antarctic and their winter breeding grounds in the tropics, particularly around Tonga (Shirihai 2002). It is likely that sightings of humpback whales within the northern and southern Taranaki bights are of migrating whales. A total of 75 individuals were observed in the 25 km buffer area, with almost 88 % (n = 65) of individuals recorded in winter months. All but 1 sighting of humpback whales were within, or near, Area 1 (Figure 9.9).

Minke whale (Balaenoptera bonaerensis)

No minke whales were sighted in the STB region. However, two sightings of Minke whales, one recorded in 1981 and another in 1989, were made in the 25 km buffer area. These two sightings occurred in Area 2 (Figure 9.9) in spring months.

Sei whale (Balaenoptera borealis)

Sei whales typically favour deep waters and are rare near coasts, but likely migrate past New Zealand as they travel south to Antarctic summer feeding grounds and return north to warmer breeding waters in winter (Shirihai 2002). Only one sighting of a Sei whale was recorded in the STB region or the 25 km buffered TTR area. This sighting recorded two individuals, and was made during the summer season, in depths close to 100 m near Area 2 (Figure 9.9).

Southern right whale (*Eubalaena australis*)

Southern right whales in the New Zealand are considered nationally endangered due mainly to whaling that reduced the population from about 17,000 animals to just 1,000 today (Suisted & Neale 2004). Southern right whales follow traditional annual migration routes between southern ocean summer feeding areas and their nearshore calving grounds. Right whales are frequently found in sheltered coastal waters close to shore to give birth, nurse calves, and avoid predators during migrations. During the breeding season in winter months, they are mostly found in the waters around the sub-Antarctic Auckland and Campbell Islands but there are occasional sightings around mainland New Zealand, which may represent re-colonization of breeding grounds largely unused since the 1830s.

Two sightings of southern right whales were recorded in the STB region (Figure 9.10). One of these sightings occurred during the spring of 1983 and consisted of a cow/calf pair. The other sighting recorded a solitary animal in the winter of 2004. Two more southern right whales were observed in the 25 km buffer area. One of these sightings recorded 5 individuals ‘moving about in shallows’ on the west side of Kapiti Island during the summer of 2002. This sighting likely represents a surface active group (SAG) of right whales. The other sighting recorded one individual in the spring of 2003 offshore in Area 2.

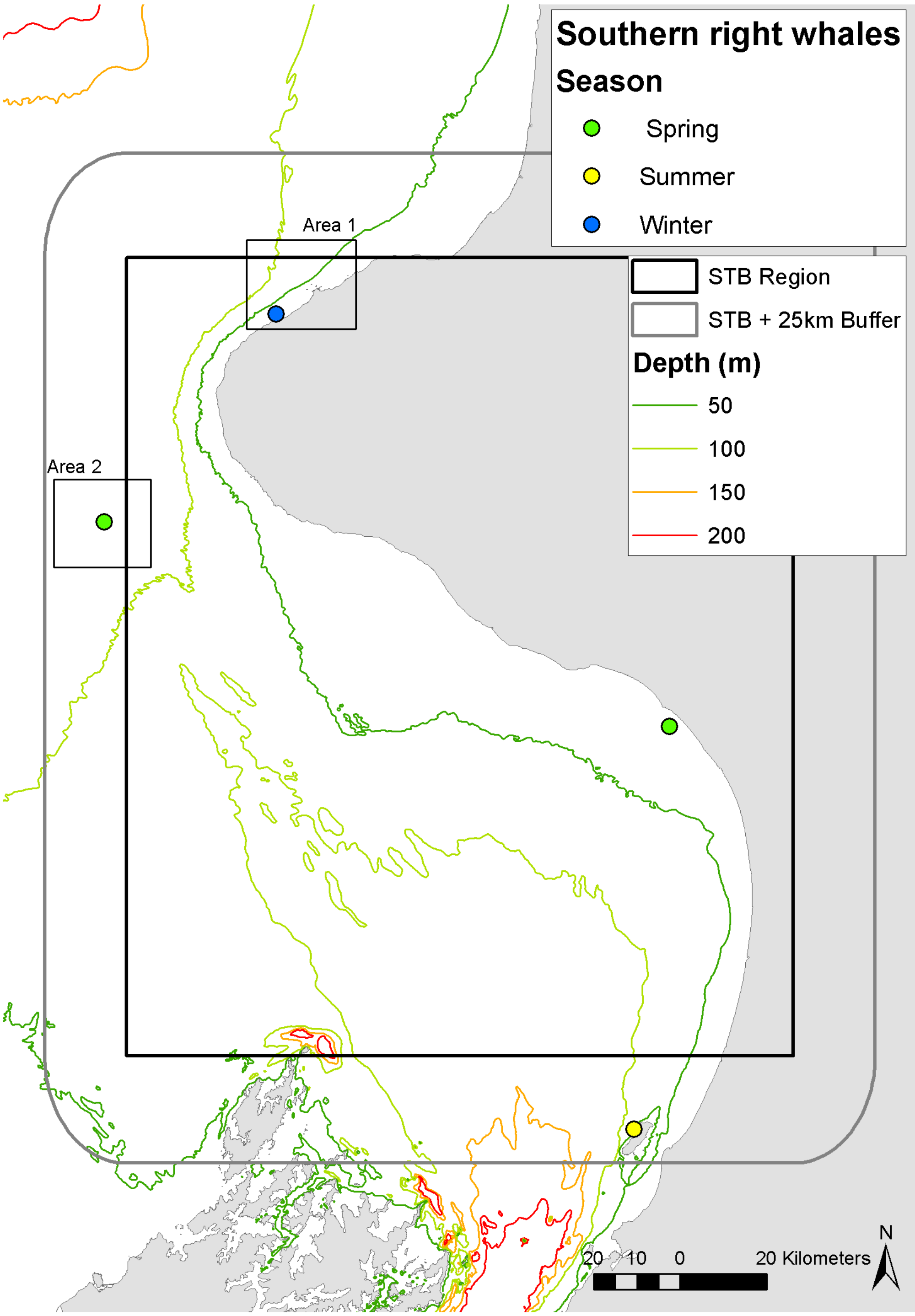

Figure 10. Seasonal distribution from DOC and Cawthorn datasets of all sightings of Southern right whales (*Eubalaena australis*) symbolized by season within the southern and northern Taranaki Bights. Data provided courtesy of DoC and Martin Cawthorn.

