Noises Islands Rocky Reef Survey

Summary

Prepared by

Tim Haggiitt (PhD) – eCoast




eCoast
eTakutai

MOHIO - AUAHA - TAUTOKO
UNDERSTAND - INNOVATE - SUSTAIN

PO Box 151, Raglan 3225, New Zealand
Ph: +64 7 825 0087 I info@ecoast.co.nz I www.ecoast.co.nz

Executive Summary

A first-order biological survey of 8 rocky reef sites and 1 soft sediment sites within the Noises Islands group was undertaken in October 2017. Sampling was targeted at documenting dominant subtidal rocky-reef habitats and associated reef fish abundance and diversity. Main findings were:

- Biological habitats associated with rocky reef varied across sites in accordance with depth and exposure. At many sites shallow depths between 0-4 m were characterised by diverse mixed algal stands and large patches of the green lipped mussel *Perna canaliculus*. Beyond this, urchin barrens habitat was common feature down to 8m depth with expansive barrens habitat recorded at Otata Island and Motuhoropapa Islands. The fucalean alga *Carpophyllum flexuosum* and *Ecklonia radiata* formed enclosed canopies > 8m depth. Patchy rhodolith beds were also observed at Maria Island.
- Urchin barrens habitat was prevalent on the north-eastern coastline of Otata and Motuhoropapa Islands, synonymous with the effects of fishing and low densities of large predators such as snapper and lobster.
- Additional rocky reef habitats of note included diverse shallow-water sponge and sessile invertebrate communities; particularly surrounding Otata Island.
- The large dog cockle *Tucetona laticostata* was common in soft-sediment habitat adjacent rocky reef at many sites and low density patches of the scallop *Pecten novaezelandiae* and horse mussel *Atrina zelandica* were present around the south-eastern region of Otata Island.

Contents

1.0 Preamble

The Noises Islands are a group of privately owned Islands and rocky outcrops situated in the Hauraki Gulf. The Island group is dominated area-wise by Motuhoropapa, Otata, and Orapapa Islands and sits north-east of Rakino Island. The Islands are popular for fishing and diving, and have rich cultural history and significance. However, there is concern by the Islands' owners - the Neureuter family - regarding perceived and observed changes (declines) in habitat forming species, e.g., horse mussels, seaweeds and fish, other shellfish and seabird (the little blue penguin, *Eudyptula minor* abundance. Reasons for the perceived declines is likely related to a combination of fishing pressure and effects associated with reduced water quality through time. The Neureuter family have stressed their concern over the effects of fishing and the need for protection and restoration methods that takes into account both terrestrial and marine environs. This is to ensure that the biodiversity and ecological functioning of the Islands is restored, protected and preserved for future generations.

The potential for protection of the Noises Islands has further been acknowledged in the recently formulated Hauraki Gulf Spatial Plan that has a vision to restore the Gulf to a healthy, abundant and productive marine area. Initiatives to achieve this include: Transitioning trawling, dredging and Danish seining out of the Hauraki Gulf Marine Park; Setting catchment-based sediment and nutrient limits; Removing harvest pressure from some areas through the establishment of Type 1 marine protected areas (MPAs) and seabed-damaging activities from additional areas through Type 2 MPAs; and, to actively restore marine habitats.

Previous subtidal surveys of the Noises Islands have been both ad-hoc and spatially limited (see Smith 2004; Dewars and Oshea 2012) and there is no long-term quantitative surveys to accurately gauge the magnitude and extent of any changes that may have occurred. In October 2017, eCoast were commissioned by the Neureuter family to undertake a baseline survey of the rocky reef habitats and reef fish communities surrounding the Noises Islands. Funding for the survey was made available by Foundation North.

The purpose of the subtidal survey was to evaluate the current biological makeup of the area and place the findings within the context of the wider Hauraki Gulf including possible options for marine reserve protection. This report documents some of the key findings of the first-order biological survey. It must be stressed that the report is intended as a discussion document and a more in-depth report will be produced once data are collated and analysed in full.

2.0 Methods

Sampling of the Noises Island group was undertaken between the 5th and 6th October 2017. A total of eight rocky reef sites were surveyed using SCUBA to enumerate reef fish abundance and diversity and to document main rocky reef habitat types. Sites included 1) Motuhoropapa Island north-east; 2) Motuhoropapa Island north-west; 3) Otata island north-east; 4) Otata Island south; 5) Orapapa Island; 6) Maria Island; 7) David Rocks; and 8) Ahaaha Rocks. One soft sediment site on the south-western tip of Otata Island was also surveyed to estimate scallop and horse mussel occurrence and characterise sediment types.

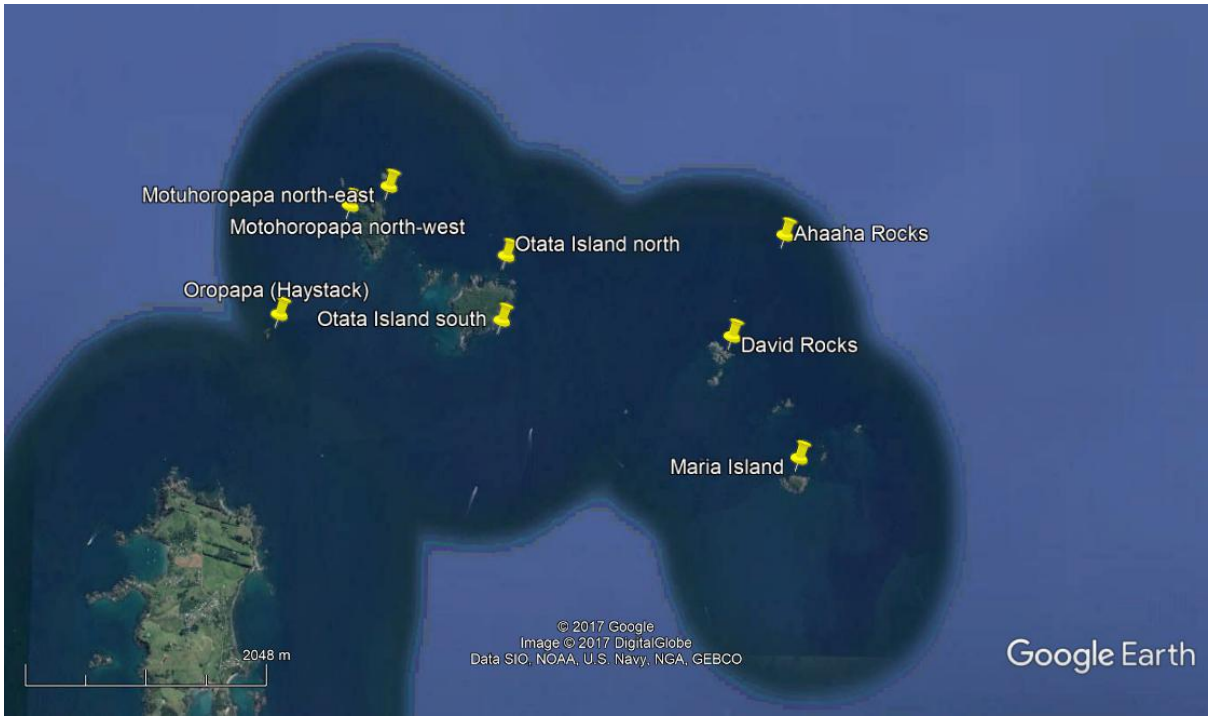

Figure 1. Eight survey sites sampled around the Noises Island group in October 2017.

To maximise sampling efforts benthic sampling and fish surveys were combined simultaneously with two teams of two divers. For each pair, one diver recorded fish along a sample transects with the other diver following and taking photos of the dominant benthic habitats (see below). All transects were haphazardly sampled beginning at the deepest areas of rocky reef at each site and moving progressively into the shallow subtidal. Table 1 provides a breakdown of transects sampled at each site.

Table 1. Sampling site and level of replication of haphazard transects sampled for reef fish and benthic survey components.

