RANGATIRA REEF BENTHIC SURVEY AND ASSESSMENT OF ENVIRONMENTAL EFFECTS

OF THE PROPOSED WHAKARIRE AVE, BREAKWATER

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1.0 INTRODUCTION

1.1 BACKGROUND

Coastal erosive processes at the southern end of Westshore Beach have received a considerable amount of attention over the years (Gibb, 2002; Gibb, 1996; Kirk and Single, 1999; Mead et al., 2001; Smith, 1986; Smith, 1993). A comprehensive précis of the coastal erosion issues facing South Westshore concluded that the breadth of knowledge of coastal processes was continuing to be used to effectively manage the coastline (Komar, 2007). However, there have been a number of remedial measures carried out that have attempted to address the erosion in the South Westshore area with limited success. In 1995 dredge spoil sourced from the inner harbour channel was deposited along the Whakarire Avenue – Charles Street foreshore reserve (Resource Consent CL950059D). Unfortunately the sediment was rapidly redistributed, dispersed and eventually lost from the foreshore over a 6 month period (P. Frizzell *pers com*). A sea wall and groyne system built soon after to protect properties and the foreshore reserve along the western side of Whakarire Avenue and to provide an anchor for retaining sand in the area has been of some benefit in halting the erosion. However, the sea wall has had the unintended effect of funnelling waves into a specific area, where Westshore Beach ends and the sea wall along Whakarire Avenue begins, exacerbating the erosion at this point. It was also reported that the integrity of the seawall could be compromised in a major storm (Beca, 2003).

A number of coastal protection options to address the erosion where outlined to the Napier City Council (NCC) (Beca, 2003) and eventually the construction of an attached breakwater with a created beach was decided upon as the preferred option. A report on the likely effects of a breakwater on the surfability of waves at the Rangatira Reef surf break found that waves reflected from a breakwater would negatively impact on surf quality (MetOcean, 2008). However, it was noted that a "V" shaped breakwater would greatly reduce this impact. Taking this recommendation into account a preliminary engineering report was completed which examined the effect of various configurations of a V-shaped breakwater on surf quality (Beca, 2008). Following the selection of a preferred design, a scoping report identifying the extent and key issues to be addressed in the preparation of an Assessment of Environmental Effects (AEE) was completed (EAM, 2008).

1.2 THIS STUDY

Nearshore rocky reef environments within the Napier City limits comprise a relatively small area of coast, compared to the city's landmark gravel beaches. Many of these reef environments are not easily accessible to the public, such as the artificial reef substrates that comprise the Port of Napier's breakwater and reclamations. Rangatira Reef is one of the few easily accessible reef environments in Napier City, and provides important public amenity value for activities such as recreational fishing, diving, and surfing and as an educational resource. In addition the Maori people of Te Whanganui a Orotu place significant cultural value on Rangatira Reef, with references to this reef system in the Pania mythology. As well as providing valuable public amenity and cultural values it is generally well accepted that the complex habitats of rocky reefs support a high species diversity, including nearshore finfish, grazing gastropods and echinoderms, filter feeding bivalves and a myriad other invertebrate species. Moreover, the intrinsic value of these reef environments is also now widely recognised.

Previous ecological studies of the reef have focused on the intertidal zone (Anderson, 1997; Anderson, 1998), with these surveys undertaken as a result of resource consent conditions associated with the disposal of dredge spoil along the Whakarire Ave. foreshore in 1995. A further study, also undertaken as part of resource consent conditions to monitor effects of dredge spoil disposal, used indicator species *Perna canaliculus* (green lipped mussels), *Evechinus chloroticus* (kina) and *Turbo smaragdus* (cat's eye) as a basis to detect change (EMS, 2004). However, the limited extent of these intertidal surveys leaves a large gap in the ecological information of the reef in terms of subtidal assemblages.

With increasing pressure on environments surrounding towns and cities there is the risk that these environments may become degraded over time. Given these values, the risk of degradation, and the small amount of ecological information available on the subtidal Rangatira Reef environment, NCC engaged Environmental Assessments and Monitoring Ltd. (EAM) to conduct a benthic survey of the reef and compile an AEE for the proposal to construct a breakwater.

Due to the highly dynamic, physically dominated nature of the reef a fast, easy and robust survey technique was employed whereby underwater digital photography with integrated GPS location data was used to map subtidal reef habitats. The classification and mapping of reef habitats is one of the primary tools used by resource managers to establish baselines and detect change in their spatial extent (Parsons et al., 2004). For this study baseline community structure of Rangatira Reef was assessed by standardised qualitative classification of habitat type from photo transects. The survey methodology allowed an estimate of the extent and types of reef habitats that will be removed, altered or may become vulnerable to effects from the proposed breakwater. These data were then used as the basis for the AEE.

2.0 METHODOLOGY

2.1 STUDY AREA

The proposed breakwater will be built adjoining the existing sea wall on the western side of the Whakarire Avenue foreshore, South Westshore, Napier. Surrounding this area is Rangatira Reef, a complex of substrate types including boulders, cobbles, pebbles, sand and gravel that extends from the point of the western Ahuriri training mole to the concrete cube groyne at the southern end of Westshore Beach, and from mean high water springs to between 100m and 200m offshore (Figure 1). The areal extent of the reef was determined by the GPS track of a SCUBA diver, with attached float and GPS unit, swimming around the discernable edge of the reef. Difficulties were encountered in trying to delineate the reef boundary because, like most marine habitats, there are no “hard” boundaries between habitat types. Therefore the areal extent of the reef is best viewed as a generalized boundary and indicative only .

2.2 REEF PHOTO TRANSECTS

The benthic environment of Rangatira Reef was surveyed using underwater digital photography with integrated GPS location data (methodology modified from Roelfsema (2007)). This technique involved a SCUBA diver taking underwater still photographs along a transect line (photo transect) as a basis to identify and assess subtidal reef habitat types. Each habitat type represents the biological community or assemblage that is the product of the physical and biological variables influencing the reef. The photos were geo-referenced through post processing of the track recorded by a GPS, with the GPS being towed by the same diver taking the photos (Figure 2).

FIGURE 2: GRAPHIC OF DIVER WITH RAFT AND GPS UNIT ATTACHED AND PHOTO TRANSECT

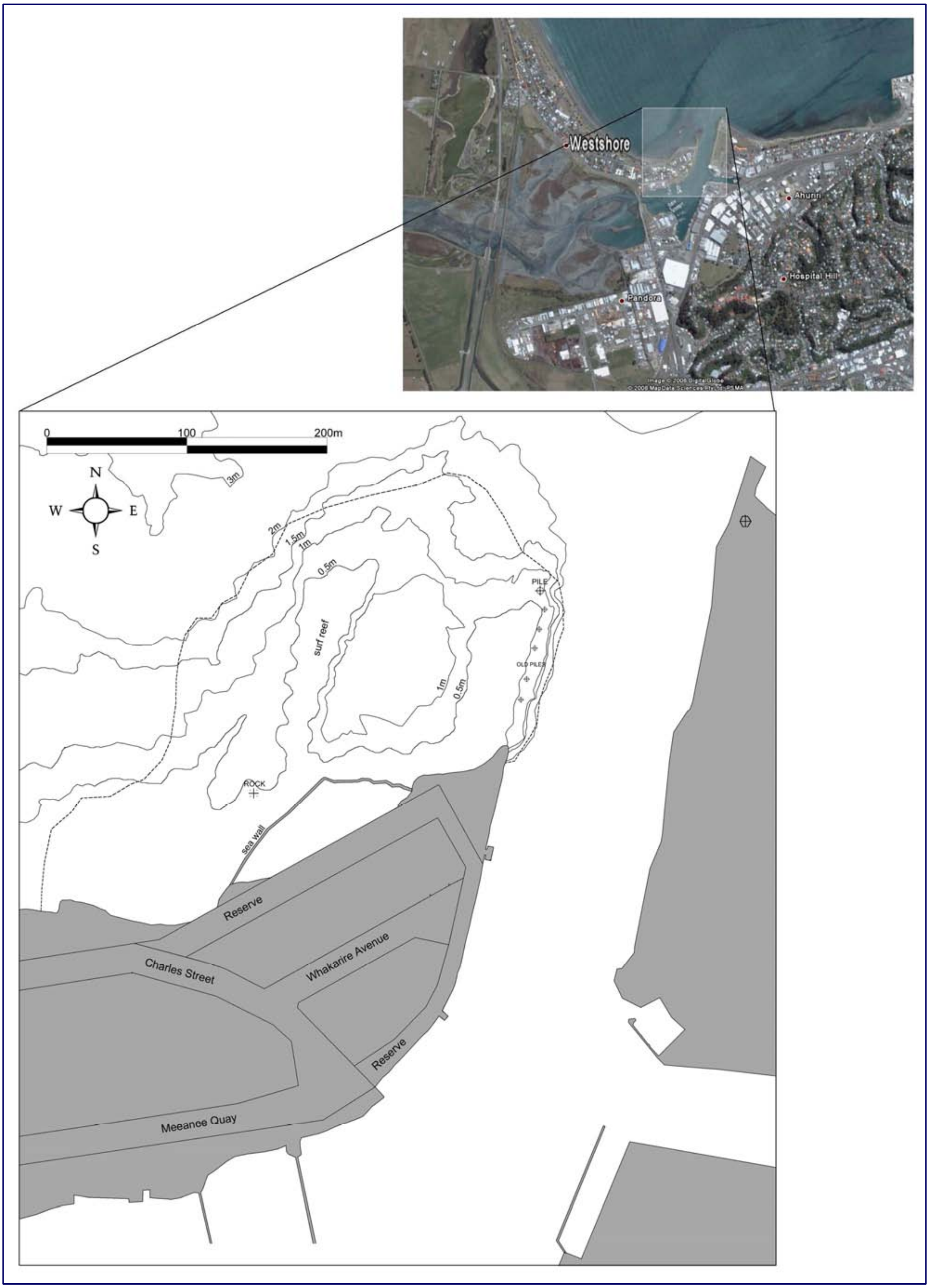


FIGURE 1: SOUTH WESTSHORE AND RANGATIRA REEF, WITH EXISTING SEA WALL AND SURF REEF SHOWN. DEPTH CONTOURS ARE SHOWN REDUCED TO NAPIER CHART DATUM AND AREAL EXTENT OF RANGATIRA REEF (DASHED LINE) IS INDICATIVE ONLY.