9.3 Summary

While the cetacean sightings data presented here must be interpreted with caution as the distribution of sampling effort is unknown (presence only), it appears that relatively few sightings of cetaceans have been made within the northern and southern Taranaki bights. However, 3 endangered or critically endangered species do frequent this area: the Maui's dolphin, killer whale, and southern right whale. The populations of these species are extremely low.

Additionally, Area 1 and Area 2 appear to be particularly important habitat for a range of species. The ecological function and use of these areas for cetaceans remains poorly understood due to limited information about the physical and biological marine environment at these locations concurrent with cetacean distribution, abundance and behaviour data.

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10. Seabirds of the South Taranaki Bight

10.1 Background

New Zealand supports the most diverse seabird assemblage on earth: approximately 84 species breed in New Zealand, with close to half of this total classified as endemic (Taylor 2000a). However, the SBT lacks suitable, predator-free breeding habitat for many species. The nearest offshore islands are the Nga Motu/Sugar Loaf Islands group off New Plymouth, which support perhaps a few tens of thousands of breeding pairs of seabirds. Elsewhere, breeding seabirds are confined to the mainland coast and are exposed to the full range of introduced predators. However, a number of coastal estuarine sites are of significant value to coastal, shore, wading, and migratory bird species. These include the Waikirikiri Lagoon, and the Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei river estuaries. The Manawatu estuary is particularly significant and was declared a Wetland of International Importance under the Ramsar convention in July 2005.

Although the opportunities for breeding seabirds in the area are relatively limited or relatively high risk, the South Taranaki Bight is certainly visited by a larger diversity of seabirds that either pass through the region or use the area as a foraging destination. However, there have been no systematic and quantitative studies of the at-sea distributions and abundances of seabirds within the area and it would be fair to say the amount of published information on seabirds in this region is modest.

This review summarises information from published and unpublished sources and draws upon ‘expert opinion’ in order to build a picture of those species of seabirds that are likely to be associated with the area of interest at some point during the year. It should be noted that no attempt has been made to quantify the use of the area by any species, nor have numbers of any particular species that use the area been reported – these data are simply unavailable. In this respect, seabird species are noted on a presence basis only.

10.2 Albatrosses and petrels

There is very limited evidence that the great albatrosses occur in the area of interest. Robertson et al. (2007) noted unidentified wandering albatross and unidentified royal albatross *Diomedea* spp. as present, but Walker and Elliott (2006), in a tracking study of New Zealand wandering albatrosses (both Antipodean wandering albatross *D. antipodensis antipodensis* and Gibson’s wandering albatross *D. a. gibsoni*) using satellite telemetry found no evidence that this area was used. It is likely that black-browed albatross *Thalassarche melanophrys* and Campbell albatross *T. impavida* (likely mainly Campbell albatross which is very hard to distinguish when seen at distance and at sea) occur in the area (Robertson et al. 2007), as do white-capped albatross *T. steadi* (Robertson et al. 2007, Thompson unpublished data), but there is little evidence of other albatross species utilising the area to any extent.

It is very likely that giant petrels *Macronectes* spp. occur in the area (Jenkins 1981) as they have been noted off Foxton, west Taranaki and New Plymouth (Robertson et al. 2007). Similarly, flesh-footed shearwater *Puffinus carneipes*, sooty shearwater *P. griseus*, fluttering shearwater *P. gavia*, Buller's shearwater *P. bulleri*, common diving petrel *Pelecanoides urinatrix*, Cape petrel *Daption capense*, grey-faced petrel *Pterodroma macroptera* and fairy prion *Pachyptila turtur* occur in the area, either in transit to and from relatively near-by breeding colonies, or from breeding colonies further afield (Jenkins 1981, 1988, Taylor 2000a, 2000b, Robertson et al. 2007, Shaffer et al. 2009), and there is some evidence that Cook's petrel *Pterodroma cookii* may venture into the area (Rayner et al. 2008).

10.3 Blue penguin, Australasian gannet and shags

Robertson et al. (2007) noted relatively infrequent sightings of blue penguin *Eudyptula minor* at a few locations along the south Taranaki coastline. No other penguin species are likely to occur in the area. Although the nearest breeding colony is much further to the north of this area, Australasian gannet *Morus serrator* was noted along most of the south Taranaki coastline (Robertson et al. 2007), and its at-sea distribution is likely to extend throughout the area. A total of five species of shag occur in the area – black shag *Phalacrocorax carbo*, pied shag *P. varius*, little black shag *P. sulcirostris*, little shag *P. melanoleucos* and spotted shag *P. punctatus* (Robertson et al. 2007). Of these, black shag and little shag were the most numerous and had the most widespread distributions throughout the area (Robertson et al. 2007).

10.4 Skuas, gulls and terns

The brown skua *Catharacta lonnbergi* breeds in New Zealand's sub-Antarctic, but has been infrequently recorded along the coast to the south of this area outside the summer breeding season (Robertson et al. 2007), and is likely to occur sporadically throughout the area. Arctic skuas *Stercorarius parasiticus* visit New Zealand during the summer months and this species has been noted coastally in Taranaki and off New Plymouth (Roberston et al. 2007). Black-backed gull *Larus dominicanus* and red-billed gull *L. scopulinus* occur throughout the area, and are both more widespread and numerous than the black-billed gull *L. bulleri*, which is noted only from sites to the south of the area (Robertson et al. 2007). A total of six species of tern likely occur in the area, but only two – Caspian tern *Sterna caspia* and white-fronted tern *S. striata* – can be considered relatively widespread and common throughout the area. The remaining four species – black-fronted tern *S. albostriata*, little tern *S. albifrons*, fairy tern *S. nereis* and white-winged black tern *Childonias leucopterus* – are uncommonly to very rarely recorded in the area Robertson et al. 2007).