Site	Transect
Motuhoropapa Island north-east	10
Motuhoropapa Island north-west	10
Otata island north-east	11
Otata Island south	12
Orapapa Island	7
Maria Island	9
David Rocks	9
Ahaaha Rocks	11

2.1 Reef fish

To census reef fish, a diver fastened a 30 m fibreglass transect tape to the holdfast of a large macroalga (commonly *Ecklonia radiata*) substratum, which was then swam out to 5 m before commencing counts, to avoid sampling any fish attracted to the diver. The transect tape was then swum out to 30 m, with all fish visible 2.5 m either side of the swim direction counted.

Where certain schooling species (e.g., sweep *Scorpis lineolatus*) were too numerous to be counted, numbers were estimated in their 20's. Cryptic species were not counted. Cryptic species were not surveyed due to their small size (e.g., clinids, syngnathids, and tripterygiids other than the oblique swimming triplefin *Obliquichthys maryannae*- if present). All fish censused were sized to ± 50 mm based on visual estimation. In instances where fish followed divers between transects, care was taken to not include previously censused individuals. Similarly, fish seen outside of the transect survey width were not be sampled, but their presence and corresponding depth were noted. Depth (m) at the start and end of each transect and the occurrence of 8 habitat types (*Ecklonia radiata*; *Ecklonia radiata* and sponge; mixed algae; sponge; *Carpophyllum flexuosum*; urchin barrens habitat; shallow *Carpophyllum*; and, sand) where present were also recorded at 5 m intervals along each transect. All UVC censuses were done between 08:00 and 16:00 NZST.

2.2 Benthic habitats

Following behind the diver censusing reef fish, the second diver took images of the seabed and dominant habitats at 5m intervals along each 25m transect using an Olympus Stylus TOUGH TG-4 Digital Camera, i.e., for each 25m transect sampled there were 6 corresponding images taken. A Sensus Ultra depth logger (https://reefnet.ca/products/sensus/) was attached to the camera housing to record depth and a hand held Garmin 60csx GPS in a waterproof housing and surface float (Fig. 2) was tethered to the diver via bungee cord. Care was taken to ensure that the bungee cord was pulled tight to ensure that the GPS unit at the surface was directly above the diver taking each photo. The GPS continually logged position (at 4 second intervals) and the camera, GPS and depth logger clocks were synchronised at the start of each day's data collection to ensure correct geolocation of the photos.

Figure 2. GPS unit attached to surface buoy, used to record sampling position.

2.4 Lobster occurrence

During the photo survey component, areas of reef deemed suitable as lobster habitat were searched for the presence of the spiny rock lobster *Jasus edwardsii*. When encountered the size, and where possible, sex of each lobster was determined by visual estimation (see MacDiarmid, 1991). Torches were used to aid in the detection of lobster within any deep holes or crevices encountered.

2.5 Data analysis

For reef fish abundance, data are presented as total counts (pooled across sites), average taxa richness and total richness. To test for differences in community composition across sites whole assemblages were analysed using permutational multivariate analysis of variance (PERMANOVA, Anderson *et al.* 2008), with "Site" (8 survey sites) treated as a fixed factor. Analysis was run on log (x+1) transformed data and a Bray-Curtis (Bray and Curtis 1957) similarity matrix. Relative dissimilarities among the fish assemblages observed at different stations were visualised using principal coordinate analysis (PCO, Gower 1966), also known as metric multi-dimensional scaling (mMDS). Pearson's correlation coefficients were used to evaluate which species contributed to any of the separation of sites across the PCO axis associated with PCO axis 1 and 2.

3.0 Results

Results are presented as descriptions of the main benthic habitats sampled and reef fish diversity and community composition.

3.1 Rocky reef benthic habitat types

At a broad-scale level there were distinct patterns in the depth-distribution of rocky reef habitat types in accordance with depth and wave exposure. Main rocky reef habitat types encountered included:

1) shallow mixed algae (0-2m depth);
2) green-lipped mussel (*Perna canaliculus*) beds (0-4m depth);
3) urchin grazed barrens (1-8m depth);
4) mixed algal habitat (3-10m depth);
5) *Carpophyllum flexuosum* (5-15m depth);
6) *Ecklonia radiata* (5-15m depth); and,
7) sponge and encrusting invertebrates (3-15m).

Typically, where the rocky reef habitat terminated in deeper water, coarse shell and shell hash became the predominant habitat type.

3.1.1 Macroalgal habitat

Macroalgal habitat sampled included shallow mixed algae, mixed algae and monospecific stands of the fucalean *Carpophyllum flexuosum* and laminarian alga *Ecklonia radiata*. Of all habitat types macroalgal habitat varied the most across sites, reflecting exposure and the depth-distribution of rocky reef habitat. For the more exposed sites (Otata north, Motuhoropapa Island north, Ahaaha Rocks) deeper areas of reef (8-15m) were largely dominated by *Carpophyllum flexuosum* (Fig. 1A) and smaller patches of *Ecklonia radiata* (Fig. 1B). *Ecklonia radiata* was found to form larger monospecific stands at David Rocks and Ahaaha Rocks, although was narrow in terms of spatial extent due the steepness of the reef at these sites. Both *Carpophyllum flexuosum* and *Ecklonia radiata* canopies were typically < 1m in height across sites (Fig 1C). Substratum algae associated with *Carpophyllum flexuosum* and *Ecklonia radiata* habitats was dominated by foliose red algae such as *Pterocladia lucida*, *Pterocladia capillacea Gigatina* spp, and *Asparagopsis taxiformis* with brown algae represented by *Zonaria turneriana, Dictyota* spp and *Halopteris* spp (Fig. 2). Crustose coralline algae was however by far the dominant substratum algae across all depth strata. On the southern sides of Motuhoropapa Island and Otata Island where the depth distribution of rocky reef habitat was narrower (i.e., transitions from rocky reef to coarse shell occur < 8m depth), both *Carpophyllum flexuosum* and *Ecklonia radiata* formed continuous mixed canopies (Fig 1C).