A total of 5 photo transects were completed, with the first carried out on the 15th-16th July, 2008 and the remaining four carried out over a week long period from the 4th-10th September, 2008. Locations of each geo-referenced quadrat for each transect are included in Appendix 1. The time lag between completing the initial and final transects was a result of a combination of heavy sea conditions and poor visibility over the period. The time lag between sampling dates was not considered to significantly affect results between dates because both dates occurred during the winter low water temperature period, i.e. there was no seasonal effect between sampling dates.

Transect starting positions, and headings were selected from an aerial photo of the area prior to sampling (Appendix 1). A hand held Garmin eTrex H GPS unit was used to locate the starting positions (accuracy ± 2m) and compass used to determine the correct heading. A photo was then taken of the clock on the GPS screen, for time correction purposes, and the GPS unit attached to a small raft which was in turn attached to the diver by an extendable length of rope. From the starting position the diver progressed along the planned track and at set intervals, estimated by 5 kick cycles, horizontal projective photos were taken of the seabed. The amount of reef area each set of photos represented was 0.25m^2 (one quadrat). The location of photos was continuously recorded by the GPS unit in the raft at the surface. Despite extra care being taken to keep the rope to the raft taut, in order to keep the raft and GPS directly above the camera, it was inevitable that the raft lagged slightly behind the diver, estimated to be in the order of 1-2m. Also, with the influence of waves and swell, difficulties were encountered in maintaining a straight transect line underwater.

At the completion of a dive photos were downloaded to a PC and linked with GPS coordinates by matching the corrected timestamp of each photo with the respective timestamp of each GPS track coordinate. The location data from each photo along respective transects was then imported into a geo-referenced map of the area (projection: NZMG Geodetic Datum 1949) using MapInfo (MapInfo, 2006) Geographical Information System (GIS) software (Figure 3).

2.3 PHOTO TRANSECT ANALYSIS

Once photo transect data was integrated into a GIS environment each set of quadrat photos were assessed for species composition and substrate. From these assessments each quadrat was subjectively classified into one of 6 different qualitative habitat type descriptors. The habitat type descriptors used in this study were based on those developed by Shears (2004), however some modification of the descriptions for each habitat type were made to better reflect the nature of Rangatira Reef, including the addition of a sand habitat type. Habitat types were categorised according to the list in Table 1. It is important to note that the abundance and/or percentage cover values provided in the definitions are indicative only. Categorisation of photos into specific habitat types was based on subjective assessment of visual dominance of particular species.

After classifying photos into habitat groupings a thematic map was created, which displayed transect data points by habitat type. These data were then used as the basis from which a spatially continuous habitat map was created using IDW (inverse distance weighted, or spline) interpolation, with coincident points aggregated by their averages. The grid from which the map was generated was clipped against the areal extent of the reef with the grid dimensions being 206x198 with a cell size of 1.16m.

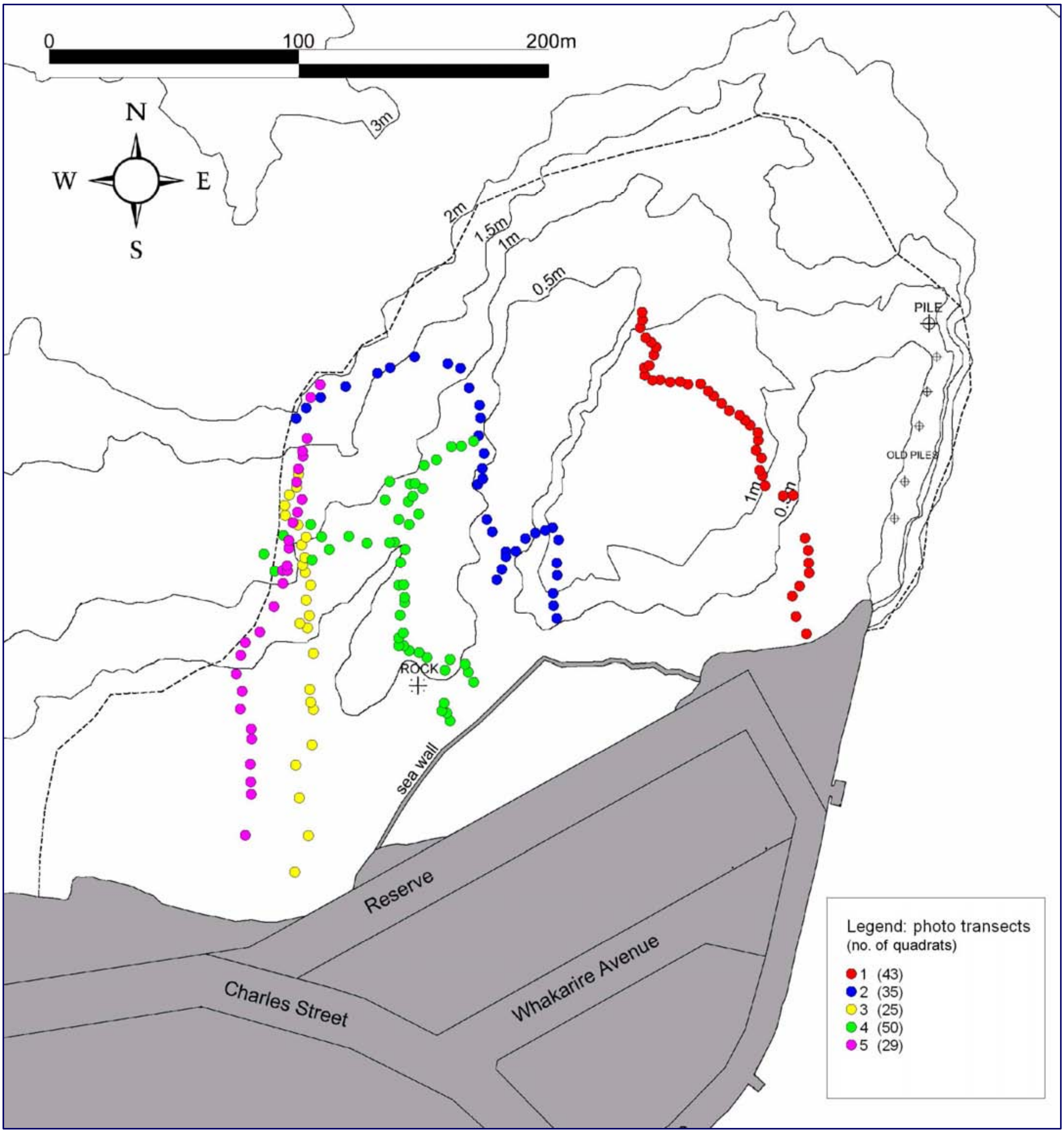


FIGURE 3: LOCATION OF PHOTO TRANSECTS, ONE COLOURED CIRCLE REPRESENTS ONE HABITAT TYPE. DEPTH CONTOURS ARE SHOWN REDUCED TO NAPIER CHART DATUM AND AREAL EXTENT OF RANGATIRA REEF (DASHED LINE) IS INDICATIVE ONLY.

TABLE 1: DESCRIPTION OF HABITAT TYPES USED IN THE BENTHIC SURVEY OF RANGATIRA REEF. FIGURES ARE INDICATIVE ONLY AND HABITAT TYPES DETERMINED BY SUBJECTIVE ASSESSMENT OF DOMINANT SPECIES.

HABITAT TYPE	DESCRIPTION
Cobbles*	Reef comprises cobbles (c. < 0.5m diam.), unstable and subject to high levels of agitation from wave exposure. Crustose coralline algae are dominant along with a high cover of bare rock and sand. Large brown algae are generally absent.
Sand	General absence of hard reef substrate, coarse sand dominant. Highly dispersive and ephemeral with noticeable rippling. Crustose coralline algae occurring sparsely in firmer areas.
Red foliose algae†	Substratum predominantly covered (>40%) by red foliose algae such as Karengo (*Porphyra* sp.) and *Pterocladia lucida*. Low numbers of large brown algae. Reef substratum mainly boulders (c. 0.5m diam.) with some cobbles.
Shallow *Carpophyllum*†	Dominated by high abundances (≥ 10 adult plants m^{-2}) of *Carpophyllum maschalocarpum*. *Cystophora* species are also common. Reef substratum consisting mainly of stable aggregations of cobbles and pebbles.
Turfing algae†	Substratum predominantly covered by turfing algae (e.g. articulated corallines and other red turfing algae) (>30% cover). Low numbers of large brown algae. Reef substratum mainly pebbles and gravel with few cobbles.
Encrusting invertebrates†	Usually occurring in deeper areas, reef substratum comprised of gravelly mud interspersed with cobbles. Substratum predominantly encrusted with the solitary ascidian (*Cnemidocarpa bicornuta*) and common anemones (*Actinothoe albocincta*). Horse mussels (*Atrina zelandica*) and 11 armed sea star (*Coscinasterias muricata*) may be common. Large brown algae generally absent.

*habitat type described by Shears (2004)
†description modified from Shears (2004)

2.4 REEF VIDEO TRANSECTS

Using the video functionality of the digital camera a similar methodology to that described for photo transects was used to record geo-referenced video transects of the reef. Video offers the benefit of being able to be replayed, and in slow motion, in order to gain a clearer picture of the scale and heterogeneity of habitat types. GPS locations along the track of the video transects were used to generate poly lines within MapInfo which allows a visualisation of the tracks (Figure 4). Start and finish locations of video transects are included in Appendix 1. Assessment of the video transects provided a general description of habitats encountered.