10.5 Conclusions

The area of interest supports a relatively modest seabird assemblage, but detailed, systematic and quantitative information on the at-sea distribution of virtually all species is currently lacking. Many of the species occurring in the area are likely to be relatively coastal in their distributions. Such species include blue penguin, shag species and the gulls and terns, although these latter taxa can extend to more offshore areas. By contrast, and although some species have been observed from and relatively close to the coast, albatross and petrel species tend to be more pelagic and wide-ranging in their distributions and will likely occur anywhere throughout the area. The area does not support large breeding colonies for many species but a number of coastal estuarine sites are of significant value to coastal, shore, wading, and migratory bird species. These include the Waikirikiri Lagoon, and the Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei river estuaries.

10.6 References

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11. Characterisation of commercial fisheries in the South Taranaki Bight

11.1 Introduction

Commercial fisheries for fish and invertebrates occur in the South Taranaki Bight region. As iron sand mining operations may overlap with, and impact directly or indirectly these fisheries, in this section we summarise these fisheries.

11.2 Methods

An extract of commercial fishing catch and effort data for fishing activities within the study area over the past six fishing seasons was obtained from the Ministry of Fisheries in August. The extract included all fishing events (trawl, set of a net or longline, pot drop etc.) for which the geographical coordinates were recorded by the fisher. The extract did not include any fishing events which were recorded without coordinates and instead assigned to broad "Statistical Areas" defined by the Ministry of Fisheries. These statistical areas mostly extend well beyond the study area boundaries and so are far less useful for assessing fishing activity within the area, but it should be noted that they were not used. Increasingly, fishers record their activities with coordinates taken from GPS devices, and the lack of data available for this analysis for some methods in the earlier years of this period may be partly due to this change in recording practice.

The catch effort data obtained were used to make summaries of fishing activity by fishing year (1 Oct–30 Sep) and fishing method. Although summaries for the current fishing year (2009–10) are included in this report, complete data were available only up until mid-July 2010.

11.3 Fishing methods

Trawling has been the most common fishing method used over the past five years, split evenly (in terms of effort) between bottom and midwater trawling (Table 11.1). Levels of both have been variable, but there was a general increase in bottom trawling effort between 2004–05 and 2009–10, and fluctuating levels of midwater trawling during the same period. The total catch from midwater trawling was about ten times that from bottom trawling, due to the different species targeted and caught. Set netting was the next most common fishing method, although no set netting was recorded in 2004–05 or 2005–06, with 360–570 sets per year recorded in the last four years. Similarly, bottom longlining has only been recorded in the area in the last three fishing years, with 70–90 sets per year. Squid jigging was also recorded in the area, mainly in 2004–05, but this information appears unreliable, as no catch was recorded. Other fishing methods reported in the region, at low levels, were trolling, rock lobster potting, drop lining, and fish trapping.

Table 11.1. Summary of commercial fishing effort by fishing year (1 Oct–31 Sep) and fishing method, and total catch by method.

	Number of fishing events							Total
	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	Total	catch (t)
Bottom trawling	410	438	376	1,026	1,108	802	4,160	6,653
Midwater trawling	338	824	676	435	529	890	3,692	66,410
Set netting	0	0	361	570	529	505	1,965	1,855
Bottom longlining	1	0	0	94	94	71	260	120
Squid jigging	127	8	3	1	3	1	143	0
Purse seining	16	7	8	11	9	0	51	1,879
Trolling	2	0	0	6	0	1	9	<1
Rock lobster potting	0	0	0	2	1	5	8	<1
Drop lining	0	0	0	1	0	0	1	<1
Fish traps	0	0	0	0	0	1	1	<1

The lowest levels of commercial fishing effort in the region were in the central south sector, offshore of the coastline south of Whanganui, and also very close to the shore north of Opunake and north and south of Whanganui (Figure 11.1). The highest levels of effort were off the coastline between New Plymouth and Cape Egmont, between Hawera and Whanganui especially near the 50 m contour, and in some locations between the centre of the area and Tasman Bay in the South Island. The distribution of total catch was quite different to that of effort and was dominated by the large, offshore midwater trawl fishery for jack mackerel, focussed on the western central and southern sectors of the study area.

