Taranaki
Regional Council

AGENDA
Policy & Planning

Tuesday 7 February 2023, 10.30am

Policy and Planning Committee

07 February 2023 10:30 AM

Agenda Topic | Page

Taranaki Regional Council

AGENDA
Policy & Planning

Whakataka te hau

Karakia to open and close meetings

Whakataka te hau ki te uru	Cease the winds from the west
Whakataka te hau ki tonga	Cease the winds from the south
Kia mākinakina ki uta	Let the breeze blow over the land
Kia mātaratara ki tai	Let the breeze blow over the ocean
Kia hī ake ana te atakura	Let the red-tipped dawn come with a sharpened air
He tio, he huka, he hauhu	A touch of frost, a promise of glorious day
Tūturu o whiti whakamaua kia tina.	Let there be certainty
Tina!	Secure it!
Hui ē! Tāiki ē!	Draw together! Affirm!

Nau mai e ngā hua

Karakia for kai

Nau mai e ngā hua	Welcome the gifts of food
o te wao	from the sacred forests
o te ngakina	from the cultivated gardens
o te wai tai	from the sea
o te wai Māori	from the fresh waters
Nā Tāne	The food of Tāne
Nā Rongo	of Rongo
Nā Tangaroa	of Tangaroa
Nā Maru	of Maru
Ko Ranginui e tū iho nei	I acknowledge Ranginui above and
Ko Papatūānuku e takoto ake nei	Papatūānuku below
Tūturu o whiti whakamaua kia tina	Let there be certainty
	Secure it!
Tina! Hui e! Taiki e!	Draw together! Affirm!

AGENDA
Policy & Planning

Taranaki Regional Council

Purpose of Policy and Planning Committee meeting

This committee attends to all matters of resource management, biosecurity and related environment policy.

Responsibilities

Prepare and review regional policy statements, plans and strategies and convene as a Hearing Committee as and when required for the hearing of submissions.

Monitor plan and policy implementation.

Develop biosecurity policy.

Advocate, as appropriate, for the Taranaki region.

Other policy initiatives.

Endorse submissions prepared in response to the policy initiatives of organisations.

Membership of Policy and Planning Committee

Councillor C S Williamson (Chairperson)	Councillor B J Bigham (Deputy Chairperson)
Councillor D M Cram	Councillor S W Hughes
Councillor A L Jamieson	Councillor D H McIntyre
Councillor C L Littlewood (ex officio)	Councillor N W Walker (ex officio)

Representative Members

Councillor C Filbee (STDC)	Councillor G Boyde (SDC)
Councillor B Haque (NPDC)	Ms L Gibbs (Federated Farmers Representative)
Ms E Bailey (Iwi Representative)	Mr P Moeahu (Iwi Representative)
Mr M Ritai (Iwi Representative)	

Health and Safety Message

Emergency Procedure

In the event of an emergency, please exit through the emergency door in the committee room by the kitchen.

If you require assistance to exit please see a staff member.

Once you reach the bottom of the stairs make your way to the assembly point at the birdcage. Staff will guide you to an alternative route if necessary.

Earthquake

If there is an earthquake - drop, cover and hold where possible.

Please remain where you are until further instruction is given.

AGENDA
Policy & Planning

Date 7 February 2023

Subject: Policy and Planning Committee Minutes - 22 November 2022

Approved by: A D McLay, Director - Resource Management

S J Ruru, Chief Executive

Document: 3140948

Recommendations

That the Taranaki Regional Council:

a) receives the minutes of the Policy and Planning Committee meeting of the Taranaki Regional Council held in the Taranaki Regional Council Boardroom, 47 Cloten Road, Stratford on Tuesday 22 November 2022 at 1pm

b) adopts the recommendations therein.

Matters arising

Appendices/Attachments

Document: 3124621 Minutes Policy and Planning - 22 November 2022.

MINUTES
Policy & Planning

Taranaki Regional Council

Date 22 November 2022, 1.00pm

Venue: Taranaki Regional Council Boardroom, 47 Cloten Road, Stratford

Document: 3124621

Members	Councillors	C S Williamson	*Committee Chairperson*
		B J Bigham *(via zoom)*	*Deputy Chairperson*
		D M Cram	
		S W Hughes	
		A L Jamieson	
		D H McIntyre	
		C L Littlewood	*ex officio*
		N W Walker	*ex officio*
Representative Members	Ms	E Bailey	Iwi Representative
	Mr	P Moeahu	Iwi Representative
	Mr	M Ritai *(via zoom)*	Iwi Representative
Attending	Mr	S J Ruru	Chief Executive
	Mr	A D McLay	Director - Resource Management
	Ms	A J Matthews	Director – Environment Quality
	Mr	M J Nield	Director – Corporate Services
	Ms	L Hawkins *(via zoom)*	Planning Manager
	Mr	S Tamarapa	Iwi Communications Officer
	Mr	C Wadsworth	Strategy Lead
	Miss	A Campbell	Policy Analyst
	Miss	G Marcroft	Senior Policy Analyst
	Mr	C Woollin	Communications Adviser
	Miss	N A Chadwick	Executive Assistant to CE
	Mrs	M G Jones	Governance Administrator
	Miss	C Filbee	South Taranaki District Council
	Mr	G Boyde	Stratford District Council
	Miss	L Gibbs	Federated Farmers

one member of the media via zoom
one member of the public

Apologies
Apologies were received and sustained from Mr B Haque
Walker/Littlewood

Conflicts of Interest
No conflicts of interest
Walker/Littlewood

1. Freshwater Implementation Report August 2022

1.1 Mr C Wadsworth, Strategy Lead, spoke to the memorandum to provide the Committee with a Freshwater implementation programme update.

Resolved

That the Taranaki Regional Council:

a) received the Memorandum on Freshwater implementation programme.

Bailey/Littlewood

2. National Policy Statement – Highly Productive Land

2.1 Ms L Hawkins, Policy Manager, spoke to the memorandum to provide the Committee with a programme update on HPL and its implications for the Council.

Resolved

That the Taranaki Regional Council:

a) received the memorandum – National Policy Statement – Highly Productive Land.

b) noted that the requirements to map Highly Productive Land are to be included in the work programme of the proposed Natural Resources Plan.

McIntyre/Littlewood

3. National direction for Plantation and Exotic Carbon Afforestation

3.1 Ms A Campbell, Policy Analyst, spoke to the memorandum to provide the Committee with an update on the national direction and Exotic Carbon Afforestation.

Resolved

That the Taranaki Regional Council:

a) received this memorandum entitled *Submission on the National direction for plantation and exotic carbon afforestation*

b) noted the attached *Submission on the proposed changes to the National Environmental Standards for Plantation Forestry*

c) endorsed the submission made on the Discussion Document of the NES-PF

d) determined that this decision be recognised as not significant in terms of section 76 of the *Local Government Act 2002*

e) determined that it has complied with the decision-making provisions of the *Local Government Act 2002* to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Walker/Cram

4. Submissions on Agricultural Emissions Pricing Consultation Document

4.1 Mr C Wadsworth, Strategy Lead, spoke to the memorandum to provide the Committee with updates on the Ag Emissions pricing Consultation Document.

G Boyde Stratford District Council Representative left the meeting at 2.25pm

Resolved

That the Taranaki Regional Council:

a) received this report titled *Submission on Agricultural Emissions Pricing Consultation Document*

b) amended and approved the *Submission on Agricultural Emissions Pricing*.

c) determined that this decision be recognised as not significant in terms of section 76 of the *Local Government Act 2002*

d) determined that it has complied with the decision-making provisions of the *Local Government Act 2002* to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determined that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Walker/Littlewood

Iwi representative E Bailey noted that she was strongly against the content of this Submission.

There being no further business the Committee Chairperson, Councillor C Williamson, declared the meeting of the Policy and Planning Committee closed at 2.32pm. The meeting closed with a karakia.

Policy and Planning Chairperson: ______________________________

C Williamson

Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date	7 February 2023
Subject:	**Inhalable Particulate ($PM_{2.5}$) State of the Environment Monitoring Annual Report 2020-2021**
Approved by:	AJ Matthews, Director - Environment Quality S J Ruru, Chief Executive
Document:	3138551

Purpose

1. The purpose of this memorandum is to provide the Committee with an overview of continuous monitoring of airborne particulate matter in urban New Plymouth and the findings of the related report: *Inhalable Particulate ($PM_{2.5}$) State of the Environment Monitoring Annual Report 2020-2021*.
2. A copy of the technical report accompanies this memorandum, and a copy is also available on the Taranaki Regional Council (the Council) website.

Executive summary

3. Section 35 of the Resource Management Act 1991 requires local authorities to undertake monitoring of the region's environment. The Council undertakes a range of monitoring and reporting of the current state and changes in land, water and air quality.
4. This technical report describes the results of the Taranaki Regional Council's Inhalable Particulate Monitoring Programme across the 2020-2021 monitoring year and summarises the complete data record at the site for the five year period from 2016-2021.
5. Research has demonstrated the link between exposure to elevated concentrations of inhalable particulate matter (PM) and a range of adverse health outcomes. Hence, exposure to elevated levels of particulate matter presents a public health risk. The Council's Inhalable Particulate Monitoring Programme is designed to assess the quality of the ambient air in the New Plymouth central business district (CBD) through the continuous monitoring of $PM_{2.5}$ concentrations (particulate matter < 2.5 microns in diameter).
6. Ambient $PM_{2.5}$ concentrations are continuously measured at a monitoring site installed at Central School, New Plymouth. The site is located within a predominantly residential area on the fringe of the New Plymouth CBD, approximately 600 m inland from the coast. The site is located in a sensitive area, which is exposed to $PM_{2.5}$ emissions arising

from natural sources, as well as anthropogenic sources such as traffic, commercial, and residential emissions.

7. The Council has opted to monitor for $PM_{2.5}$ to align with proposed amendments to the National Environmental Standards for Air Quality (NES-AQ), which recommend $PM_{2.5}$ as a more meaningful measure of public health risk than the current PM_{10} standard.

8. Data collected across the monitoring period shows that New Plymouth experiences low concentrations of airborne $PM_{2.5.}$ Under the Ministry for Environment's (MfE) grading criteria, 96% of daily mean concentrations achieved either an 'excellent' or a 'good' grading across the five year period from 2016-2021.

9. Global Air Quality Guidelines developed by the World Health Organisation (WHO) (2005) set a mean daily $PM_{2.5}$ exposure limit of 25 $\mu g/m^3$, and an annual average of 10 $\mu g/m^3$. The WHO subsequently recommended more stringent limits for $PM_{2.5}$ exposure in an update to the guidelines in September 2021 (15 $\mu g/m^3$ & 5 $\mu g/m^3$, respectively).

10. There were no exceedances of the WHO's 2005 guideline values and a single exceedance of the revised (2021) daily mean threshold (15 $\mu g/m^3$) over the course 2020-2021 monitoring year. The guidelines permit up to three exceedances of the daily mean threshold over the course of a year.

11. Trend analysis undertaken on the complete Central School data record (2016-2021) shows no evidence that $PM_{2.5}$ concentrations in New Plymouth are increasing (or decreasing).

12. Previous analysis of monitoring data (TRC, 2020) has found that the major source of inhalable particulate at the Central School monitoring site is our marine environment as a result of sea-spray. The report also notes that average concentrations of $PM_{2.5}$ at the Central School site are higher over winter months due to the contribution of emissions from domestic fires used for heating.

13. While the monitoring shows that air quality is very good at the Central School monitoring site in New Plymouth, the report recommends that the Council continues to carry out screening monitoring to determine the extent and severity of winter domestic heating pollution in the region's other urban centres.

Recommendations

That the Taranaki Regional Council:

a) receives the technical report, *Inhalable Particulate ($PM_{2.5}$) State of the Environment Annual Monitoring report 2020-2021*

b) notes the recommendations therein.

Background

14. Section 35 of the Resource Management Act (1991) requires local authorities to undertake monitoring of the region's environment, including land, air, and fresh and marine water quality. The Council has delivered a number of targeted investigations into air quality at representative locations across the region. These investigations have demonstrated that the region generally has very good air quality.

15. The Council's *Regional Air Quality Plan for Taranaki*, along with other objectives, seeks '*to maintain the existing high standard of air quality in the Taranaki region*' and '*to safeguard the life-supporting capacity of air throughout the Taranaki region*'.

16. Amongst other pollutants of concern in air quality management, scientists, health experts, and regulators are concerned with the effects on human health of microscopically small airborne particles. This particulate matter is hundreds to thousands of times smaller in diameter than the thickness of a human hair, and can remain suspended in the atmosphere for days to months.

17. Particulate matter found in the air can originate from a wide variety of sources, both natural and anthropogenic. In general, the most prevalent anthropogenic sources of particles are emissions from combustion processes, such as motor vehicle emissions, solid fuel and oil-burning processes (e.g. from residences, industry or power generation) and the incineration and burning of waste. Natural sources, such as sea-spray and pollen, also contribute to overall levels.

18. Research has demonstrated a correlation between short-term episodes of exposure to particulate matter and increased adverse medical outcomes for heart, respiratory and circulatory conditions (e.g. asthma, emphysema, heart attack and stroke). Longer-term exposure to increased concentrations correlates with increased cancer rates, premature death rates and chronic respiratory illnesses.

19. Presently, there is a national standard for PM_{10} exposure over a 24 hour period (50 $\mu g/m^3$), and a national guideline for annual average PM_{10} exposure of 20 $\mu g/m^3$. Increasingly it is recognised however, that smaller particles ($PM_{2.5}$) pose the greatest risk to human health. There is presently no national standard for concentrations of $PM_{2.5,}$ although MfE has consulted on proposed revisions to the NES-AQ to include limits on $PM_{2.5}$.

20. Global Air Quality Guidelines developed by the World Health Organisation (WHO) (2005) set a mean daily $PM_{2.5}$ exposure limit of 25 $\mu g/m^3$, and an annual average of 10 $\mu g/m^3$. The WHO subsequently recommended more stringent limits for $PM_{2.5}$ exposure in an update to the guidelines in September 2021 (15 $\mu g/m^3$ & 5 $\mu g/m^3$, respectively).

21. Ambient $PM_{2.5}$ concentrations are continuously measured at a monitoring site installed at Central School, New Plymouth. The site is located within a predominantly residential area on the fringe of the New Plymouth CBD, approximately 600m inland from the coast (Figure 1).

22. The site is located in a sensitive area, which is exposed to $PM_{2.5}$ emissions arising from natural sources, as well as anthropogenic sources such as traffic, commercial, and residential emissions. Main traffic routes are located 100-200m north of site. The site is also located at the 'crossroad' of the prevailing wind directions from the west and south-east, lying in the path of air flows that have either just passed over, or are about to enter, residential areas.

23. A Met Instruments Inc. Model E-BAM measurement system was used to automatically measure and record airborne $PM_{2.5}$ concentrations at the Central School site in 2016 (Figure 2). The E-BAM equipment was decommissioned in December 2021, and replaced with an upgraded BAM1022 system in July 2022.

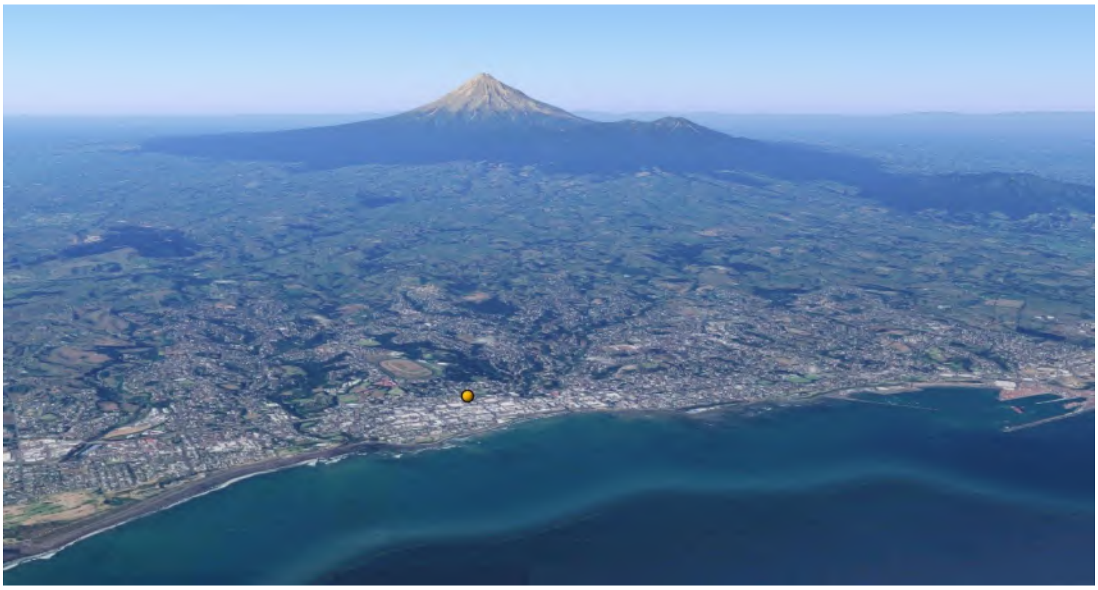

Figure 1: *Overview of the regional setting of the Central School $PM_{2.5}$ monitoring site (yellow dot). The image is taken facing true South. (Background image: Google, 2020)*

Figure 2: The original *E-BAM monitoring system set-up and installation at Central School, New Plymouth. This equipment was upgraded in July 2022.*

Discussion

24. Overall, the results of continuous $PM_{2.5}$ monitoring at Central School over the 2020-2021 period reinforce the findings of previous monitoring carried out between 2016 and 2020 that show $PM_{2.5}$ concentrations are consistently very low at the Central School site.

25. Under MfE's grading criteria, 96% of daily mean concentrations measured at the site achieved either an 'excellent' or a 'good' grading across the 2016 to 2021 period, with all but one day of the remaining 4% falling into the 'Acceptable' category.

26. The annual mean concentration of $PM_{2.5}$ at the Central School site across the 2016-2021 period was 4 $\mu g/m^3$, well below the WHO's 2005 guideline for annual mean exposure (10 $\mu g/m^3$) and compliant with the revised threshold of 5 $\mu g/m^3$ set in 2021.