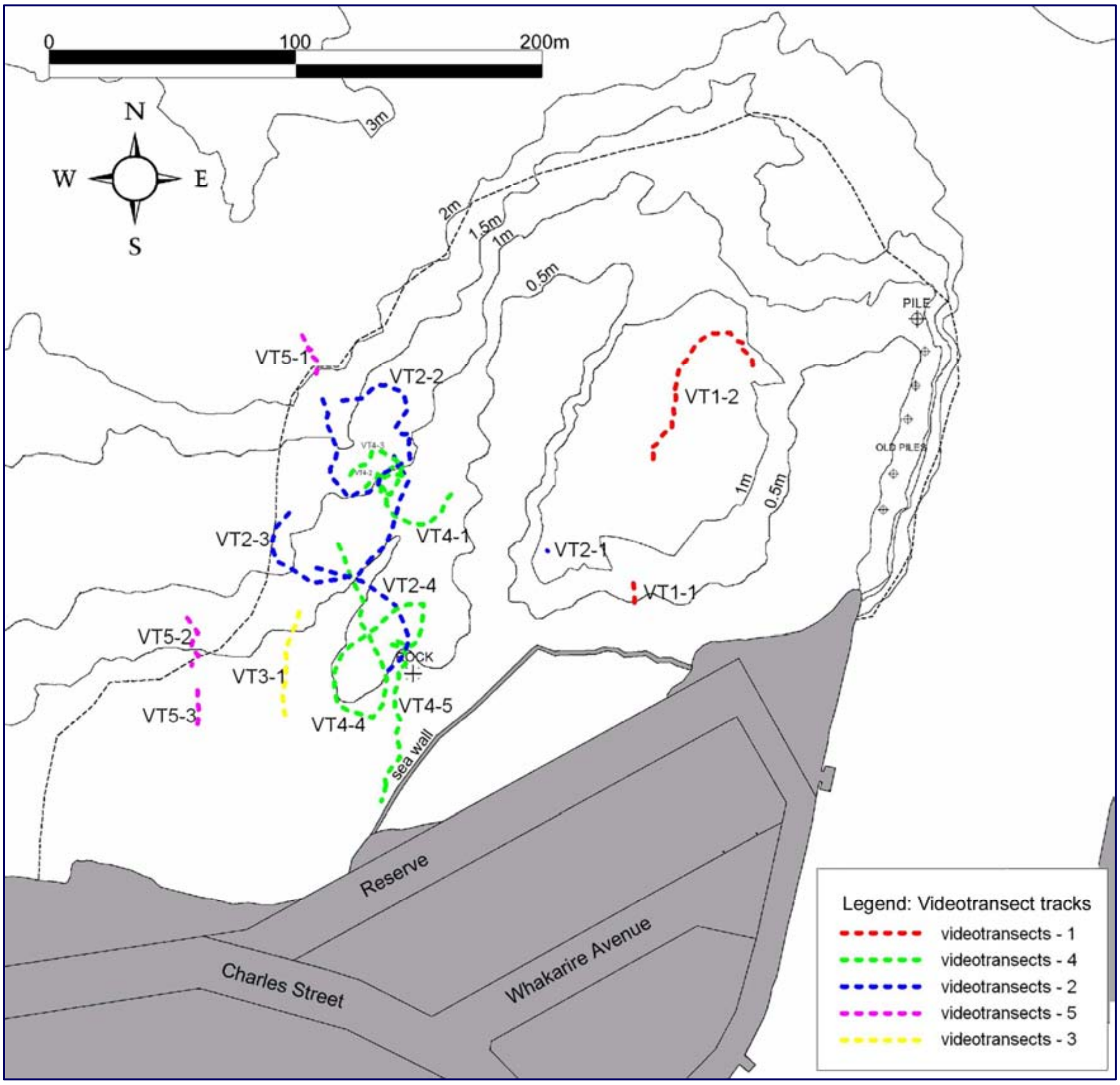


FIGURE 4: LOCATION OF VIDEO TRANSECTS, LABELLED ACCORDING TO VIDEO TRANSECT NUMBER (VT) AND FILE NUMBER. DEPTH CONTOURS ARE SHOWN REDUCED TO NAPIER CHART DATUM AND AREAL EXTENT OF RANGATIRA REEF (DASHED LINE) IS INDICATIVE ONLY.

3.0 RESULTS

3.1 REEF PHOTO TRANSECTS

A total of 182 quadrats, representing all photo transects were assessed. A non-exhaustive list of species identified from these quadrats is detailed in Table 2 and photographic plates of example specimens and habitat types are included in Appendix 2. Brown algae (Phaeophyta) were common throughout, with *Carpophyllum maschalocarpum* and *Colpomenia durvillaei* present in all 5 transects. Other species that were observed in all 5 transects included *Codium fragilis,* coralline turf, *Actinothoe albocincta, Patiriella regularis, Atrina zelandica* and *Cnemidocarpa bicornuta.*

TABLE 2: LIST OF SPECIES IDENTIFIED FROM PHOTO TRANSECTS OF RANGATIRA REEF.

TAXA	PHOTO TRANSECT 1 (N=43)	PHOTO TRANSECT 2 (N=35)	PHOTO TRANSECT 3 (N=25)	PHOTO TRANSECT 4 (N=50)	PHOTO TRANSECT 5 (N=29)
Chlorophyta					
Codium fragilis	X	X	X	X	X
Ulva lactuca				X	X
Phaeophyta					
Carpophyllum	X	X	X	X	X
maschalocarpum				X	X
Carpophyllum flexuosum	X	X	X		X
Cystophora sp.	X	X	X	X	X
Colpomenia durvillaei		X			
Glossophora kunthii				X	
Xiphophora gladiata	X	X		X	X
Undaria pinnatifida					
Rhodophyta					
Porphyra sp.					
Apophloea sinclairii		X			
Pterocladia lucida	X	X			
Coralline turf	X	X	X	X	X
Champia sp.	X	X			X
Gigartina sp.				X	
Anthozoa					
Actinothoe albocincta	X	X	X	X	X
Hydrozoa					
Hydroids	X	X			
Bryozoa					
Bryozoan		X			
Echinodermata					
Patiriella regularis	X	X	X	X	X
Coscinasterias muricata		X	X		X
Gastropoda					
Turbo smaragdus	X	X	X	X	
Cookia sulcata		X	X	X	
Phenatoma rosea		X			
Cymatium spengleri				X	
Melagraphia aethiops			X		
Bivalvia					
Atrina zelandica	X	X	X	X	X
Perna canaliculus			X		
Cirripedia					
Chamaesipho brunnea		X			X
Polychaeta					
Serpulidae		X		X	X
Tunicata					
Cnemidocarpa bicornuta	X	X	X	X	X
Pyura pachydermatina			X	X	X
Osteichthyes					
Tripterygidae		X			
TOTAL NO. TAXA/TRANSECT	**14**	**23**	**15**	**18**	**18**

The thematic map produced from interpolation of the habitat type point data provides a visualisation of the areal extent of habitat types (Figure 5). In general there was a ordering of habitats along a depth gradient with deeper areas of the reef (>1m) predominantly encrusting invertebrate habitat and shallower areas cobble (0.5m). The sand habitat was found only in the two eastern most transects and also tended to occur in shallower areas. Turfing algae and shallow *Carpophyllum* habitat types tended to occur patchily throughout the mid depth region (0.5m—1m), due mainly to the patchy nature of the larger, more stable cobbles and boulders that these seaweeds attach to. Similarly, the red foliose algae habitat type although rarely recorded tended to also occur patchily, also growing on the larger more stable cobbles and boulders.

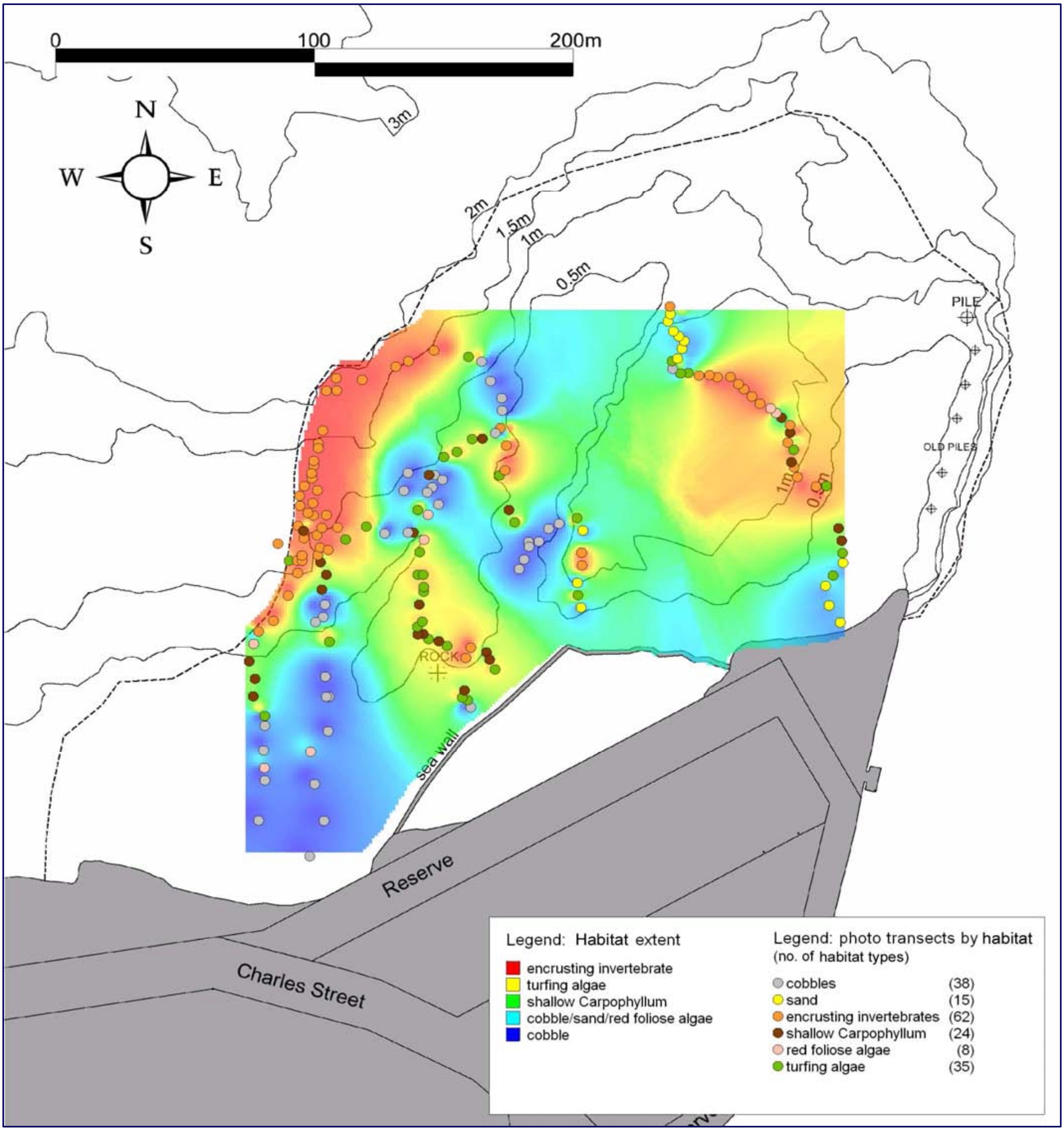


FIGURE 5: HABITAT TYPE LOCATIONS AND EXTENT DERIVED FROM PHOTO TRANSECT DATA. DEPTH CONTOURS ARE SHOWN REDUCED TO NAPIER CHART DATUM AND AREAL EXTENT OF RANGATIRA REEF (DASHED LINE) IS INDICATIVE ONLY.