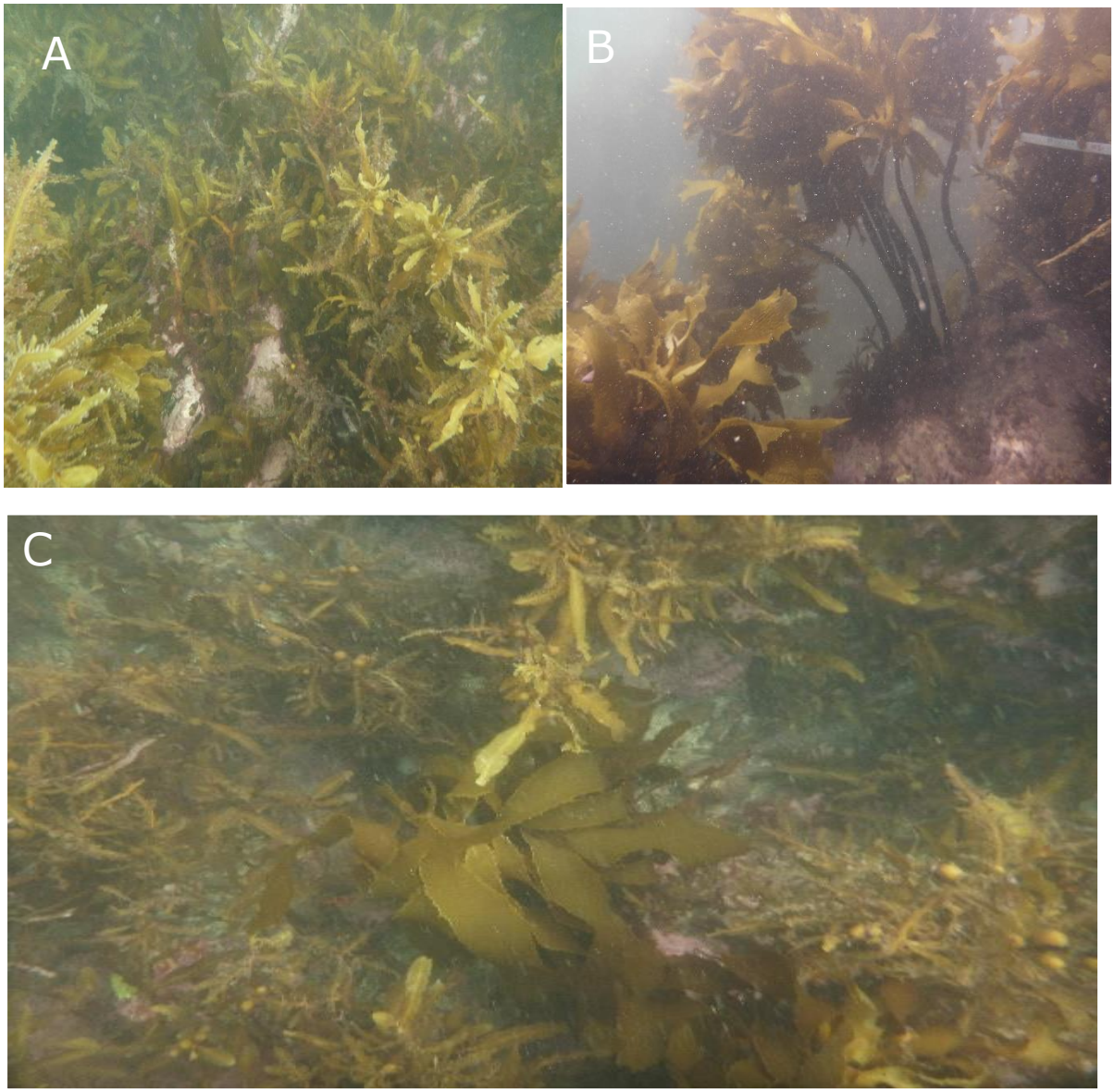

Figure 1. Dominant macroalgal habitats between 5-15m depth, Noises Islands A) *Carpophyllum flexuosum*, and *Ecklonia radiata* (Otata Island north); *Ecklonia radiata* (David Rocks); *Carpophyllum flexuosum and Ecklonia radiata* (Motuhoropapa Island) north-west.

At most sites, irrespective of exposure, the shallow 1-2m depth stratum was characterised by a diverse array of algal species including the brown algae *Carpophyllum maschalocarpum, Carpophyllum plumosum, Cystophora retroflexa, Xiphophora chondrophylla, Colpomenia sinuosa,* small *Ecklonia radiata*, *Halopteris* spp*,* and *Dictyota* spp; red algae *Pterocladia capillacea, Hildenbrandia sp* a diverse variety of other red foliose species; and, the green algae *Codium convolutum* and *Caulerpa* spp (Fig. 2).

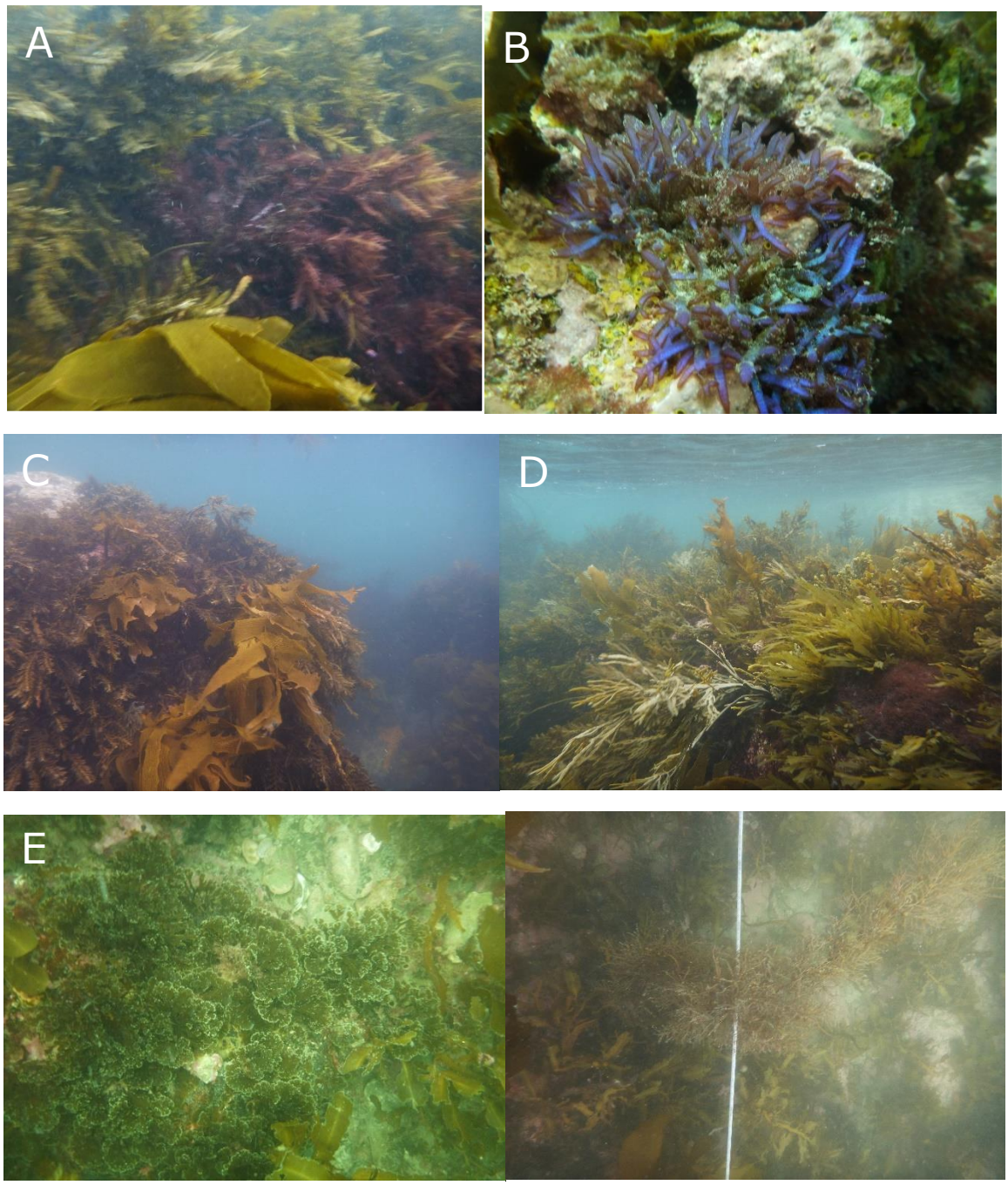

Figure 2. Shallow-water (1-3m depth) mixed algal habitats. A) *Carpophyllum maschalocarpum*, *Ecklonia radiata* and *Pterocladia lucida* (Motuhoropapa Island north); B) *Champia* spp (Otata Island); C) *Carpophyllum maschalocarpum, Ecklonia radiata* David Rocks; D) *Xiphophora chondrophylla*, *Ecklonia radiata*, *Dictyota* and *Pterocladia lucida* (Maria Island). E) F) *Cystophora retroflexa* Motuhoropapa Island (north-west).

3.1.2 Urchin barrens habitat

Urchin barrens habitat (absence of macroalgae and presence of the urchin *Evechinus chloroticus*) was a prominent and continuous feature of the northern coastline of Motuhoropapa Island, both northern and western coastlines of Otata Island, and the northern coastline of Maria Island (Fig. 2e). At other locations, urchin barrens habitat was present, but was often patchily distributed with mixed macroalgal stands, or had a narrow depth distribution, e.g., Ahaaha Rocks (2-4m depth).