27. There were no exceedances of the WHO's 2005 guideline value for mean daily exposure over the course of the 2020-2021 period, and only a single exceedance of the revised

(2021) threshold (15 µg/m^3). The guidelines permit up to three exceedances of the daily mean threshold over the course of a year.

28. A strong seasonal variation is observed in $PM_{2.5}$ levels at the Central School site due to increased emissions from domestic heating over the colder months. Previous analysis has found that the increased concentrations correlated with cold calm evenings when the dispersal of pollutants from home heating is reduced by stable atmospheric conditions (TRC, 2020).

29. The effect of domestic heating emissions is likely to be greater in other localised areas in the region. Such vulnerable areas include non-coastal sites and sheltered valleys. Here, air drainage from the surrounding higher land may lead to stronger temperature inversions and an increased level of trapped $PM_{2.5}$ emissions near ground level.

30. Given the potential elevation of $PM_{2.5}$ concentrations in some areas, it is recommended that the Council continues to carry out screening monitoring to determine the extent and severity of winter domestic heating pollution in the region's urban centres.

31. A copy of the report accompanies this memorandum, and has also been made available on the Council's website.

Financial considerations—LTP/Annual Plan

32. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

33. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

34. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

35. Air quality is identified as a key issue in Iwi Management Plans, with a particular focus on national and regional policy development and management of the effects of consented activities. This monitoring programme provides data on the current state and trends in aspects of air quality that affect human health, which can inform decision-making around ambient air quality in the New Plymouth area. The report contains a recommendation to continue screening for air quality issues in other rohe through the region.

Community considerations

36. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

37. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

References

Taranaki Regional Council. 2020. *Inhalable Particulate ($PM_{2.5}$) Regional Monitoring Programme Report 2016-2020*. Document 2506963.

Appendices/Attachments

Document 3128733: *Inhalable Particulate ($PM_{2.5}$) State of the Environment Monitoring Annual Report 2020-2021.*

Inhalable Particulate ($PM_{2.5}$)

State of the Environment Monitoring

Annual Report

2020-2021

Technical Report 2022-83

Working with people | caring for Taranaki

Taranaki Regional Council

Taranaki Regional Council
Private Bag 713
Stratford

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Document: 3094356 (Word)
Document: 3128733 (Pdf)
February 2023

Inhalable Particulate ($PM_{2.5}$)

State of the Environment Monitoring

Annual Report

2020-2021

Technical Report 2022-83

Inhalable Particulate ($PM_{2.5}$)

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Executive summary

Section 35 of the Resource Management Act (RMA) requires local authorities to undertake monitoring of the region's environment, including land, air, and fresh and marine water quality. This report describes the results of the Taranaki Regional Council's Inhalable Particulate programme from throughout the period 2020-2021. The programme is designed to assess the quality of the ambient air in the New Plymouth CBD through the continuous monitoring of $PM_{2.5}$ concentrations (particulate matter less than 2.5 microns across) at Central School. The Council decided to monitor for $PM_{2.5}$ in lieu of PM_{10}, to align with proposed amendments to the National Environmental Standards for Air Quality, which proposes that $PM_{2.5}$ is more meaningful for evaluating public health risk than the current PM_{10} standard.

The monitoring programme entailed the sampling of air using a Beta Attenuated Monitor (BAM) equipped with a $PM_{2.5}$ size selective inlet, sited at Central School, New Plymouth. Continuous sampling has been conducted from February 2016 – December 2021, when the equipment was decommissioned and replaced. This report is focussed on monitoring results obtained at the site between January 2020 and December 2021, and is supplementary to the Inhalable Particulate ($PM_{2.5}$) Monitoring Programme Report 2016-2020.

Results show that between 2016 and 2021, 96% of daily mean $PM_{2.5}$ concentrations fell into the Ministry for Environment's 'excellent' or 'good' air quality categories. There were no exceedances of the 2005 World Health Organisation's (WHO) daily mean threshold of 15 $\mu g/m^3$. However, the maximum individual daily mean recorded over the entire dataset, 18 $\mu g/m^3$, represents a single exceedance of WHO's updated and more stringent 2021 guidelines. An annual mean of 4 $\mu g/m^3$ was recorded for each of the six years of monitoring at the Central School site, which is below both the 2005 and 2021 WHO maximum annual mean guidelines.

Monitoring results from the 2020 and 2021 years lend weight to previous findings that emissions from domestic fires used for heating are a major contributor to concentrations of $PM_{2.5}$ levels during winter months. The elevated levels of $PM_{2.5}$ recorded during colder winter months result in a clear seasonality in the overall Central School dataset. Exploratory long-term trend analysis undertaken on the complete Central School $PM_{2.5}$ record shows no evidence that overall $PM_{2.5}$ concentrations in New Plymouth are either increasing or decreasing. It is however, recommended that the Council continues to carry out screening monitoring to determine the extent and severity of winter domestic heating pollution in the region's other urban centres.

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1 Introduction

1.1 General

This report summarises the results for the Inhalable Particulate ($PM_{2.5}$) State of Environment programme over the 2020-2021 calendar years. This is the second report on the Council's continuous $PM_{2.5}$ monitoring programme, which was initiated in 2016. With the decommission of the Central School E-BAM monitoring equipment in December 2021, this report summarises the results of the last two years of monitoring at this site, and completes the reporting of results from this particular E-BAM set-up. The present report is written as a supplement to the more major 2016-2020 report. The reader is referred to this earlier report for an in-depth introduction to the programme and more complete discussion of air quality in New Plymouth.

1.2 Background

In October 2004, the National Environmental Standards for Air Quality (NES-AQ) were released by the Ministry for the Environment (MfE). The NES is built up of 14 standards, which together aim to set a guaranteed minimum level of health protection for all New Zealanders. One aspect of air quality which is covered by the NES, and forms the focus of this report, is fine particulates, which can pose a health hazard when inhaled into the body.

While relatively coarse particulate matter of 2.5-10 µm diameter may deposit in the nose, throat and upper airways, finer particulates of less than 2.5 µm ($PM_{2.5}$) can be inhaled deeper into the lungs, where air-blood exchange occurs. Ultrafine particles, of less than 0.1 µm diameter, are small enough to transfer into blood vessels and circulate around the body. While coarser particulates settle on the ground relatively quickly, fine and ultrafine particles can remain suspended in the air for extended periods of time. Short term episodes of exposure to PM pollution has been shown to correlate with increased adverse medical outcomes for heart, respiratory and circulation conditions (eg asthma, emphysema, heart attack, strokes); over the longer term, increased concentrations correlate with increased cancer rates and premature death rates as well as chronic respiratory illnesses.

While the current NES-AQ, set by MfE in 2004, is for fine particulate matter of 10 µm diameter (PM_{10}), it is anticipated that the next revision of the NES-AQ will focus on $PM_{2.5}$, given its higher potential for adverse health effects. As a result, in this report exposure to $PM_{2.5}$ has been assessed against the 2005 World Health Organisation guidelines, which are expected to be taken up in the revised NES-AQ. For the first time, exposure is also assessed against the more stringent $PM_{2.5}$ air quality guidelines that the World Health Organization recommended in September 2021.

Table 1 WHO guidelines for $PM_{2.5}$ monitoring

Averaging Period	Permissible Exceedances (per year)	2005 Threshold (µg/m^3)	2021 Threshold (µg/m^3)
24-hours	3	25	15
Annual	NA	10	5

2 Monitoring methodology

2.1 Site location

The Central School site, shown in Figure 1 through Figure 3, is centrally located, with the edge of the New Plymouth CBD and main traffic routes 100-200 m to the north, and residential area surrounding the site to the south, west, and east. The site is located at the 'crossroad' of the prevailing wind directions from the west and south-east, lying in the path of air flows that have either just passed over, or are about to impinge on, residential areas. The site is thus located in a sensitive area, which is exposed to possible $PM_{2.5}$ emissions arising from traffic, commercial, and residential sources.

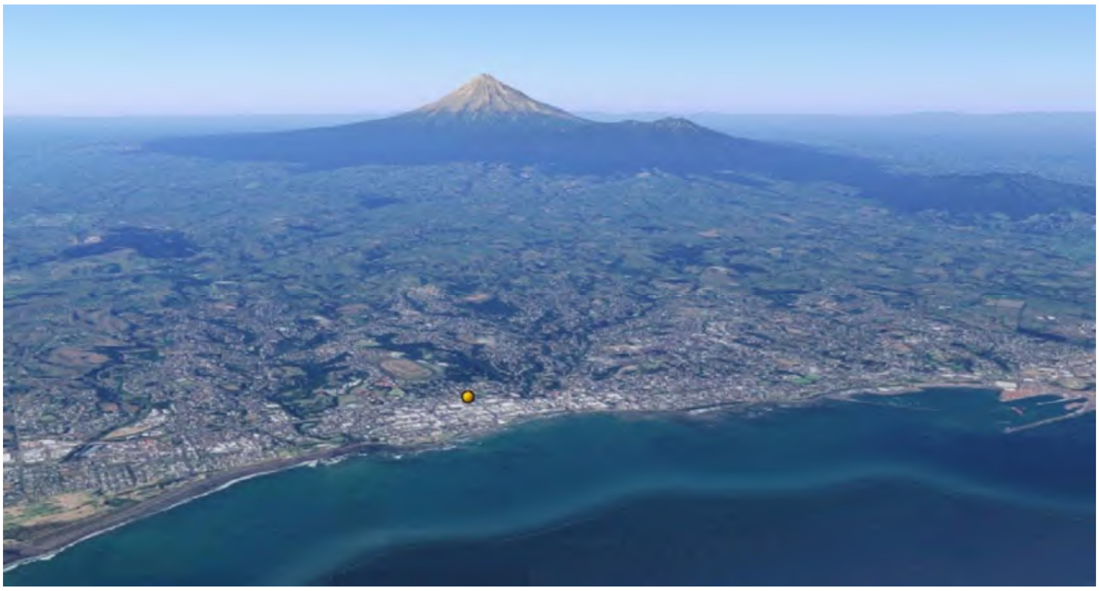

Figure 1 Overview of the regional setting of the Central School $PM_{2.5}$ monitoring site (yellow dot). The image is taken facing true South. (Background image: Google, 2020)

2.2 Monitoring equipment and method

A Met Instruments Inc. Model E-BAM measurement system (Figure 4) was used to automatically measure and record airborne $PM_{2.5}$ concentration levels at the Central School site between 2016 and 2021. While the beta attenuation method is one of four general recognised equivalent methods for $PM_{2.5}$ monitoring, the E-BAM system employed is not currently designated as a US EPA Federal Equivalent Method (FEM). It was, however, deemed to be the most appropriate instrument to use in this case, given that this monitoring programme represented a first test both of continuous monitoring at a permanent ambient air site, and of SEM $PM_{2.5}$ monitoring in the region. The E-BAM equipment at Central School was decommissioned in December 2021, and replaced with an upgraded BAM1022 system in July 2022. Further details on the E-BAM equipment and data collection can be found in the report Inhalable Particulate ($PM_{2.5}$) Monitoring Programme Report 2016-2020 (TRC, 2020).

Figure 2 Location of the Central School $PM_{2.5}$ monitoring site within New Plymouth

Figure 3 Location of the $PM_{2.5}$ monitoring site in the NE corner of Central School (yellow dot)

Figure 4 E-BAM set-up and installation at Central School, New Plymouth

2.3 Data processing and analysis

In accordance with the *MfE Good Practice Guide for Air Quality Monitoring and Data Management 2009*, data collected during the calibration and maintenance period was excluded to provide sufficient time within the data record for instrument stabilisation. Data screening was also undertaken, with data removed for periods where the E-BAM air-flow rate dropped by more than 5% from its usual steady state of 16.7 L/min. Spikes in $PM_{2.5}$ levels were also investigated, with data removed when the spike was found to be due to monitor malfunction, or other anomalous events – such as when it was found people were smoking directly underneath the monitoring equipment.

In line with *MfE 2009,* negative data values were left in the data record. This is particularly important given the generally low ambient concentrations of $PM_{2.5}$ measured, as there were a notable number of hourly measurements with $PM_{2.5}$ concentrations between 0 and -5 µg/m^3. These measurements are, within analytical uncertainty, indistinguishable from the lower detection limit of the E-BAM, so were retained in the overall data set as to avoid artificially increasing the average ambient concentration. The exception to this was between midnight and 01:00 each day, when the E-BAM automatically undertook a filter change and recalibration. Here, a large negative spike was consistently encountered in the record. The decision was made to omit the 24:00 to 01:00 hour from daily average calculations, resulting in 23-hour averages been calculated, rather than 24-hour.

All hourly averages in the main database apply to the preceding hour (e.g. the hourly measurement for 13:00 represents data collected between 12:00 and 12:59). However, for compatibility reasons, all measurements were stepped back one hour when imported into R software. Thus in all plots and statistics in this report, data assigned to e.g. 13:00 is for the time period 13:00 to 13:59. All measurements are recorded and reported in NZST.

All statistical analyses and plots produced in this report were undertaken and produced using the R statistical software (R Development Core Team. 2011), using the package 'openair' (Carslaw and Ropkins. 2012).

3 Results

3.1 Summary statistics

Daily $PM_{2.5}$ concentration means were calculated from hourly data for days where at least 18 hours of data was obtained (a 75% data acceptance threshold). A summary of results from the entire monitoring period, and for each year, is given in Table 2 and Figure 5, below. It is noted that while the 75% data threshold is met for every year of the monitoring programme, there may be some bias in the 2016 statistics, as the monitoring programme was only commenced at the end of February.

Table 2 $PM_{2.5}$ air quality summary statistics, based on daily means

Year	Days of Data	% Data Capture	Mean	Max	Median	25^{th} percentile	75^{th} percentile	95^{th} percentile
2016	310	84.7	4	14	4	3	5	8
2017	344	94.2	4	13	4	3	5	7
2018	357	97.8	4	11	4	3	5	7
2019	365	100.0	4	13	4	3	5	8
2020	327	89.3	4	13	3	2	4	7
2021	330	90.4	4	18	4	3	5	7
Total	**2,033**	**92.7**	**4**	**18**	**4**	**3**	**5**	**8**

3.2 Comparison to WHO guidelines

Overall, data across the entire monitoring period shows that New Plymouth experiences low concentrations of $PM_{2.5}$, with the annual mean remaining steady at 4 µg/m^3 throughout the entire six years of monitoring. All annual means are below both the 2005 WHO guideline of 10 µg/m^3, as well as the more stringent revised 2021 guideline of 5 µg/m^3. In addition, there have been no exceedances of the 2005 WHO daily mean guideline of 25 µg/m^3 throughout the entire monitoring programme. A single exceedance of the revised 2021 WHO daily mean guideline (15 µg/m^3) was recorded, in February 2021. With three allowable exceedances of the daily mean guideline within a year, this single exceedance is not of major concern. Over the entire six years of monitoring, the 95^{th} percentile of $PM_{2.5}$ concentrations lies around 44% of the maximum daily value that was recorded. This indicates that it is only a few days that have mean $PM_{2.5}$ levels significantly higher than the typical range, and indeed, mean concentrations exceeded 10 µg/m^3 on only 26 days over the near six years of monitoring.

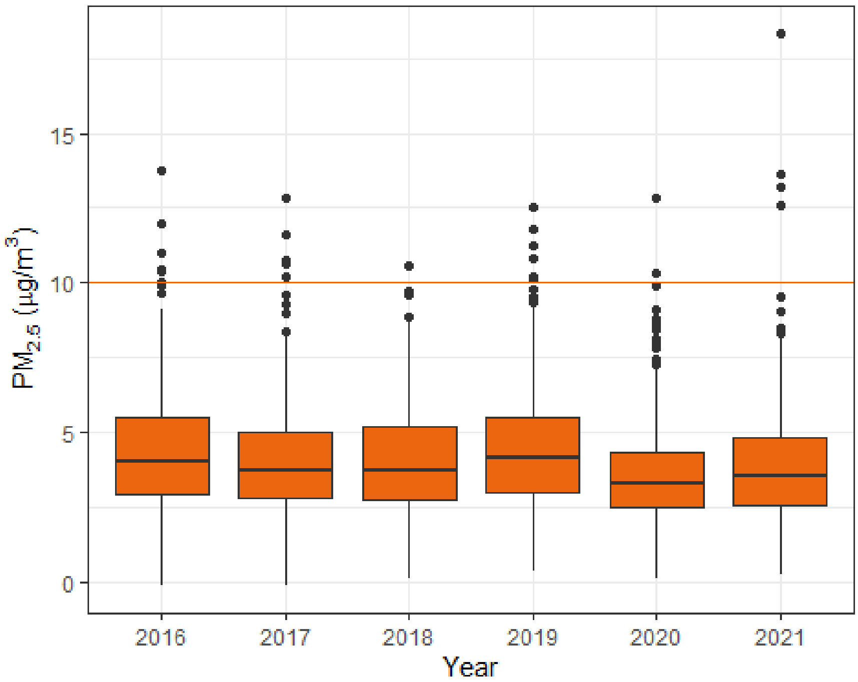

Figure 5 Boxplots of daily mean $PM_{2.5}$ concentrations from each year of the monitoring programme. The orange line depicts the 2005 WHO guideline for mean annual $PM_{2.5}$ levels. The guideline for daily average concentration advised by WHO in 2005 is 25 µg/m³, well above the maximum recorded concentration, and outside the bounds of the plot

The MfE ambient air quality guidelines (MfE 2002) propose that regional air quality can be categorized based on a comparison with the ambient guidelines. These categories are set out in Table 3, using the 2005 WHO daily mean threshold of 25 µg/m³ as a reference. The results show that the over the six years of monitoring, the air in New Plymouth can be considered to have been 'excellent' or 'good' 96% of the time, and at least 'acceptable' on all bar one day. Results are relatively constant across the six years of monitoring. Further details on the air quality categories recorded for each year are given in Table 3 and Figure 6.

