Urchin barrens and algal community zonation; a transect-based study, Maunganui Bay and Cape Brett

December 2016

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Cover Photo: A shallow urchin barren (transect A20) in Maunganui Bay dominated by the red-spined urchin *Centrostephanus rodgersii*

For: Fish Forever, Bay of Islands Maritime Park Inc.

Report by: V.C. Kerr B.Sc.

Kerr and Associates, Whangarei

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Table of Contents

1 Summary

Algal forest zonation and urchin barren presence and extent were examined on twelve transects running perpendicular to the shoreline in the Maunganui Bay to Cape Brett area. Eight sites were selected on the exposed coast from Maunganui Bay to Pig Gully and four sites were surveyed on a sheltered coast in Maunganui Bay. Eleven of the twelve transects had urchin barrens. Five transects had large urchin barrens > $10m^2$ and seven sites had small and patch urchin barrens. *Centrostephanus rodserii* the red-spined urchin was found in densities greater than $1/m^2$ on four transects on exposed and sheltered sites. Further study of the spread and apparently increasing numbers of *Centrostephanus* urchins is recommended.

Transect data was compared to a recent habitat map of this area (Kerr, 2016). This comparison or ground-truthing exercise showed that large urchin barrens could be accurately mapped from aerial photos taken in favourable conditions and where the reef was gentle sloping. Where aerial photos fell short of displaying underwater features–due to shadows, light reflection on the water surface or where reef slopes are steep or vertical–large urchin barrens were not reliably mapped. Small urchin barrens $<10m^2$ and patch urchin barrens were recorded on seven of the twelve transects and were not successfully captured in the habitat map drawn at 1:500 scale, due to their small size limiting detection in the aerial image. As a result, habitat maps drawn to date relying on the aerial photography method are likely to be significantly under-reporting urchin barren extent. New methods should be investigated to augment the current method that uses aerial photography to map urchin barrens. Overall results of this survey add to the concern that fishing impacts in the Bay of Islands are resulting in a chronic decline in shallow algal forest, primarily due to removal the reef predators–rock lobster *Jasus edwardsii* and snapper *Pagrus auratus*–that control urchin populations and their grazing. The emergence of *Centrostephanus rodgersii* as additional algal grazers adds to concerns that a serious decline of shallow algal forests is underway in northeast New Zealand. Recommendations are put forward to: 1) expand research and monitor knowledge of urchin barren ecology and 2) gain better understanding of the localised impacts and ecological cost of fishing on shallow reefs versus the benefits of a network of marine protected areas.

2 Introduction

This report presents the results of a survey of shallow algal forest zonation carried out on the northern exposed shore of Cape Brett and in Maunganui Bay in the Eastern Bay of Islands. Recent work by the author (Kerr, 2016) has produced a fine-scale marine habitat map of the shallow coastal waters and intertidal habitats of this area. The 2016 habitat map for Cape Brett along with another report and map set for the Eastern Bay of Islands area around Okahu, Waewaetorea and Urupukapuka Island (Kerr and Grace, 2015) has descriptions of the subtidal zonation and algal community composition, which are relevant to this area and report. This field study was designed to add detail to the description of the shallow kelp forest communities and, in particular, the occurrence and extent of the condition described as urchin barrens.

For some years the Bay of Islands community group, Fish Forever, of the Bay of Islands Maritime Park Inc. has encouraged and supported ecological research in the Eastern Bay of Islands. The group has had a particular focus on the two areas that have been proposed as candidate marine reserve areas (Fish Forever, 2014). One of those areas is the exposed coast of the Cape Brett Peninsula between Maunganui Bay and Pig Gully. Fish Forever has also been a keen supporter of the *rahui* project at Maunganui Bay and carried out monitoring and ecological survey work there in co-operation with the Rawhiti hapu, Ngati Kuta and Patukeha. This year, Fish Forever has continued with a research and monitoring program for this area. This study is one small part of that larger effort.

Habitat mapping studies in this area and elsewhere in Northeast New Zealand have provided a way to track changes in algal forest health and community composition. The context of this spatial mapping approach is well described in another Fish Forever-sponsored project carried out at Urupukapuka, Waewaetorea and Okahu Islands, also in the Eastern Bay of Islands (Kerr, 2015). On a broader scale there is a habitat-mapping project for Northland's entire east coast, (Kerr, 2010). Of particular importance to this current work is a habitat-mapping project completed for the area of the Leigh Marine Reserve near Cape Rodney, (Leleu, 2012). In the Leigh study the authors were able to compare a habitat map drawn for the area in 1981 (Ayling et al.) –five years after the marine reserve was established–with the present condition of the algal communities. Results of this comparison were dramatic. Urchin barrens were widespread in the shallow waters during the time the marine reserve was established and had all but disappeared after three decades of marine protection. An equally significant result of the Leleu study showed that the shorelines immediately adjacent to the marine reserve boundaries had not markedly changed in terms of urchin barren extent since the first survey. The pattern of urchin barrens establishing and persisting in areas that are heavily fished has now been documented at Mimiwhangata, (Kerr & Grace, 2005) Doubtless Bay (Grace & Kerr, 2005), Poor Knights Islands, Mokihinau Islands and Leigh (Shears & Babcock, 2002), (Shears, 2006) in the Bay of Islands generally, (Booth, 2015) and around the Eastern Bay of Islands, Waewaetorea Island area (Kerr & Grace, 2015).

In Northeast New Zealand there has been a clear pattern of relationship between increases in abundance of the dominant urchin grazer *Evechinus chloroticus* (kina) and the loss of reef predators by fishing. This ecological imbalance leads to overgrazing of algal species and establishment of urchin barrens. This pattern has also been widely studied and reported overseas from similar temperate waters (Ling, 2015). In some locations in Northland there is a pattern of urchin barrens being more significant on more sheltered shorelines; but this assumption is tempered by the knowledge that there are challenges associated with mapping steep and exposed shorelines using aerial photographic images. This study was carried out to provide some detailed information that could further inform and ground-truth previous habitat mapping work, and also fill in the gaps of our knowledge of the extent and nature of urchin barrens on the more exposed and steep shorelines of the Cape Brett peninsula.

A secondary objective of this transect-based study was to examine the abundance of the long-spined urchin *Centrostephanus rodserii*, which is believed to be increasing in numbers in these outer habitats of the Bay of Islands.

3 Methods

Twelve sites were selected in a haphazard manner, divided between the sheltered and semi-sheltered shores in Maunganui Bay (4 sites) and the exposed coast lying between Maunganui Bay and Pig Gully (8 sites). The transects selected were located to run through recorded quadrats or survey points from another study of urchin barrens and algal communities being carried out by Vicky Froude and Chris Richmond (personal comm. V. Froude). This site selection process avoided bias of transects located in areas of the habitat map considered easy to map, or the opposing bias towards areas more difficult to map. The Froude/Richmond survey points were located at fixed intervals along the coast further reducing site selection bias.

At each survey site a weighted drop-line was lowered as close as possible to a waypoint from the Richmond/Froude study). For convenience of follow-up surveying and analysis, the same waypoint number was used with an A added to the front of the number. A transect tape was attached to rock or seaweed on the shoreline and then the diver swam the tape down the reef profile, leaving the shore in more or less a perpendicular angle, lining up the dropped waypoint marker and a chosen compass bearing. This approach produced a profile transect running down the slope of the reef from the intertidal area to an endpoint where the reef changed to a soft bottom habitat, or the habitat changed to solid Ecklonia radiata forest with no sign of urchin barren or high densities of urchin species.

As the transect line was being laid out from shore, the diver regularly checked the compass bearing to maintain a straight line. Time of day was recorded for all dives to allow tide correction calculations. At each change of habitat along the transect, position on the tape was recorded and notes taken of the habitat and algal community zonation and composition. At significant zone changes, a set of photos was taken at the recorded position on the tape. Depths were taken at all recorded points and later corrected to chart datum to standardise and aid any future comparisons and surveys. Where habitats changed to the urchin barren condition, two $1m^2$ quadrats were counted for urchin abundance, recording numbers and species. The quadrats were typically located just inside the edge of the urchin barren, using the tape as a guide to measure a 1m distance and then estimating the other sides of the quadrat. Where there were small urchin patches instead of large barren zones, notes were made and distance and depth recorded along with a photo set. As a provisional guide for describing urchin barren size and condition, the following convention was adopted from the system used in Tasmania (Tracey, 2015). In the Tasmanian protocol large urchin barrens were described as being >10m^2 and predominantly barren of large algae. Small urchin barrens were described as being < 10m^2 in area and with the large algae species absent. In the Tasmanian protocol a third category ‘incipient urchin barren’ is used. This condition is described as a partially barren area with significant urchin densities and a ‘thinning kelp forest’ with small barren patches. For the purposes of this study the term patches was adopted for the variety of conditions found at fine scale where urchins were affecting the algal forest, but not creating a true barren devoid of large algal species. When the transect ran out into undisturbed Ecklonia forest beyond 12m depth, or where the reef made a transition to soft sediment habitat, an end distance and depth was recorded. Locations of the 12 transects is presented in the Figure 1 map below.