Examining individual transects in photo transect 1, a total of 43 quadrats were assessed for habitat type with approximately 33% classified as encrusting invertebrate habitat, 28% sand, 19% turfing algae, 12% shallow *Carpophyllum*, 7% red foliose algae and 2% cobble (Figure 6a). A distinctive pattern of zonation is evident with sand occurring at the beginning of the transect followed by an area of patchy shallow *Carpophyllum*, turfing algae and cobble and moving into encrusting invertebrate habitat within a basin type depression of the reef. Within this area a bed of *Atrina zelandica* (horse mussel) was encountered. The sand habitat evident, at the north – western edge of the basin were highly rippled, indicating that sediments in this area are prone to dispersion, and likely affected significantly by swell and wave action.

Photo transect 2 had a total of 35 quadrats assessed for habitat type, with 37% of these encrusting invertebrate, 34% cobble, 14% turfing algae, 9% sand and 6% shallow *Carpophyllum* (Figure 6a). The first few habitat types were assessed as sand, which changed to encrusting invertebrate habitat upon moving into the basin type depression as described above. Here two locations were assessed as encrusting invertebrate habitat type with a small bed of *Atrina zelandica* present. The surfing reef was encountered after the 7th quadrat was classified (*see* Figure 5) with the influence of waves and swell noticeable as depth decreased. The appearance of the cobble habitat type, also signified the beginning of the surfing reef, and interestingly the first occurrence of *Undaria pinnatifida* was noted. As the transect progressed to the western side of the surf reef a small area of encrusting invertebrate habitat type was encountered followed by another cobble area leading into the encrusting invertebrate habitat type proper.

Photo transect 3 comprised 25 quadrats with the cobble and encrusting invertebrate habitat types each accounting for 40% of quadrats, while shallow *Carpophyllum* accounted for 12% and red foliose and turfing algae habitats comprised 4% each (Figure 6a). The beginning of the transect was almost exclusively cobble with shallow *Carpophyllum* and turfing algae occurring patchily in the mid stages of the transect. Encrusting invertebrate habitat dominating toward the end of the transect.

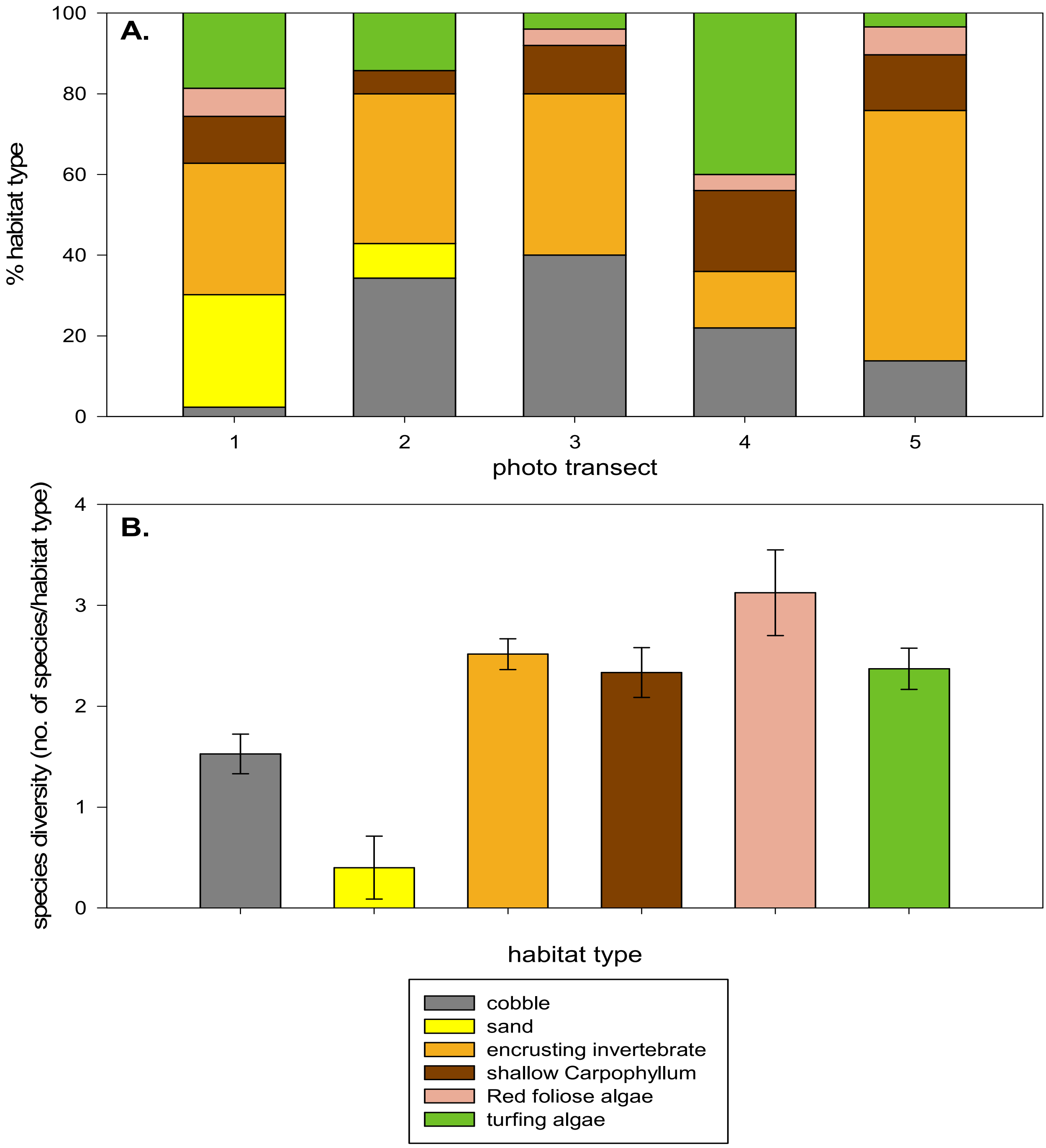
Photo transect 4 comprised 50 quadrats with a large proportion of these turfing algae (40%) followed by shallow *Carpophyllum* (20%) and cobble habitat types (22%), while encrusting invertebrate and red foliose algae habitat comprised 14% and 4% respectively (Figure 6a). It is evident that the second half of the transect was oriented more along shore than perpendicular to the shore (*see* Figure 5), likely resulting in fewer occurrences of the encrusting invertebrate habitat type. However one of the two encrusting invertebrate habitat types closest to the rock awash at chart datum, near the sea wall contained small *Atrina zelandica* beds.

The western most photo transect 5 began on the shallow cobble area of the reef, moving offshore into shallow *Carpophyllum* habitat and further offshore, skirting the edge of the reef into encrusting invertebrate habitat (*see* Figure 5). Of the 29 quadrats assessed in transect 5, 62% were encrusting invertebrate habitat, 14% each of cobble and shallow *Carpophyllum*, 7% red foliose algae and 3% turfing algae (Figure 6a). At the northern end of the transect a large bed of *Atrina zelandica* were encountered.

Overall the most abundant habitat type was encrusting invertebrate, followed by cobble, turfing algae, shallow *Carpophyllum*, sand and then red foliose algae (Figure 6a).

Species diversity, or the average number of species within each habitat type was highest within the red foliose algae habitat (Figure 6b), with an average of 3.13 ± SE 0.43, followed by encrusting invertebrate (2.51 ± 0.15), turfing algae (2.37 ± 0.2), shallow *Carpophyllum* (2.33 ± 0.25), cobble (1.53 ± 0.2) and lastly sand (0.4 ± 0.31).

FIGURE 6: COMPARISON OF A) PERCENTAGE HABITAT TYPE BY PHOTO TRANSECT AND B) SPECIES DIVERSITY, OR MEAN NUMBER OF SPECIES PER HABITAT TYPE. ERROR BARS REPRESENT ± 1 STANDARD ERROR (SE).



3.2 REEF VIDEO TRANSECTS

Video footage confirmed the existence of distinct habitat types used to categorise quadrats from photo transects. Moreover, the footage also confirmed the patchy nature of habitats and that essentially all habitats are based on a cobble/pebble substrate but can be readily distinguished by the size of these cobbles or pebbles and amount of sand, mud or silt situated around these hard substrate types. In other words cobbles with some evidence of fine sediments was indicative of shallow *Carpophyllum*, turfing algae, and red foliose algae habitats, whereas cobble with no fine sediments was strictly cobble habitat and conversely small pebbles and gravel with an abundance of silt, mud or sand was indicative of encrusting invertebrate habitat. These observations are borne out by the descriptions of habitats encountered along video transects (Table 3).

TABLE 3: DESCRIPTIONS OF HABITAT TYPES ENCOUNTERED IN VIDEO TRANSECTS.