Table 3 Number of days falling into environmental performance indicator category each year of monitoring

Year	Excellent (>2.5)	Good (2.5–8.3)	Acceptable (8.3-16.6)	Alert (16.6-25)	Action (>25)
2016	58	234	18	0	0
2017	70	264	10	0	0
2018	74	274	9	0	0
2019	54	294	17	0	0
2020	85	233	9	0	0
2021	81	238	10	1	0
Total	422 (20.8%)	1537 (75.6%)	73 (3.6%)	1	0

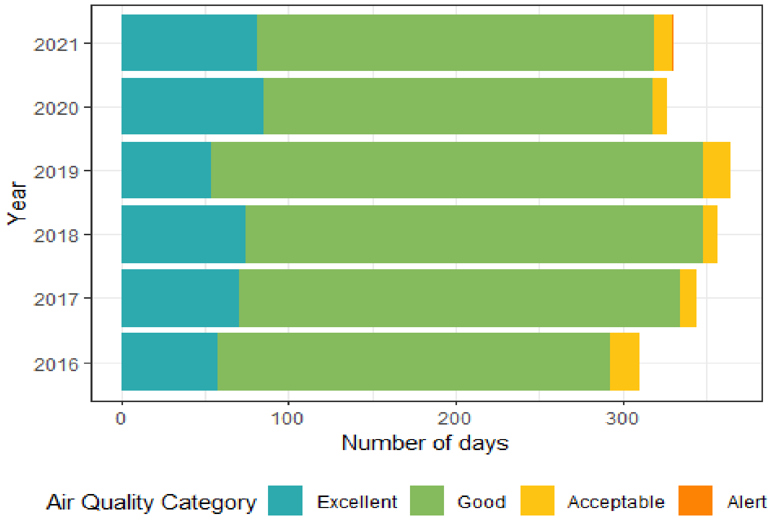

Figure 6 Number of days per calendar year with $PM_{2.5}$ concentrations in each air quality category

3.3 Temporal Patterns

Throughout 2020 and 2021, observed diurnal variations in $PM_{2.5}$ concentrations continued to show similar patterns to the previous four years (Figure 7). In particular, a strong seasonality is observed, with winter $PM_{2.5}$ concentrations displaying a different diurnal pattern to the other three seasons. In particular, dual peaks in $PM_{2.5}$ concentrations are observed in the mornings and evenings during winter months (June – August). These are consistent with the influence of wood fires being used for home heating throughout winter, with a large peak in evenings while a smaller morning peak could be due to some households relighting burners during the cool morning hours.

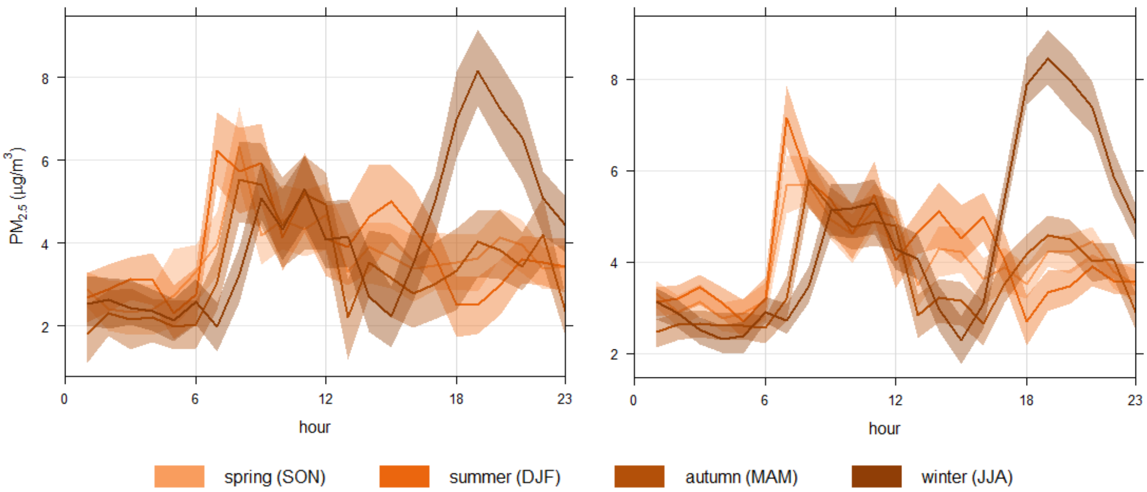

Figure 7 Comparison of the diurnal variation in $PM_{2.5}$ concentration during different seasons, for 2020 and 2021 (left), and for the full 2016-2021 monitoring period (right). 95% confidence intervals for the means are shown by the shaded areas

4 Trend Analysis

Mean daily $PM_{2.5}$ concentrations throughout the entire monitoring period are shown in Figure 8. Long term trend analysis was carried out on the Central School measurement records using a non-parametric Theil-Sen approach. Long term trends are more easily identified in longer continuous data sets than that currently recorded at this site, or when a known change of regulations or conditions has occurred in the region. However, an exploratory analysis is none-the-less undertaken in this case.

The Theil-Sen trend estimate, undertaken on de-seasonalised monthly-mean data, is shown in Figure 9. Data is analysed between March 2016 and December 2021. Given the breadth of the 95% confidence interval, which encompasses 0, it is indeterminate whether $PM_{2.5}$ levels are increasing, decreasing, or remaining steady.

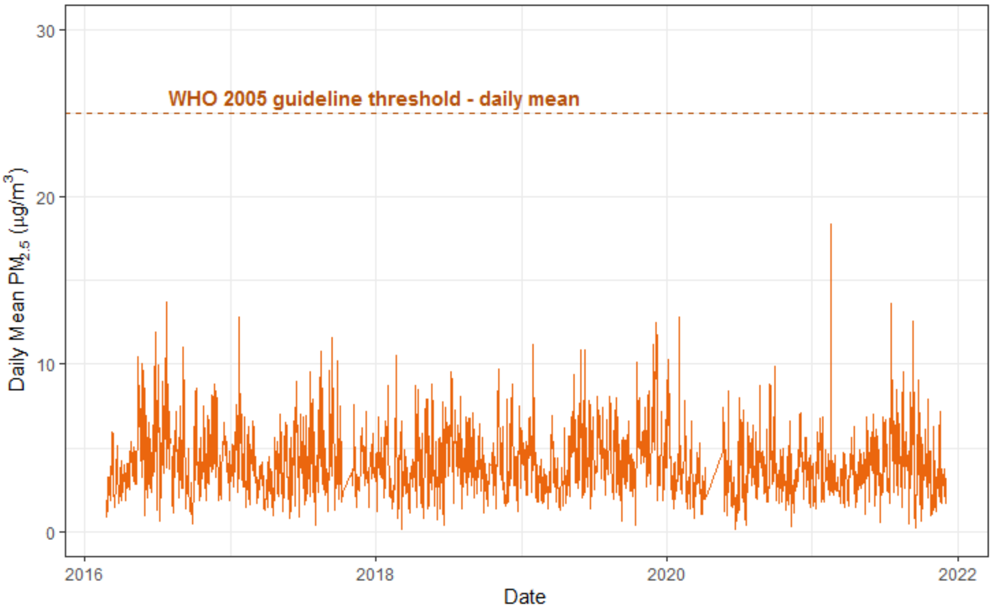

Figure 8 Daily average time series of $PM_{2.5}$ for the monitoring period.

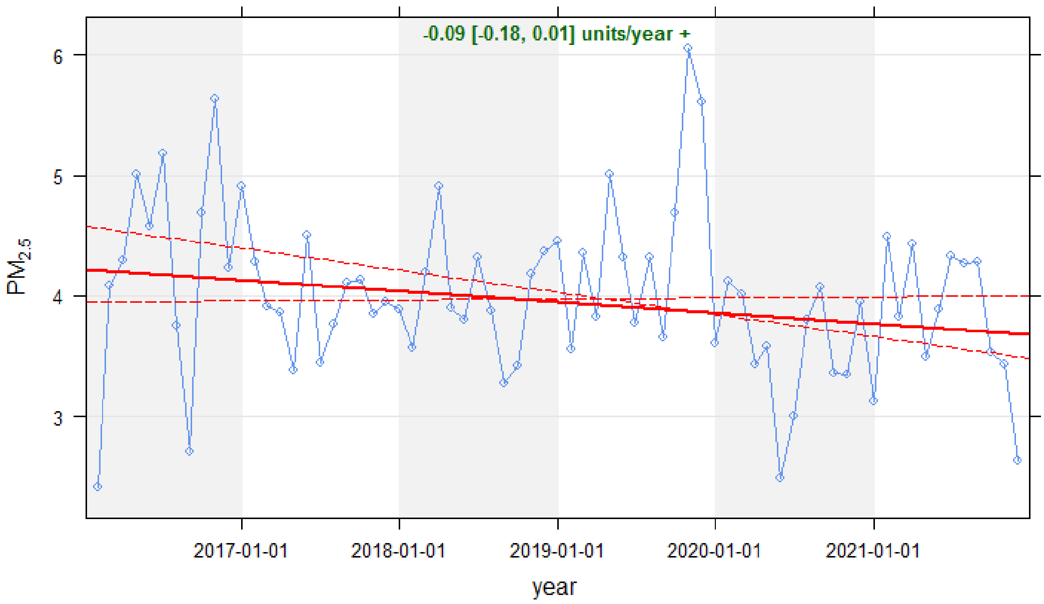

Figure 9 De-seasonalised monthly mean $PM_{2.5}$ concentrations and Theil-Sen trend line for data from the Central School site between March 2016 and December 2021. Dashed red lines represent the trend lines containing the 95% confidence interval

5 Discussion

Overall, the results of continuous $PM_{2.5}$ monitoring at Central School over the 2020 and 2021 calendar years reinforce the findings of monitoring between 2016 and 2020. The reader is referred to the 2016-2020 report (TRC 2020) for a detailed discussion of inhalable particulate air quality in New Plymouth, including meteorological correlations and possible anthropogenic drivers of pollution.

Results of monitoring to date show that $PM_{2.5}$ concentrations are consistently very low at the New Plymouth site, with an annual mean of 4 $\mu g/m^3$ recorded throughout the entire monitoring period, well below the guideline of 10 $\mu g/m^3$ set by WHO in 2005. Throughout the 2016-2021 monitoring period, 96% of days were categorised as having 'Excellent' or 'Good' $PM_{2.5}$ levels, with all but one day of the remaining 4% falling into the 'Acceptable' category. There were no exceedances of WHO's 2005 daily mean guideline of 25 $\mu g/m^3$, and only one exceedance of the recently revised 2021 WHO guideline of 15 $\mu g/m^3$.

A strong seasonal variation is observed in $PM_{2.5}$ levels due to domestic heating in the colder months. In the 2016-2020 report, this increase in $PM_{2.5}$ concentrations was shown to be correlated with cold calm evenings when the dispersal of pollutants from home heating is reduced by stable atmospheric conditions. It was suggested in this report that the effect of domestic heating emissions was likely to be greater in other localised areas in the region. Such vulnerable areas include non-coastal sites and sheltered valleys. Here, air drainage from the surrounding higher land may lead to stronger temperature inversions and an increased level of trapped $PM_{2.5}$ emissions near ground level.

Given the potential elevation of $PM_{2.5}$ concentrations in vulnerable areas, it is recommended that the Council continues to carry out screening monitoring to determine the extent and severity of winter domestic heating pollution in the region's urban centres.

6 Future Monitoring at Central School

This report completes the analysis of the full data set obtained with the decommissioned Met-One systems E-BAM monitoring set-up at Central School. Following the decommission of the E-BAM monitoring equipment in December 2021, the Central School site has been upgraded with the installation of a Met-One BAM1022 system completed in July 2022 (Figure 10). The BAM1022 uses a Federal Equivalent Method, improving the robustness and thus reporting uses of the data obtained at this site. Monitoring with the BAM1022 commenced on 2nd July 2022. Initial data will be compared to that obtained with the E-BAM set up, ensuring the compatibility of the two datasets to enable a continuous and ongoing record of $PM_{2.5}$ at the Central School site.

Once repaired, it is hoped that the Met-One E-BAM equipment will be used as a mobile ambient air quality monitoring set up, enabling $PM_{2.5}$ screening surveys to be undertaken at different locations around the region.

Figure 10 The new BAM1022 monitoring set-up at Central School. July 2022

7 Recommendations

1. THAT it be noted that Taranaki Regional Council has now carried out continuous gathering of $PM_{2.5}$ data in New Plymouth's CBD for a period of almost 6 years, spanning February 2016 – December 2021.
2. THAT it be noted that the E-BAM equipment used in monitoring at Central School to date is now decommissioned, and replaced with an upgraded Met One BAM1022 monitor, with data collection resuming on 2nd July 2022.
3. THAT it be noted that $PM_{2.5}$ monitoring of ambient air in New Plymouth has shown low mean $PM_{2.5}$ concentrations, with no exceedances of the 2005 WHO recommended thresholds, and only one exceedance of the more stringent 2021 WHO recommended thresholds.
4. THAT it be noted that sea spray is a major contributor of $PM_{2.5}$ in the Taranaki region year-round, with domestic heating also being a significant contributor during winter months.
5. THAT the Taranaki Regional Council continues to carry out regional screening $PM_{2.5}$ monitoring to determine the extent and severity of winter domestic heating pollution in the region's urban centres.

Bibliography and references

Carslaw, D.C. and K. Ropkins. 2012: *openair - an R package for air quality data analysis.* Environmental Modelling & Software. Volume 27-28, pp.52–61, doi: 10.1016/j.envsoft.2011.09.008.

Ministry for the Environment. 2002: *Ambient air quality guidelines – 2002 update*. Air Quality Report No. 32, Wellington.

Ministry for the Environment. 2020: *Proposed amendments to the National Environmental Standards for Air Quality: particulate matter and mercury emissions*. Consultation document. Wellington: Ministry for the Environment.

R Development Core Team. 2011: *R: A language and environment for statistical computing. R Foundation for Statistical Computing*, Vienna, Austria. Retrieved from http://www.R-project.org/

Taranaki Regional Council. 2020: Inhalable Particulate ($PM_{2.5}$) Regional Monitoring Programme Report 2016-2020 Document 2506963.

Taranaki Regional Council. 2022: Memorandum: Inhalable Particulate Air Quality Monitoring – Stratford 2021 Document 2952333.

World Health Organization. 2021: WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and Carbon Monoxide.

Taranaki Regional Council

AGENDA
Policy & Planning

Date 7 February 2023

Subject: Submission on Enabling Investment in Offshore Renewable Energy

Approved by: A D McLay, Director - Resource Management

S J Ruru, Chief Executive

Document: 3139119

Purpose

1. The purpose of this memorandum is to seek Members' endorsement of the submission on *Enabling Investment in Offshore Renewable Energy* (the Discussion Document).
2. The deadline for submissions is 26 April 2023.

Executive summary

3. The intent of the Discussion Document to create the right regulatory environment, with appropriate regulatory settings, to allow the sustainable development of offshore renewable energy is supported, subject to appropriate Council involvement. The initial focus is on wind energy.
4. Key parties are being asked for input to the project, which is positive and should lead to better policy and operational outcomes.
5. However, there is considerable existing interest in Taranaki in wind energy with existing coastal land based generation operating and interest in the offshore environment where by the Council will soon receive an application for coastal permits under the Resource Management Act. There is already competition for the offshore wind resource, prior to the development of a new regulatory regime, which may be problematic, unless appropriate transition provisions are available.
6. There will be opportunities for further Council engagement with MBIE to hopefully develop an appropriate regulatory regime for offshore renewable energy.

Recommendations

That the Taranaki Regional Council:

a) <u>receives</u> the memorandum entitled *Submission on Enabling Investment in Offshore Renewable Energy*

b) <u>notes</u> the attached *Submission on Enabling Investment in Offshore Renewable Energy - Discussion Document*

c) adopts (alternatively amends) the submission

d) determines that this decision be recognised as not significant in terms of section 76 of the *Local Government Act 2002*

e) determines that it has complied with the decision-making provisions of the *Local Government Act 2002* to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Background

7. As part of the commitment to reaching net zero carbon emissions by 2050, the Government is exploring offshore renewable energy becoming part of New Zealand's future energy mix.

8. To provide a springboard for the kind of innovation and investment the right regulatory environment needs to be in place and the Discussion Document sets out to focus on the regulatory settings necessary to enable prospective developers to explore the feasibility of developing off shore energy infrastructure. The second step is to further consult in 2023, to focus on the broader regulatory settings for how infrastructure will be constructed, operated, and decommissioned.

9. A copy of the Discussion Document is attached and the local area of interest map and commentary are attached to this item.

Submission

10. The submission responds to the 32 questions in the Discussion Document and provides some background information on how the Council regulates activities within the Territorial Sea. A central issue raised in the submission is the high level of interest in wind energy in the region and the likelihood that an application for a wind farm in the Territorial Sea will be made shortly, prior to the development of a new regulatory system. This may be problematic, unless appropriate transition provisions are available.

11. Members are referred to the attached submission for further information.

Financial considerations—LTP/Annual Plan

12. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

13. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

14. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.
15. The Council has shared its submission with iwi in the region.

Community considerations

16. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

17. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Appendix One: Excerpt - Enabling Investment in Offshore Renewable Energy - Discussion Document

Document 3135795: Submission on Enabling Investment in Offshore Renewable Energy - Discussion Document

Document 3140618: Enabling Investing in Offshore Renewable Energy- Discussion Document.

Appendix One

Taranaki

Figure 2 shows the highest level of potential wind capacity in the South Taranaki Bight, generally in water depths of less than 100 m. Mean wind speeds at 100m elevation are predominantly in the range of 8 – 11 m/s within 60 km of the shore. The majority of the central and northern area is within 100 km of Transpower high voltage infrastructure with nearby significant major energy consumers. It should be noted that there are relatively high levels of constraints due to existing oil and gas industry infrastructure (petroleum platforms and wells, and three pipeline protection corridors) and minerals and petroleum permits, and New Zealand Defence Force areas.