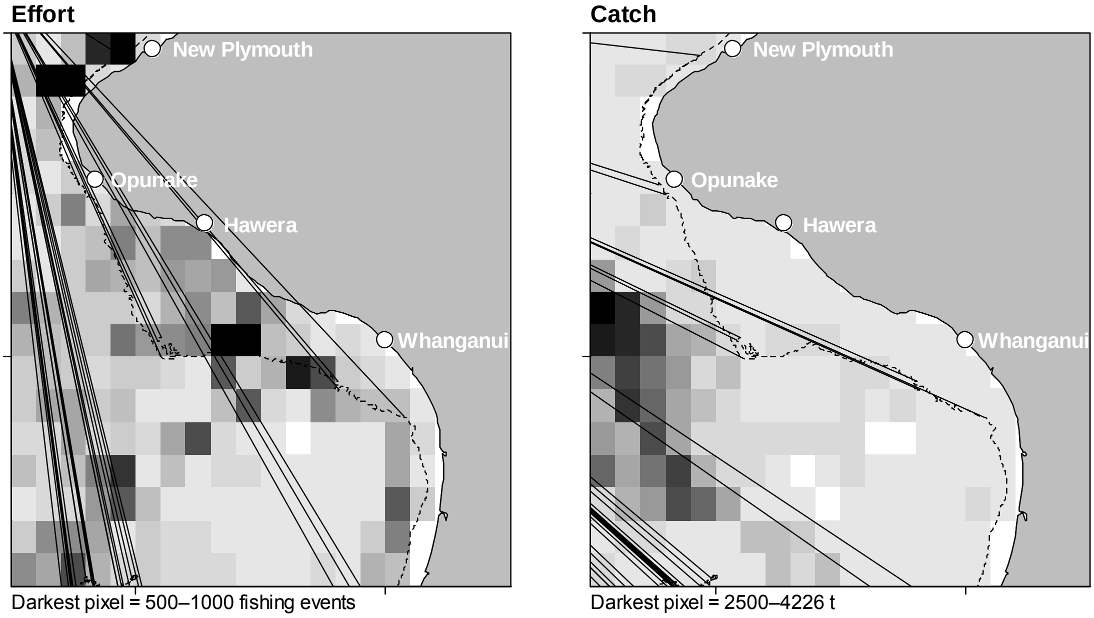

Figure 11.1. All fishing methods. Density plots showing the spread of fishing effort and total catch within the study area between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour.

11.4 Bottom trawling

The main species targeted by bottom trawling in most years was red gurnard, with 130–280 trawls per year and an average total catch (all species) of over 200 t per year for the period (Table 11.2). Several other species were consistently targeted, including tarakihi, trevally, barracouta, blue warehou, flatfish (several species), leatherjackets, john dory, snapper. Target trawling for jack mackerel, although less common than for these other species, produced the second largest total catch for the period. Bottom trawling occurs year round with no obvious seasonality in effort.

Table 11.2: Bottom trawling. Summary of fishing effort by target species and fishing year, and total catch by target species.

	Number of trawls							Total
Target species	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	Total	catch (t)
Red gurnard	178	156	133	166	283	248	1,164	1,550
Tarakihi	69	108	32	107	171	116	603	550
Trevally	45	90	44	67	79	98	423	841
Barracouta	12	6	29	223	71	41	382	832
Blue warehou	16	42	61	71	137	54	381	574
Flatfish	22	6	12	155	171	33	399	233
Leatherjacket	12	16	31	44	63	92	258	605
John dory	14	5	8	59	43	56	185	101
Snapper	14	1	2	51	47	54	169	119
Jack mackerel	16	0	23	67	15	1	122	1,194
School shark	11	8	1	5	12	2	39	39
Dark ghost shark	0	0	0	0	8	3	11	7
Red cod	0	0	0	5	2	1	8	3
Hapuka and Bass	0	0	0	4	2	1	7	3
Rig	1	0	0	1	2	1	5	2
Moki	0	0	0	0	1	1	2	1
Kahawai	0	0	0	1	0	0	1	<1

Bottom trawling was spread out over much of the study area, with the main areas of effort and catch being adjacent to New Plymouth, between Opunake and Hawera, south of Wanganui, and in the southwest corner of the area, to the north of Tasman Bay (Figure 11.2).

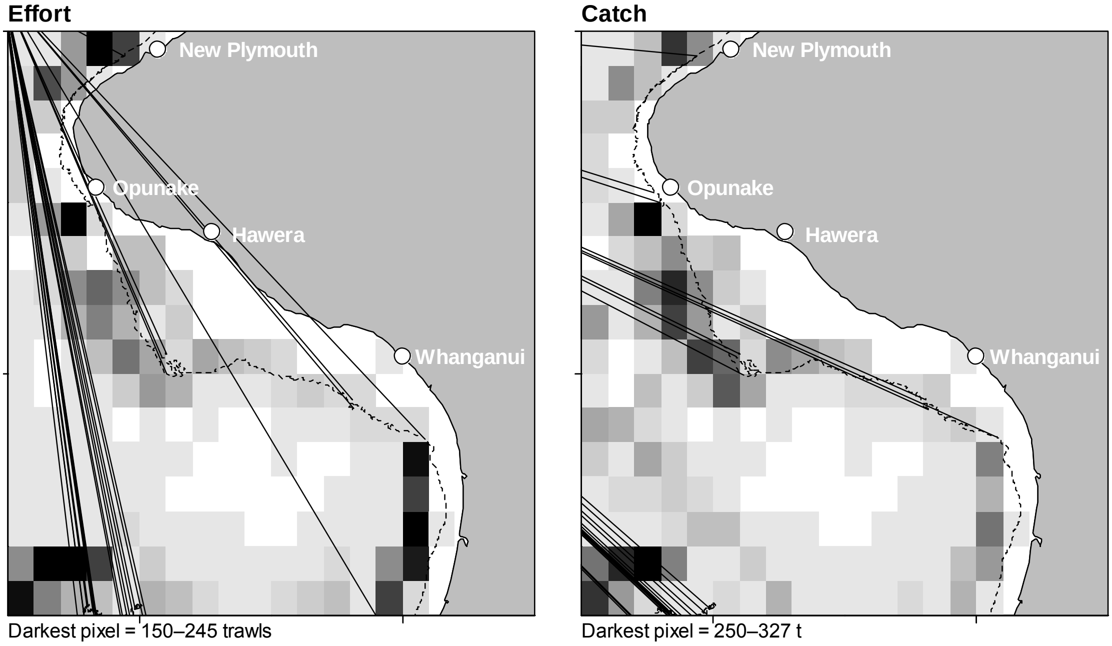

Figure 11.2. Bottom trawling. Density plots showing the spread of fishing effort and total catch within the study area between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour.