Video transect	Description
VT1-1	Sandy habitat with some pebble and small cobble. No evidence of large brown algae
VT1-2	Beginning of transect silty mud and pebble substrate with patches of *Carpophyllum*, encrusting invertebrates, and turfing algae. Towards the end of transect abundance of cobble habitat and shallow *Carpophyllum* habitat increases.
VT2-1	*Atrina zelandica* assemblage. Substrate gravely sand and silt.
VT2-2	Beginning and end of transect mostly small cobble in silty mud, with encrusting invertebrates attached to larger boulders. Mid section of transect characterised by loose cobble with many large brown algae, e.g. *Carpophyllum* and *Cystophora*.
VT2-3	Beginning of transect gravel, silt and mud. Mid section characterised by large brown algae, mostly *Undaria pinnatifida*, attached to moveable cobbles. Final stage of transect is encrusting invertebrate habitat with cobbles and pebble in mud with anemones and ascidians common
VT2-4	Transect begins in cobble habitat, with numerous large brown algae present. End of transect is predominantly shallow *Carpophyllum* habitat with some turfing algae and solitary ascidians on larger boulders.
VT3-1	Habitat consists predominantly of cobble situated in silty mud. Larger rock outcrops harbour encrusting organisms and turfing algae.
VT4-1	Beginning of transect is cobble, shallow *Carpophyllum* habitat and as transect continues substrata becomes progressively less mobile, increase in silty mud and smaller cobbles with encrusting invertebrate habitat becoming more dominant.
VT4-2	Transect a mix of shallow *Carpophyllum* habitat and encrusting invertebrate habitat. Substrate varies between moveable cobble with larger boulders used by large brown algae for attachment and smaller pebbles and gravel which is colonised by ascidians and turfing algae.
VT4-3	Start of transect is encrusting invertebrate habitat with pebble in sand as substrate and as transect progresses habitat changes to cobble and shallow *Carpophyllum* habitat.
VT4-4	Start of transect is cobble and shallow *Carpophyllum* habitat. *Atrina zelandica* bed encountered (encrusting invertebrate habitat). End of transect is shallow *Carpophyllum* habitat.
VT4-5	Start of transect predominantly turfing algae. Shallow *Carpophyllum* habitat in mid stages of transect while end of transect a mix of turfing algae and cobble habitat.
VT5-1	Substrate comprised of silty mud and sand, large bed of *Atrina zelandica* encountered
VT5-2	Habitat predominantly cobble with large brown algae present on isolated large stationary boulders.
VT5-3	Cobble habitat predominantly with occasional turfing algae habitat and large brown algae on larger stationary boulders.

4.0 DISCUSSION

The subtidal area of Rangatira Reef is a highly dynamic, physically dominated environment prone to disturbance from waves and swell. This disturbance affected environment promotes high biodiversity but also tends to result in a mosaic of habitats making it difficult to predict where habitats occur. Habitat classification of reef areas at fine scales as described in this study provides a map of ecologically meaningful units (habitat type), that can be used as a baseline to detect changes in spatial extent over time.

The high biodiversity of subtidal Rangatira Reef was reflected in the 32 taxa recorded from analysis of photos, including significant biogenic habitat formers such as *Atrina zelandica*. Algal diversity was also particularly high (15 species), with the dominance of particular algal species a highly significant factor in the assessment of habitat type. Interestingly, the potentially invasive Wakame kelp, *Undaria pinnatifida*, observed in 4 of 5 photo transects formed a major component of the brown algal biomass. This fast growing species can outcompete native brown seaweeds for space with the potential to form dense stands. In this study, there was no evidence to suggest that the presence of *Undaria* was negatively affecting reef ecology, however further monitoring of the situation is advisable. More generally, this study extends the level of information on biodiversity within the Rangatira Reef system by adding subtidally occurring species to the intertidal species list compiled by (Anderson, 1998).

The use of geo-referenced photographs to survey habitat types and the extent of these proved to be a reliable and robust method. Video footage confirmed the existence of distinct habitat types and patchy nature of habitats. It was also evident from the footage that the size of hard reef substrata (cobbles and pebbles) and presence of soft sediment around hard reef substrata were distinguishing features of habitat types. The habitat map generated from photo transect data also presents a picture of habitat patchiness and suggests an ordering of habitats along a depth gradient.

The intermediate disturbance hypothesis (Sousa, 1980) states that highest diversity is seen in habitats with an intermediate level of disturbance. Diversity is lower in habitats with infrequent disturbance with competitively dominant species more abundant. Similarly, very frequent disturbance is suggested to result in lowered species diversity, as frequent disturbance prevents species from establishing. It is suggested that the apparent ordering of habitats along gradients of substrate size and depth is actually more accurately described as an ordering of habitats along gradients of disturbance frequency and intensity. The suggestion is that cobble substrate, generally located in shallower areas of the reef, is subject to frequent, high intensity disturbance events from swells, waves and surge. Conversely fine sediments, requiring less force to mobilise, tend to deposit in deeper, less frequent and lower intensity disturbance zones. In the context of how this affects the ecology, it is evident that on Rangatira Reef the red foliose algae habitat type, located in the mid depth region supports the highest species diversity while the highly disturbed, shallower cobble and sand habitat types support the least diverse community. However, the encrusting invertebrate habitat type, although the deepest habitat and likely one of the most stable, is the second most diverse. It is suggested that the abundance of the complex 3D habitat provided by *Atrina zelandica* beds in the encrusting invertebrate habitat type is a significant factor influencing the higher than expected diversity of this habitat type. Given that the encrusting invertebrate habitat type is the most stable habitat of the reef, species that live within this habitat, or that form the habitat, such as *Atrina zelandica,* are relatively long lived and slower growing than more frequently disturbed species, making them less able to deal with sudden changes to their environment.

It is clear that Rangatira Reef is both a dynamic and highly diverse environment, supporting a changeable yet rich array of marine life. Of particular interest are the *Atrina zelandica* beds, which give 3D structure to the deeper less cobbly areas of the reef. This 3D structure provides valuable surface area for the attachment of encrusting invertebrate and turfing algae species and refugia for small fish and grazing invertebrates, and therefore these "hotspots" of biodiversity are seen as important ecosystems and worthy of future monitoring and protection.

5.0 ASSESSMENT OF ENVIRONMENTAL EFFECTS

5.1 ECOLOGICAL CHANGES

The proposed construction of a breakwater and the creation of a sandy beach will result in the loss of subtidal reef habitats and will alter those remaining habitats adjacent to the breakwater and sandy beach. A summary of the areas that will determine the extent of the change are presented in Table 4. These figures suggest that approximately 8% of the reef will be lost in the construction of the breakwater with a further 16% of reef area lost to the created beach, giving a total of 25% of the reef area that will be lost.

TABLE 4: SUMMARY OF APPROXIMATE AREAL EXTENT OF PROPOSED BREAKWATER AND CREATED BEACH AND RELATIVE AMOUNT OF RANGATIRA REEF LOST TO THE PROTECTION STRUCTURES.

	Area (m^2)	Relative area of the reef lost (Rangatira Reef approx. 54,930 m^2)
Proposed Breakwater	4,320	7.9%
Created beach	9,586	17.5%
Total	**13,906**	**25.3%**

A schematic of the proposed breakwater with the habitat map superimposed provides an indication of the habitat types that will be directly removed by the construction of the breakwater and creation of sandy beach (Figure 7).

The area occupied by the proposed breakwater will result in a loss of high biodiversity habitat types; red foliose algae, shallow *Carpophyllum*, turfing algae and encrusting invertebrate, including a small *Atrina zelandica* bed in the area just off the existing sea wall. Along the seaward edge of the proposed breakwater habitat created will likely be the same as that seen along the base of the existing sea wall which is a mixture of shallow *Carpophyllum*, turfing algae and cobble habitats. The north-western edge of the proposed breakwater will be directly adjacent to the start of significant encrusting invertebrate habitat, including large *Atrina zelandica* beds and it is expected that over time this habitat will establish at a more distant location from the breakwater as the final habitat type in a gradation of cobble, shallow *Carpophyllum* and turfing algae habitats.

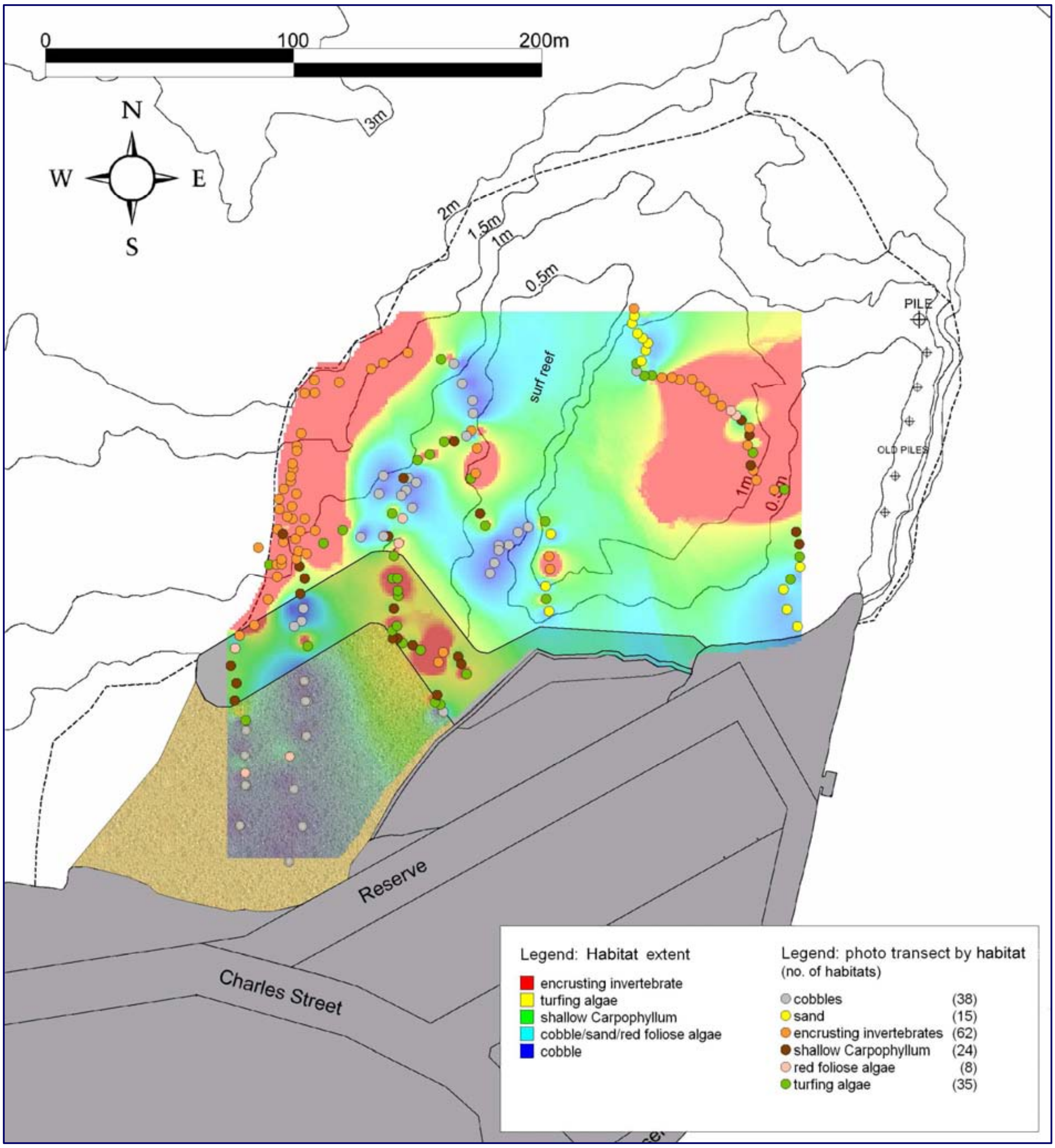


FIGURE 7: PROPOSED BREAKWATER AND CREATED BEACH WITH HABITAT MAP SUPERIMPOSED. DEPTH CONTOURS ARE SHOWN REDUCED TO NAPIER CHART DATUM AND AREAL EXTENT OF RANGATIRA REEF (DASHED LINE) IS INDICATIVE ONLY.