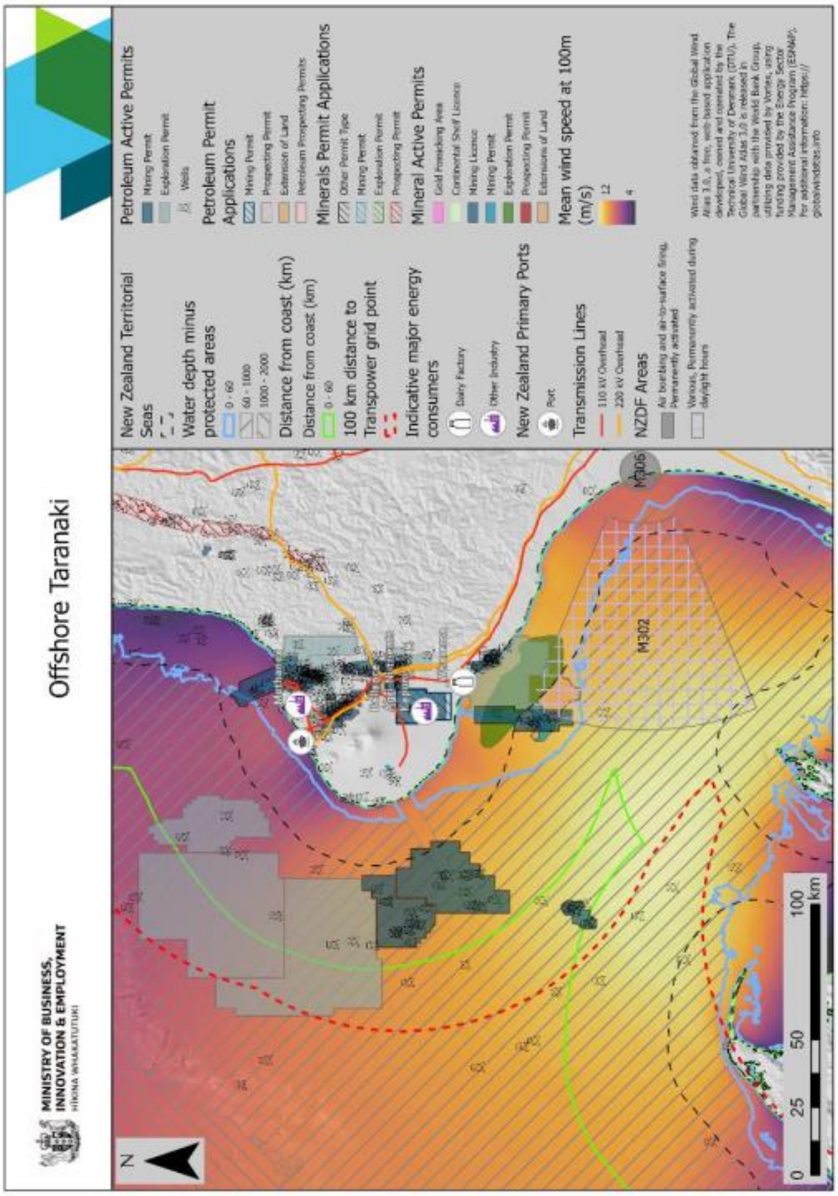

Figure 2: Wind potential and high-level constraints for development in Taranaki

Taranaki Regional Council

21 January 2023
Document: 3135795

Offshore Renewable Energy Submissions
Building, Resources and Markets
Ministry of Business, Innovation and Employment
PO Box 1473
Wellington 6140
New Zealand

Via email: offshorerenewables@mbie.govt.nz

Submission on Enabling Investment in Offshore Renewable Energy - Discussion Document

Introduction

1. The Taranaki Regional Council (the Council) thanks the Ministry of Business, Innovation and Employment (MBIE) for the opportunity to provide feedback on the *Enabling Investment in Offshore Renewable Energy discussion document (2022)* (the Discussion Document).

2. The Council notes that it has experience in successfully regulating major industrial projects associated with the development of oil and gas in the region, including in the coastal environment, that is valuable for addressing the regulation of other infrastructure. The Council was also involved in a marine sand extraction project to mine iron in the Taranaki Bight which is part of the focus area for wind renewable energy.

3. The Council makes this submission in recognition of:
   - its functions and responsibilities under the *Resource Management Act 1991* (RMA), *Biosecurity Act 1993* and under the *Local Government Act 2002*;
   - its experience in establishing a successful regulatory regime and funding arrangements under the RMA; and
   - its regional advocacy responsibilities whereby it represents the Taranaki region on matters of regional significance or concern.

4. The Council has also been guided by its Mission Statement across all of its various functions, roles and responsibilities, in making this submission, which reads as follows:

   "To work for a thriving and prosperous Taranaki by:
   - *Promoting the sustainable use, development and protection of our natural and physical resources.*

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Working with people | caring for Taranaki

- *Safeguarding Taranaki's people and resources from natural and other hazards.*
- *Promoting and providing for significant services, amenities and infrastructure.*
- *Representing Taranaki's interests and contributions regionally, nationally and internationally."*

5. The Council also notes the Government's desire for clean, renewable energy generation to be critical to realising our vision for Aotearoa New Zealand's energy system to be highly renewable, sustainable and efficient by 2050.

6. There is already significant interest from experienced developers in establishing offshore wind energy in New Zealand's territorial sea (up to 12 nautical miles) and exclusive economic zone (between 12 and 200 nautical miles), with feasibility assessments underway in three locations, including Taranaki.

7. The Discussion Document notes offshore renewable energy covers many energy sources, such as wind, solar and ocean (wave and tidal), and several technologies that are at different stages of development. The most advanced technology is fixed foundation offshore wind, which is being deployed in large scale commercial projects in Europe and Asia-Pacific. The Document focuses on offshore wind as a specific example, owing to its advanced nature, but also applies to other forms of offshore renewable energy. The narrow focus is probably appropriate given the regulatory and environmental issues raised by such development will be similar to those of infrastructure for other types of renewable energy capture.

General comments

8. The Council's approach to regulation under the RMA may be worth considering for the successful regulation of offshore renewable energy. The regime, which includes regulating the territorial sea, involves engaging extensively up front with iwi and the community to establish the appropriate policy framework to determine the regulatory regime. Equal weight is then given to consent processing, compliance monitoring of consent conditions and enforcement. The first two elements are funded by resource users and enforcement is funded by sanctions from those in non-compliance.

9. Ratepayers fund the establishment of the system and resource users pay the cost of using it. The system has transparency through reporting back to the community about consent compliance and enforcement activities. There is a high level of community trust in the system, as opposed to a regulatory system which has little or no compliance monitoring and minimal enforcement in place.

10. The intent of the Discussion Document to create a regulatory environment, with appropriate regulatory settings, to allow the sustainable development of off shore renewable energy, is supported, subject to some matters raised below being addressed. Key parties are being asked for input to the project which is positive and should lead to better overall outcomes. There is considerable existing interest in Taranaki in wind energy. A 130 megawatt land based wind project, involving 31 turbines, already exists on the south Taranaki coast near Waverley and was operational in February 2020.

11. In the offshore environment, there is existing interest, including a project led by Wind Quarry Zealandia Ltd that is in advanced stages of planning. The Council will soon receive an application from them for a wind farm in the territorial sea. The Company, has in good faith, been developing the project over the last two years, involving iwi consultation and technical assessments. The Council has also been consulted, as an interested party, by parties wanting to establish wind farms in the exclusive economic zone.

12. So there is already competition for the offshore wind resource prior to the development of a new regulatory regime which may be problematic, unless appropriate transition or other provisions are available.

13. To establish regulatory settings to enable prospective developers to explore the feasibility of developing offshore energy infrastructure will likely involve some minor activities, with temporary and minimal environmental effects that should be permitted by regulations, rather than requiring a marine consent. The Council's Regional Coastal Plan may already provide for such activities as permitted activities in the territorial sea.

14. The regulatory focus should be on the broader regulatory settings for how generating plant and associated infrastructure will be constructed, operated, maintained and decommissioned and the Council looks forward to the proposed consultation on this in 2023.

15. The Resource Management Act is currently under review and new measures proposed include spatial planning. Consideration should be given to using spatial planning in the management of the territorial sea and exclusive economic zone, including for enabling investment in offshore renewable energy.

Objectives

16. In terms of questions 1 to 5, concerning the objectives for feasibility activity regulation and the criteria to be used to assess the proposals (set out on page 16), they appear appropriate and in line with the way the Council would operate.

Role of government

17. In terms of questions 6 to 8 (set out on page 19), concerning who should gather feasibility activity information, the Council suggests the potential developer should gather the information rather than the government. If applications are made then the information obtained should be shared with the regulator and be publically available.

Developer led approach

18. In terms of questions 9 to 12 (set out on page 21), concerning methods to determine feasibility activity permits and whether a permit or collaborative model should apply, the Council supports the MBIE preferred permit option. The Discussion Document proposes a developer-led approach to gathering feasibility information that could be used in the preparation of relevant consent and other permissions to construct and operate. As this will involve a significant investment, developers are seeking the confidence to invest without potential for a different developer gaining priority over

them through a first-in-time consent application over the same location. The permitting approach is a familiar model for NZ (in Crown minerals regime) and internationally, with clear roles and responsibilities.

Māori Involvement

19. Māori should be involved in the assessment of feasibility and the Council has a collaborative/partnership arrangement in place with iwi for freshwater management policy development. In terms of questions 13 to 17 (page 23) feedback is best provided by iwi.

Permitting framework

20. In terms of questions 21 and 22 (page 26), feasibility licence permit durations of five years with an option to extend for a further two years seems appropriate for such large scale wind projects. A feasibility licence should be subject to 'use it or lose it' provisions with activities having to commence for permits to remain valid.

21. The development of offshore renewable energy infrastructure is undoubtedly a nationally significant activity that bridges the territorial sea and exclusive economic zones. The latter representing a much larger area. In terms of question 24 (page 28) there probably is a case for one regulator to assess applications for permits and managing permits. However, there should be scope for regional councils to be actively involved given the cross boundary consideration assessments required for successful integrated management of coastal/oceanographic waters. Just who should be the Minister, acting on advice from officials, who should make the decision, is an important point. Is the Minister of Energy and Resources independent enough, given the projects deliver more energy?

22. In terms of question 26, the ability to charge actual and reasonable costs for inviting, and assessing feasibility permit applications, and monitoring permit holders, is strongly supported. As noted, user pays provisions are a feature of the Council's approach to successful resource management.

23. In terms of question 28, there should be an opportunity for public input for those interested in proposals to conduct feasibility activities. However, this should be limited to those directly impacted by the activity as opposed to the wider public.

24. Annual ongoing reporting obligations (questions 29 to 31) on permit holders are supported for transparency and accountability reasons. Any monitoring reporting should be based on independent assessment, rather than permit holders reporting their own results to the regulator. A fully transparent reporting system holds permit holders to account and delivers higher compliance levels.

25. The Council strongly supports developers, who are not complying, being subject to compliance actions, including with a risk of losing their rights to conduct feasibility activities as a last resort (question 32).

Conclusion

26. The Council again thanks MBIE for the opportunity to comment on the Discussion Document.

27. The intent of the Discussion Document to create the right regulatory environment, with appropriate regulatory settings, to allow the sustainable development of offshore renewable energy is supported, subject to appropriate Council involvement. Key parties are being asked for input to the project which is positive and should lead to better policy and operational outcomes.

28. However, there is considerable existing interest in Taranaki in wind energy with existing coastal land based generation operating and interest in the offshore environment as noted above. So there is already competition for the offshore wind resource prior to the development of a new regulatory regime which may be problematic, unless appropriate transition provisions are available.

29. The Council looks forward to continuing to work with MBIE and the Government to successfully develop an appropriate regulatory regime for offshore renewable energy.

Yours faithfully,

A D McLay
Director- Resource Management

Enabling Investment in Offshore Renewable Energy
Discussion Document

DECEMBER 2022

MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Te Kāwanatanga o Aotearoa
New Zealand Government

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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ONLINE: ISBN 978-1-99-106904-7

DECEMBER 2022

Minister's Foreword

Clean, renewable energy generation will be critical to realising our vision for Aotearoa New Zealand's energy system to be highly renewable, sustainable and efficient by 2050. A strong renewable energy system will help us achieve our goals to have a low-emissions and high-wage economy, while we support international efforts to limit global temperature rises.

New Zealand is very lucky to have access to significant renewable energy sources, and we are well positioned to transition to 100 per cent renewable energy generation. Offshore renewable energy sources – like wind and tidal – have the potential to be a key part of our future energy mix.

This is why our first Emissions Reduction Plan commits to accelerating the development of new electricity generation technologies and ensuring that by 2024, we have regulatory settings in place to enable investment in offshore renewable energy.

The right regulatory environment can be a springboard for the kind of innovation and investment that will help deliver the offshore renewable infrastructure needed to help us get to net zero carbon emissions by 2050. We want to ensure that any regulatory settings are carefully considered to be in the best interests of New Zealanders now and in the future, while enabling targeted research and exploration as early as possible.

To allow for this consideration, the Government has agreed to consider the regulatory settings in two steps:

- The first step, this discussion document, focuses on the regulatory settings necessary to enable prospective developers to explore the feasibility of developing offshore energy infrastructure in our waters. Recognising that these exploratory studies can take several years, it is critical we establish these settings soon.

- The second step is further consultation in 2023, to focus on the broader regulatory settings for how infrastructure will be constructed, operated, and decommissioned.

I look forward to hearing the views of Māori, industry, and communities on these proposals and invite you to stay engaged in future consultations on this topic

Hon Dr Megan Woods
Minister of Energy and Resources

Contents

Executive summary

Offshore renewable energy could contribute to Aotearoa New Zealand's net-zero emissions goals and economic development

The Government has committed to reaching net zero for long-lived gases by 2050, set a target that 50 per cent of total energy consumption will come from renewable sources by 2035, and has an aspirational target of 100 per cent renewable electricity by 2030. The New Zealand Energy Strategy, currently under development, will help set the direction for Aotearoa New Zealand's pathway away from fossil fuels and towards greater levels of renewable electricity and other low-emissions alternatives.[i]

Offshore renewable energy is one such alternative that could become a part of Aotearoa New Zealand's future energy mix. Surplus offshore renewable energy could also be used to grow energy-intensive activities such as the construction of data centres and the production of hydrogen or ammonia.

Offshore renewable energy covers many energy sources, such as wind, solar and ocean (wave and tidal), and several technologies that are at different stages of development. The most advanced technology is fixed foundation offshore wind, which is being deployed in large-scale commercial projects in Europe and the Asia-Pacific.[ii]

While this discussion document is concerned with all forms of offshore renewable energy, we use and refer to offshore wind as a specific example throughout, owing to its advanced nature.

Developers are currently exploring Aotearoa New Zealand's world-leading offshore wind resources

Aotearoa New Zealand's average wind speeds are higher than in most other places, meaning that our wind farms can produce more energy per unit than the global average. The least-windy sites in Aotearoa New Zealand have better wind energy potential than the windiest sites in Australia.[iii]

There is already significant interest from experienced developers in establishing offshore wind energy in New Zealand's territorial sea (up to 12 nautical miles) and exclusive economic zone (between 12 and 200 nautical miles), with initial feasibility assessments underway in Taranaki, Waikato, and Southland.

To harness this potential, the Government is consulting on an approach to manage feasibility activities

Internationally, many countries are moving at speed to leverage their low-emissions resources by reducing barriers to enable the significant investment needed for offshore renewable energy projects. One barrier is how the establishment of this infrastructure is regulated.

In May 2022, the Government's first Emissions Reduction Plan committed to developing regulatory settings by 2024, to enable investment in offshore renewable energy (such as offshore wind farms) and innovation.[iv]

The objectives of regulatory settings are to:

- enable selection of both the developer and the development to meet Aotearoa New Zealand's national interests, including appropriate safeguards and benefits for the environment
- enable Māori participation in offshore renewable energy development
- provide certainty for developers to invest in the short term, and
- ensure New Zealand remains competitive and can secure access to offshore renewable energy technology in a timely way.

Currently, existing regulatory regimes such as the Resource Management Act 1991 and Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 are insufficient to enable early feasibility activity by offshore renewables developers to proceed in a way that meets the above objectives. This discussion document consults on:

- implementing a permitting or collaborative approach to the production of feasibility assessments for offshore renewables developments in a way that meets the above objectives, and
- gathering more information about existing rights and uses in areas where offshore renewables may develop.

Next steps

Consultation on the proposals in this document will run from mid-December 2022 to April 2023. During this time, officials will meet with interested parties to discuss the proposals.

A second discussion document in 2023 is expected to canvas further elements of required regulatory settings such as how best to manage the construction, operation, and decommissioning phases of offshore renewable infrastructure.

Any regulatory changes would require either regulations made under an existing Act of Parliament, or a new Act. The Government remains committed to establishing fit for purpose regulatory settings by 2024. Where it is feasible and desirable to do so, the Government will implement these settings sooner.

Chapter 1: Purpose of this consultation

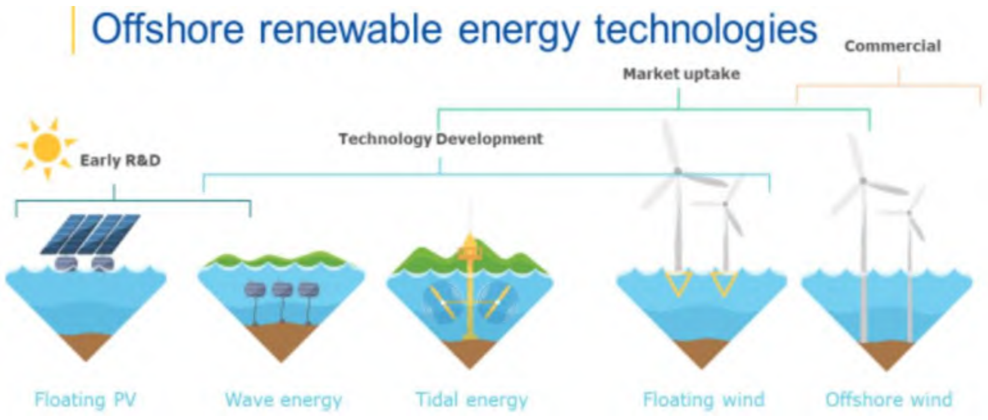
Why we are consulting?