11.5 Midwater trawling

Midwater trawling in the area mostly targeted jack mackerel, with a small amount of barracouta targeting, and a single trawl targeting hoki (Table 11.3). In terms of both effort and total catch, midwater trawling for jack mackerel has been the most important fishery in the area, with over 64,000 t caught during the period, from over 3500 trawls. Midwater trawling occurs year round, but there has been a concentration of effort in December and January.

Midwater trawling tends to be in deeper water with most reported trawls well beyond the 50 m depth contour and focussed on a region parallel to the coast between Opunake and Whanganui (Figure 11.3). Fishing effort and catch has been most intense in the northern part of this area.

Table 11.3. Midwater trawling. Summary of fishing effort by target species and fishing year, and total catch by target species.

	Number of trawls							Total
Target species	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	Total	catch (t)
Jack mackerel	332	803	635	433	505	869	3,577	64,243
Barracouta	6	21	41	1	24	21	114	2,159
Hoki	0	0	0	1	0	0	1	8

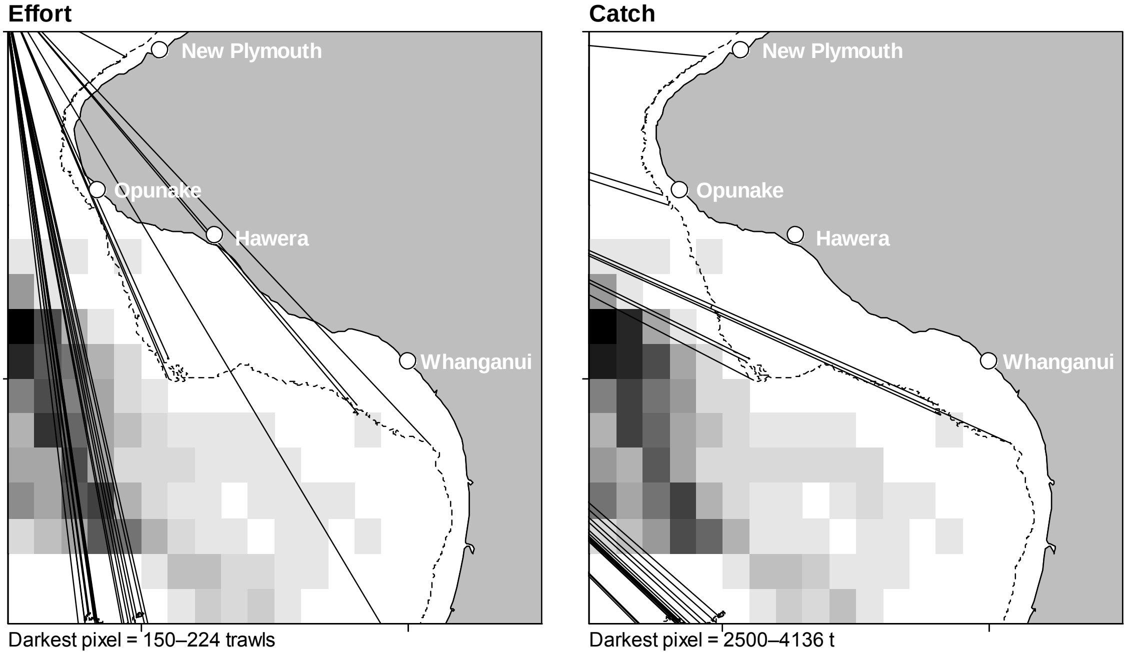

Figure 3. Midwater trawling. Density plots showing the spread of fishing effort and total catch within the study area between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour.

11.6 Set netting

Set netting in the area targeted three main species, rig, blue warehou, and school shark, with a moderately consistent level of effort in each year after 2005–06 (Table 11.4). A small fraction of set netting effort targeted trevally (39 t of total catch), and several other species were occasionally targeted. The total catch for all set netting combined was about 1,800 t during the last four years (including the incomplete current year) from about 2,000 sets. Set netting occurs year round with no obvious seasonality in effort.

Table 11.4. Set-netting. Summary of fishing effort by target species and fishing year, and total catch by target species.

	Number of sets							Total
Target species	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	Total	catch (t)
Rig	–	–	198	326	198	259	981	823
Blue warehou	–	–	96	114	171	127	508	351
School shark	–	–	58	125	135	85	403	634
Trevally	–	–	6	3	12	27	48	39
Flatfish	–	–	0	0	7	6	13	1.6
Kahawai	–	–	0	0	5	0	5	3.1
Elephantfish	–	–	1	0	0	0	1	0.0
Red gurnard	–	–	1	0	0	0	1	0.1
Hapuka/Bass	–	–	1	0	0	0	1	0.3
John dory	–	–	0	1	0	0	1	0.1
Snapper	–	–	0	1	0	0	1	1.8
Spiny dogfish	–	–	0	0	1	0	1	0.3
Tarakihi	–	–	0	0	0	1	1	1.0

Set netting was widespread throughout the study area, but with a focus on the coastline around New Plymouth and between Hawera and Whanganui, around or within the 50 m depth contour (Figure 11.4). There was a lower level of set netting effort recorded between this latter area and Tasman Bay and also along other parts of the coastline, but no effort recorded in the central South region of the area.