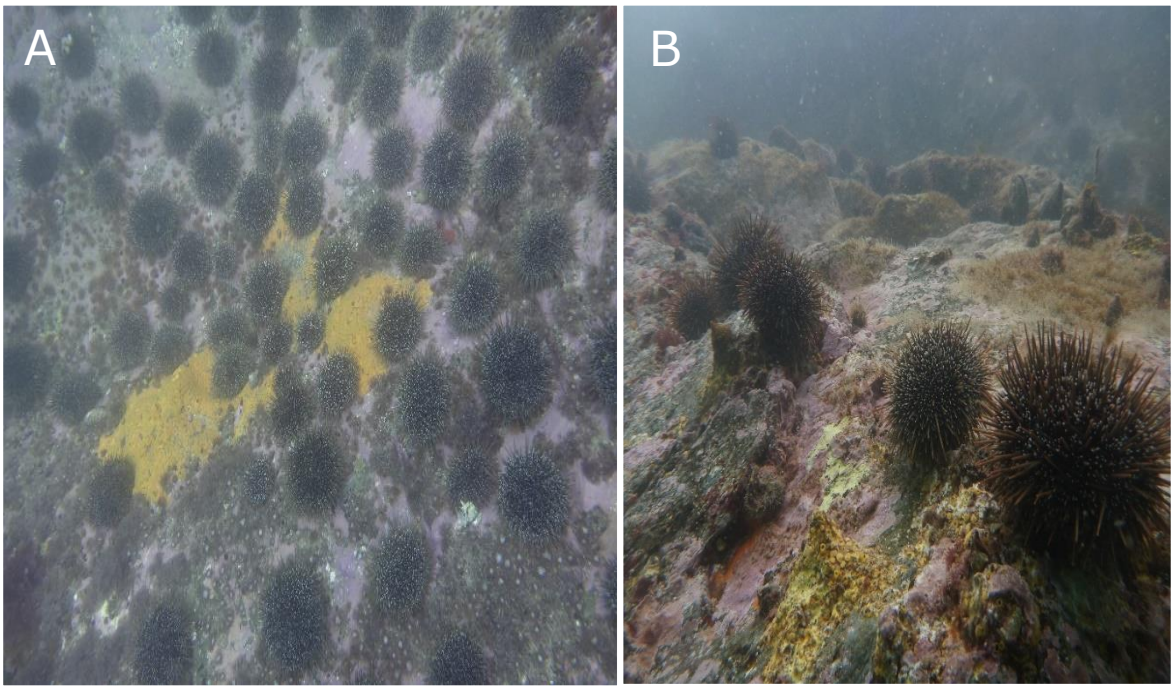

Figure 3. Example of urchin barrens habitat at A) Motuhoropapa Island (north) and B) Otata Island (South).

2.1.3 Sessile invertebrates

In addition to macroalgae, two rocky reef habitat types also of note were encrusting invertebrate communities dominated by sponges (Fig. 4) and subtidal green-lipped mussel beds (Fig. 5). Sponge habitat was especially notable at Ahaaha rocks (< 12 m depth) and Otata Island on northern and western coastlines in shallow water < 8 m depth. Some very large individuals of *Ancorina alata* < 2m in length (Fig. 4) were encountered at Otata Island, especially where currents were strong. Other species routinely observed were the golf ball sponges *Tethya burtoni*, *Tethya bergquistae*, finger sponges *Raspailia topsenti* and *Callyspongia ramosa* and the encrusting sponge *Cliona celata*. Other common sessile invertebrates included the solitary ascidians *Asterocarpa coerulea* and *Cnemidocarpa biocornuta*, hard corals *Culicea rubeola* and *Clathria rubens* and anemone *Actinothoe albocincta.* The David Rocks site was also notable for large patches of the jewel anemone *Corynactis australis* on vertical walls in shallow water < 3m depth. Sponges and ascidians were also a common feature of urchin-barrens habitat, although tended to be encrusting in nature.

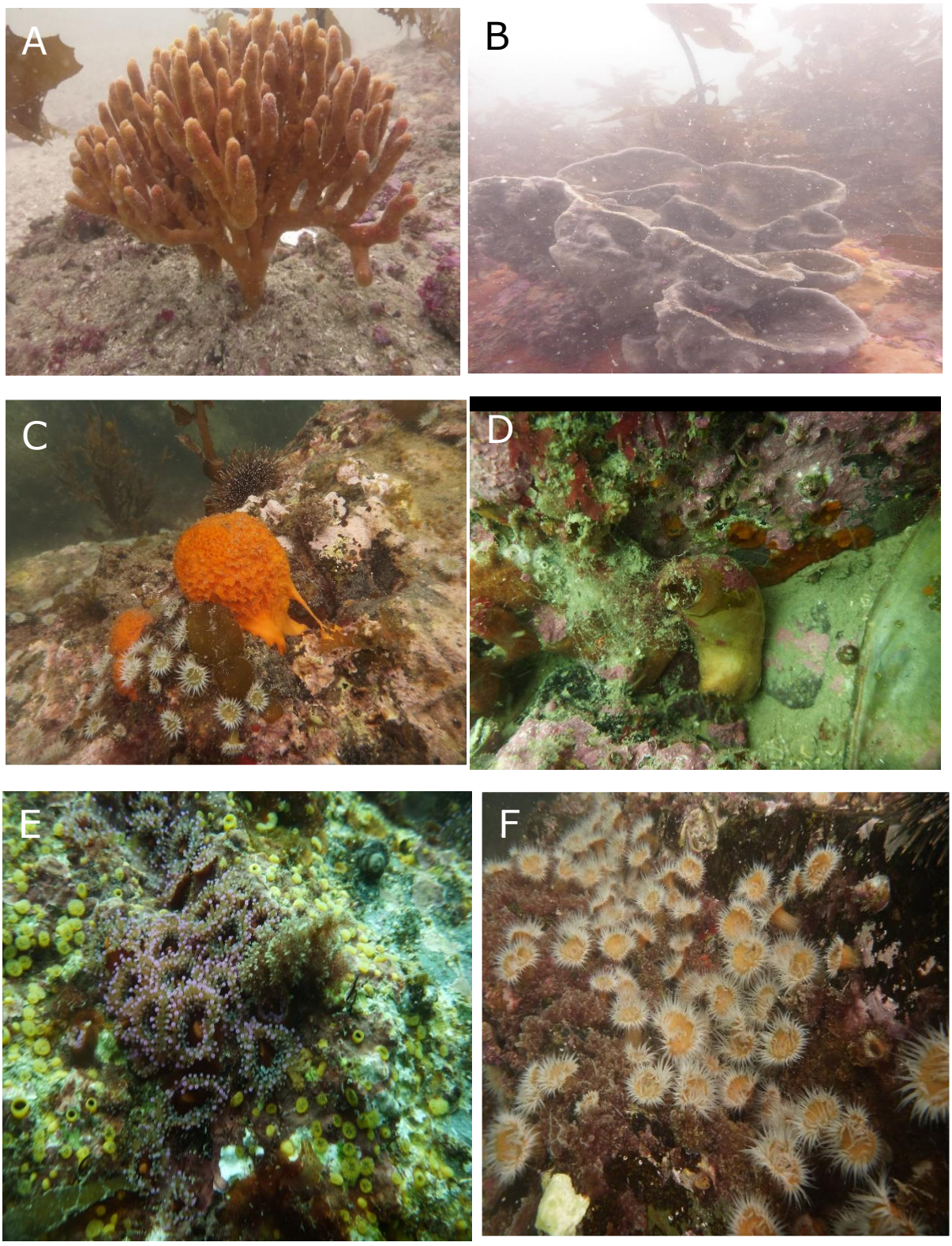

Figure 4. Common sponges and encrusting invertebrates of the Noises Island group. A) *Raspailia topsenti;* B) *Ancorina alata;* C) *Tethya burtoni*; D) *Cnemidocarpa bicornuta*; E) *Corynactis australis*; and, F) *Actinothoe albocincta*.

At many of the more exposed sites surveyed dense mussel beds (*Perna canaliculus*) were a conspicuous feature (Fig. 5). These often occurred in continuous bands from the intertidal

down to a depth of 3-4 m, sometimes deeper e.g., Ahaaha Rocks, Orapapa (Haystack), Motuhoropapa north. Typically, the mussel beds were associated with high biodiversity and colonised by a diverse array of sessile invertebrates (algae, sponges, ascidians, anemones). Narrow patches of pacific oyster were also conspicuous at most sites extending from the lower intertidal to shallow subtidal (Fig. 6).