Aotearoa New Zealand has considerable renewable energy potential within the territorial sea (up to 12 nautical miles) and exclusive economic zone (between 12 and 200 nautical miles).

What is offshore renewable energy?

Offshore renewable energy refers to any type of infrastructure placed in or on the sea, and that generates energy from wind, ocean currents, light or heat from the sun, rain, and geothermal heat. These sources are abundant, natural, and clean.

The technologies used to harness these sources of energy are at different stages of development.



Source: European Commission

Offshore renewable energy can involve large-scale, multi-year infrastructure projects. Offshore wind, for example, combines the scale of large hydro and the complexity of offshore petroleum extraction, making it different from onshore renewables. Developing an offshore renewable energy industry in a new market such as Aotearoa New Zealand therefore requires a careful approach that considers economic, cultural, environmental, and social criteria.

The Government's first Emissions Reduction Plan committed to developing regulatory settings by 2024 to enable investment in offshore renewable energy and innovation.[v]

The scope of this discussion document

Regulatory proposals are focused on the initial feasibility stage of development

There are generally four broad stages to offshore renewable energy infrastructure developments: feasibility, construction, operation and maintenance, and decommissioning.

The proposals in this document concern the early stage of exploring the feasibility of offshore renewable energy projects. The purpose of the feasibility stage for a developer is to determine the appropriate scale and location of infrastructure. Data gathered during this stage would inform the development of appropriate consents and any other permission to construct and operate.

While the proposals in this discussion document apply to all offshore renewable energy generation, we specifically use the example of offshore wind, since this technology is the most advanced, and because experienced developers have expressed interest in establishing offshore wind energy in Aotearoa New Zealand's waters.

Our engagement with Te Tiriti o Waitangi partners

To inform this discussion document, the Government has conducted preliminary engagement with iwi from the regions that offshore wind energy developers are currently exploring, namely Waikato, Taranaki and Southland. Chapter 5 reflects insights from these initial conversations.

This engagement will continue through the public consultation of this discussion document and will remain ongoing.

Have your say

You have an opportunity to tell us what you think of the proposals by providing feedback on the matters raised in this discussion document. You are welcome to make submissions on some or all of the discussion questions set out in this document, and/or to raise any other relevant points.

The Ministry of Business, Innovation and Employment (MBIE) invites written comments on the proposals in this document. Please provide relevant facts, figures, data, examples and documents where possible to support your views. Please also include your name and (if applicable) the name of your organisation in your submission.

You can make a submission by:

- emailing your submission to offshorerenewables@mbie.govt.nz
- mailing your submission to:

  Ministry of Business, Innovation and Employment
  15 Stout Street
  PO Box 1473, Wellington 6140
  Attention: Offshore Renewable Energy Submissions

A submission template has been provided to respond to the questions in this discussion document. You can find this template at: https://mbie.govt.nz/offshorerenewables.

Submissions are due on or before **14 April 2023**.

Use of information

The information provided in submissions will be used to inform MBIE's policy development process, and will inform advice to Ministers.

We may contact submitters directly if we require clarification of any matters in submissions.

MBIE will publish a summary of submissions

After submissions close, MBIE will publish a summary of submissions on our website at www.mbie.govt.nz. We will not be making any individual submissions public. Should any part of your submission be included in the summary of submissions, MBIE will seek your permission to publish your information, and ensure it does not refer to any names of individuals.

When businesses or organisations make a submission, MBIE will consider that you have consented to the content being included in the summary of submissions unless you clearly state otherwise.

If your submission contains any information that is confidential or you otherwise wish us not to publish, please:

- indicate this on the front of the submission, with any confidential information clearly marked within the text
- provide a separate version excluding the relevant information for publication on our website.

Submissions may be the subject of requests for information under the Official Information Act 1982 (OIA). Please set out clearly if you object to the release of any information in the submission, and in particular, which part (or parts) you consider should be withheld (with reference to the relevant section of the OIA). MBIE will take your views into account when responding to requests under the OIA. Any decision to withhold information requested under the OIA can be reviewed by the Ombudsman.

Privacy Act 2020 applies to all submissions and survey responses.

The Privacy Act 2020 applies to submissions and survey responses. Any personal information you supply to MBIE in the course of making a submission will only be used for the purpose of assisting in the development of policy advice in relation to this review.

Please clearly indicate in the cover letter or e-mail accompanying your submission if you do not wish your name, or any other personal information, to be included in any summary of submissions that MBIE may publish.

What happens next

MBIE will analyse all submissions received and then report back to the Minister of Energy and Resources on the feedback, with recommendations for her consideration. Your submission will help inform policy decisions to develop a responsible offshore renewable energy industry in Aotearoa New Zealand.

A second discussion document in 2023 is expected to canvas further elements of required regulatory settings such as how best to manage the construction, operation, and decommissioning phases of offshore renewable infrastructure.

Any regulatory changes would require either regulations made under an existing Act of Parliament, or a new Act. The Government remains committed to establishing fit for purpose regulatory settings by 2024. Where it is feasible and desirable to do so, the Government will implement these settings sooner.

Chapter 2: Context

Offshore renewables could contribute to our climate change goals

Aotearoa New Zealand needs a highly renewable, sustainable, and efficient energy system that is accessible and affordable, secure and reliable, and supports New Zealanders' wellbeing. The Government has committed to reaching net zero emissions for long-lived gases[1] by 2050, set a target that 50 per cent of total energy consumption will come from renewable sources by 2035, and has an aspirational target of 100 per cent renewable electricity by 2030.

The New Zealand Energy Strategy, currently in development and due to be completed by the end of 2024, will help set pathways to achieve our objectives and provide certainty for the sector, consumers, and industry. It will set the direction for New Zealand's pathway away from fossil fuels and towards greater levels of renewable electricity and other low emissions alternatives.[vi]

Reducing our reliance on fossil fuels and moving towards greater levels of renewable energy and other low-emissions alternatives will increase demand for electricity over the coming decades. The magnitude and timing of the increase is uncertain, but analysis by MBIE projects that electricity demand could grow between 18 and 78 per cent between 2018 and 2050 across five different scenarios assuming different levels of economic growth, technological progress and policy changes.[vii] Analysis by Transpower, the electricity grid operator, shows that demand could grow from ~43 TWh (terawatt hours) today to 70 TWh by 2050 primarily from electrifying transport and process heat.[viii] Recent Climate Change Commission (CCC) modelling to support its emissions budget advice also shows the potential for significant increases in demand for electricity out to 2050 as the number of electric vehicles (EVs) on the country's roads grows, and industrial demand electrifies.[ix]

Offshore renewables can contribute to this increased demand for electricity, providing a more stable source of renewable energy, for more constant and predictable generation.

There are other potential benefits from developing offshore renewable energy

Offshore renewable energy can provide for increased economic development

Developments can generate economic benefits by creating jobs to support the manufacture, construction, and operation of infrastructure. A localised supply chain can add value to an economy by providing a range of components and services that are required. For example, the development of a typical 500 MW offshore wind farm requires around 2.1 million person-days of work and there are synergies with offshore oil and gas, specifically in terms of skills and occupational groups.[x]

Surplus renewable energy, such as that provided from offshore sources could be used to grow energy-intensive activities. These potentially include the construction of data centres and the production of hydrogen or ammonia. Green hydrogen has potential as an alternative fuel source to decarbonise many hard-to-abate industries and applications. Green ammonia can be used to create urea, which is widely used in the agricultural sector both as a fertilizer and animal feed additive. Both the green

[1] Carbon dioxide, nitrous oxide, F-gases and non-biogenic methane. Subsequently referred to as 'carbon' for simplicity.

hydrogen itself, and its applications, such as green ammonia and urea could provide export opportunities for Aotearoa New Zealand.

Attracting these activities to Aotearoa New Zealand would reduce global greenhouse gas emissions and create sustainable high-wage jobs for New Zealanders. Suppliers with access to low-cost renewables will tip the scales when it comes to green hydrogen production.[xi]

There is an opportunity to enable technology innovation

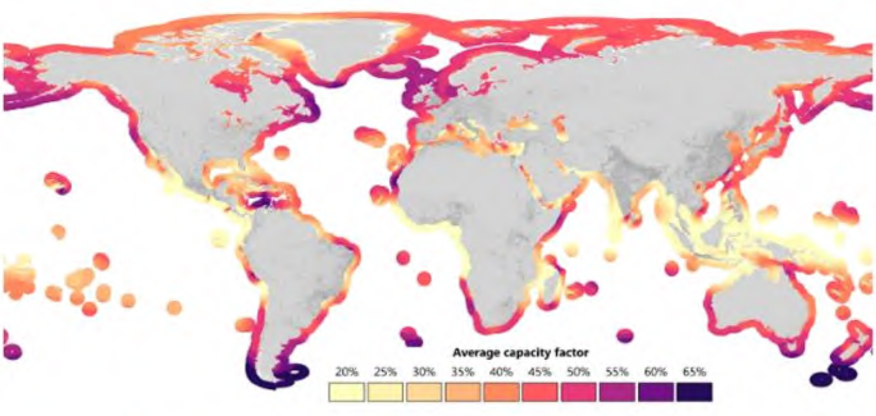
The technologies to exploit offshore renewable energy sources are at different stages of development. There is an opportunity to enable technology developments and innovation, as well as investment in renewable offshore energy beyond wind. There is interest from innovative energy organisations in testing, trialling, and developing other renewable marine technology, including current, wave and tidal renewable electricity generation. It will be important to de-risk investment in both innovation and testing technologies.

Offshore wind is the most mature technology

Offshore wind technology is the most mature of the offshore renewable energy technologies today, and it continues to develop at pace. Offshore wind installations have the potential to provide significant new renewable electricity generation capacity in the future. Offshore wind technology allows the exploitation of the generally higher and more consistent wind resources offshore, while achieving gigawatt-scale projects close to large load centres (eg the densely populated coastal areas prevalent in many parts of the world).[xii] Also, being at sea, offshore wind is less visible and less audible – key objections raised with regards to onshore wind developments in some communities.[xiii]

Aotearoa New Zealand has world-class offshore wind resources

According to the International Energy Agency, Aotearoa New Zealand is optimally located in an area of the world with quality wind resources. The average capacity factor (average performance over the course of a year) for wind projects in Aotearoa New Zealand is estimated between 50 to 65 per cent.[xiv] The least-windy sites in New Zealand have better wind energy potential than the windiest sites in Australia.[xv]



Average capacity factors reflect the quality of the wind resources available offshore around the world

Source: International Energy Agency analysis developed in collaboration with Imperial College London based on Renewables.ninja

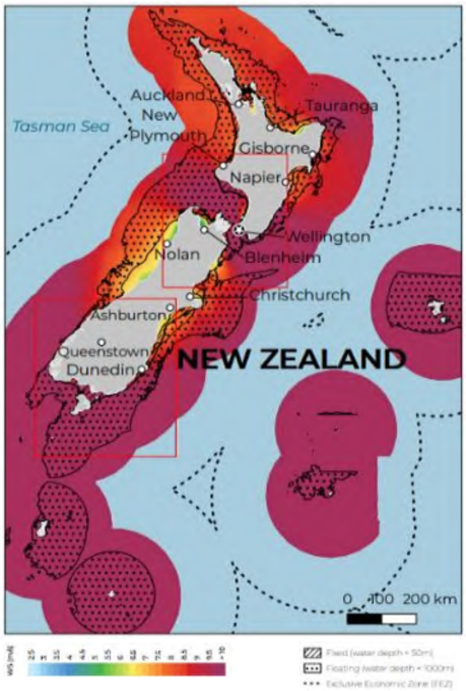
Water depth is another important technical consideration. Turbines are now routinely being installed in water depths of up to 40 metres and as far as 80 kilometres from shore. These turbines, rooted in the seabed by monopile or jacket fixed-bottom foundations, are easier to access and currently restricted to waters less than 60 metres deep.[xvi]

Scaling up offshore wind markets requires offshore wind turbines to move into deeper waters with higher wind resources. Floating foundations offer this potential, as they allow access to sites with deeper water and further from shore. Significant and encouraging developments in floating foundations have been seen in recent years. For example, the Norwegian energy company Equinor will complete the world's largest floating wind installation by 2023. Located 140 kilometres offshore with water depths ranging between 260 metres and 300 metres, it will have a system capacity of 88 MW.[xvii]

Floating offshore wind in deeper water is likely to become cost competitive with offshore wind on fixed foundations in shallower water by the early to mid-2030s, which will open up new markets with good wind resources close to population centres, but with deeper water.[xviii]

Offshore wind could be feasible in a number of locations in Aotearoa New Zealand

Based on wind quality and water depth alone, the technical potential for offshore wind in Aotearoa New Zealand is concentrated in a few different locations according to analysis by the Global Wind Energy Council in 2021.



Source: Global Wind Energy Council

Other technical factors will also influence the economic viability of an offshore wind project. These include distance from shore (near shore <60km or far from shore 60 – 300km), availability of grid connection, grid capacity, distance to port (for construction and maintenance), and proximity to consumers. These are generally the first order considerations that offshore wind developers will take into account when identifying potential locations for projects.

A 2019 study of Aotearoa New Zealand's offshore wind resource identified at least 7 GW of potential capacity from fixed foundation wind turbines in South Taranaki alone, with the potential for additional capacity from floating turbines, and in other locations.[xix]

In Aotearoa New Zealand, developers currently interested in offshore wind energy, both fixed and floating foundations, have identified the following potentially technically viable locations: Waikato, South Taranaki Bight, North Taranaki Bight, and Southland.

Annex 1 provides further information on the locations of developer interest.

The lifecycle of an offshore wind project

Offshore wind projects are long-term propositions. They can take a decade to establish and remain in operation for thirty years or longer. The four major stages in the lifecycle of an offshore wind project are feasibility, construction, operation and maintenance, and decommissioning.

Feasibility

The feasibility stage is an opportunity to determine the appropriate scale and location of offshore wind infrastructure. Determining this involves gathering all the information necessary to assess whether a project is technically, commercially, environmentally, culturally, and socially appropriate.

Feasibility activities can include geotechnical, geophysical, wind speed, and environmental and ecological impact surveys. They also include engineering and design studies, economic analysis, onshore and human impact studies (such as visual impact), as well as assessing options for connecting offshore energy infrastructure to an electrical grid or directly to users. Depending on their nature, some feasibility activities may need consenting.

The data gathered during the feasibility stage would be used to inform the preparation of necessary consents and other permissions to construct and operate.

Construction

Constructing offshore wind energy infrastructure can cost hundreds of millions of dollars and take several years. There are a series of activities that take place to prepare the site and manufacture the components needed.

Operation and maintenance

Offshore wind infrastructure can be in operation for decades. It needs frequent maintenance and inspections to check that components are working efficiently. Ongoing compliance with health, safety and environmental regulation will also be a large part of the activities in this stage.

Decommissioning

Components, such as the turbines, will come to the end of their design life and will need to be decommissioned. As the majority of offshore wind energy infrastructure has been constructed in the twenty-first century, there is little global experience in this area, but there are many similarities with offshore oil and gas, and lessons learned.

Chapter 3: Why does the government need to enable feasibility activity now?

Early developer interest needs to be managed in a way that benefits Aotearoa New Zealand

Offshore renewable energy infrastructure is long-lived and could become a critical part of our national electricity system. It is therefore important for the government to carefully select both the developer and the development to meet Aotearoa New Zealand's national interests. This includes examining a developer's technical and financial competence to deliver the project on time and meet Aotearoa New Zealand's renewable energy objectives; the potential environmental impacts from the development; and the range of benefits that may be realised for Aotearoa New Zealand, such as through job creation and skills development, supply chain development, and technology innovation.

On potential environmental impacts, the research undertaken during the feasibility stage will provide significant insight into Aotearoa New Zealand's marine environment and will assist with understanding and quantifying the potential for positive or adverse effects. Governments around the world are increasingly examining offshore wind projects at the feasibility stage to ensure that developers collect appropriate data and complete a detailed environmental impact assessment prior to seeking relevant consents to construct.

Under current regulatory settings, the most significant developer interaction with the resource management system occurs at construction when consents will be required under the Resource Management Act 1991 (RMA) and/or Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act).[2] Consent applications under these Acts are processed in the order in which they are received ie on a 'first-in, first-served' basis, and the focus is on promoting the sustainable management of natural resources.

There is currently no appropriate system for assessing the suitability of offshore renewable energy developers to operate in Aotearoa New Zealand, or for comparing proposed developments against each other. Despite this, developers are beginning initial activity now. Without a specific approach to enabling feasibility, there is a risk that developments will be assessed without adequate information and the ability for the government to judge the most appropriate development and developer.

Providing for Māori interests in the moana

The moana (ocean) around Aotearoa New Zealand is of significant cultural and economic value to Māori. As Te Tiriti partners and citizens of Aotearoa, Māori may have a broad range of interests in the development of an offshore renewable energy industry. We understand that recognising these interests is integral to assessing feasibility.

The moana has spiritual significance to Māori as it plays a critical role in informing whakapapa and turangawaewae (belonging). It provides ancestral connection to Māori from the rohe it embodies and, in te ao Māori, cannot be viewed purely as a commodity. It is important that developers understand

[2] There are currently limited regulatory requirements for developers undertaking feasibility activities. Activities can range from being 'permitted' to 'controlled' under the EEZ Act and relevant regional coastal plans.

the spiritual significance of the moana, and that it is often local marae who will have a deep understanding of the mātauranga and tikanga for that moana.

As kaitaki (guardians) of the moana in their rohe, certain iwi, hapū and whānau will have heightened interests in how offshore areas are used from an intergenerational perspective. As mana moana they have a responsibility to preserve and protect taonga in their rohe. Mana moana hold vast amounts of knowledge – mātauranga Māori - of the flora and fauna in their rohe. For example, the migratory patterns of Tītī (muttonbird) – a New Zealand native bird common to coastal New Zealand south of Banks Penninsula with economic, social and cultural importance in te ao Māori – have been studied by Ngāi Tahu for centuries. Development in this area could have an impact on such species and will therefore need to involve the participation of mana moana.