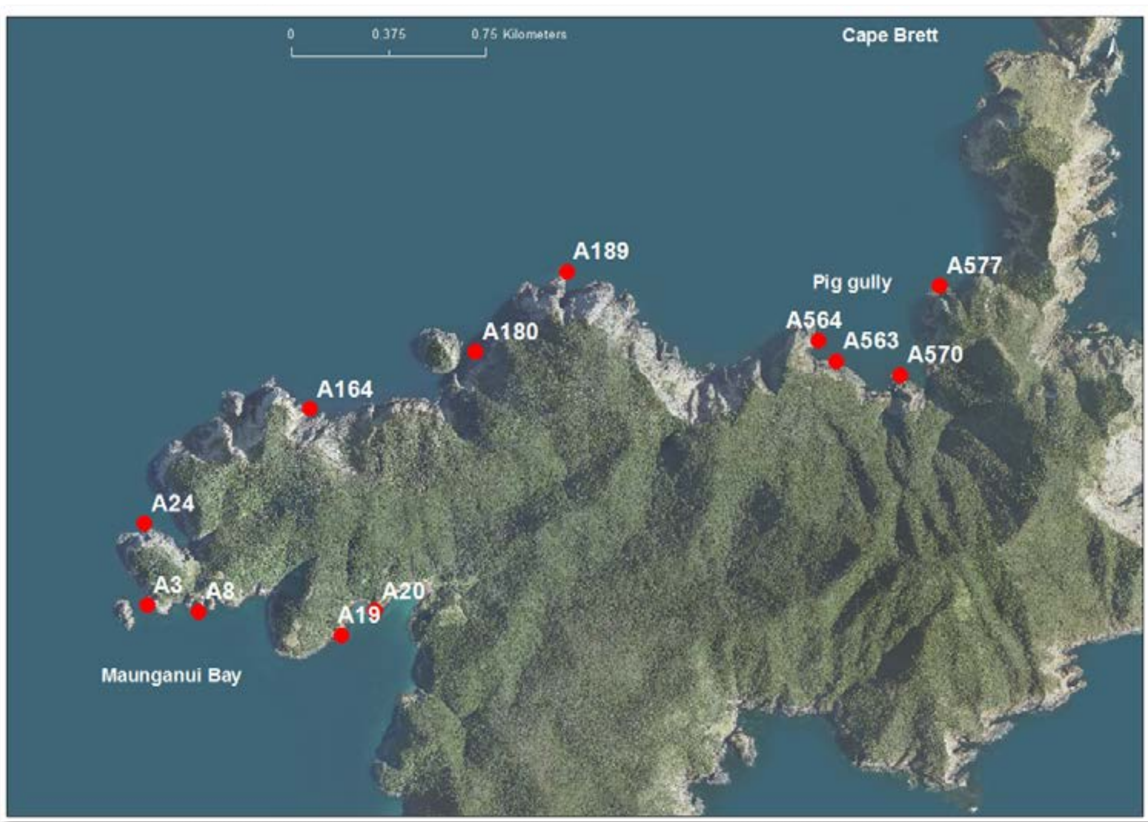

Figure 1 Map of twelve transect locations on the exposed Cape Brett Coast and inside of Maunganui Bay.

4 Results

4.1 Zonation of algal communities and urchin barrens

Distances and depths of zonation changes are presented in Table 1 below. The sites in the sheltered areas of Maunganui Bay are indicated with grey shading. Unshaded rows denote the exposed coast area (refer to location map in Figure 1). Tables 2 and 3 detail the abundance counts of urchin species made along the transect line corresponding to the change in habitats.

Table 3 below lists the urchin species counts for two transects that had large urchin barrens (>10m^2). These barrens had urchin densities counted at both the top and bottom of the barren along the transect profile. Each count consisted of two 1m^2 quadrats, resulting in the average density value from two quadrats displayed in Table 3.

Site	Shallow mixed weed zone		Urchin barren/patch #1		*Ecklonia* forest		Urchin barren/patch #2		*Ecklonia* forest	
	position from shore	depth range	position from shore	depth range	position from shore	depth range	position from shore	depth range	position from shore	depth range
A24	0-6.5	0-4.2	6.5-15	4.2-12.7	15-25	12.7-11.7	20.0	10.7	na	na
A164	0-9	0-7.4	na	na	9-27	7.4-7.9	na	na	na	na
A180	0-7	0-2.7	7.0	2.7	7-31	7.4-12.7	17.0	7.7	na	na
A189	0-13	0-8	13.0	8.0	13-41	8-20	20.0	14.0	na	na
A563	0-11	0-6.7	11-13	6.7-7.7	13-15	7.7-8.2	na	na	na	na
A564	0-10	0-3	10-16	3-8	16-25	8-11.5	na	na	na	na
A570	0-8	0-5.2	2	2.6	9-11	5.2-6.1	11.0	6.1	11-22	6.1-8.1
A577	0-3	0-4.2	3-12	4.2-9.2	12-21	9.2-12.2	na	na	na	na
A20	0-9	0-1.9	9-12	1.9-2.9	9-19	2.9-5.4	na	na	na	na
A19	0-3	0-.6	3-8	.6-3.7	8-18	3.7-6.6	na	na	na	na
A8	0-5	0-1.9	5-9	1.9-4	5-19	1.9-8.4	na	na	na	na
A3	0-3	0-2.2	3-6	2.2-11.3	6-12	11.3-3.2	12-25	3.2-6.75	25-28	7.7

Table 1 Depths and transect position of habitat change points. Transects located in Maunganui Bay in semi-sheltered locations are shaded in grey. All distance and depth values are listed in metres corrected to chart datum. Note, where urchin barrens are listed as at a single distance from shore and depth instead of a range this indicates that it was a small or patch barren (<10m^2).

Site	Urchin barren/patch #1		Urchin barren/patch #2		Notes
	kina/m^2	***Centrostephanus* /m^2**	**kina/m^2**	***Centrostephanus* /m^2**	
A20	**0**	**2**	na	na	shallow reef, small urchin barrens
A19	10	0	na	na	shallow reef, small urchin barrens
A8	4.5	0	na	na	shallow reef, small urchin barrens
A3	7.5	0	12	0	shallow reef, small urchin barrens
A24	12.5	0	**0.5**	**3.5**	#1 is a significant vertical urchin barren and #2 is a *Centrostephanus* patch barren
A164	0	0	0	0	no urchin barrens present
A180	3.5	0.5	1.5	0.5	patchy urchin barrens amongst algal stands
A189	5.5	0.5	**0**	**2.5**	patchy urchin barrens amongst algal stands
A563	1.5	0	na	na	patchy urchin barrens amongst algal stands
A570	11.5	0	3.5	0.5	patchy urchin barrens amongst algal stands

Table 2 Urchin species counts for 1m^2 quadrats. Transects located in Maunganui Bay in semi-sheltered locations are shaded in grey. Bold counts indicate where *Centrostephanus* was the dominant urchin species or present at a density >.5m^2.

site	Urchin barren #1 top count		Urchin barren #1 bottom count		Notes
	kina/m²	***Centrostephanus* /m²**	**kina/m²**	***Centrostephanus* /m²**	
A564	12.5	0	5.5	0.5	extensive urchin barren
A577	**4**	**1.5**	2.5	0	#1is a significant steeply sloping urchin barren and #2 is a *Centrostephanus* scattered under Ecklonia forest

Table 3 Urchin species counts for 1m^2 quadrats. Bold counts indicate where *Centrostephanus* was the dominant urchin species or present at densities >5m^2.