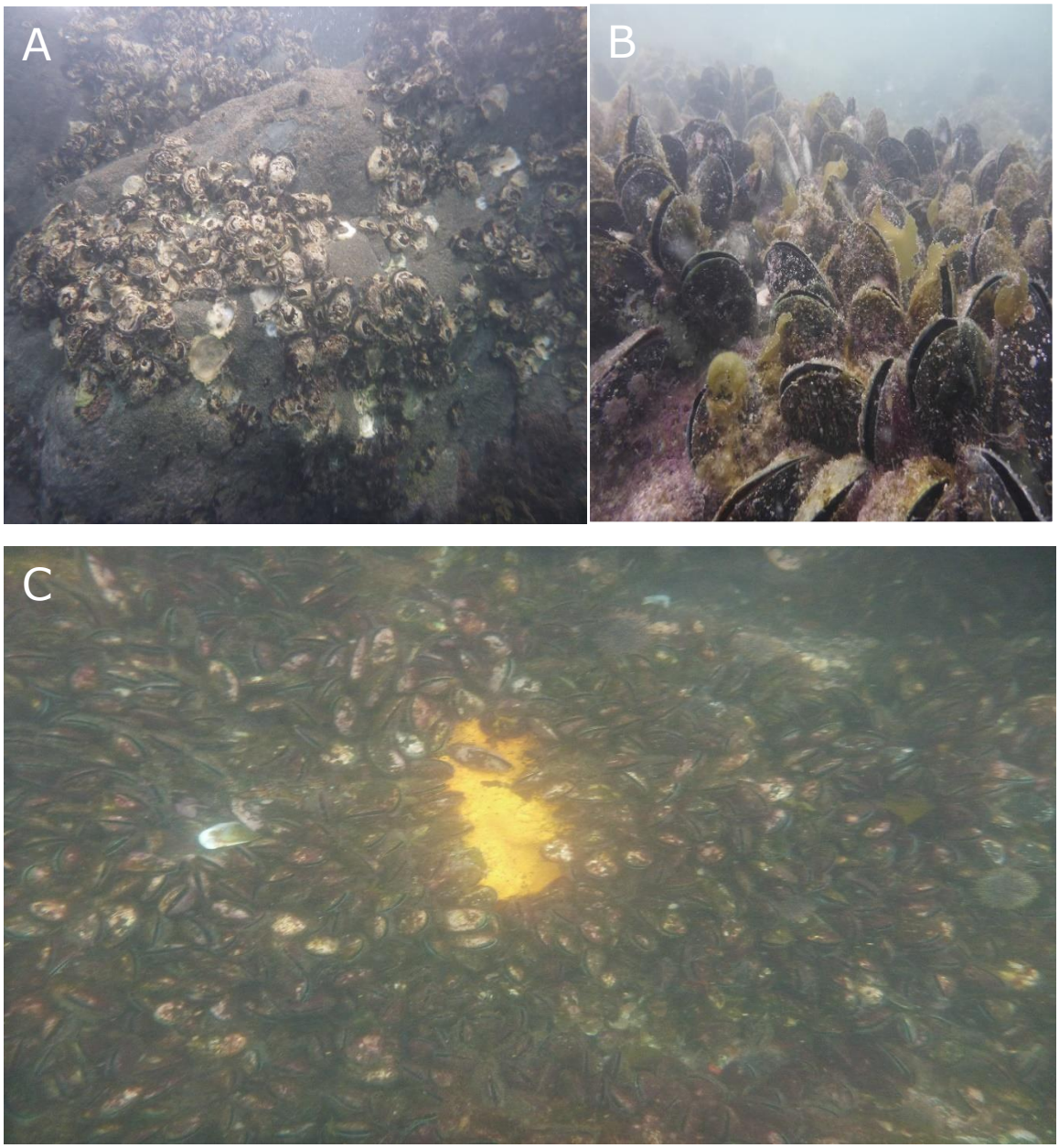

Figure 5. A) Pacific oyster, *Crassostrea gigas* (David Rocks); B) mussels, *Perna canaliculus* (David Rocks; and, C) mussels, *Perna canaliculus* (Ahaaha Rocks).

3.1.4 Mobile invertebrates

Dominant molluscs associated with kelp and urchin barrens habitat across the majority of sites and depth strata surveyed included the gastropods *Cookia sulcata*, *Trochus sulcata, Dicathis orbitata, Charonia lampus,* and whelks *Buccinulum linea, and Xymenella* spp. In shallow water < 3m paua *Haliotis iris* (sub-legal) and the cat's eye *Turbo smaragdus* were common. The sea-

cumber *Stichopus mollis* was also conspicuous at many of the survey sites, especially on soft sediment habitat adjacent rocky reef. Octopus (*Pinnoctopus cordiformis,* and *Macroctopus maorum*) were very common across the survey sites and were routinely observed in the open, often within or adjacent to mussel beds. Greatest numbers occurred at Maria Island with 11 observed across sample transects. However, of all mobile invertebrates surveyed, the sea urchin *Evechinus chloroticus* (kina) was very common, forming very high density patches along the northern coastline of Motuhoropapa Island and the northern and southern coastline of Otata Island (Fig. 6).

3.1.5 Lobster

Despite extensive searches at all survey sites, no spiny rock lobster, *Jasus edwardsii* were encountered.

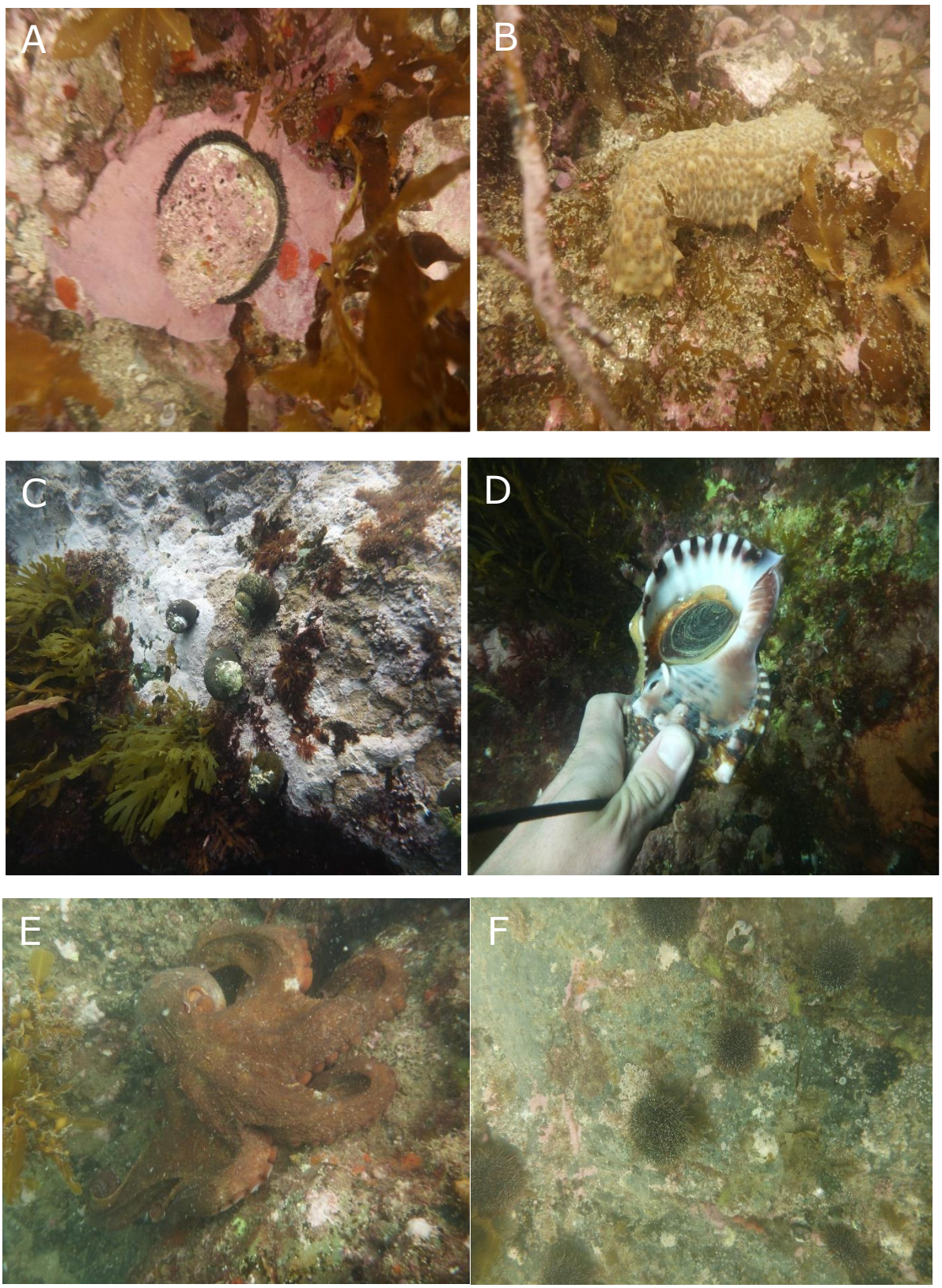

Figure 6. Common mobile invertebrates of the Noises Island group. A) Paua (*Haliotis iris*); B) sea cucumber (*Stichopus mollis*); C) *Turbo smaragdus*; D) *Charonia lampus;* E) *Macroctopus maorum*; F) *Evechinus chloroticus*.