Māori also have legally recognised customary interests under the *Te Takutai Moana Act 2011* and *Ngā Rohe Moana o Ngā Hapū o Ngāti Porou Act 2019* (takutai moana legislation), Treaty of Waitangi settlement legislation, and relevant case law which need to be preserved.

Equitable economic opportunities for development

Mana moana have continuously expressed a strong desire to work with developers to ensure their interests, knowledge and aspirations are appropriately considered and given effect. Māori want equitable opportunities to be involved in all aspects of the feasibility process and assurance that developers understand Te Tiriti o Waitangi, tikanga principles, mātauranga Māori and the interests of mana moana. Māori are also interested to explore the potential economic benefits to their communities from the construction and operation of offshore renewables.

Without a specific approach to feasibility, it is unlikely that the Government can ensure an appropriate level of involvement in the preparation of feasibility assessments, and identification of existing rights and interests.

To invest in feasibility activities, developers want certainty

Experienced offshore wind developers are seeking to support Aotearoa New Zealand's emissions reduction targets through a greater supply of renewable energy. As these developments can take a decade or longer, developers want to commence their feasibility activities now.

The data gathered during feasibility would assist a developer in the preparation of relevant consent applications and any other permissions that may be required to construct. As noted above, these applications are processed under the RMA and EEZ Act in the order in which they are received.

Feasibility activities can cost tens of millions of dollars, especially in a new market like Aotearoa New Zealand. Developers are seeking confidence to invest in the preparation of relevant consent applications without the potential for a different developer gaining priority over them through a first-in-time consent application over the same location.

Maintaining consistency with international obligations

New Zealand is party to a number of international treaties and conventions that impact how we use and manage the marine area. Key to the issues raised by offshore renewable energy development is the obligations under United Nations Convention on the Law of the Sea 1982. This convention stipulates rights and obligations on members states relating to territorial sovereignty, environmental protection and decommissioning infrastructure in the territorial sea and the Exclusive Economic Zone. A more detailed summary of the rights and obligations of members states under UNCLOS is provided in Annex 4.

Regulations need to be timely

Finally, internationally many countries are moving at speed to leverage their low-emissions resources and as a result, global demand for offshore renewable energy construction is significant and growing. If early feasibility activity is not enabled, Aotearoa New Zealand risks slower access to offshore renewable energy technology to support us to meet our climate ambitions.

The Government has prioritised developing fit-for-purpose regulatory settings for offshore renewable energy by July 2024 and may implement them sooner where it is feasible and desirable to do so.

Policy objectives and criteria

The policy objectives for enabling feasibility activities are to:

- enable selection of both the developer and the development to meet Aotearoa New Zealand's national interests, including appropriate safeguards and benefits for the environment
- enable Māori participation in offshore renewable energy development
- provide certainty for developers to invest in the short term, and
- ensure New Zealand remains competitive and can secure access to offshore renewable energy technology in a timely way.

Based on this, we will use the following criteria to assess the proposals outlined in this document:

- **Effectiveness:** Will the proposals effectively meet the policy objectives described above, especially around selecting developers and developments and enabling Māori participation?
- **Certainty:** Do the proposals provide sufficient certainty for developers to invest in Aotearoa New Zealand?
- **Timeliness:** Can the proposals be implemented in a timely manner so that Aotearoa New Zealand remains competitive internationally?

1. Do you agree with the proposed objectives outlined above? Why or why not?
2. Are there other objectives that we should consider that are not captured above? If so, what are they are why are they important?
3. Do you agree with the proposed criteria for assessing the proposals for regulating offshore renewable energy? Why or why not?
4. Are there other criteria that we should consider that are not captured above? If so, what are they are why are they important?
5. Do you agree that the criteria should be equally weighted? Why or why not?

Chapter 4: Proposals for managing feasibility activities

The proposals in this document only deal with the early stage of exploring the feasibility of offshore renewable energy projects. A second discussion document in 2023 is expected to canvas further elements of required regulatory settings such as how best to manage the construction, operation and maintenance, and decommissioning stages of offshore renewable energy infrastructure.

Together, the two discussion documents will contribute to establishing timely and fit-for-purpose regulatory settings by 2024.

Feasibility is the first step of development

The feasibility stage is an opportunity to determine the scale and location of renewable infrastructure through assessments and studies that could subsequently inform applications for relevant consents to construct. The purpose of the feasibility stage is to determine whether the construction of offshore renewable energy is technically, commercially, environmentally, culturally, and socially appropriate in a given location. This involves:

- gathering the necessary information, and
- balancing any competing uses, interests, and values in deciding whether to proceed with the development.

The government can have different degrees of involvement in the feasibility stage of an offshore renewable energy project. On one side of the spectrum, the government could prepare the information itself, involving significant time and cost to the Crown. On the other, this task can be assigned to developers who would absorb these costs themselves. In a new market like Aotearoa New Zealand, the data across the different categories of information may not be available, may be limited, or may be of variable quality. For example, although some offshore areas are specifically protected for their conservation value, significant habitats for species, and their migratory paths may lie outside of marine protected areas or marine mammal sanctuaries in both the territorial sea and the exclusive economic zone. Obtaining a better understanding of the importance of areas for marine species and ecosystems needs to be an integral part of the feasibility stage.

The availability of data could also vary by region. For example, in Taranaki where oil and gas exploration has been occurring for decades in the territorial sea and exclusive economic zone, much is known about the geotechnical and geophysical characteristics. This may not be the same in other regions such as Waikato and Southland.

In Aotearoa New Zealand, competing uses, interests and values would usually be balanced during the consenting process to construct offshore renewable energy developments. The feasibility process will be vital to gather information about these uses, interests, and values, particularly for local iwi, hapū, and whānau.

Internationally, governments have taken different approaches to gathering information and balancing uses, interests, and values

The Dutch tendering model is an example of the greatest role for government, in which the government identifies specific areas where renewable energy development could be feasible, having itself conducted significant feasibility work. This includes environmental and conservation assessments and specific studies about wind, soil and water conditions to determine construction and operation conditions.

Scotland's marine sector plan for offshore wind energy is based on government-led environmental and socio-economic impact assessments to identify locations for offshore wind energy deployment. The assessments are designed to identify potential constraints to steer future investigations by developers.

Australia's "declared areas" policy is an example where the government identifies broad areas where renewable energy development could potentially be feasible, having identified and undertaken some consideration of potential conflicts with other users, interests, and values.

The Danish "open door" policy is an example where government plays a limited role by inviting developers to conduct comprehensive studies and assessments to identify areas where renewable energy development could be feasible.

Annex 3 includes detailed information on several other jurisdictions' approaches to offshore wind regulation.

We propose a developer-led approach to feasibility

From overseas experience it is clear that information can be gathered by the government, a developer, or a combination of both. However, balancing competing uses, interests, and values is always performed by a government and the choice is about when it occurs – prior to feasibility or when the developer is ready to construct. The choice of timing is influenced by how much baseline information is available to confidently balance other uses, interests, and values.

The potential advantages of greater and earlier government involvement in feasibility are:

- increased investor confidence through government balancing competing uses, interests, and values up front (rather than at construction) and allocating space for renewable energy generation
- wider dissemination of environmental and other information to all interested parties, and
- data standardisation.

On the other hand, the potential advantages of a developer-led approach are:

- greater opportunity for developers to identify optimal areas for development, with the lowest levelized cost of energy generation
- more timely development where developers are incentivised to conduct feasibility analysis, and
- fewer costs for government.

Timing is a key consideration in choosing an approach for Aotearoa New Zealand. In the short-to-medium term, progressing a government-led approach to gathering feasibility information could mean materially slowing down the development of offshore renewable energy development in New Zealand. As outlined in Chapter 2, offshore renewable energy has potential to contribute to our emissions reduction goals. Adding the time for a potential government-led sectoral planning exercise to existing offshore development timelines (ten years plus) would delay and possibly undermine the ability of offshore renewable energy to contribute to these important goals.

There are also a number of offshore renewable energy developers, specifically offshore wind developers, exploring Aotearoa New Zealand right now. They are operating in an environment in which international demand for offshore wind is growing rapidly, with opportunities in many countries. Therefore, even once some form of government-led assessment, such as a marine spatial plan, has been completed, it cannot safely be assumed that developers will be ready and waiting to resume activity. This could result in even further delays to activity or an absence of activity altogether.

Below we discuss two options for implementing a developer-led approach to improve our understanding of where offshore renewable energy development could occur in New Zealand.

More government involvement may be suitable and possible in the medium-to-long term

Internationally, there is a trend towards using government-led processes, though this often reflects the result of a gradual maturing of the market. In the Netherlands, for example, prior to its adoption of a "one-stop-shop" in 2013, developers were responsible for initiating site selection and verification.

More and earlier government involvement in the medium-to-long term would align with proposed reforms of our resource management system that will gradually introduce regional spatial strategies that will identify areas for specific uses, including in the territorial sea. However, no equivalent planning process is proposed for the exclusive economic zone right now, where most offshore renewable energy development is likely to occur. Annex 2 describes the proposed replacement of the Resource Management Act 1991.

6. What role do you think government should have in gathering feasibility information for offshore renewable energy development?
7. Do you agree that, at least in the short-to-medium term, a developer-led approach to gathering feasibility information is appropriate for Aotearoa New Zealand? Why or why not?
8. Is there another approach not considered above that may be more suitable?

Implementing a developer-led approach

We propose a developer-led approach to gathering feasibility information that could be used in the preparation of relevant consent and other permissions to construct and operate. As this will involve a significant investment, developers are seeking the confidence to invest without the potential for a different developer gaining priority over them through a first-in-time consent application over the same location.

To address this, we compare two options below:

- **Option 1:** establish a permit for feasibility activities that would provide a sole right to apply for later permissions to construct and operate, or
- **Option 2:** enable a collaborative approach among developers, government and iwi, hapū, and whānau.

Option 1: Establish a feasibility permit with rights to apply

Under this approach, the government would grant permits over specific offshore areas (with limits on size) for the purpose of conducting feasibility activities. The permit would offer the holder a sole right to apply for subsequent permissions to construct and operate offshore renewable energy infrastructure, but would not guarantee these permissions.

Permit holders would remain responsible for complying with all relevant legislation when carrying out their feasibility activities, including relevant requirements under the RMA and EEZ Act.

We note that other general research and activity in a given area would not be prohibited. The permit would only apply to feasibility activities undertaken for the purpose of seeking later rights to construct and operate renewable energy generation.

The advantages of a feasibility permit are:

- **The ability to select the developer and development**: The government needs to consider whether the developer and development is appropriate for New Zealand's national interests.

A permitting approach enables the government to assess initial proposals against defined criteria in a competitive manner.

- **Improved investor confidence**: With a permit providing a sole right to apply for construction and operation, a developer could be assured that their investment in feasibility will be justified as they will have an advantage compared with other developers. This will reduce investment uncertainty for offshore renewable energy developers.
- **Provide for participation by mana moana**: A permitting approach enables government to set specific and enforceable criteria to ensure that Māori participate in the feasibility process.
- **Timely and efficient**: Permitting is a familiar model in New Zealand (in the Crown minerals regime) and internationally, with clear roles and responsibilities. This experience would make a permitting approach more straightforward to establish and administer.

There are a range of considerations in establishing a feasibility permit, which we examine below.

Option 2: Enabling collaboration among developers

As an alternative to granting exclusive feasibility permits, the Government could enable an approach whereby interested developers, the Crown and Māori collaborate to conduct feasibility activities. Technical studies and environmental assessments are an obvious area for collaboration, while more commercially sensitive assessments may not be suitable.

A collaborative approach need not be formally regulated, but a formal agreement would be needed between all parties, including cost-sharing arrangements.

These participating developers would effectively have an exclusive opportunity to apply for subsequent permissions to construct and operate, since other non-participating developers would lack the detailed site information necessary to seek these permissions.

Following the feasibility assessment, developers would individually choose whether to seek permissions to construct and operate, and over what sites that were identified through the collaborative feasibility assessment process.

The advantages of a collaborative approach are:

- The possibility of **lower costs and efficiencies** through pooling resources and skills.
- The possibility of **more, better-quality data**. The collaborative approach may allow a greater quantity and quality of data to be gathered through pooling of resources, skill sets, and cooperation.
- **Developers and developments would be selected later** in the project lifecycle. The government could take a decision on the competitiveness of a developer in meeting criteria based on a greater degree of information.

The drawbacks of a collaborative approach are:

- **Lower investment confidence:** This approach is unlikely to provide sufficient investment certainty to developers, which would risk developments proceeding, and therefore not achieve the objectives set out in this document.
- **Higher administrative costs:** There may be higher administrative costs for all parties in negotiating to set up a collaborative approach, which may also take significant amounts of time.

We see a strong case for a permitting approach, but seek your views on the viability of the collaborative model

International experience and the observations of developers active in Aotearoa New Zealand suggest that reducing investor risk is a prerequisite to greater investment in feasibility analysis. An exclusive feasibility permit could make a significant contribution to reducing investor uncertainty, while helping to mitigate the first-in-time features of the current resource management system. A collaborative model could be preferable if it is viable. We seek views on the viability of the collaborative model, including how it could function in practice.

9. Do you agree with the two shortlisted options (permitting and collaborative) that we have identified? If not, what other viable options might we be looking at?
10. Assuming a developer-led process to propose sites and assess feasibility, do you think the permitting approach or the collaborative approach would deliver a better outcome for Aotearoa New Zealand and why?
11. How could a collaborative approach be designed to enable the objectives set out above, and what could the government do to support collaboration?
12. Have we captured a complete list of trade-offs between the two shortlisted options? What else, if anything, should we be considering?

Chapter 5: Māori involvement in the assessment of feasibility

Regardless of the approach chosen by Government to manage feasibility activities, sufficient involvement of local iwi, hapū, or whānau will be required to determine feasibility and understand the potential environmental and cultural impacts.

Above, we noted the various interests and information that iwi, hapū, and whānau have, which will be critical to inform any future decisions on a development. As we prefer to take a permitting approach, this section focuses on the requirements that developers might be required to meet to involve iwi, hapū, or whānau both before and during any feasibility assessments. Appropriate involvement would, however, also need to be provided for if a non-permitting approach was used.

In seeking to apply for a feasibility permit, developers could be required to:

- demonstrate a sufficient level of initial discussion with relevant iwi, hapū, or whānau about the potential development prior to applying for a permit
- demonstrate an understanding of Te Tiriti o Waitangi, mātauranga Māori, tikanga principles and the aspirations or interests of the mana moana of the area in which feasibility activities are being proposed
- demonstrate initial understanding of those areas where a development may impact existing rights or tikanga, and how information will be gathered to further understand these impacts, and
- provide a plan for how the feasibility assessment process will meaningfully involve iwi, hapū, or whānau throughout, including which tikanga and environmental issues that will need to be assessed in more detail with the involvement of iwi, hapū, or whānau.

Throughout the duration of the permit, developers could be required to:

- identify impacts of the proposed development on any legal rights, on tikanga and taonga species
- incorporate mātauranga Māori in identification of the potential impacts
- identify relevant economic interests in the construction and operation of the development, and a plan for implementing these if the development proceeds, and
- show how the plan for iwi, hapū, or whānau involvement is being met.

Some enforcement mechanism is likely to be required to ensure that iwi involvement occurs throughout the preparation of feasibility activities. This could occur through a regular reporting mechanism, and/or penalties for non-compliance.

We acknowledge that greater participation, which involves and empowers mana moana to play a more active role, will have significant impacts on time, resources and capability of both developers and mana moana.

As has been the case for other permitting regimes, guidelines could be prepared for developers. There will also be a continuing role for the Crown to provide support and advice, which we are considering in assessing the proposals in this document.

13. What broad opportunities do you see for iwi, hapū, and/or whānau to be involved in the feasibility stage of development (both before and during feasibility activities)?
14. Are the above requirements sufficient to achieve this? How can the requirements be implemented to reduce undue burden on mana moana or developers?
15. What information/mātauranga Māori and process/tikanga will be important for developers to incorporate into their feasibility plans, and how should iwi, hapū, and/or whānau be involved in gathering this information?
16. What mechanisms for monitoring and enforcing these requirements are appropriate (regular reporting by developers that is reviewed by iwi etc)?
17. How should the adequacy of iwi involvement be assessed? What does good faith and meaningful participation look like?

Chapter 6: Considerations for a permitting framework

If establishing feasibility permits is the preferred option, there are a number of further considerations in the design of the process and the permit.

Criteria to obtain permits

Feasibility permits would be granted to the applicant with the strongest qualifications to complete the feasibility assessment. As the feasibility permit-holder would have a right to apply for subsequent permission to construct and operate, the criteria would need to make an initial consideration the developer's potential capability for these later stages. Further consideration would also be done based on the feasibility information once prepared, in order to seek any consents or other permissions to construct and operate.

Internationally, criteria for assessing the capability of developers to deliver projects on time typically include technical and economic feasibility of proposed project design, technical and management experience, and capability to provide or raise finance.[xx]

We are considering the following criteria:

- technical, financial and commercial capability of the developer, and
- whether the proposed development is not contrary to Aotearoa New Zealand's national interest.

Technical, financial and commercial capability

Offshore energy generation is technically complex. By requiring evidence of capability to install, operate, maintain, and decommission energy infrastructure, the government would have assurance that applicants had the necessary technical capability.

We propose to assess the following information to determine technical capability:

- a track record of successfully managing similar projects
- clear project plans, including accurate identification of critical planning and obtaining relevant consents in the project schedule
- an assessment of the complexity of the project, and appropriate risk mitigations
- the technical advice that will be available to the applicant, and
- relevant information on the applicants' ability to comply with relevant legislation (including health and safety).

Offshore energy generation is a high cost and commercially complex operation. By requiring evidence of sufficient financial means, commercial sophistication, and business planning capability, the government would have assurance that applicants had the necessary revenue and commercial expertise.