Urchin abundance counts in this survey varied within a range that is consistent with that reported in other New Zealand work (Shears and Babcock, 2012) in relation to the formation and persistence of urchin barrens with kina densities > 1m^2. On the sheltered shores there were small urchin barrens (<10m^2) at two sites (A20 and A8). One site (A3) had one large and one small urchin barren. The fourth site (A19) had a large urchin barren (>10m^2). Kina abundance counts were in a range of 1.5 to 11.5 kina/m^2. Site A20 had a small barren with only *Centrostephanus* present with a density count of 2/m^2.

On the exposed sites there were three sites with extensive urchin barrens <10m^2 (A564, A577 and A24). A24 and A564 had high kina counts of 12.5/m^2 and A577 had a count 4/m^2 with *Centrostephanus* also present at a density of 1.5/m^2 in the shallow part of the barren, but absent from the deep part of the barren. Four sites had urchin barrens that were described as very small or patchy with areas well under 10/m^2. The range of kina counts in these locations was 1.5-11.5m^2. Three sites on the exposed shore had small urchin barren patches with *Centrostephanus* counts ranging from 1.5-3.5m^2. Two of the three barrens with Centrostephanus densities > 1.5m^2 also had kina present at densities of 4 and .5/m^2.

Site	Transition to soft bottom sand, gravel, cobble or patch reef		Transect bearing from shore (degrees, magnetic)
	distance from shore (m)	depth (m)	
A24	70	25	360
A164	184	25	360
A180	112	22	315
A189	96	30	45
A563	107	19	360
A564	111	22	90
A570	64	15	360
A577	115	24	315
A20	22	4.0	180
A19	20	7	135
A8	26	10	225
A3	20	7	225

Table 4 Transect bearings from shore (magnetic) and estimated distance and depths to transition from rocky reef to soft bottom habitat. Depth and distance estimates are based on the OS 20/20 bathymetry data and the Kerr (2016) habitat map drawn for this area.

For the four sheltered sites in Maunganui Bay, a transition from rocky reef to soft bottom or scattered patch reef occurred at shallow depths (approximately 7m) and not far from shore (approximately 20m). For these sites the diver transect and records were extended to this habitat transition. For the exposed sites the diver transects were concluded at the point considered to be a transition to continuous *Ecklonia radiata* forest with low or no numbers of urchins present. It can normally be assumed, based on past experience, that urchin barrens do not form below 20m depth. In order to complete the information on the extent, depth and distance of the rocky reef profile, a desktop exercise was carried out to indicate the position and depth of the transition of the rocky reef *Ecklonia* forest to soft bottom habitat. Table 4 lists values derived from the fine scale multi-beam data provided by the OS 20/20 Bay of Islands survey project (Mitchell et al., 2010) and the recently-drawn habitat map for this area (Kerr, 2016). Included in Table 4 also are the magnetic compass bearings used for the diver transect swimming outwards from shore.

In the sections 4.2 and 4.3 aerial photographs (OS 20/20) are presented for each transect showing the position of the transect in relation to an overlay of the current drawn habitat map (Kerr, 2016).

Accompanying the aerial photos are a series of representative photographs of the subtidal communities encountered, along with descriptive and explanatory notes that add to the data presented here.

4.2 Sheltered shores transect maps and photo examples

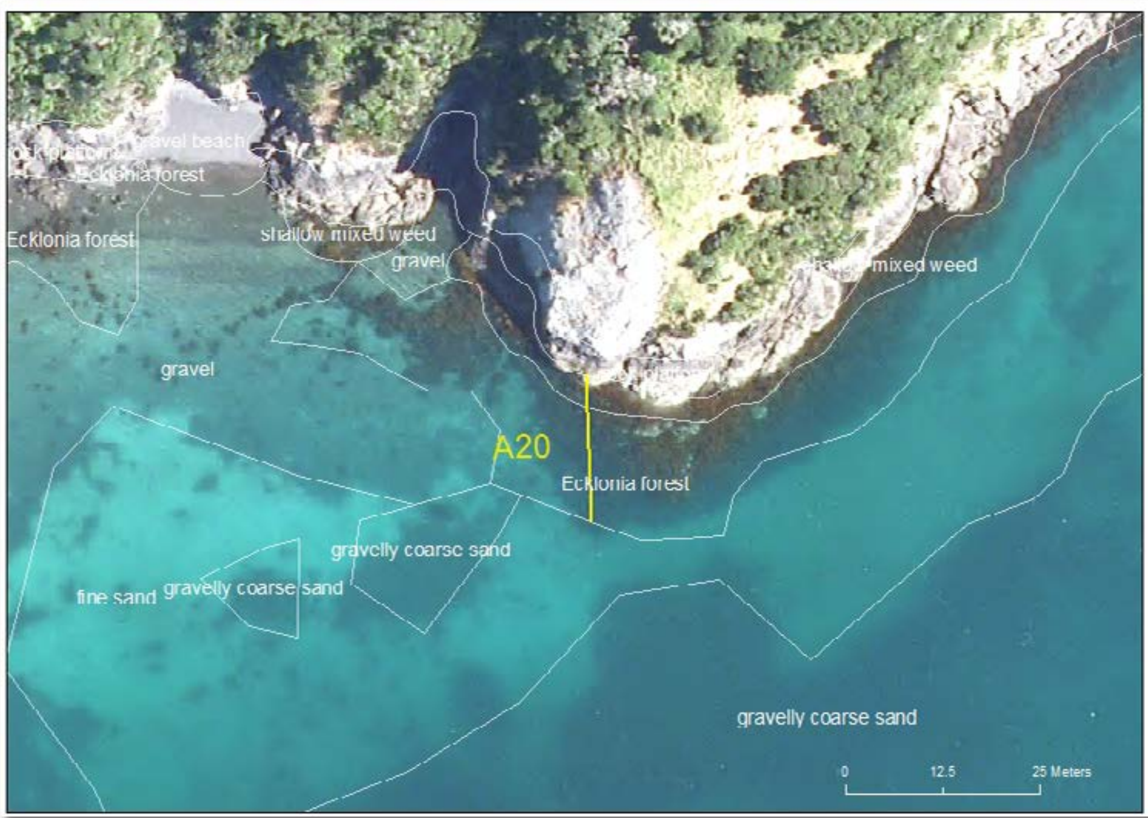

Figure 2 Transect A20 (yellow line) with habitat map overlay. Note small urchin barrens to the right of the transect at the bottom edge of the shallow mixed weed zone. OS 20/20 Aerial photograph.

Figure 3 Transect A20 (left) small urchin barren area with *Centrostephanus*, (right) *Ecklonia* forest at 4m depth.

Transect A20 had very small urchin barren patches with *Centrostephanus* and no kina present. These patches are difficult to see on the aerial photograph in Figure 2 which was captured from a GIS platform at 1:500 scale. In the shallowest part of the transect all that is visible is a faint light colour. These very small patches cannot be reliably interpreted on the aerial photograph at the working scale of the habitat map (1:2000 – 1:500).