On the leeward side of the proposed breakwater the known cobble, shallow *Carpophyllum* and turfing algae habitats will be replaced when the sandy beach is created (Figure 7). It is expected that the area outside of the habitat map grid and within the areal extent of Rangatira Reef that will also become sandy beach is likely to also predominantly consist of cobble habitat. In addition to the species identified from these habitats during photo transects as outlined in Table 1, Paua (*Haliotis iris*) and large demersal reef fish, such as Marblefish, *Aplodactylus arctidens* are also known to reside in this area (EAM, 2008).

5.2 ENVIRONMENTAL EFFECTS

5.2.1 Construction phase

Aside from the destruction of reef habitats during construction there is potential for effects on the ecology in the surrounding reef areas also. Effects will be short term, intermittent and temporary. The ecology will be affected at different periods and at different times during the construction programme. Construction is expected to occur in bouts of activity, as up to 10 barge loads of rock will be required, and each barge will be unloaded over the course of 1-2 days with up to 4 truck and trailer units operating per hour (Beca, 2008). The total duration of construction will be approximately 5 months. It is considered that the main effect on the ecology in the surrounding reef areas during the construction phase will be from the input of fine sediment to the marine environment.

Sediments in the water column can alter water chemistry, reduce light intensity affecting photosynthesis in seaweeds, and visual acuity in organisms that rely on sight for food gathering, sediments can also affect the ability of filter feeding organisms to filter food from the water as much energy is wasted by having to sieve out non food particles, while smothering and burial by large amounts of sediments directly reduces abundance. Although there is some risk of sediment entering the marine environment during construction the flora and fauna in the area are adjusted to living with high suspended sediment loads and high turbidity events, which regularly occur when sediments in the area offshore are stirred up by large swells and waves or when storm discharges from rivers can carry fine sediments into the bay. In addition, the physically dominated nature of the environment acts to quickly disperse sediments that do settle within short time scales.

It is expected that the main sediment pathways to the marine environment are through disturbance of the seabed during rock placement, dewatering of the dredge spoil used in creating the sandy beach and if the area behind the existing sea wall is reclaimed then runoff from this area prior to stormwater channelling.

5.2.2 Operational phase

The effects on ecology during the post-construction, operational phase are also concerned principally with sediment. Redistribution of sediments used to create the sandy beach behind the proposed breakwater into remaining areas of reef is possible. It is expected that the areas of sediment deposition, will be in areas currently prone to deposition, i.e. the deeper encrusting invertebrate habitats. Given the high biodiversity of encrusting invertebrate habitat and associated *Atrina zelandica* beds it is therefore considered that these habitats are vulnerable to potential adverse effects from the deposition of large volumes of sediment. However, it is unlikely that the large swells and waves necessary to transport sufficiently large volumes of sediment into vulnerable habitats will significantly influence the sediments of the created beach due to the sheltering nature of the breakwater.

Therefore, there is some potential for sediment transport and accumulation into encrusting invertebrate habitat and adverse effects but the risk is deemed low, given that these habitats naturally occur in reef substrate that is a mixture of sand, gravel, and mud, the high energy wave climate of the area is likely to rapidly redistribute sediments over short time scales, and the sheltering nature of the breakwater will prevent larger scale sediment transport events.

5.3 MITIGATION AND MONITORING

It is recommended that monitoring of the reef complex be undertaken by a qualified marine scientist on a routine basis. The results of the present benthic survey could be used as a baseline against which the results of future monitoring surveys can be compared against. To monitor any effects into the future it is recommended that two follow up surveys of the reef be carried out after three and then six years, using the same methodology as described in the present benthic survey. Particular attention should be given to assessing changes to the spatial extent of habitat types identified in the present benthic survey with a particular emphasis on re-assessing the location and extent of mapped *Atrina zelandica* beds.

A recommended mitigation measure that will help to reduce the long term impact of the reduction in reef area is the collection and use of some of the existing cobble substrate that will be covered by the created beach and breakwater. These cobbles may be used to create a more natural progression of habitat along the seaward edge of the breakwater.

Due to the large amount of habitat that will be lost to the proposed breakwater, a Construction Environmental Management Plan should be implemented that details systems and procedures to minimise the environmental effects of sedimentation on vulnerable habitats and ecology during construction.

5.4 SUMMARY

The predominantly cobble, shallow *Carpophyllum* and turfing algae habitats of the reef in the lee of the proposed breakwater will give way to a sandy beach. On the seaward side of the proposed breakwater an increase in the shallow *Carpophyllum* and turfing algae habitat types, already present along the base of the existing sea wall is envisaged. This increase will occur at the expense of existing cobble, shallow *Carpophyllum*, turfing algae habitat type along with a small amount of encrusting invertebrate habitat, including a small *Atrina zelandica* bed.

There is potential for adverse sediment related environmental effects on the reef areas surrounding the proposed breakwater during both the construction and operational phases. The risk is that the ecology in reef areas will be subject to episodic (during construction) and longer term effects (during operation) from sedimentation. The highly dynamic, physically dominated nature of the environment increases the likelihood of sediment mobilisation, meaning that sediments will not remain in an area for long periods, suggesting that the risks posed from sediment related effects are low.

The scale of the reduction in reef area is considerable, resulting in an obvious major effect on the habitats removed. It is widely held that habitat loss has large, consistently negative effects on biodiversity, and following a reduction in reef size of the magnitude reported it is inevitable that biodiversity will be affected. Given that a large portion of the reef proposed to be removed is largely the shallower habitats, i.e. cobble habitat type, which are subject to frequent and high intensity disturbance, the effect of a loss of biodiversity will also largely be borne by these habitats.

The mitigation measure to collect the cobbles that will be covered by the breakwater and created beach and use them to create additional cobble habitat along the edge of the breakwater, the consideration that cobble habitat showed the second lowest diversity among habitat types and that the species found during the survey are common throughout other reef systems in Napier (e.g. along Hardinge Road), and there will be limited removal of *Atrina zelandica* beds, it is considered that effects on the ecology are likely to be minor.

5.5 CONCLUSIONS

- Approximately 25% of the subtidal Rangatira Reef area will be lost with the construction of the breakwater and sandy beach

- The reef area lost comprises a range of habitat types including low diversity cobble, high diversity red foliose algae and encrusting invertebrate, shallow *Carpophyllum* and turfing algae habitats.

- Despite the loss of habitat of the magnitude reported, in general the effect on biodiversity is likely to be minor

- There is a low risk of adverse sediment related effects from the construction and operation of the proposed breakwater which must be considered against the increased value of remaining reef habitats.

- Suggested response measures that aim to avoid, mitigate or provide further information on potential effects from the proposed breakwater include:
  - Conduct two follow benthic surveys to monitor any changes or effects from the breakwater and created beach
  - Use existing cobble substrate that will be covered to create a more natural progression of habitat along the seaward edge of the breakwater.
  - Implement a Construction Environmental Management Plan to address any potential issues around sedimentation.

- The coastline in the area has been highly modified over time yet the reef complex remains unique because of the high ecological, social and cultural values.

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APPENDIX 1

PHOTO AND VIDEO TRANSECT LOCATION DATA

Photo transect	Date	Start position (NZMG)		Heading (°True)
		East	North	
1	4/9/2008	2844887	6184414	350
2	5/9/2008	2844787	6184426	355
3	15/7/2008	2844677	6184334	001
4	8/9/2008	2844753	6184396	327
5	10/9/2008	2844663	6184329	355

Video transect	Start position (NZMG)		Finish position (NZMG)		Length (m)
	East	North	East	North	
VT1-1	2844821	6184431	2844821	6184439	10
VT1-2	2844831	6184488	2844873	6184525	87
VT2-1	2844787	6184451	2844787	6184451	0
VT2-2	2844699	6184515	2844706	6184514	127
VT2-3	2844728	6184503	2844685	6184471	129
VT2-4	2844694	6184447	2844720	6184403	67
VT3-1	2844679	6184406	2844678	6184389	18
VT4-1	2844749	6184476	2844720	6184483	48
VT4-2	2844728	6184489	2844731	6184483	18
VT4-3	2844709	6184484	2844731	6184483	62
VT4-4	2844704	6184456	2844724	6184417	179
VT4-5	2844722	6184414	2844716	6184352	72
VT5-1	2844696	6184523	2844692	6184541	23
VT5-2	2844629	6184433	2844642	6184410	39
VT5-3	2844644	6184399	2844643	6184383	16

Photo transect 1			
Quadrat	NZMG East	NZMG North	Habitat type
1	2844886	6184419	2
2	2844882	6184426	2
3	2844881	6184434	2
4	2844884	6184438	6
5	2844888	6184443	2
6	2844888	6184443	2
7	2844888	6184447	6
8	2844888	6184452	4
9	2844887	6184457	4
10	2844883	6184474	6
11	2844879	6184474	3
12	2844872	6184478	3
13	2844871	6184482	3
14	2844870	6184484	4
15	2844871	6184489	6
16	2844869	6184492	3
17	2844870	6184496	4
18	2844870	6184499	3
19	2844867	6184502	4
20	2844865	6184504	5
21	2844863	6184506	5
22	2844859	6184508	3
23	2844856	6184511	3
24	2844853	6184514	3
25	2844851	6184516	3
26	2844848	6184519	3
27	2844843	6184519	3
28	2844840	6184520	3
29	2844836	6184520	3
30	2844832	6184521	6
31	2844829	6184521	6
32	2844826	6184523	1
33	2844826	6184526	6
34	2844828	6184527	2
35	2844830	6184531	2
36	2844831	6184534	2
37	2844829	6184536	2
38	2844827	6184538	2
39	2844825	6184542	6
40	2844825	6184542	2
41	2844826	6184545	2
42	2844826	6184548	5
43	2844826	6184548	3