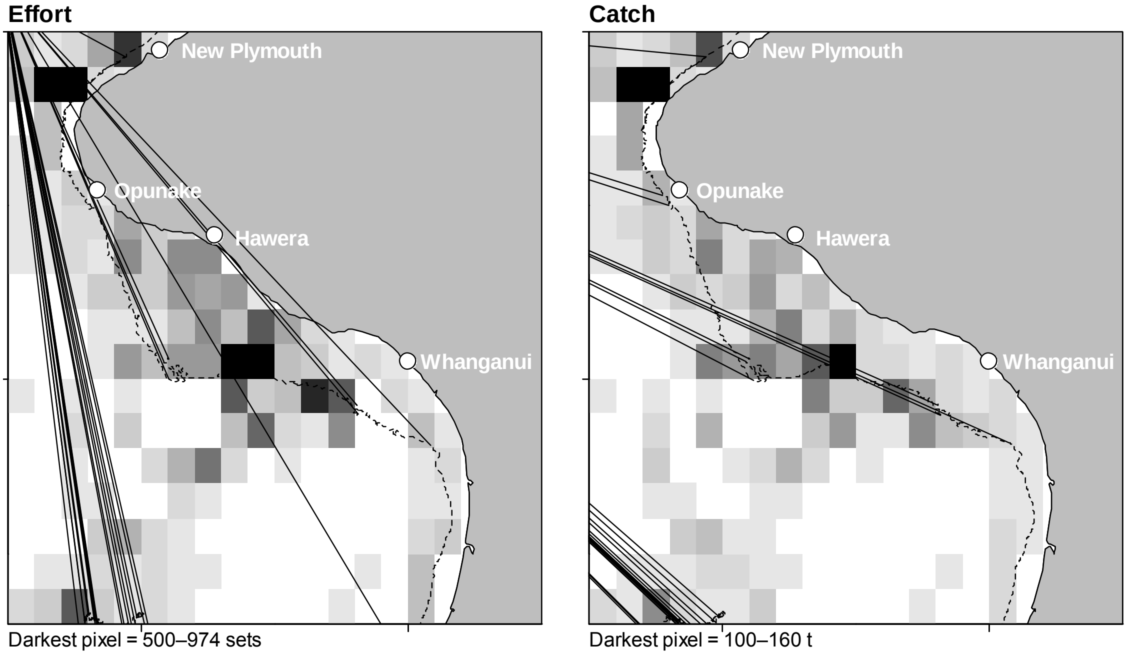

Figure 11.4. Set netting. Density plots showing the spread of fishing effort and total catch within the study area between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour.

11.7 Bottom longlining

Several species were targeted by bottom longlining in the area during the past six years, but effort data are mainly for the most recent three years, and catches were mostly related to fishing for red gurnard, school shark, and hapuka and bass (Table 11.5). Little more than 100 t of total catch were recorded for this method for the period examined. Bottom longlining occurs year round but there has been less effort in these years in the winter months.

Longlining effort was strongly concentrated on the area of coastline from New Plymouth to Cape Egmont, and also in the southwestern sector north of Golden Bay/Tasman Bay. Some longlining took place along the coastline between Hawera and Whanganui, but both effort and catch were at comparatively low levels (Figure 11.5).

Table 11.5. Bottom longlining. Summary of fishing effort by target species and fishing year, and total catch by target species.

	Number of sets							Total
Target species	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	Total	catch (t)
Red gurnard	0	–	–	34	44	27	105	29
School shark	0	–	–	14	21	27	62	56
Hapuka/Bass	0	–	–	24	11	7	42	20
Snapper	0	–	–	5	12	9	26	5
Blue cod	0	–	–	10	5	0	15	5
Tarakihi	0	–	–	7	0	1	8	2
Ling	1	–	–	0	1	0	2	3

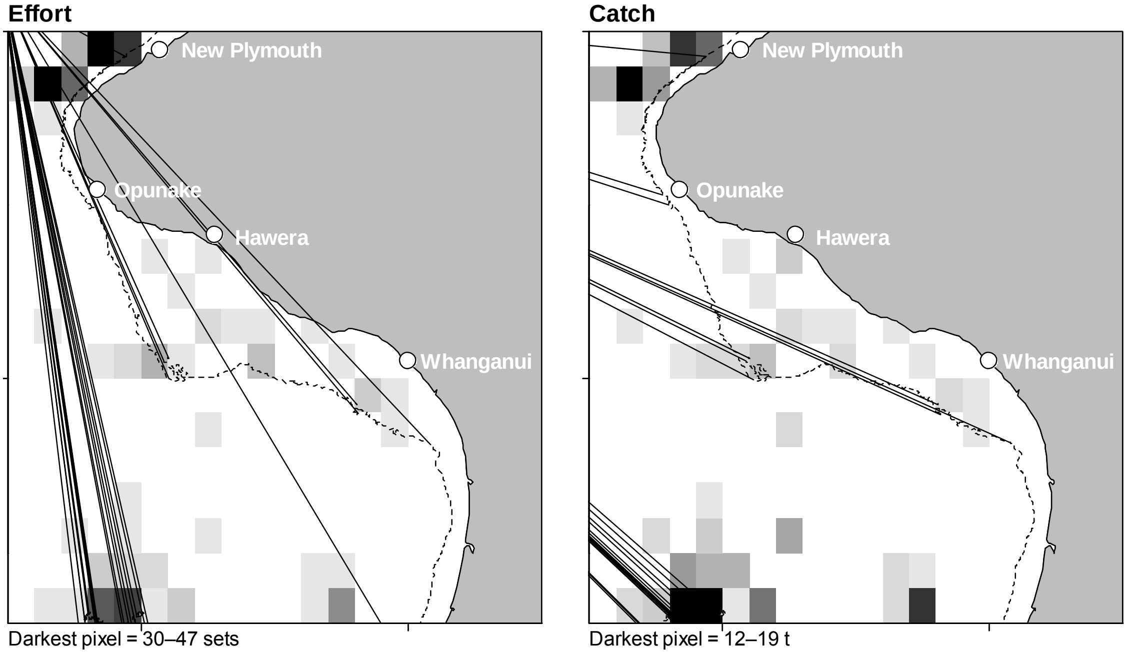

Figure 11.5; Bottom longlining. Density plots showing the spread of fishing effort and total catch within the study area between 1 October 2004 and July 2010. Pixels are 0.1° x 0.1° rectangles. The dashed line represents the 50 m contour.