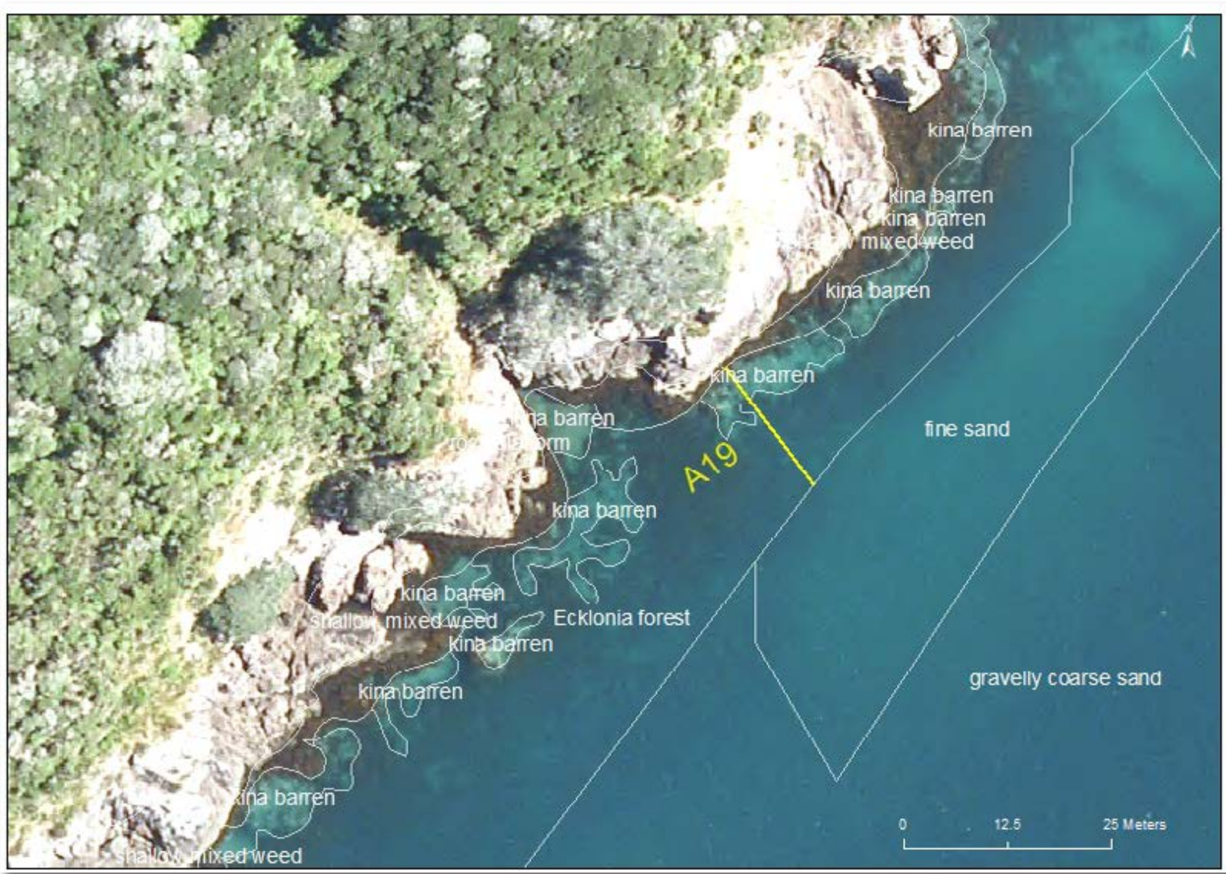

Figure 4 Transect A19 showing the shallow an urchin barren area which was successfully mapped from the OS 2020 aerial photograph.

Figure 5 Transect A19 showing two examples of the well established urchin barren and relative high densities of the kina. The shallow urchin barren at transect A19 ran from 3–8 m distance from shore and from .6–3.7m depth.

Figure 5 Transect A8, the small urchin barren was not clear in the aerial photograph of this site and was not mapped in the habitat map. Note the slightly larger urchin barren immediately to the left which was captured in the habitat map.

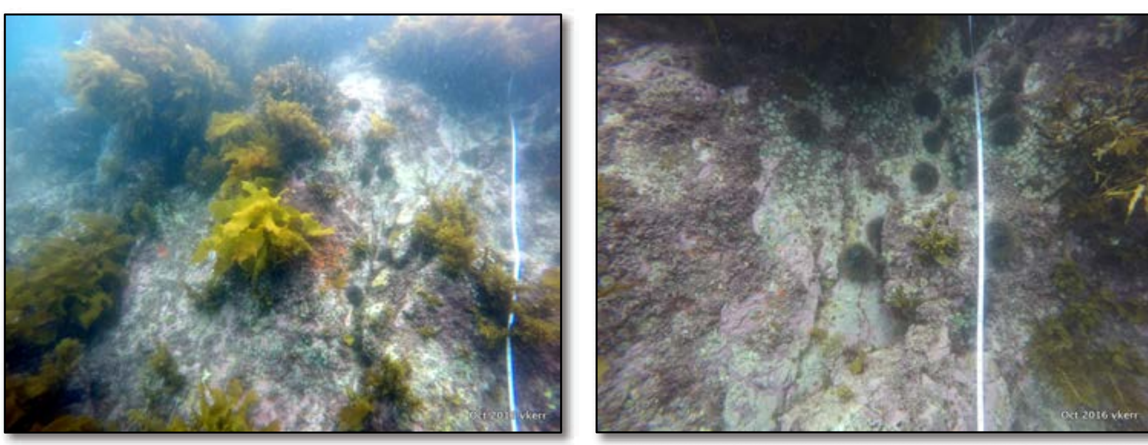

Figure 6 Transect A8, examples of the small and shallow urchin barren at this location.

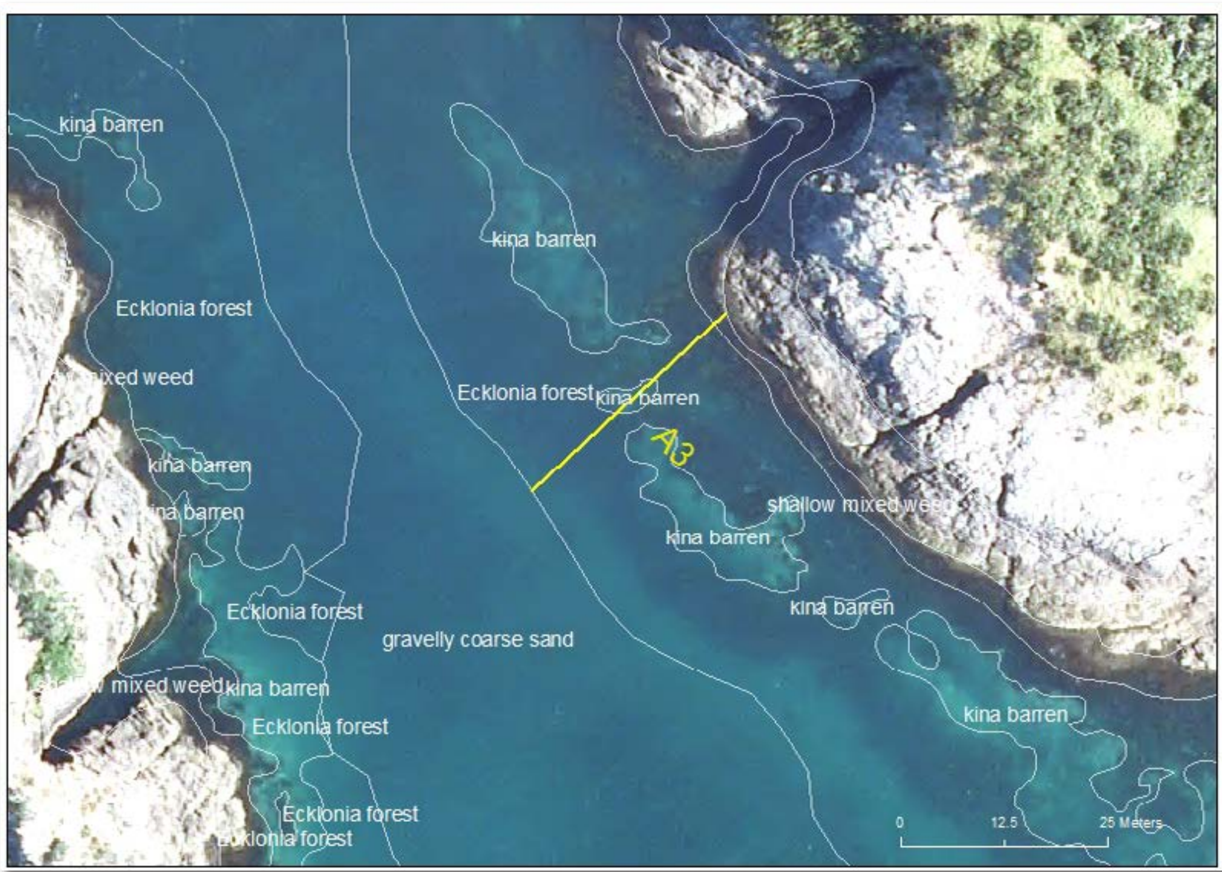

Figure 7 Transect A3, there were two distinct urchin barrens on this transect with the terrain dropping down then rising again on a little ridge. The first urchin barren was not captured on the habitat map. Only a very faint light colour can be seen on the aerial photograph where the first urchin barren should be. The second urchin barren area appears in the photo and was accurately mapped.