Photo transect 2			
Quadrat	NZMG East	NZMG North	Habitat type
1	2844787	6184428	2
2	2844786	6184433	6
3	2844786	6184438	2
4	2844788	6184445	3
5	2844788	6184450	3
6	2844789	6184459	2
7	2844787	6184464	4
8	2844784	6184463	6
9	2844780	6184462	1
10	2844776	6184460	1
11	2844776	6184460	1
12	2844772	6184455	1
13	2844768	6184455	1
14	2844768	6184453	1
15	2844766	6184448	1
16	2844764	6184444	1
17	2844763	6184463	6
18	2844761	6184468	4
19	2844758	6184482	6
20	2844760	6184484	3
21	2844760	6184488	3
22	2844761	6184494	3
23	2844759	6184501	3
24	2844760	6184508	1
25	2844760	6184513	1
26	2844756	6184520	1
27	2844753	6184528	1
28	2844748	6184530	6
29	2844735	6184533	3
30	2844725	6184529	3
31	2844720	6184527	3
32	2844707	6184522	3
33	2844697	6184518	3
34	2844691	6184514	3
35	2844687	6184510	3

Habitat type key

1 cobble
2 sand
3 encrusting invertebrate
4 shallow *Carpophyllum*
5 red foliose algae
6 turfing algae

Photo transect 3			
Quadrat	NZMG East	NZMG North	Habitat type
1	2844679	6184331	1
2	2844685	6184345	1
3	2844682	6184360	1
4	2844681	6184373	5
5	2844688	6184381	1
6	2844689	6184395	1
7	2844688	6184398	1
8	2844688	6184403	1
9	2844690	6184417	6
10	2844688	6184427	1
11	2844685	6184429	1
12	2844689	6184432	1
13	2844688	6184438	4
14	2844690	6184444	4
15	2844688	6184449	4
16	2844687	6184452	3
17	2844688	6184455	3
18	2844687	6184460	3
19	2844689	6184463	3
20	2844686	6184468	3
21	2844681	6184472	3
22	2844681	6184476	3
23	2844683	6184480	3
24	2844686	6184483	3
25	2844687	6184488	3

Habitat type key

1 cobble
2 sand
3 encrusting invertebrate
4 shallow *Carpophyllum*
5 red foliose algae
6 turfing algae

Photo transect 4			
Quadrat	NZMG East	NZMG North	Habitat type
1	2844743	6184389	1
2	2844742	6184392	6
3	2844740	6184393	6
4	2844741	6184396	4
5	2844753	6184404	6
6	2844751	6184408	4
7	2844750	6184411	4
8	2844744	6184413	3
9	2844742	6184409	3
10	2844735	6184414	6
11	2844732	6184416	4
12	2844728	6184417	6
13	2844726	6184419	4
14	2844724	6184419	4
15	2844724	6184422	6
16	2844726	6184424	6
17	2844725	6184431	4
18	2844727	6184436	6
19	2844727	6184438	6
20	2844725	6184443	6
21	2844727	6184443	6
22	2844726	6184452	6
23	2844728	6184457	5
24	2844724	6184460	4
25	2844726	6184469	6
26	2844730	6184476	1
27	2844731	6184483	4
28	2844737	6184490	6
29	2844742	6184492	6
30	2844748	6184497	6
31	2844752	6184497	4
32	2844757	6184499	1
33	2844721	6184477	1
34	2844723	6184484	1
35	2844733	6184483	1
36	2844732	6184478	1
37	2844736	6184481	1
38	2844734	6184471	1
39	2844730	6184467	5
40	2844722	6184460	1
41	2844713	6184460	1
42	2844706	6184463	6
43	2844698	6184458	6
44	2844691	6184454	3
45	2844681	6184452	6
46	2844676	6184450	6
47	2844672	6184457	3
48	2844680	6184464	3
49	2844691	6184468	3
50	2844695	6184463	3

Photo transect 5			
Quadrat.	NZMG East	NZMG North	Habitat type
1	2844660	6184346	1
2	2844663	6184362	1
3	2844663	6184367	5
4	2844663	6184374	1
5	2844664	6184384	1
6	2844664	6184388	6
7	2844660	6184396	4
8	2844661	6184403	4
9	2844659	6184410	4
10	2844661	6184417	5
11	2844663	6184422	3
12	2844669	6184426	3
13	2844675	6184436	3
14	2844679	6184445	3
15	2844679	6184450	3
16	2844681	6184450	3
17	2844681	6184452	3
18	2844682	6184459	3
19	2844682	6184462	4
20	2844684	6184469	3
21	2844686	6184473	3
22	2844688	6184478	3
23	2844686	6184485	3
24	2844687	6184490	3
25	2844689	6184495	3
26	2844689	6184497	3
27	2844691	6184502	3
28	2844693	6184518	3
29	2844697	6184523	3

Habitat type key

1 cobble
2 sand
3 encrusting invertebrate
4 shallow *Carpophyllum*
5 red foliose algae
6 turfing algae

APPENDIX 2
PHOTOGRAPHIC PLATES

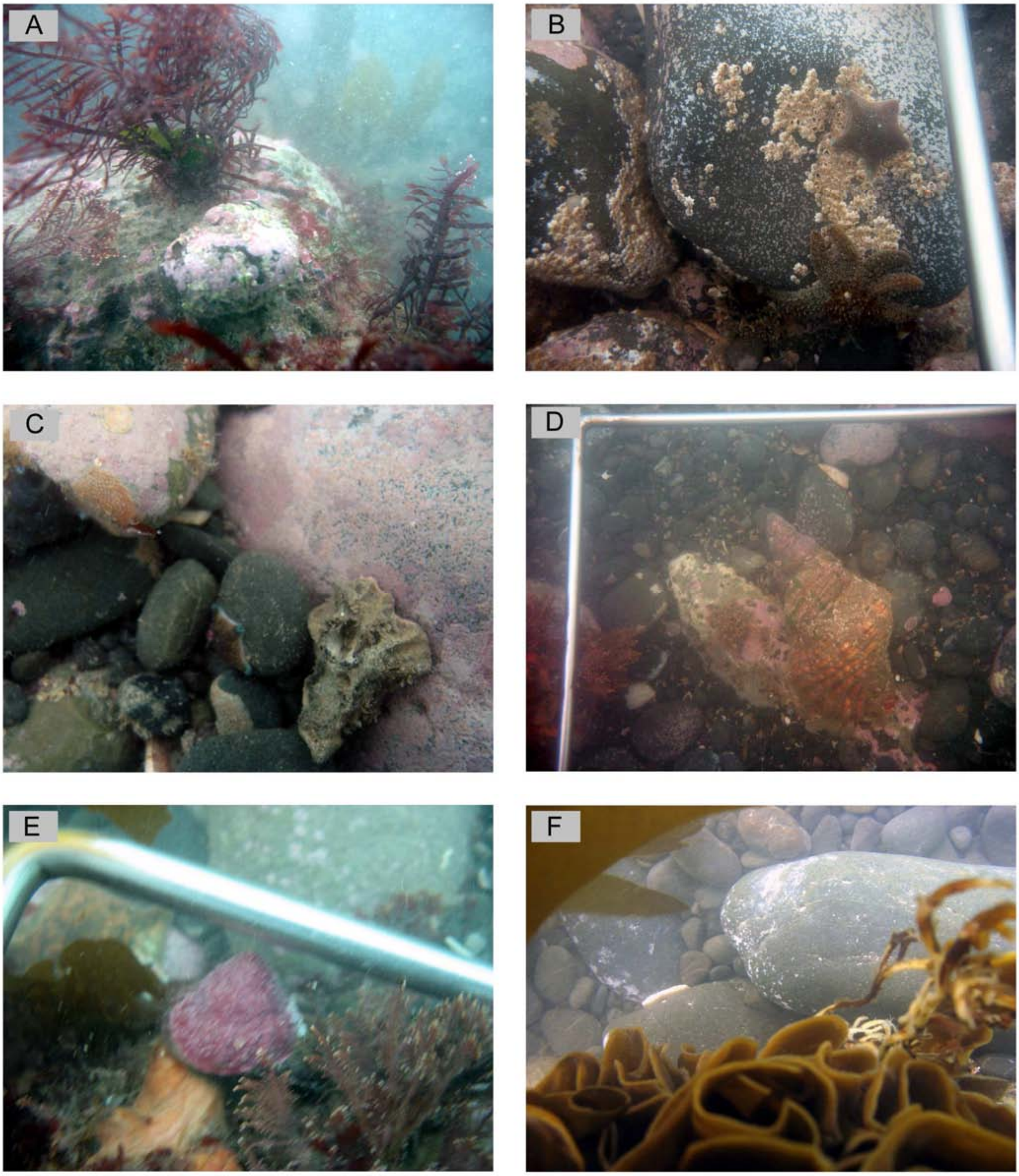

PLATE 1: PHOTOS SHOWING TYPICAL REEF SPECIES ENCOUNTERED WHILE CONDUCTING PHOTO TRANSECTS: A) TURBO SMARAGDUS AND RED SEAWEED *GIGARTINA* SP. – RED FOLIOSE ALGAE HABITAT TYPE, B) *PATIRIELLA REGULARIS* AND JUVENILE *COSCINASTERIAS MURICATA* SEA STARS FEEDING ON *CHAMAESIPHO BRUNNEA* BARNACLES – COBBLE HABITAT TYPE C) *SACCOSTREA GLOMERATA* (RIGHT) AND ORANGE COLOURED BRYOZOAN (LEFT) – ENCRUSTING INVERTEBRATE HABITAT TYPE D) *CYMATIUM SPENGLERI*, LARGE PREDATORY TRITON – SHALLOW *CARPOPHYLLUM* UNDERSTORY, E) COOKIA SULCATA – TURFING ALGAE HABITAT TYPE F) SPOROPHYLL OF *UNDARIA PINNATIFIDA* – COBBLE HABITAT TYPE.