3.1.6 Soft sediment habitats

For all sites surveyed, where rocky reef habitat terminated, typically combinations of coarse grained sediment, whole shell and shell hash was the predominant habitat type. This habitat was often inhabited by the large dog cockle *Tucetona laticostata* (Fig. 7A,B). Whole shell material also provided a stable habitat for colonisation of encrusting sponges and algae. Two other habitats of note were patchy rhodolith beds at the edge of the shallow rocky reef adjacent Maria Island (northern coastline) and low-density horse mussels *Atrina zelandica* (Fig. 7C) around the south-eastern end of Otata Island. The scallop, *Pecten novaezelandiae* was also observed at this site in a coarse shell hash/sand and articulated coralline matrix (Fig. 7D).

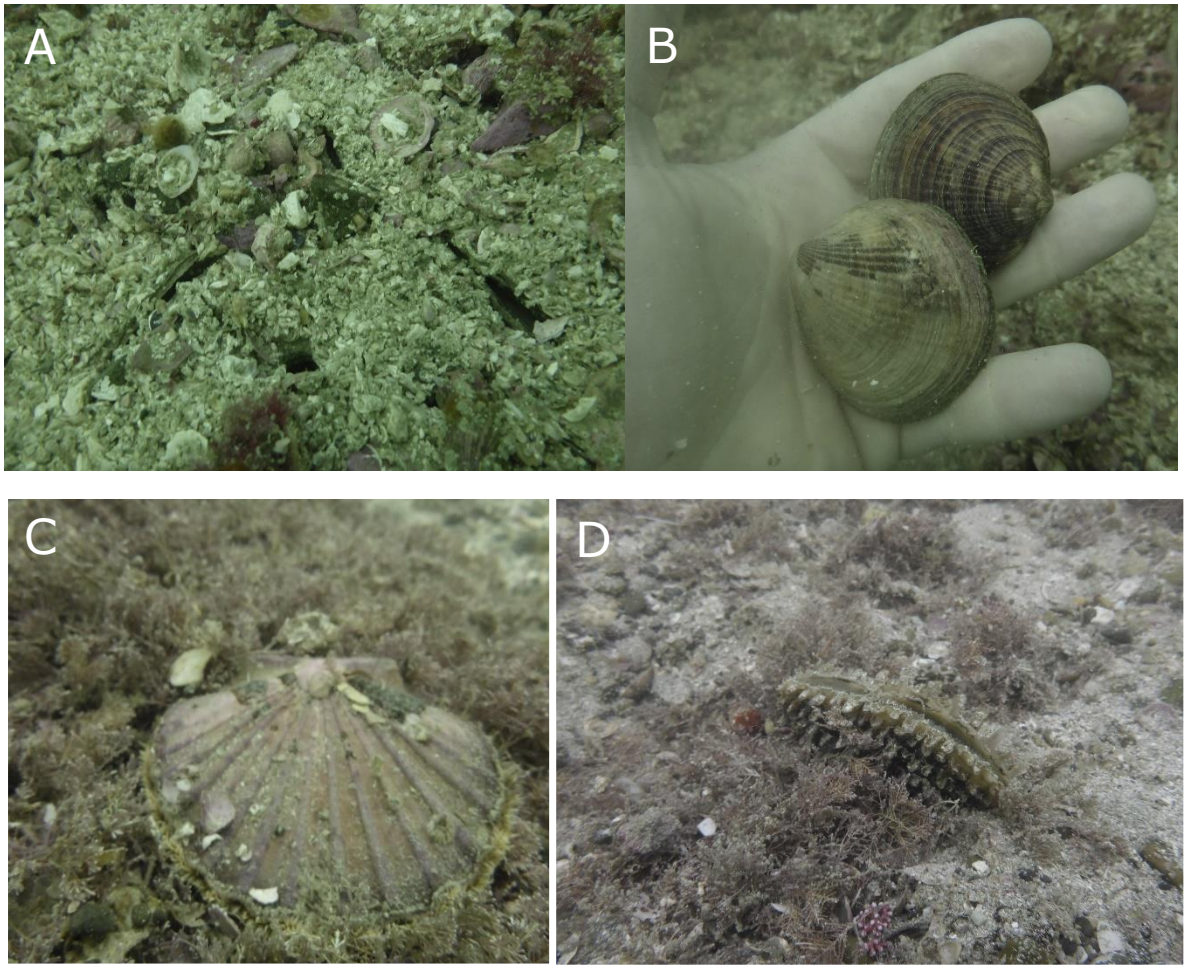

Figure 7. A,B) *Tucetona laticostata* in coarse sand/shell hash adjacent rocky reef habitat – a common feature of most sites; C) Scallop, *Pecten novaezelandiae*; and, D) low-density horse mussel *Atrina zelandica* in a coarse sand and articulated coralline matrix south-east of Otata Island.

3.2 Reef fish

A total of 17 reef-fish species were enumerated across the 8 survey sites sampled. Of these, the spotty *Notolabrus celidotus* was numerically dominant (Fig. 8) followed by schooling species such as blue maomao, *Scorpis violacea*; sweep *Scorpis lineolata*; and, jack mackerel,

Trachurus novaezelandiae. Parore, *Girella tricuspidata*; and, goatfish, *Upeneichthys lineatus* were also commonly encountered at many of the sampling sites.

3.2.1 Diversity and community composition

Reef fish diversity, represented by taxa richness and total richness (Fig. 9) was relatively low across sites with highest taxa richness occurring at Maria Island and Ahaaha Rocks. Reef fish community composition was statistically different among survey sites based on PERMANOVA analysis ($P < 0.001$), supported further by PCO analysis with clear separation of sampling sites across the ordination (Fig. 10). Motuhoropapa and Otata Island sites were positively associated with PCO Axis 1, with remaining sites negatively associated with PCO Axis 1. Ahaaha Rocks and, in particular Oropapa (Haystack) Island, fish faunas were distinct from the other sites. Ahaaha rocks was distinct from other survey sites due the presence of snapper which was not observed elsewhere. Species responsible for site-specific differences based on Pearson's correlation coefficients with PCO Axis 1 and 2 are presented in Fig. xxx The majority of snapper, *Chrysophrus auratus* censused were sub-legal (< 300 mm fork length), although legal-sized individuals were present (n=3 in total) (Fig. 11). Blue cod, *Parapercis colias* were observed at Ahaaha Rocks, Otata Island, and Motuhoropapa Island, but were all juveniles or sub-legal < 300 mm total length (Fig 12). Jack mackerel, spotty and goatfish were numerically abundant at Orapapa Island.

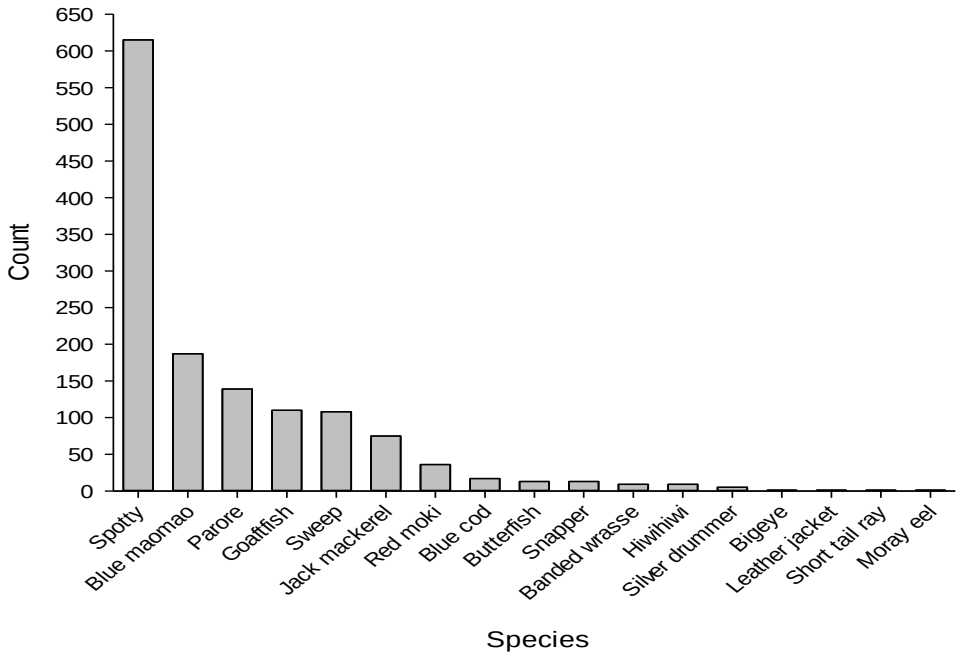

Figure 8. Count of reef fish (17 species). Data are pooled across sample transects for 8 sites - Noises Island group.