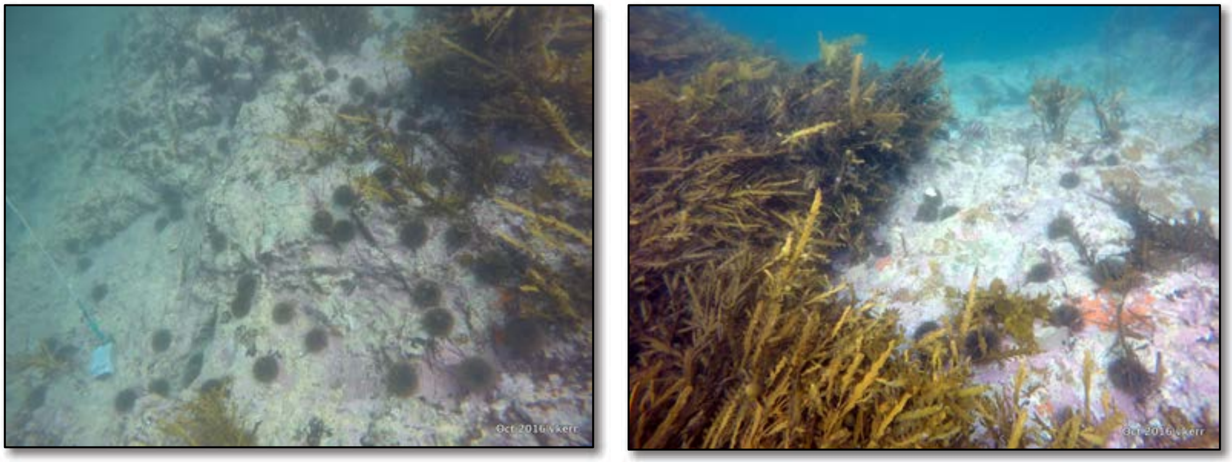

Figure 8 Transect A3 (left) is the shallower #1 urchin barren near the shoreline and (right) is the #2 urchin barren further from shore.

4.3 Exposed shores transect maps and photo examples

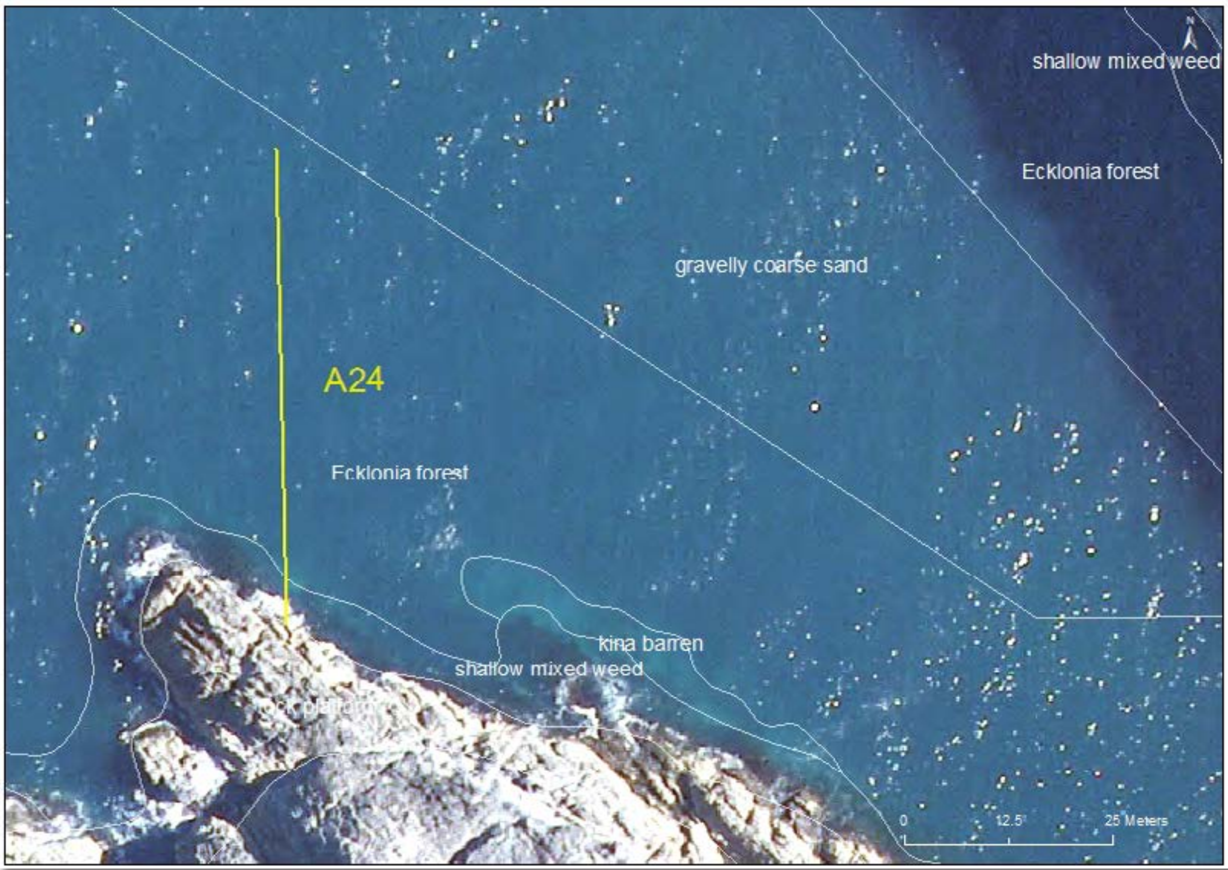

Figure 9 Transect A24 had two urchin barrens: the first was very close to shore where a near vertical wall descends from 4.2–12.7m depth; the second is an area of small patches with *Centrostephanus* at 20m distance from shore. The large vertical urchin barren near the shore does not show well enough on the aerial photo to enable mapping. The second patchy area further offshore is also not visible in the aerial photo. Both were missed in the mapping process.

Figure 10 Transect A24, (left) the shallow #1 urchin barren which drops off very steeply to 15m depth, (right) an example of #2 urchin barren composed of small *Centrostephanus* barrens at 11m depth.

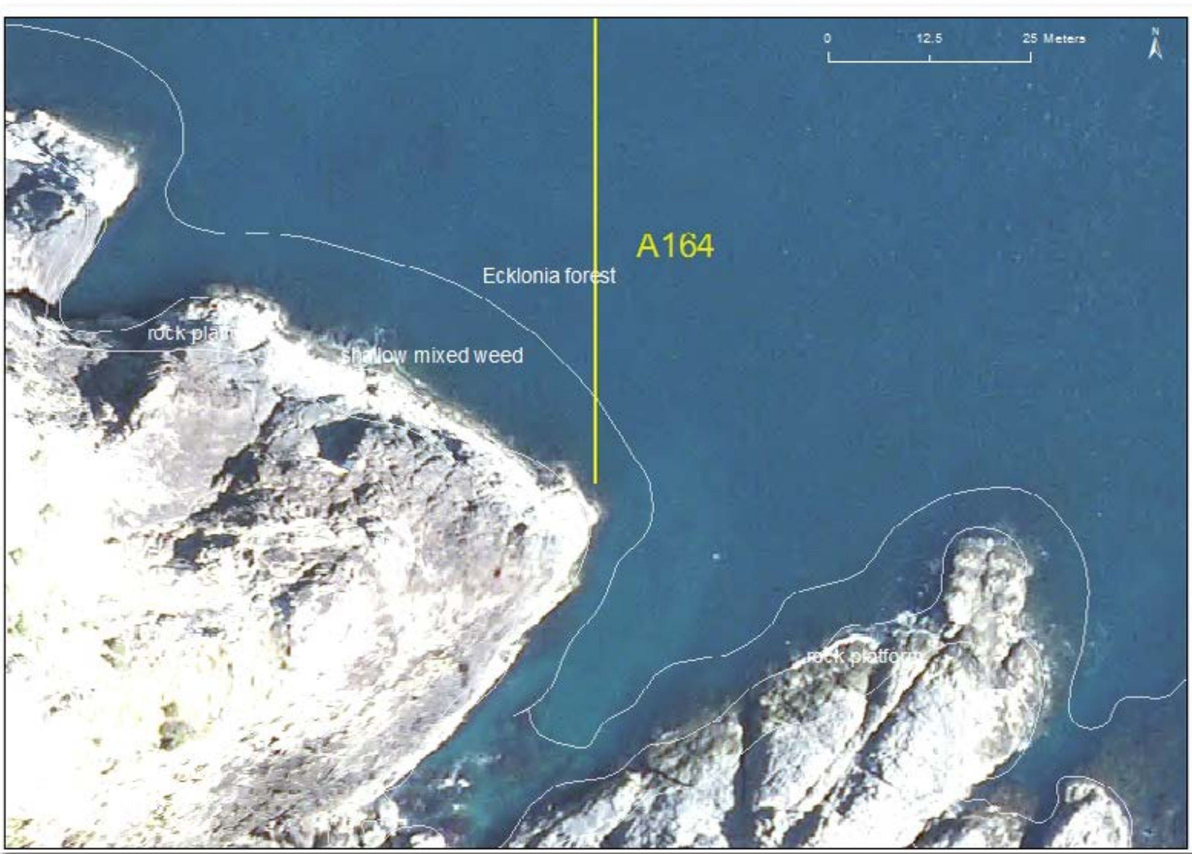

Figure 11 Transect A164, no urchin barrens were seen on this transect, in agreement with the habitat map interpretation.