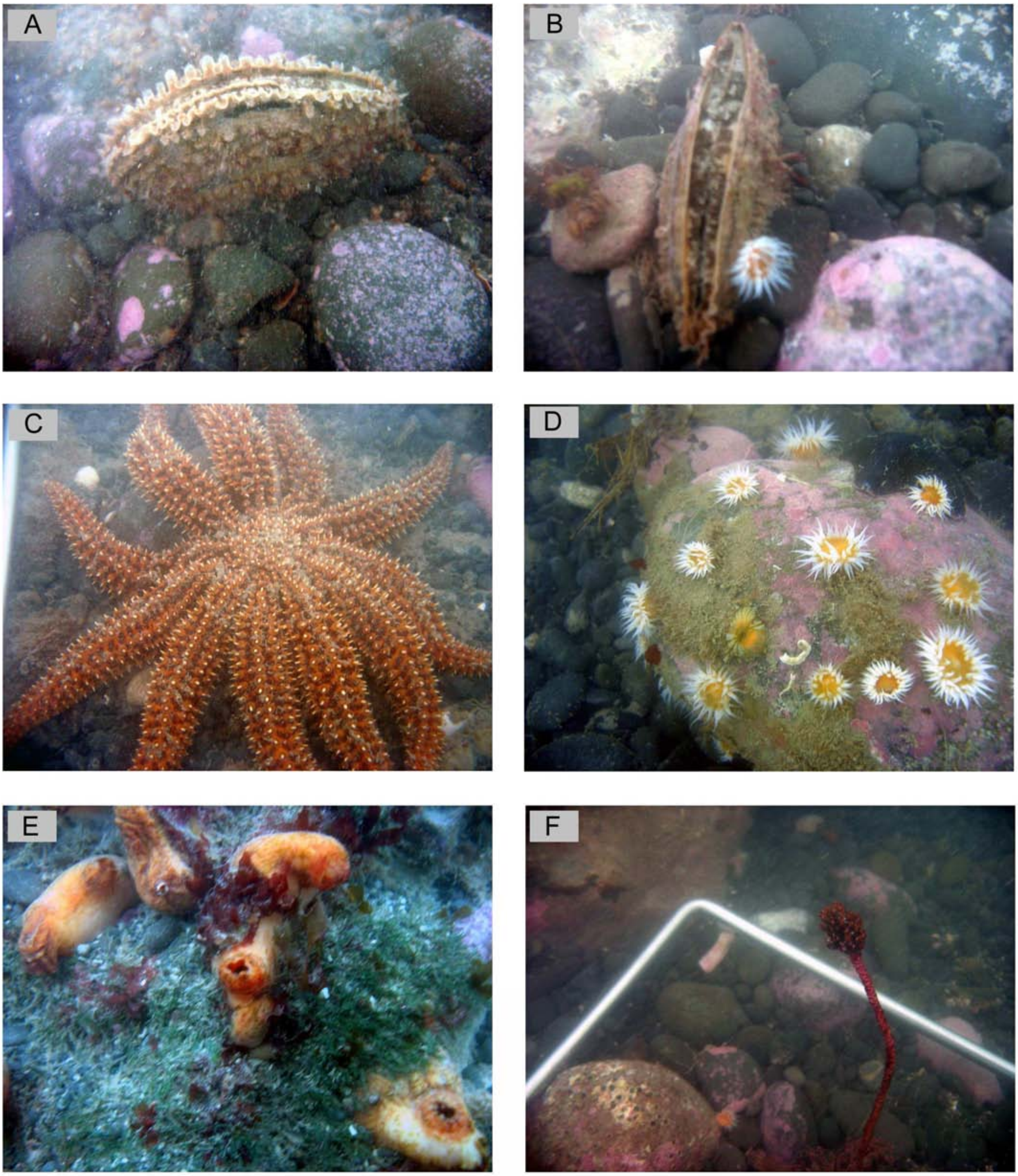

PLATE 2: PHOTOS SHOWING TYPICAL ENCRUSTING INVERTEBRATE HABITAT TYPE: A) *ATRINA ZELANDICA*, HORSE MUSSEL, B) *ATRINA ZELANDICA* AND EPIBIONT *ACTINOTHOE ALBOCINCTA*, C) *COSCINASTERIAS MURICATA*, D) COMMON ANEMONES, *ACTINOTHOE ALBOCINCTA,* E) SOLITARY ASCIDIANS *CNEMIDOCARPA BICORNUTA*, F) STALKED, SOLITARY ASCIDIAN *PYURA PACHYDERMATINA.*

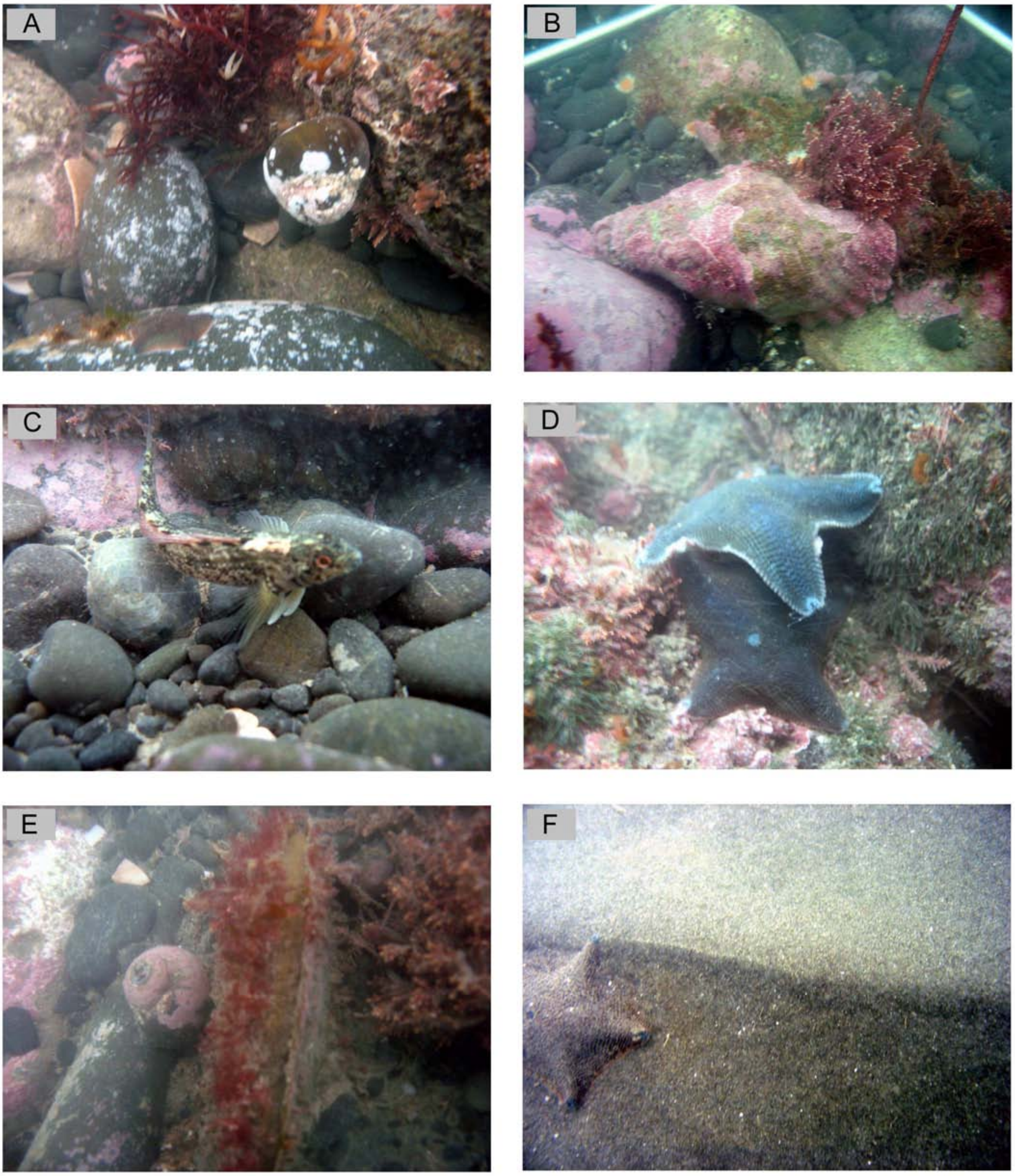

PLATE 3: PHOTOS SHOWING TYPICAL REEF SPECIES ENCOUNTERED WHILE CONDUCTING PHOTO TRANSECTS: A) *TURBO SMARAGDUS* – SHALLOW *CARPOPHYLLUM* HABITAT (UNDERSTORY), B) *CYMATIUM SPENGLERI* BESIDE A CLUMP OF THE UBIQUITOUS ENCRUSTING RED SEAWEED, CORALLINE TURF – TURFING ALGAE HABITAT TYPE, C) *TRIPTERYGION* SP. UNIDENTIFIED TRIPLEFIN SPECIES – TURFING ALGAE HABITAT TYPE D) TWO *PATIRIELLA REGULARIS* – TURFING ALGAE HABITAT TYPE, E) *TURBO SMARAGDUS* AND *ATRINA ZELANDICA* WITH RED ALGAE EPIPHYTIC GROWTH – ENCRUSTING INVERTEBRATE HABITAT TYPE F) *PATIRIELLA REGULARIS* – SAND HABITAT TYPE.

APPENDIX 3
REPORT LIMITATIONS

REPORT LIMITATIONS

This Document has been provided by Environmental Assessments & Monitoring Ltd (EAM) subject to the following limitations:

I. This Document has been prepared for the particular purpose outlined in EAM's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

II. The scope and the period of EAM's Services are as described in EAM's proposal, and are subject to restrictions and limitations. EAM did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by EAM in regards to it.

III. Conditions may exist which were undetectable given the limited nature of the enquiry EAM was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

IV. In addition, it is recognized that the passage of time affects the information and assessment provided in this Document. EAM's opinions are based upon information that existed at the time of the production of the Document. It is understood that the services provided allowed EAM to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

V. Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

VI. Where data supplied by the Client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by EAM for incomplete or inaccurate data supplied by others.

VII. The Client acknowledges that EAM may have retained sub-consultants affiliated with EAM to provide Services for the benefit o EAM. EAM will be fully responsible to the Client for the Services and work done by all of its sub-consultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from EAM and not EAM's affiliated companies, and their employees, officers and directors.

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