We propose to use the following criteria in assessing financial and commercial capability:

- evidence of a strong financial position
- satisfactory initial financing arrangements
- an indicative business plan for a subsequent commercial development phase (construction, operation, and decommissioning)

- evidence that key project risks have been identified
- the intended route-to-market for the project, and
- the estimated commercial return to the developer.

National interest considerations

Offshore renewable energy infrastructure could be a significant part of Aotearoa New Zealand's electricity system. Therefore, we consider that a feasibility permit should be granted only if the prospective development is not contrary to Aotearoa New Zealand's national interest.

To ease administrative burden and maintain legislative coherence, we propose to align these criteria with the Overseas Investment Act 2005. Under this Act the bar for requiring mitigation action or prohibiting a transaction is high and the presumption is that overseas investment is in New Zealand's national interest.[xxi]

Core interests that could be considered include:

- national security, public order, and international relations
- competition, market influence, and the economy
- economic and social impact
- alignment with New Zealand's values and interests (consideration is given to broader issues – for example, environmental policy, and giving better effect to Te Tiriti o Waitangi), and
- the character of the investors.

Permit holders would need to continue to meet the qualification criteria

Given the potentially long duration of a permit and the scale of investment, ensuring permit holders continue to meet the criteria for obtaining a permit is highly desirable.

Most commonly, ownership structures of permit holders may change over time (eg changes in directorships, acquisitions or mergers). Permit holders may also wish to sell or share their interests (ie a transfer of ownership).

These changes can make a material difference to the suitability of a permit holder to continue feasibility activities and carry out further development activities in the future. To ensure a permit holder continues to meet the criteria to hold a permit, we propose regulations could:

- empower a regulator to review the suitability of a permit holder when there is a material change to ownership, with the ability to revoke permits, and
- require permit holders to seek approval to transfer any interests in a permit.

Having the ability to impose conditions or review permits allows any risks around timely development to be effectively managed. In particular, effective review mechanisms would enable ongoing consideration of national interests and financial capabilities which are likely to change over time.

Similar mechanisms are included in the Crown Minerals Act 1991 to ensure permit holders continue to meet the legislative requirements for obtaining minerals permits.

Duration of a permit

International experience suggests that the time to complete feasibility activities for an offshore wind farm – the most mature form of offshore renewable energy generation – can take from three to five years. In Scotland, Option Agreements (an equivalent to permits) are valid for up to 10 years. In Australia, feasibility licences are valid for up to seven years. The Crown minerals permitting regime in Aotearoa New Zealand awards minerals exploration permits for 10 years.

Since the process for obtaining feasibility rights would be robust, it is likely that only committed developers would obtain them. However, there is still a risk that some developers would seek feasibility permits simply to obtain the option of conducting feasibility activities. This type of 'land-banking' activity would stall the industry's development.

A shorter duration for permits, such as five years, and/or 'use-it or lose-it' provisions could mitigate this risk, by requiring permit holders to begin feasibility work in earnest within a set time-period. While any time-period will be arbitrary, a 12-month period within which feasibility work must begin appears reasonable. Where feasibility work does not begin within this period, permits could become invalid.

We therefore propose:

- feasibility permits to be awarded for a period of five years, with an option to extend durations for up to two years for unavoidable delays, and
- a 12-month period in which activities must commence for permits to remain valid.

It could be difficult to identify clear tests for whether a project has commenced, and hence whether 'use it or lose it' provisions would be triggered. These tests could be linked the feasibility project's planned milestones.

In any case, it could be useful for permit-holders to provide annual reports on the progress of their feasibility activities.

Managing overlapping applications

The offshore areas where energy generation is feasible are finite. It is very likely that developers will seek feasibility rights for overlapping areas. Overlaps could be large or small.

The government will assess applications for permits based on which developer best meets the criteria. It may however be beneficial to amend the size of the area applied for in cases of overlap, so that two developers can assess feasibility side by side. This could be achieved by a mechanism allowing two applicants to negotiate or amend their proposals, or for the government to make a decision on an amended application based on who best meets the criteria.

Criteria for permits

18. Do you agree that developers should be required to meet prequalification criteria to be eligible for exclusive feasibility rights?
19. Are our proposed criteria appropriate? Are they complete? If not, what are we missing?

Change in status

20. How should we consider material changes to permit holders' status and capability? Do you think mechanisms to review permit criteria would be appropriate?

Duration of permits

21. Do you agree that a feasibility licence should last for five years with an option to extend for a further two years?
22. Do you agree that a feasibility licence should be subject to 'use-it or lose-it' provisions, with permits not exercised within 12-months lapsing? What circumstances would trigger the use it or lose it provisions?

Managing overlapping applications

23. How should government best deal with the issue of overlapping applications?

Administrative arrangements for permitting

A single national entity would manage the offer and application process

As the development of offshore renewable energy infrastructure is a nationally significant activity it is desirable to provide a nationally consistent approach to inviting and assessing applications for permits and managing permits. This suggests a single national entity should hold these responsibilities, with opportunities for iwi, hapū, and whānau and the community to inform the allocation of permits, and to participate in the conduct of feasibility activities.

This single national entity could be an independent Crown entity, or an existing government department or ministry. The Ministry of Business, Innovation, and Employment could be a natural choice given its policy responsibilities in the energy portfolio, and existing regulatory role for Crown minerals. The Ministry may require additional resources to develop the necessary capability for this role.

Final decisions on applications could sit with the single national entity, or the Minister of Energy and Resources, acting on advice from officials.

Public submissions could be sought on permit applications

There will be widespread public interest in proposals and preparations to conduct feasibility activities towards establishing offshore energy generation.

Developers have, to date, publicised their intentions, including areas of interest to them. Resource management consent processes may also involve public notification. The process for assessing applications could involve a period of public consultation.

Monitoring compliance through ongoing reporting

Ensuring permit holders continue to comply with any obligations or conditions relating to their permit will require ongoing monitoring and disclosure requirements.

The Government could prescribe standards for reporting which set out the information that needs to be disclosed, the quality of this information, and by when. This could also include public disclosure requirements or notification requirements to ensure Māori and local communities have access to the information. Alternatively, the information provided could be held by government if the information is considered to be commercially sensitive.

Information that we consider should be reported on includes:

- feasibility activities being conducted and next steps (akin to a project update)
- data or other information gathered from feasibility activities
- participation of mana moana
- engagement with local communities
- financial statements, and
- ownership structures of interest holders

While ongoing reporting adds an administrative burden, regular reporting is critical to maintaining productivity (ie permit holders are conducting feasibility activities and progress is being made), compliance with permit criteria, and any conditions that apply to a permit.

Compliance measures could be needed

To facilitate compliance, the government would apply the VADE model. VADE stands for voluntary, assisted, directed and enforced. The VADE model is commonly used by regulatory agencies across the New Zealand government. The government's first preference will be to ensure compliance through dialogue. Instances of non-compliance could lead to infringement notices, compliance orders, or (as a last resort) the loss of rights to conduct feasibility activities.[3]

Managing and funding the offer and application process

24. Do you agree that a single national entity should hold responsibility for inviting and assessing applications?
25. Do you agree that the Minister of Energy and Resources, acting on advice from officials, should make the final decision on applications for permits?
26. Do you agree with charging fees sufficient to recover the costs of inviting, and assessing feasibility permit applications, and monitoring permit holders?
27. What other steps would ensure that processes are transparent and fair for developers?

Ensuring wider consultation

28. Do you think that public submissions should be sought on permit applications? What other steps would ensure sufficient opportunity for iwi , hapū, whānau, and stakeholders to inform decision-making?

Ongoing reporting obligations

29. Do you agree that permit-holders should regularly report on the progress of their feasibility activities? How frequently should the reporting be?
30. What reporting standards should the Government set to make the disclosures meaningful?
31. Who should have access to this information? How should it be shared?

Ensuring compliance

32. Do you agree that developers not complying with obligations could face compliance actions, with risk loss of rights to conduct feasibility activities as a last resort? What sorts of non-compliance could lead to the loss of these rights?

[3] https://www.nzpam.govt.nz/how-we-regulate/our-regulatory-operating-model/

Chapter 7: Information on existing uses, interests, and values

Aotearoa New Zealand's territorial sea (up to 12 nautical miles) and exclusive economic zone (between 12 and 200 nautical miles) are home to a number of cultural, recreational, environmental and economic uses, interests, and values. Any offshore renewable energy developments could either co-exist or come into conflict with these uses, interests, and values. It is important that we identify the ones that may come into conflict early on. In the future, it will also be important to consider how any offshore renewable energy developments and other uses could co-exist (or be co-located) in the same space. While it may not be realistic to map broad and intangible interests, such as those pertaining to Tikanga Māori, (including kaitiakitanga and whanaungatanga) these remain important to considering the feasibility of establishing offshore renewable energy.

The range of uses, interests, and values in Aotearoa New Zealand's territorial sea and exclusive economic zone would include:

- **Iwi, hapū, whānau / Māori , Te Tiriti o Waitangi**
  - Takutai moana legislation decisions and application areas
  - Treaty of Waitangi (Fisheries Claims) Settlement Act 1992
  - Māori Commercial Aquaculture Claims Settlement Act 2004
  - Customary fishing areas,
  - individual historic treaty settlements, and
  - food gathering or landing place of ancestral canoes considered to be wahi tapu.
- **Economic**
  - commercial fisheries
  - tourism activities, and
  - aquaculture.
- **Environmental**
  - closed seamounts
  - benthic protected areas
  - marine protected areas under the marine management Acts
  - marine reserves, and
  - marine mammal sanctuaries.
- **Safety**
  - high-traffic shipping routes
  - cable and pipeline protection zones
  - New Zealand Defence Force firing practice, exercise and submarine safe bottoming areas, and
  - safety zones around existing petroleum and minerals mining infrastructure.
- **Social**
  - recreational fishing.

Where data is available, we have mapped a non-exhaustive range of identified existing uses, interests and values in the three regions currently being explored for offshore renewable energy potential. Annex 5 provides full size versions of these maps.

33. Are there other uses, interests, and values not covered above that can be readily mapped? What are they?
34. Of the uses, interests, and values identified above, which ones do you consider should be prohibitive, ie the existence of those uses, interests, and values in a given area should exclude an area from consideration for offshore renewable energy generation? Why?
35. What opportunities do you envisage for offshore renewable energy developments and other uses, interests and values to co-exist, or be co-located in the same space?
36. How could conflicts with existing uses, interests and values be managed?
37. What uses, interests and values cannot readily be mapped? How should these be taken into account when considering the feasibility of establishing offshore wind farms?

Annex 1: Location of interest maps

Waikato

Figure 1 shows the highest level of potential wind capacity to be near shore, however beyond the 60m depth contour (indicated by the outer limit of the light blue line) there is a relatively broad shelf of less than 200 m water depth and mean wind speed at 100m elevation in the order of 8.2 m/s within 60 km of the shore. The majority of the area is within 100 km of Transpower high voltage infrastructure with nearby significant major energy consumers.

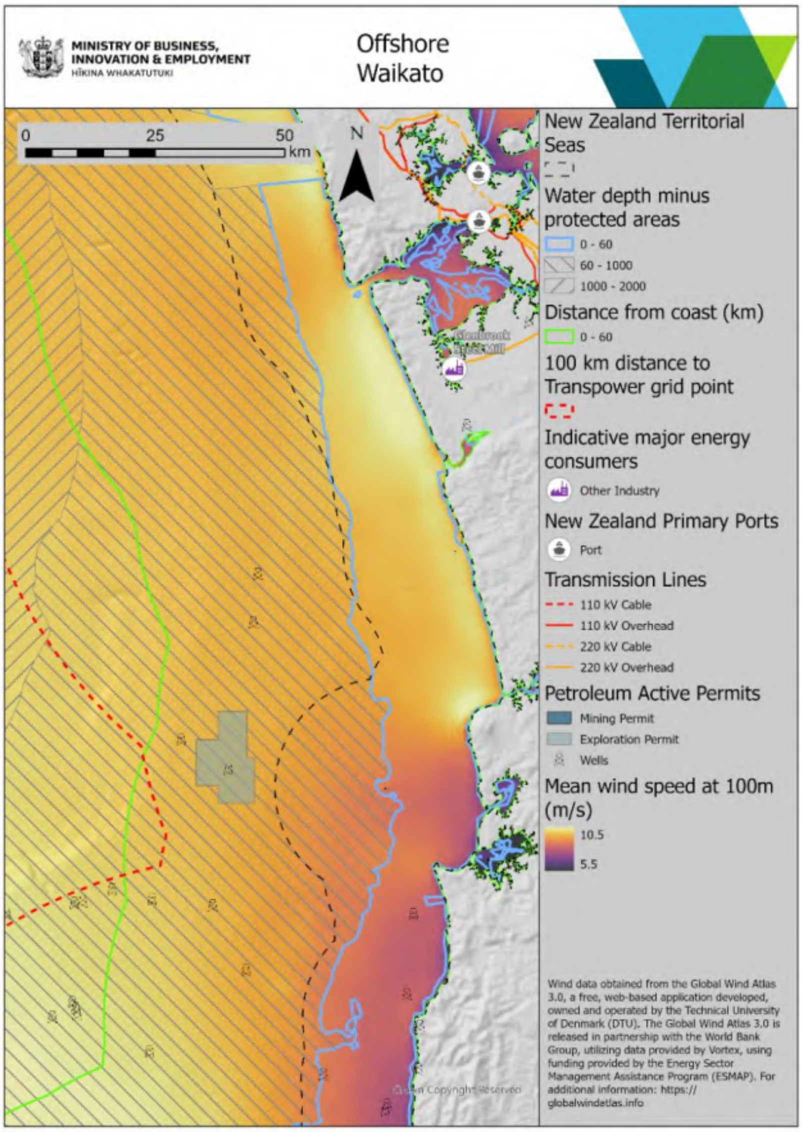


Figure 1. Wind potential and high-level constraints for development in Waikato

Taranaki

Figure 2 shows the highest level of potential wind capacity in the South Taranaki Bight, generally in water depths of less than 100 m. Mean wind speeds at 100m elevation are predominantly in the range of 8 – 11 m/s within 60 km of the shore. The majority of the central and northern area is within 100 km of Transpower high voltage infrastructure with nearby significant major energy consumers. It should be noted that there are relatively high levels of constraints due to existing oil and gas industry infrastructure (petroleum platforms and wells, and three pipeline protection corridors) and minerals and petroleum permits, and New Zealand Defence Force areas.

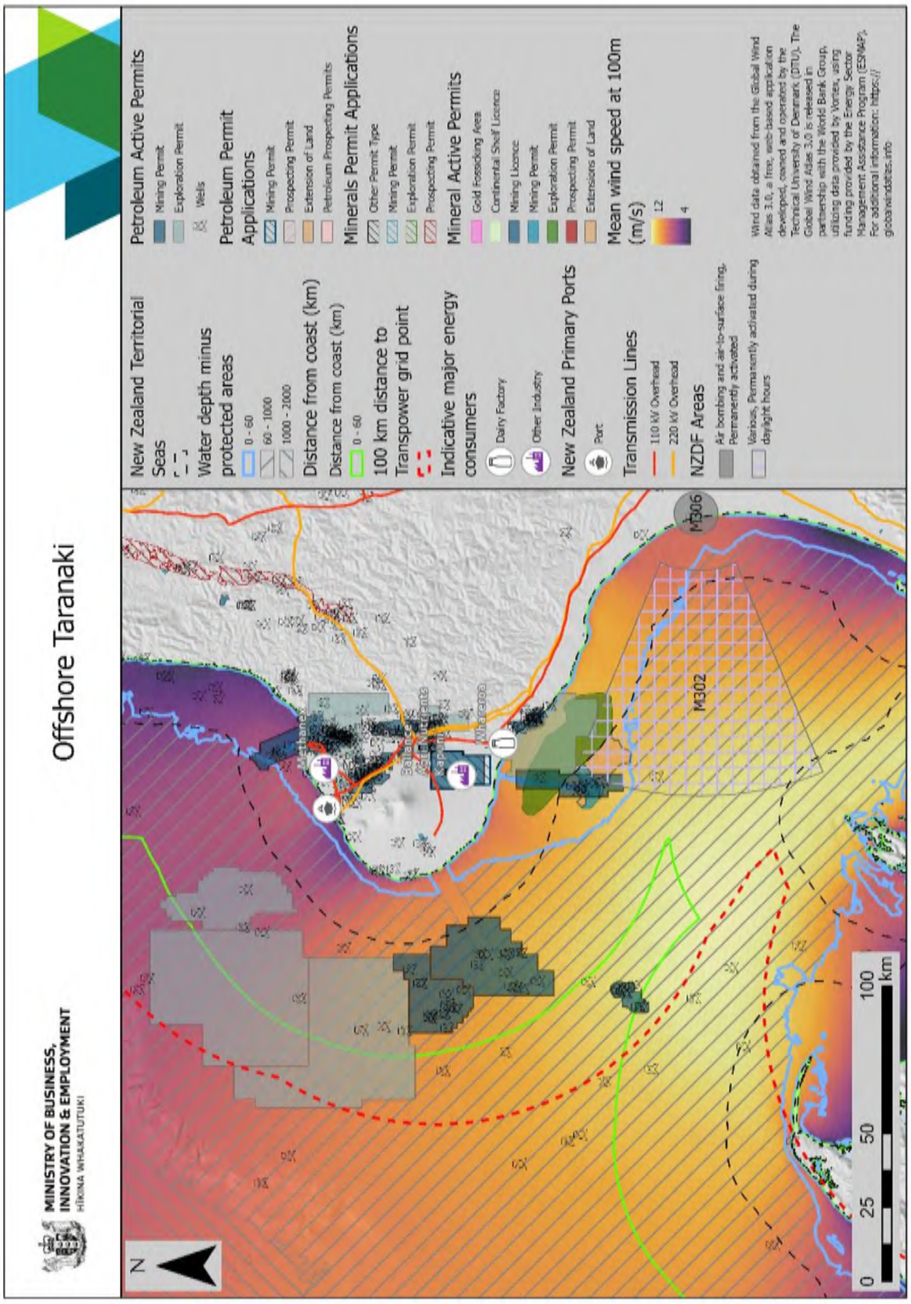


Figure 2: Wind potential and high-level constraints for development in Taranaki

Southland

Figure 3 shows the highest level of potential wind capacity to towards the south and west of the area, however this is constrained by water depth and distance to shore connection. Of the eastern areas within 60 km from shore, water depth is predominately less than 100 m, with mean wind speeds at 100m elevation in the order of 10 m/s. Of the area within 100 m water depth, the majority is within 100 km of Transpower high voltage infrastructure with nearby significant major energy consumers. There are relatively high levels of commercial fishing in and around Foveaux Strait.