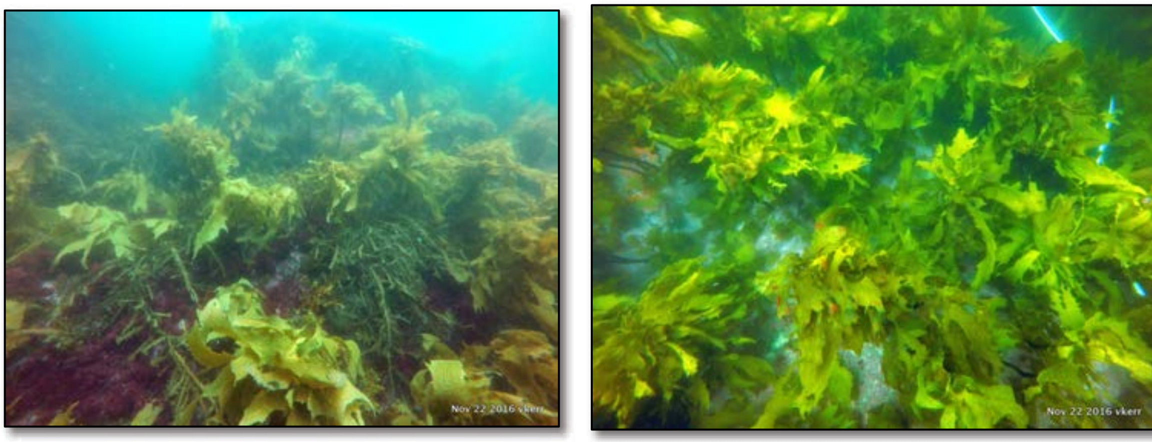

Figure 12 Transect A164, (left) showing the transition from shallow mixed weed habitat to *Ecklonia* forest at 7m depth, (right) an example of healthy *Ecklonia* forest at a depth of 10m.

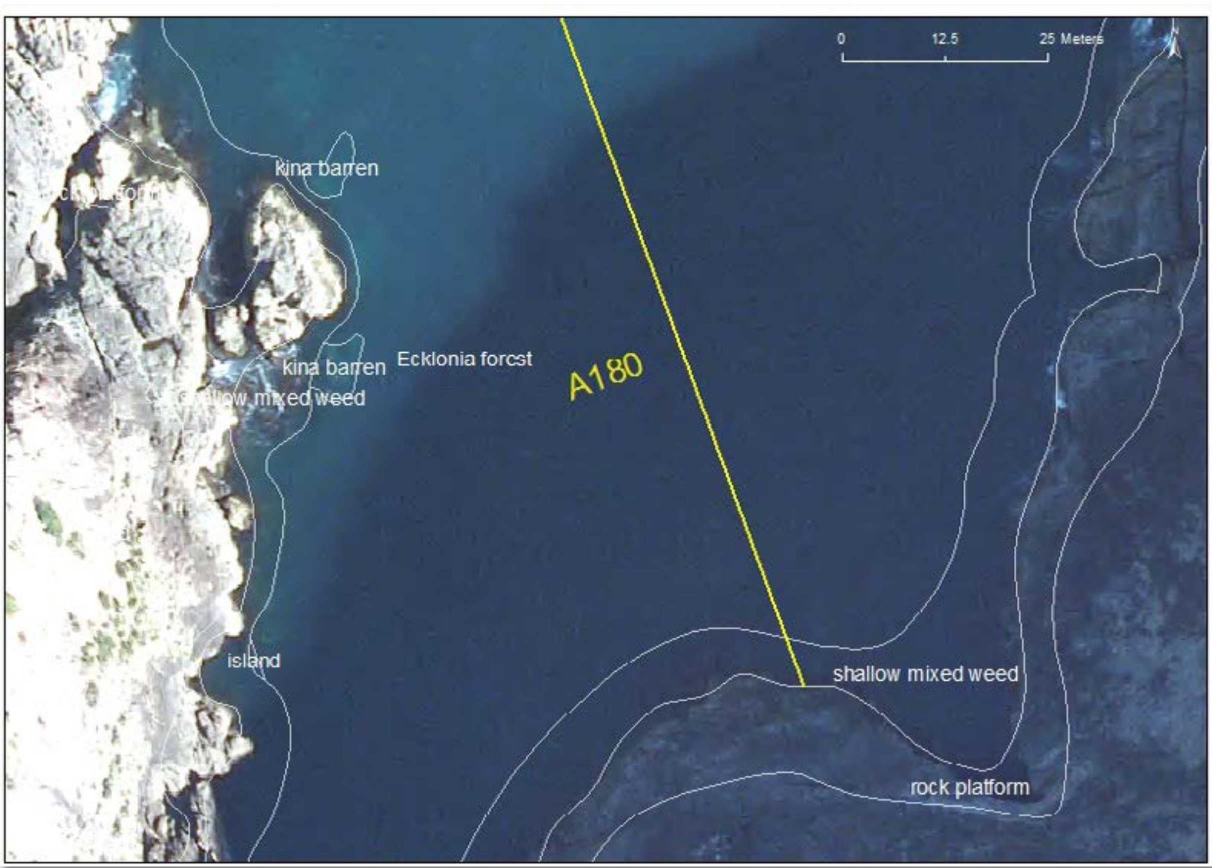

Figure 13 Transect A180 had small patches of urchin barren both close to shore at the edge of the shallow mixed weed zone, and further offshore at a distance of 17m. Both these urchin barren patch areas are completely obscured in the aerial photograph and not captured in the habitat map.

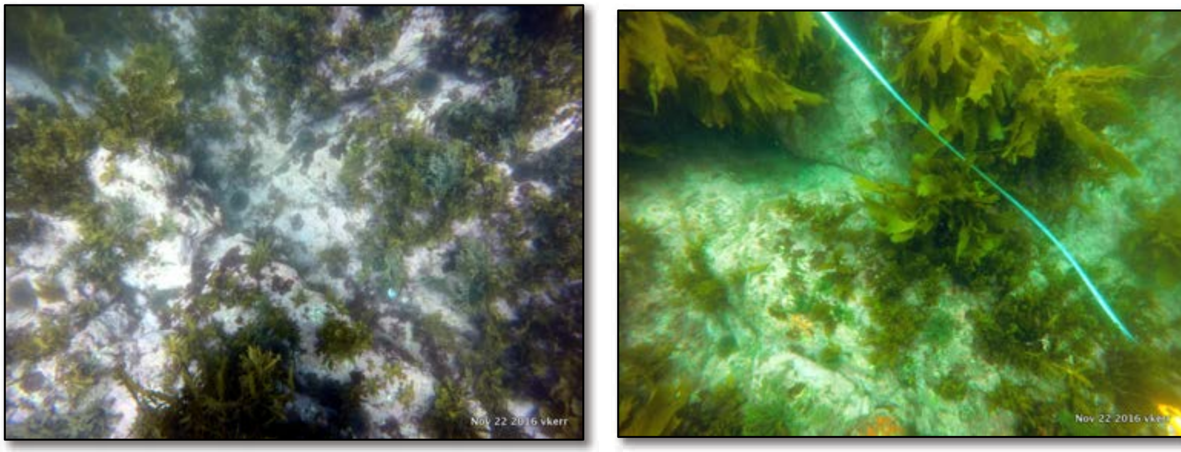

Figure 14 Transect A180, (left) urchin barren patch #1 at 2.7m depth and (right) urchin barren patch #2 at 7.7 m depth.

Figure 15 Transect A189 had two areas of very small urchin barren patches at 13m and 20m from shore, which are not visible on this aerial photograph. Larger adjacent urchin barrens are visible and were captured in the habitat map layer.