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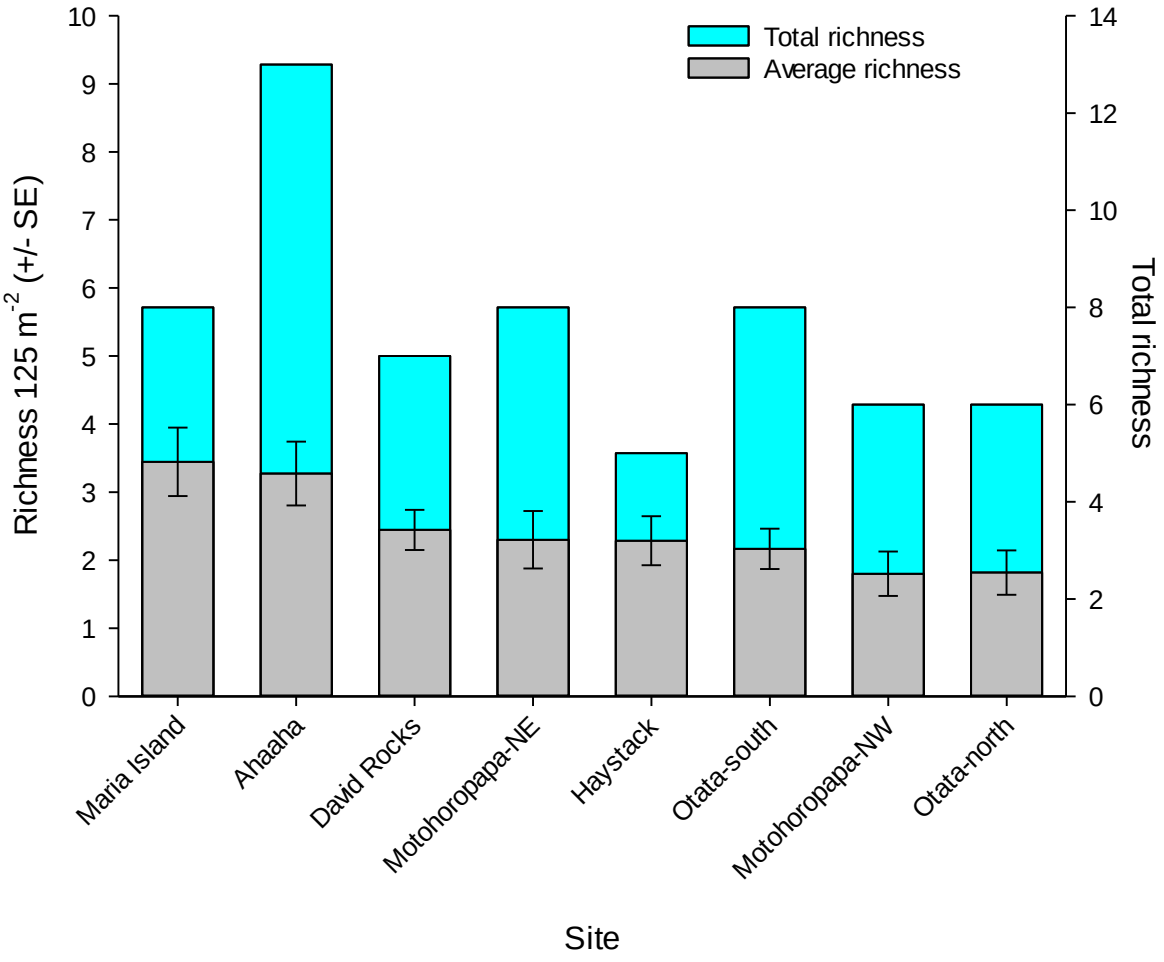

Figure 9. Average reef fish richness and total # of species (richness) enumerated at 8 sites across the Noises Island group.

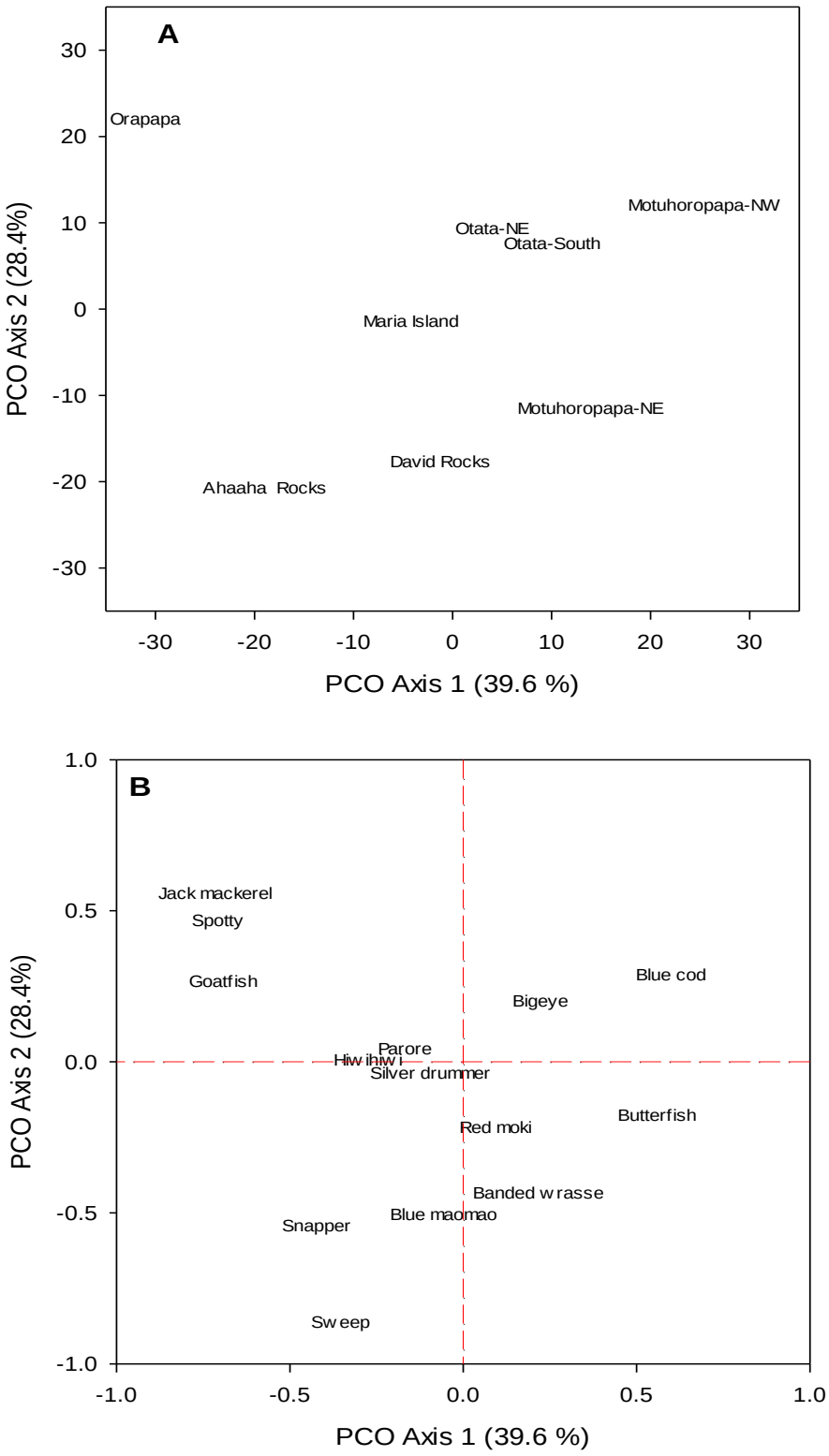

Figure 10. A) Ordination plots based on Bray-Curtis dissimilarities of ln(y+1) transformed species abundance data (17 species) for the first two PCO axes; B) Ordination of species groupings based on Pearson correlation coefficients from PCO analysis.