11.8 Conclusions

Commercial fishing operations within the study area have been dominated in recent years by three main fishing methods, bottom trawling (for a variety of species), midwater trawling (mainly for jack mackerel), and set netting (mainly for rig, blue warehou, and school shark). Together these methods have accounted for 95% of all fishing events recorded with position data, between 1 October 2004 and mid-July 2010. Bottom longlining, squid jigging, and purse seining account for most of the remaining fishing effort, and there has also been a very small amount of trolling, rock lobster potting, drop lining, and fish trapping.

The lowest levels of fishing effort were in the offshore, central-south regions of the study area and in the shallowest parts of the southern and western coastlines. The highest levels of fishing effort (mainly bottom trawling and set netting) were between New Plymouth and Cape Egmont, relatively close to the shore, and between Hawera and Whanganui near the 50 m contour.

Fishing effort of all methods occurred throughout the year, but there was a concentration of midwater trawling effort in early summer, and notably less bottom longlining effort during winter.

This analysis is based on data only for which there was position data recorded, and does not include variable amounts of fishing effort assigned only to broad statistical areas which overlap the study area. It is expected, however, that the available data is largely representative of the total commercial fishing activities in the study area.

12. Summary and Conclusions

12.1 Wave climate

The wave climate on the 50 m isobath off the coastline of the South Taranaki Bight (STB) shows a spatial variation in mean significant wave height from a maximum of approximately 2 m off Cape Egmont, reducing progressively southward. There is a seasonal variation in wave heights, with the highest waves on average occurring in August and September. In storm conditions, significant wave heights of order 8 m can occur, particularly in the winter and early spring. Peak wave periods are most commonly in the range 10-14 seconds.

Wave energy flux shows high temporal variability, around mean values of 18 kW/m off Cape Egmont, reducing to less than 10 kW/m further south. The orientation of the coast relative to the predominant WSW incident wave direction results in the longshore component of energy being directed predominantly towards the southeast along much of the coast of the STB. We would therefore expect that in the northern part of the Bight, from Opunake to south of the Wanganui River, wave-driven processes will tend to transport sediment along the coast towards the southeast, while in much of the Manawatu coast, northward transport will predominate. More detailed study of nearshore processes would, however, be required to quantify these transports.

12.2 Tidal currents

While not quite as strong as tidal flows through Cook Strait proper, tidal currents of up to 0.4 ms^{-1} occur on the relatively shallow waters off Patea. Tidal currents are smaller (with peak speeds less than 0.1 ms^{-1}) in nearshore waters between Wanganui and Foxton. Peak tidal flows throughout the study region are generally aligned coast-parallel with only moderate cross-shore minimum velocities.

12.3 Shoreline stability

Most of the shoreline in the study area is unmodified and in near natural state. Apart from the areas that have been modified, it’s likely the shoreline will continue to do what it has done in the past because the processes are driven by geology and climate cycles. Climate change effects on the factors influencing shoreline change are not included in this report.

Rivers input the majority of sediment to the Taranaki, Whanganui and Manawatu coasts. The Taranaki coast is generally considered sediment starved, but episodic catchment erosion events during floods and lahars can inject large quantities of sediment to the coast from a point source. However, there is little information about whether there is input of sediments from the offshore region to the littoral zone and the shoreline.

These sediments are distributed alongshore or offshore but are eventually transported beyond the study area. There is a general understanding of nearshore and offshore sediment transport in the study area, with sediment predominantly pushed by the strong westerly wave climate along the coast from Cape Egmont to the northeast in the direction of New Plymouth, and southeast in the direction of Whanganui.

Variable shorelines dominate the North Taranaki coastline between Stony River and New Plymouth, due to episodic sediment input, especially from the Stony River.

The coastline between Stony River and Oaonui has been described as erosive due its exposure to constant wave attack, although it is also suggested that offshore reefs provide some protection and that stable vegetation surveys suggest the cliffs are stable. There were few survey data in this area and they show accretion, variable or stable shorelines.

Erosion occurs along the cliffs (both volcanic and sedimentary) from Oaonui to Whangaehu, in the centre of the study region, along the South Taranaki Bight. Accretion occurs predominantly along the south of the study area, where dunes and sand country dominate the shoreline.

There are few data for the Horizons coast, but available information suggests the dunes and sand country are prograding, although erosion is identified as a natural hazard for some coastal settlements.

12.4 Ocean Primary Productivity

Complex optical conditions are prevalent in the STB, making the quantification of chlorophyll from remotely sensed ocean colour data extremely difficult. Particulate and dissolved terrigenous material is frequently advected into the region from the Marlborough Sounds, west coast of the South Island and from Cook Strait. Phytoplankton blooms appear to peak in springtime, with an origin off-shore to the west of the study region, and apparent advection of the bloom through the study region and into the Cook Strait. River inputs of terrigenous material along the

Taranaki coastline are frequent but sporadic. Massive resuspension of bottom sediments, presumably wind-driven, occasionally causes the entire region to appear bright and turbid. Chlorophyll values at those sites deemed to be least compromised by terrigenous inputs (sites N, D1, D2) range from 0.02 to 4.4 mg m^{-3}, with blooms occurring regularly during October, and no significant autumn bloom. Apparent median chlorophyll values are relatively high throughout the year all across the study area, with an overall range of 0.02 to 32 and median 0.57 mg m^{-3}. This compares to values typically < 0.1 mg m^{-3} in clear blue waters. No significant decadal trends were observed in apparent chlorophyll concentration.

12.5 Zooplankton

The limited data set available indicates that the STB is biologically productive in terms of mesozooplankton. Biomass estimates are among the highest recorded, when other coastal regions around New Zealand are considered. The STB may represent a breeding ground for zooplankton, which in turn promotes aggregations of larger mobile predatory species, particularly squid. The mesozooplankton species composition is neritic (nearshore) and is strongly influenced by the physical oceanography of the region, including both the upwelling events off Cape Farewell and the D'Urville current.