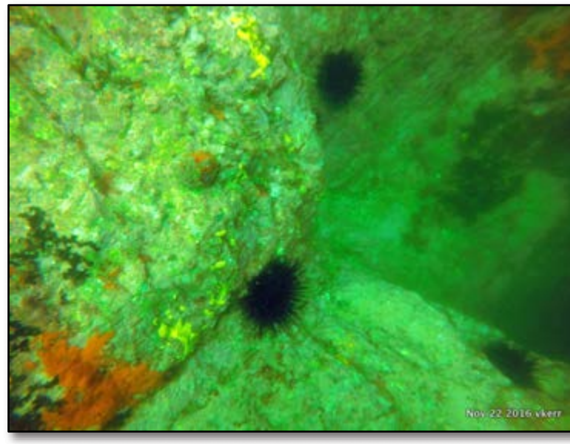

Figure 16 Transect A189, (left) urchin barren patch #1 an example of small urchin barren patch at the bottom edge of the shallow mixed weed zone, (right) urchin barren patch #2 and example of small *Centrostephanus* urchin barren patch at a depth of 14m.

Figure 17 Transect A564 and A563. Transect 564 had a large urchin barren extending from the edge of the shallow mixed weed zone at 3m–8m depth; this urchin barren can be seen as a very light shading in the aerial photo. It was not mapped because the interpretation of the imagery was not conclusive. Transect A563 has a small patch urchin barren lying between 6.7–7.7m depth; it was not detected on the aerial photo for the mapping process.

Figure 18 Transect A564, (left) a view at 3m depth looking down the slope at the urchin barren, (right) a view taken at 8m depth looking up the slope at the urchin barren.

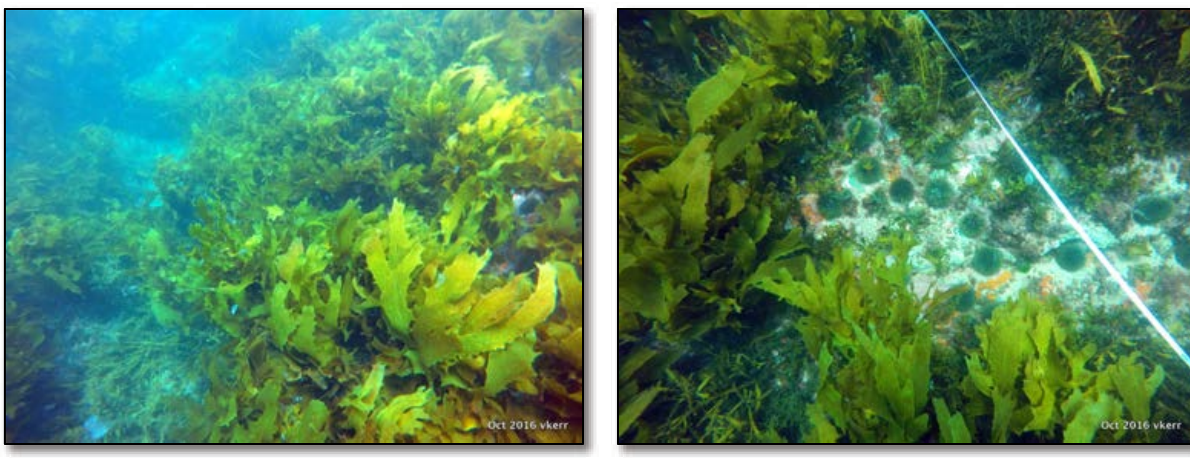

Figure 19 Transect A563, (left) a view at 6.7m depth with small urchin barrens amongst otherwise healthy *Ecklonia* forest, (right) a closer view of urchin barren patches typical at this site.

Figure 20 Transect A570 had two small patch areas of urchin barrens at 2m and 6.1m depths; although some very small areas of light coloured reef can be seen in the aerial photo an urchin barren was not confirmed in the mapping process.

Figure 21 Transect A570 (left) Urchin patch #1 at 2m depth, (right) urchin barren patch at 6.1m depth.

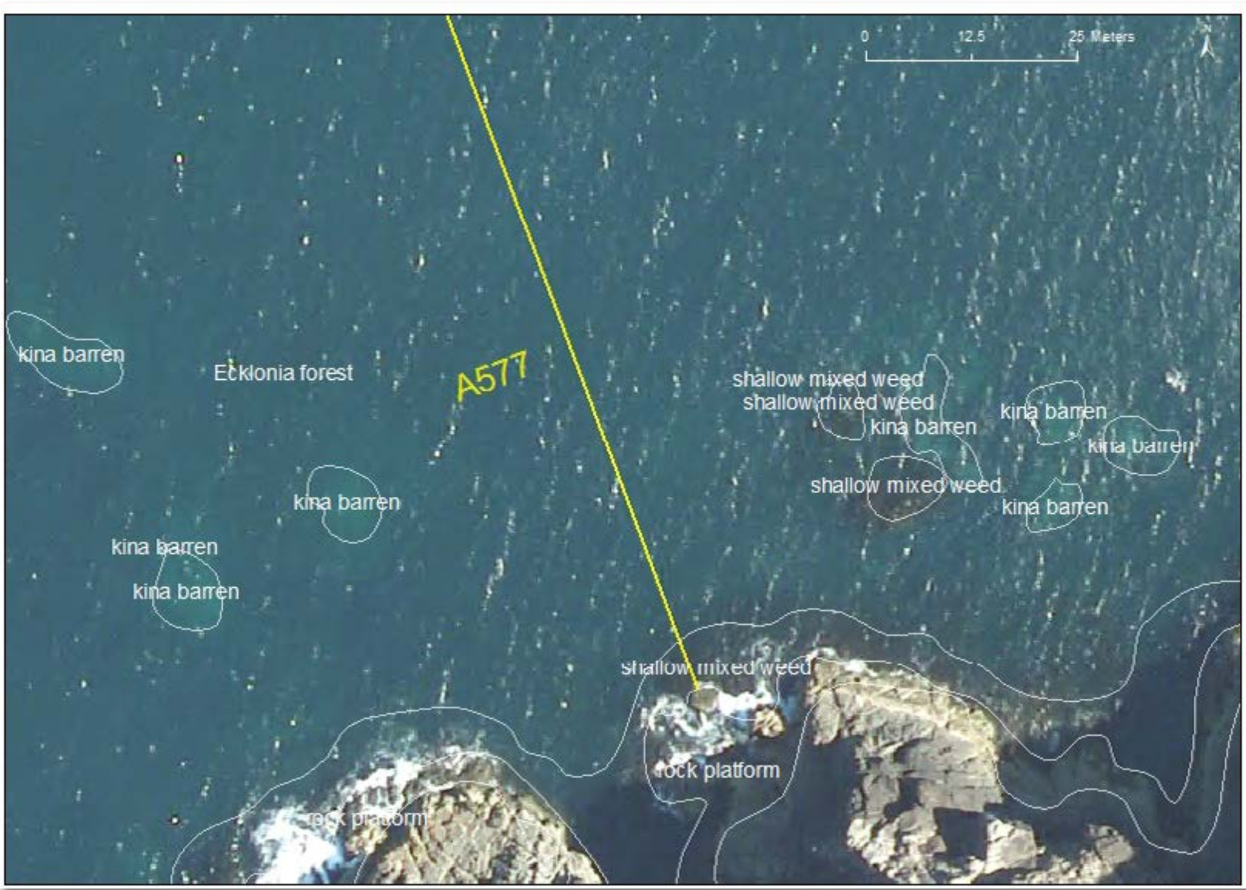

Figure 22 Transect A577 had a large urchin barren near the shoreline extending from depth 4.2–9.2m at a distance of between 3–12m from shore. Faint light colours are detectable in the aerial photo but they were not clear enough to enable accurate mapping of this urchin barren.

Figure 23 Transect A577 (left) an example of the top of the urchin barren at 4.2m depth where kina and *Centrostephanus* are present together, (right) the bottom edges of the urchin barren at 9.2m depth, *Centrostephanus* were not recorded at the bottom of this urchin barren. This urchin barren extended at least 30m along the shoreline.

4.4 Habitat map ground truthing results

Urchin barren depths and distances from shore and size descriptions were examined against the Kerr (2016) habitat map to assess how well the mapping process worked for detection and mapping of urchin barrens at the twelve transect sites. Results are summarised in Table 5 below.