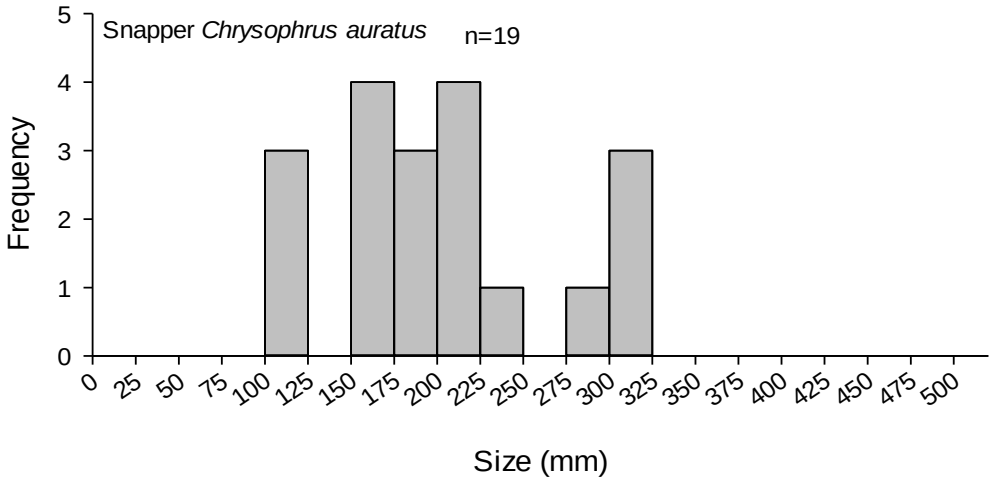

Figure 11. Size frequency of snapper *Chrysophrus auratus* based on fork length recorded at Ahaaha Rocks – Noises Island group.

Figure 12. Juvenile blue cod - Motuhoropapa Island.

4.0 Discussion

This baseline survey of the Noises Island has provided much needed insight into the current biological constructs of this region of the Hauraki Gulf. On one level it has showcased the high diversity of habitat types across a small section of the Hauraki Gulf and on another, the effects of fishing. A summary of the findings for each site surveyed are presented in Table 2.

Main findings from the survey were:

- A diverse array of biogenic habitats were present across the Noises Islands group represented by macroalgae; sponge and sessile invertebrate communities; mussel beds; bivalve beds (associated with both rocky reef and soft sediment habitat) and rhodolith beds;
- Of these, the expansive mussel beds, shallow sponge gardens and rhodolith beds are particularly important habitats to protect within the context of the wider Hauraki Gulf.
- Urchin barrens habitat was predominant on the northern coastline of Otata Island, Motuhoropapa Island, Maria Island and David Rocks indicative of fishing-related effects;
- Sessile invertebrate diversity was moderate-to-high at many sites where tidal currents were strong. Many of the sponge species encountered were large in size and morphologically complex.
- Reef fish biodiversity was low to moderate, but consistent with assemblage compositions recorded for the inner-Hauraki Gulf elsewhere (e.g., Long Bay, Waiheke Island). Commonly targeted species such as snapper (legal and sub-legal), blue cod (sub-legal) and red moki were enumerated during the survey. Snapper was encountered only at the Ahaaha Rocks sites.
- Despite complex rocky reef habitat being present at many of the sites surveyed, no spiny rock lobster, *Jasus edwardsii* were recorded.
- The large dog cockle *Tucetona laticostata* was common in soft-sediment habitat adjacent rocky reef at many sites. The scallop *Pecten novaezelandiae* and horse mussel *Atrina zelandica* were present around the south-eastern region of Otata Island.
- Based on the physical environments species and habitats surveyed the area would likely respond positively to protective measures.

Additional data analysis will be done to further evaluate benthic biodiversity, habitat depth distributions, and reef fish community structure. The findings will be compared to other studies done within the inner and outer Hauraki Gulf and recommendations around marine protection for the Noises Islands group made.

Table 2. Summary of habitat distributions across sites surveyed – Noises Island group.

Site	General description
Motuhoropapa Island north-east	Rocky reef habitat terminates in approximately 10m depth giving way to coarse soft sediment intermixed with shell hash and whole shells. Macroalgae dominated by *Carpophyllum flexuosum* and *Ecklonia radiata* between 8-10m depth and intermixed with *Ecklonia radiata* between 6-8m depth. Urchin barrens habitat dominant from 2-6 m depth; *Evechinus chloroticus* prevalent. Mussels occur in dense clumps between 0-3m depth. Mussel habitat gives way to a narrow band of fringing *Carpophyllum Ecklonia* and red algae between 0-1 m depth.
Otata Island north	Rocky reef habitat terminates in approximately 15m depth giving way to coarse soft sediment intermixed with shell hash and whole shells. Macroalgae dominated by *Carpophyllum flexuosum* intermixed with patches of *Ecklonia radiata* between 8-15 m depth. Urchin barrens habitat expansive between 1-8m depth. Sponge diversity high across depth strata. Cobble habitat present at base of rocky outcrops in shallow water. Narrow band of fringing *Carpophyllum*, *Ecklonia* and other fucalean algae and red algae between 0-1 m depth. Mussels largely absent.
David Rocks	Rocky reef habitat terminates in approximately 10m depth giving way to coarse soft sediment and shell hash intermixed with whole shells. *Ecklonia radiata* dominant forming largely monospecific stands between 8-10m depth; thereafter, intermixed with lower density patches of *Carpophyllum flexuosum*. Urchin barrens habitat expansive between 2-6m depth. Narrow band of fringing *Carpophyllum*, *Ecklonia* and other fucalean algae and red algae between 0-1 m depth. Sponge diversity high throughout all depth strata. Mussels patchily distributed. Jewel anemones common on vertical walls in shallow water < 3m depth.
Maria Island	Rocky reef habitat terminates in approximately 6m depth giving way to coarse soft sediment intermixed with shell hash and whole shells. Dog cockles and rhodolith patches prevalent adjacent rock reef habitat. *Carpophyllum flexuosum* patchily distributed between 4-6m depth giving way to urchin barrens habitat between 2-5m depth. Dense patches of continuous mussels occur between 1-2m depth. Narrow band of fringing *Carpophyllum*, *Ecklonia*, other fucalean algae and diverse red algae present between 0-1 m depth.
Ahaaha Rocks	Rocky reef habitat terminates in approximately 15m depth. Coarse sand prevalent adjacent rocky reef habitat. *Ecklonia radiata* and *Carpophyllum flexuosum* co-occurring from 6-15m depth. Urchin barrens habitat forms a narrow band between 3-6m depth. Dense and expansive mussel habitat between 0-3m depth. Sponge diversity high throughout all depth strata.
Otata Island south	Rocky reef habitat terminates in approximately 6m depth. High current. Sponge and sessile invertebrate diversity high between 5-6m depth. *Carpophyllum flexuosum* dominant from 3-6 m depth. Urchin barrens habitat expansive from 1-3m depth.
Orapapa Island (Haystack)	Rocky reef habitat terminates in approximately 10m depth. High current. *Carpophyllum flexuosum* dominant between 5-10m depth. Dense patches of continuous mussels occur between 0-3m depth. Intertidal mussels prevalent.
Motuhoropapa Island north-west	Rocky reef habitat terminates in approximately 6m depth. *Carpophyllum flexuosum* dominant between 2-6m depth. Urchin barrens patchily distributed between 1-3 m depth. Narrow band of fringing *Carpophyllum*, *Ecklonia,* other fucalean algae and diverse red algae present between 0-1 m depth.

5.0 References

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