Although a reasonable amount of mesozooplankton sampling has been done in the STB, it was conducted a number of years ago, using non-standardized techniques. Also lacking are estimates of zooplankton biomass taken from the surface to the seafloor, which are important components in ecosystem models.

12.6 Benthic Invertebrates

The available data indicate that benthic invertebrate fauna in the SBT is generally species poor with a low abundance of organisms in both subtidal and intertidal zones when compared to other coastal areas of New Zealand. This may be to be due to the high energy environment area resulting in very mobile sediments, sand inundation of reefs, sand scouring of reef habitats, and high water turbidity in nearshore areas. Species numbers and diversity tend to increase towards the shore, with the highest numbers in the nearshore area.

Analysis of data from NIWA's *Trawl* database showed a productive zone for invertebrates in the southwest of the study area where high wet weights of squid, octopus and decapods have been recorded. This offshore productive zone is most likely due to the influence of the cold, nutrient rich water that originates from the upwelling zone off Cape Farewell and the Kahurangi shoals. This may explain the rich fishery within this part of the SBT despite the generally low benthic species richness and abundances reported.

In comparison to much of the New Zealand coastline there are few data available on the macrofauna of the South Taranaki Bight and therefore any characterisation based on these data should be treated with caution. However, inspection of a variety of datasets within this study suggests generally low species richness across most taxonomic groups within the area but did however highlight some potentially interesting community compositions within the bryozoan and algal taxonomic groups.

From the available information, benthic species richness and abundance are particularly low in the sandy habitat within the study area. Benthic macrofaunal communities of the South Taranaki Bight, particularly those inshore and close to sand beds, are often exposed to naturally high levels of disturbance from high wave energy and mobile sediments, including sand scour.

Primary (Section 3) and secondary (Section 4) pelagic productivity is relatively high in the STB region compared to other similar coastal regions but this does not appear to be translated into dense or diverse benthic macrofaunal communities. This may be to be due to the high energy environment of the area.

No nationally endangered or at risk benthic macrofaunal species were found to be present within the area. However, the Department of Conservation (DOC 2006) describes the Waitotara estuary, Waiinu reef, Waverley Beach, North and South Traps, Whenuakura estuary and Whanganui river estuary, all within the study area, as being "outstanding natural areas".

12.7 Reef Fish

The South Taranaki Bight has a moderately diverse reef fish fauna with only 38 of the 72 species modelled by Smith (2008) New Zealand wide predicted to occur on reefs within SCUBA diving depth range in the region. Two species, black angelfish and common roughy, are rare in the region occurring at low abundance on just a few coastal reefs. Six other species have restricted distributions occurring at <50% of the reef sites in the region. All other twenty-nine species are predicted to be much more widespread and either occur in low abundance throughout the region (14 species), are moderately common over the entire area (13 species), or are abundant widely distributed species (2 species).

An important caveat with these predicted reef fish abundances is that none of the reef sites surveyed around New Zealand that generated the original data used by Smith (2008) were from along the south Taranaki coast. Thus, these predictions need to be interpreted cautiously.

Many of the reef fish are predicted to occur on the off-shore shoals as well as on coastal rocky reefs. In Smith's (2008) study, all seabed features with abrupt changes in vertical relief were assumed to be reef structures, but this may not always be the case. In some cases large sand waves may have been interpreted as reefs and the modelled predictions of reef fish abundance applied to these areas.

12.8 Demersal Fish

Fifty-one species of demersal fish occur in the region. The richness of this assemblage is moderate on a New Zealand wide scale with on average 12-16 species likely to occur within a standard research tow. A few species are very widespread and abundant but most species are common only within a restricted depth range. A few species had a very restricted distribution in the region.

Species with main distributions along the South Taranaki coastline that coincide with areas of interest to TTR include anchovy, blue cod, eagle rays, red gurnard, golden mackerel, leather jacket, lemon sole, snapper, rig and trevally.

Depth, temperature, and salinity are the main predictors of demersal species abundance (Leathwick et al. 2006).

12.9 Whales and Dolphins

While the cetacean sightings data used must be interpreted with caution as the distribution of sampling effort is unknown (i.e.presence only), it appears that relatively few sightings of cetaceans have been made within the northern and southern Taranaki bights. However, three endangered or critically endangered species do frequent this area: the Maui's dolphin, killer whale, and southern right whale. The New Zealand populations of these species are extremely low.

12.10 Sea Birds

The SBT supports a relatively modest seabird assemblage, but detailed, systematic and quantitative information on the at-sea distribution of virtually all species is currently lacking. Many of the species occurring in the area are likely to be relatively coastal in their distributions. Such species include blue penguin, shags, gulls and terns, although these latter taxa can extend to more offshore areas. By contrast, and although some species have been observed from and relatively close to the coast, albatross and petrel species tend to be more pelagic and wide-ranging in their distributions and will likely occur anywhere throughout the area. The area does not support large breeding colonies for any species but a number of estuarine sites are of significant value to coastal, shore, wading, and migratory bird species. These include the Waikirikiri Lagoon, and the Whanganui, Whangaehu, Turakina, Manawatu and Rangitikei river estuaries.

12.11 Commercial Fisheries

Commercial fishing operations within the study area have been dominated in recent years by three main fishing methods, bottom trawling (for a variety of species), midwater trawling (mainly for jack mackerel), and set netting (mainly for rig, blue warehou, and school shark). Together these methods have accounted for 95% of all fishing events recorded with position data, between 1 October 2004 and mid-July 2010.

The highest levels of fishing effort (mainly bottom trawling and set netting) were between New Plymouth and Cape Egmont, relatively close to the shore, and between Hawera and Whanganui near the 50 m contour. Fishing effort of all methods occurred throughout the year, but there was a concentration of midwater trawling effort in early summer.

13. Appendices 1-4 see separate reports/files