Transect	Urchin barren description	Agreement with habitat map	Notes
A20	very small urchin barren patches	poor, under reported	urchin barren not captured on habitat map too small to map at 1:500 scale and not clear on aerial photo
A19	large urchin barren	excellent	accurately mapped and interpreted from aerial photograph
A8	very small urchin barren patches	poor, under reported	urchin barren not captured on habitat map too small to map at 1:500 scale and not clear on aerial photo
A3	one large urchin barren, one small patch barren	large barren good, small patch poor	large urchin barren well interpreted and mapped, small patch not mapped probably scale too small to interpret
A24	one large urchin barren near vertical and one small patch barren	both barren poor, under reported	both barren types not mapped and not apparent in aerial photo
A164	no urchin barrens	good	interpretation correct
A180	small urchin barren patches	poor, under reported	aerial photograph poor in this location and affected by shadow, probably scale of patches too small to interpret also
A189	small urchin barren patches	poor, under reported	aerial photograph poor in this location and affected by shadow, probably scale of patches too small to interpret also
A564	large urchin barren	poor, under reported	aerial photo not clear enough to allow interpretation
A563	very small urchin barren patches	poor, under reported	urchin barren not captured on habitat map too small to map at 1:500 scale and not clear on aerial photo
A570	very small urchin barren patches	poor, under reported	urchin barren not captured on habitat map too small to map at 1:500 scale and not clear on aerial photo
A577	large urchin barren	poor, under reported	urchin barren not capture in mapping interpretation, aerial photo poor quality at this location due to reflections

Table 5 Summarised notes of the comparison of the urchin barren data with the Kerr 2016 habitat map. Sheltered shores are shaded grey

The ground habitat ground-truthing exercise has shown that the small and patch urchin barrens cannot be reliably interpreted from even a good quality aerial photograph at 1:500 scale. Eight transects had small or patch urchin barrens on the transects. None were captured in the habitat map. Five transects had large urchin barrens. On the exposed shoreline there were three transects with large urchin barrens, all three were not captured by the mapping process. One of the sites (A24) had an urchin barren on a 10m high vertical rock face that would simply not appear on a horizontal aerial photo. At the other two locations the aerial photo was sub-standard with problems with shadows and sun glare. There were two sheltered sites with large urchin barrens that were mapped accurately. There was one site on the exposed shore with no urchin barrens which was mapped correctly as Ecklonia forest.

5 Discussion

This study of algal community zonation and urchin barren extent was limited in terms of the number of transects completed and the number of counts made of the urchin species abundance. However it serves to illustrate some important pointers to aid understanding of how well our habitat mapping methods are working, and how significance of the extent of urchin barrens on the exposed coasts, as well as sheltered shores studied. Eleven of the twelve transects surveyed had urchin barren areas and five of the transects had large urchin barrens >10m^2. In future, more detailed studies of this type could be undertaken with greater replication of transects and species counts including algal species and detailed documentation of reef slope and rugosity. These kinds of quantitative approaches could yield productivity data of the various forms and conditions of algal communities involved. Species interactions and growth models for two primary urchin species would be a new focus of research for New Zealand. In this simple study it was observed that interactions of the grazers and their algal communities is far from simple. Especially in the category of small and patch urchin barrens, which were common. It was not clear if the small patches or ‘thinned’ algal stands were stable, recovering or in a transition to a large urchin barren state. These dynamics and the ecological processes behind them are key areas of understanding that could be usefully addressed with more detailed studies.

These results indicate that large urchin barrens >10m^2 can be reliably mapped at 1:500 scale where good quality aerial maps are found and the slopes of the reefs are not too steep. Unfortunately in the Eastern Bay of Islands on exposed shores there are many areas where the reef slopes are very steep; further, it is common that with any aerial photo set there will be areas adversely affected with shadows and light reflections on the surface of the water. Where these adverse conditions exist it is important that they are noted and other methods are used to fill in the blanks. Alternative methods are:

- use of drones to photograph shallow subtidal reefs in ideal conditions at fine scales
- diver transects
- diver-based manta board tows with video cameras
- ROV surveys
- drop camera surveys
- fine-scale shallow water sonar survey capable of detecting vegetative cover, paired with interpretative software

This transect study also supports a view that small urchin barrens <10m^2 and urchin barren patches are common on the Cape Brett shoreline and that these habitats are essentially under-reported in habitat mapping studies carried out at a mapping scale of 1:500. It is not known if these small urchin barrens are in a transitional state or are stable in size. This raises a host of interesting questions about their ecology. Collectively these small urchin barrens add up to a significant loss of valuable shallow water algal forest habitat and they may forewarn a transition to expansive persistent urchin barrens. The results of this survey also suggest that other habitat mapping efforts in Northeast New Zealand to date have also under-reported the extent of urchin barrens.

Our transect data is indicating that the red spiny urchin *Centrostephanus rodgersii* is now widespread in the Cape Brett area and appears to be playing a significant role in the establishment of urchin barrens. *Centrostephanus rodgersii* is believed to be self-introduced to Northeast New Zealand from Australian waters via the East Auckland Current. No reliable date is known for this introduction but is believed to be in the order of 60–70 years ago (Choat and Schiel 1982), (Pecorino, 2012). In our study urchin barrens on both sheltered shores and the exposed shores had *Centrostephanus* present. Counts of >1/m^2 occurred on four occasions. There is no information on the relationship of *Centrostephanus* abundance and urchin barren formation in New Zealand conditions, however in Tasmania in similar warm temperate conditions abundances of over 1/m^2 are considered sufficient to lead to the urchin barren condition (Tracey et al., 2015), (Ling, 2008). *Centrostephanus rodserii* can reach diameters of up to 125mm which is larger than our native kina species. Indications are that their growth rates are similar or faster here than in NSW and Tasmania (Pecorino, 2012).

Based on what we have observed to date, it is apparent that numbers of *Centrostephanus rodgersii* are increasing and they are not restricted to our most exposed shorelines or offshore islands. We know from Australian experience that this species is capable, adaptable, has a wide environmental range tolerance and is an aggressive grazer. The *Centrostephanus* urchin is now in sufficient numbers in the Cape Brett areas to pose an additional overgrazing threat to our shallow algal forests–along with the native kina–in the face of persistent fishing on local reefs. The basic ecological model behind this threat has been well-documented here, in Australia and elsewhere overseas (Babcock et al., 1999), (Shears, 2006), (Ling et al., 2008, 2009, 2015). However we have no system in place to gauge the rate or extent of decline of shallow algal forests in Northland waters. By default we are accepting a future of declining productivity and decreased resilience to climate change (Ling 2009, 2015) of one of our most important and valued shallow water habitats.

5.1 Recommendations

Understanding of urchin barren ecology requires urgent further investigation. There could be useful studies of the economic impact on inshore fisheries resulting from algal forest decline and losses in ecosystem services provided by this key coastal habitat. (Ling, 2008), (Andrew et al., 1998, 2000).

A detailed study of the spread and impact on shallow algal forests of *Centrostephanus rodgersii* in the Eastern Bay of Islands should be carried out.

A long term monitoring program should be established to report on the threat of algal forest decline resulting from localised shallow reef fishing impacts.

New methods for fine-scale habitat mapping with a focus on algal forest and urchin barrens should be investigated and trialled.

Habitat mapping projects supporting the ongoing study of algal forest decline should be supported and encouraged.

Habitat mapping and monitoring projects that increase the awareness of the severity of the threat of algal forest decline in our shallow reefs, and which support MPA planning, should be pursued and encouraged.

Work on establishing an effective network of fully protected marine areas is vital in the face of the ecological impacts of persistent fishing in inshore waters. All efforts in this area should be encouraged and supported.

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8 Appendix 1 Locations of transects

	NZ transverse Mercator		WGS 1984	
Wpt	**Northing**	**Easting**	**Latitude**	**Longitude**
A164	6105705	1718394	35 11.079141 S	174 18.020247 E
A180	6105926	1719034	35 10.955141 S	174 18.440247 E
A189	6106235	1719387	35 10.785141 S	174 18.670247 E
A24	6105262	1717752	35 11.323141 S	174 17.601246 E
A19	6104830	1718517	35 11.551141 S	174 18.109247 E
A20	6104923	1718646	35 11.500141 S	174 18.193246 E
A3	6104946	1717765	35 11.494141 S	174 17.612246 E
A8	6104921	1717965	35 11.506141 S	174 17.744246 E
A563	6105890	1720430	35 10.964141 S	174 19.360247 E
A564	6105969	1720361	35 10.922141 S	174 19.314246 E
A570	6105835	1720678	35 10.992141 S	174 19.524247 E
A577	6106181	1720832	35 10.804141 S	174 19.622247 E