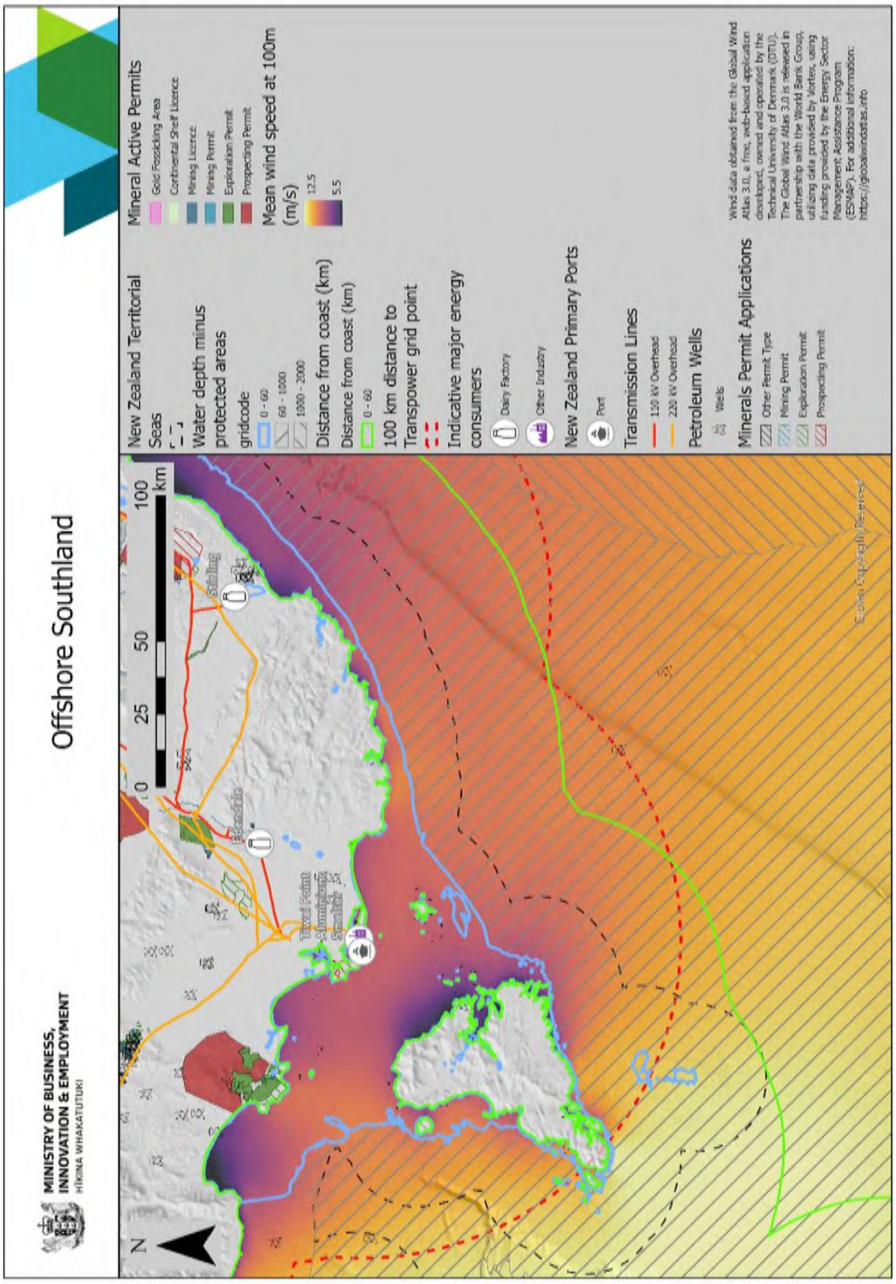


Figure 3. Wind potential and high-level constraints for development in Southland

Annex 2: Proposed resource management reforms

A proposed new resource management (RM) system will be delivered through two Acts: the Spatial Planning Act (SPA) and the Natural and Built Environments Act (NBA). The SPA and NBA will cover the onshore environment, and the territorial sea.

The system is being designed to help drive desirable outcomes, not just prevent unacceptable effects.

The SPA requires that there be a regional spatial strategy (RSS) for each region. Each RSS will set out the major changes desired in the region, including major new urban development, major shifts in regional economic development, changes in land use to deal with expected natural hazards, major shifts in how coastal space and water are used, landscape scale restoration programmes for biodiversity, landscape scale restoration of degraded land, etc.

The RSS will be developed by a committee that includes central government, local government, and iwi, hapū, and whānau representatives.

The RSS work will have to be consistent with the National Planning Framework (NPF) – a single set of national direction delivered under the NBA. That will incorporate what is currently in national policy statements such as the New Zealand Coastal Policy Statement, and National Environmental Standards. It can set both high-level policy direction, and detailed rules that apply to specific activities or environments.

The committee creating the RSS will also have to have particular regard to specified government policy statements, such as the Government Policy Statement on Transport. These will be listed in a schedule.

The RSS will be binding on NBA plans, but also on regional land transport plans and Local Government Act 2002 investment decisions. There will be an implementation plan to identify who will be delivering the desired outcomes, and there can also be detailed implementation agreements to ensure joined-up effort. For example, an implementation plan for improving port capacity by developing an inland port might involve the Port Company, KiwiRail, and a council.

One NBA plan per region will replace existing regional and district plans. These will be able to incorporate clear allocation processes for use of coastal space. NBA plans must be consistent with the RSS and give effect to the NPF. The plans will be prepared by the same committee that prepared the RSS (the Regional Planning Committee).

Annex 3: International models for offshore renewable energy regulation

Internationally, governments have adopted different approaches for regulating offshore renewable energy, in particular wind energy. There are key choices as to the role of government in conducting feasibility activities, and when to grant exclusivity to developers. Governments have taken different approaches to these choices and have evolved their approaches over time.

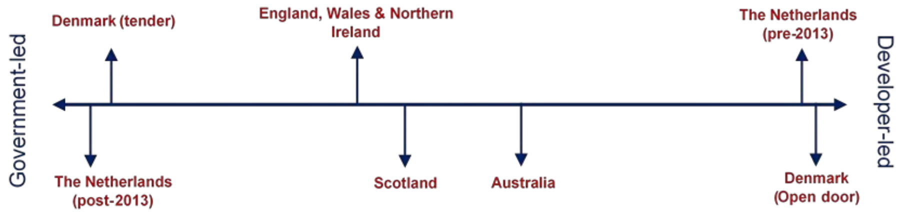


Figure 4. Continuum of international approaches to assessing feasibility for offshore renewable energy

In the early stages of an industry's development, a key question is how to identify potential areas for development and what role government should play in this. The degree of government involvement also tends to inform the point in the development cycle at which developers are granted exclusivity. This is either done at the feasibility stage or prior to construction and operation.

Usually when developers take-up responsibility for feasibility assessments, and incur the associated costs, they also seek site exclusivity. Exclusivity is the agreement that only one developer can conduct feasibility assessment in a given site, and (potentially) proceed to construction and operation. Exclusivity can be granted through instruments such as leases, options, permits, or licences.

The regimes operating in the Netherlands, Australia, Denmark, and the United Kingdom show how countries have taken different approaches to these questions.

The Dutch model

Although today the Netherlands is a leader in cost-efficient offshore wind development and installation, only a few offshore wind farms were built in the Dutch Economic Zone of the North Sea until 2017. This is often attributed to the fact that project developers were responsible for site selection and investigation, as well as having to go through the permitting process for projects with no guarantee projects would be approved – facing high costs and risks. However, in 2013, amidst accelerated climate ambitions and the start of the Dutch energy transition, the Government changed their approach and committed to assigning and developing offshore wind zones in the Dutch sector of the North Sea.[xxii]

Since 2013, the Dutch Government has used a National Water Plan to designate areas for offshore wind energy deployment. In a more proactive approach than before, the government selects locations in these areas, and specifies conditions of construction and operation. Environmental and conservation assessments are performed. The government also performs specific studies about wind, soil and water conditions in order to determine construction and operation conditions. Based on the outcomes of these assessments and studies, a private developer is selected by a tender process to construct and operate the project.[xxiii] The government can recover the costs of these assessments and studies from the party who is granted the permit.

The Australian model

Australia has followed a similar process to Scotland, except it does not have a marine spatial plan. Instead, Australia's Offshore Electricity Infrastructure Act 2021 provides for the Minister for Climate Change and Energy to declare areas that are suitable for offshore renewable electricity infrastructure.[xxiv] In deciding whether an area is suitable for offshore renewable energy infrastructure, the Minister must have regard to the potential impacts of the construction, installation, commissioning, operation, maintenance or decommissioning of offshore renewable energy infrastructure in the area on other marine users and interests. The Minister must also have regard to any submissions received as part of the mandatory consultation process on proposed declared areas; Australia's international obligations in relation to the area; and any other relevant matters.

The Government of Australia has recently proposed an area in the Commonwealth waters off Gippsland, Victoria for offshore renewable energy projects.[xxv] Consultation on the proposed area included a non-exhaustive list of identified users and interests to facilitate conversations about the suitability of the area.[xxvi] These included:

- Native title – developers need to understand their obligations if land-based transmission infrastructure is proposed.
- Commercial and recreational fishing – developers will need to undertake consultation with the local community and demonstrate how they will share the area with other users and will also need to have a plan for gathering and responding to ongoing feedback from stakeholders throughout the life of the project.
- Natural environment – matters of National Environmental Significance, such as the Orange Bellied Parrot, Pygmy Blue Whale, and threatened Albatross species are identified. Developers need to seek relevant environmental approvals to proceed.
- Existing oil and gas titles and infrastructure – developers need to undertake consultation and demonstrate how they will share the area with other uses and have a plan for gathering and responding to ongoing feedback from stakeholders throughout the life of the project.
- Tourism – developers need to assess how projects could affect participation in tourism and recreation.
- Defence – consultation with the Department of Defence is required in relation to Defence Practice Areas.
- Vessel traffic – high volume shipping channels, including traffic separation schemes, are excluded from the area.
- Weather radars – developers need to work with the Bureau of Meteorology to mitigate any service impacts.

Developers select the boundary and size of specific sites and apply for feasibility licences, which can be granted for a period up to 7 years.

Figure 5. Australian offshore renewable energy infrastructure development process, Source: Australian Government: Department of Climate Change, Energy, the Environment and Water

The United Kingdom model

The United Kingdom, which has the largest installed offshore wind generation globally, operates a four-stage leasing process to grant exclusive leases for exploration and feasibility assessments.

Seabed leasing for existing offshore wind farms has been managed by The Crown Estate through several leasing rounds that began in 2000. In 2017, a new body, Crown Estate Scotland, was formed to own and manage the seabed in Scottish Territorial Waters and adjacent areas of the United Kingdom Exclusive Economic Zone. The Crown Estate retains responsibility for the seabed in England, Northern Ireland and Wales.

Before the consenting process can begin, the developer must secure a seabed lease from The Crown Estate or Crown Estate Scotland. Leases are granted through a competitive tender process following the identification of broad areas for development.

The exact process for obtaining for leases and consents varies across the United Kingdom. In England, a Development Consent Order is granted under the Planning Act 2008 which incorporates a number of consents, including a marine licence and onshore consents. Whereas in Scotland, Marine Scotland examines applications for the offshore works and Scottish Ministers grant or refuse consent. However, the general process for seabed leases remains the same across the United Kingdom (as described below).[xxvii]

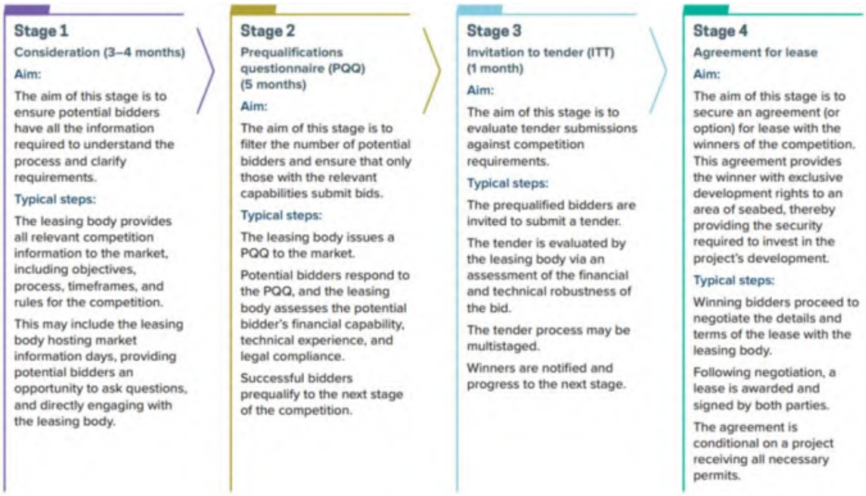


Figure 6. Offshore renewable energy infrastructure development process in the United Kingdom, Source: World Bank Group

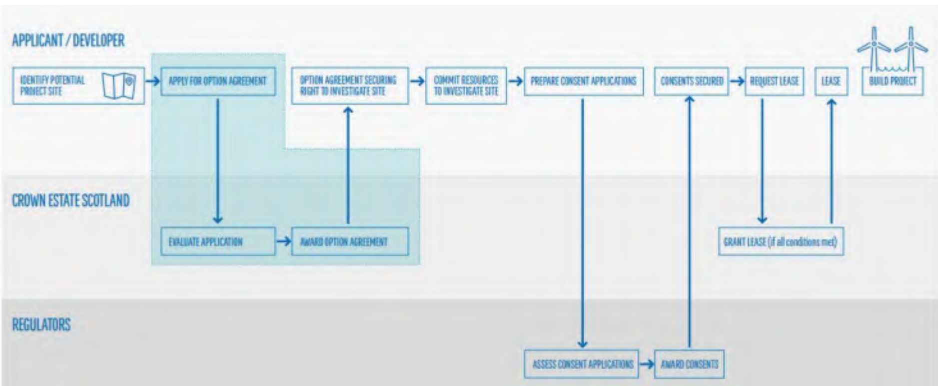


Figure 7. Offshore renewable energy infrastructure development process for Scotland, Source: Scottish Government, Marine Scotland Directorate

The Danish model

In Denmark, the establishment of offshore wind turbines can follow a tender procedure run by the Danish Energy Agency or an open-door-procedure. Most new offshore wind farms in Denmark are established after a tendering procedure. The Danish Energy Agency will operate a site-specific tender for an offshore wind farm, of a specific size, eg 200 MW. The site is awarded on the basis of the price the developer offers for producing electricity.

In the open-door procedure, the project developer takes the initiative to establish an offshore wind farm. The project developer submits an unsolicited application for a license to carry out preliminary investigations in the given area. The application must, as a minimum, include a description of the project, the anticipated scope of the preliminary investigations, the size and number of turbines, and the limits of the project's geographical siting. In an open-door project, the developer pays for the grid connection to land.

The Danish Energy Agency initiates a hearing of other government bodies to identify whether there are other major public interests that could block the implementation of the project before the Danish Energy Agency processes the application. Based on the result of the hearing, the Danish Energy Agency decides whether the area in the application can be developed, and in the event of a positive decision it issues an approval for the applicant to carry out preliminary investigations. If the results of the preliminary investigations show that the project can be approved, the project developer can obtain a licence to establish the project.

Annex 4: Aotearoa New Zealand's international obligations

Aotearoa New Zealand is party to the United Nations Convention on the Law of the Sea 1982 (UNCLOS) which provides the definitive legal order for the oceans under international law. UNCLOS enshrines freedoms of navigation and overflight, establishes maritime zones delimiting States' jurisdiction (including resource rights), and provides for protection and preservation of the marine environment, including living and non-living resources.

Aotearoa New Zealand has full sovereignty over its territorial sea, as well as the airspace and seabed and subsoil below. Within its exclusive economic zone (EEZ) Aotearoa New Zealand has rights to explore, exploit, conserve and manage the natural resources in that zone, including the production of energy from the water, currents and winds. Aotearoa New Zealand also has rights related to the construction and use of installations and structures in its EEZ and on its continental shelf, and has jurisdiction over submarine cables and pipelines constructed in connection with the use of natural resources. These rights are balanced against the rights of other states in Aotearoa New Zealand's EEZ, such as states' rights to lay cables/pipelines and freedoms of navigation and overflight.

Aotearoa New Zealand also has a number of obligations under UNCLOS related to protecting and preserving the marine environment. This includes taking all measures to ensure activities under its jurisdiction do not cause pollution to the environment of other States, and adopting (and enforcing) laws and regulations to prevent, reduce and control pollution from installations and structures within its jurisdiction.

UNCLOS also contains obligations relating to the decommissioning of infrastructure, including to consider any generally accepted international standards such as those established by the International Maritime Organisation. Aotearoa New Zealand is also a party to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters 1972 and its 1996 Protocol (the London Protocol) which stress the need to protect the marine environment from all sources of pollution, and prohibit dumping of waste at sea unless expressly permitted.

Annex 5: Mapping uses, interests, and values

Uses, interests and values of relevance in Waikato

Figure 8 shows the areas of customary rights and applications. As there is considerable overlap of areas, particularly within the Territorial Sea, readers are advised to consult individual information sources such as Te Kete Kōrero a Te Takutai Moana Information Hub[4] and the Ministry for Primary Industries NABIS web map[5]. Rohe Moana areas are labelled in italics starting with TK and generally extend seaward from the coast, however some extend onshore.

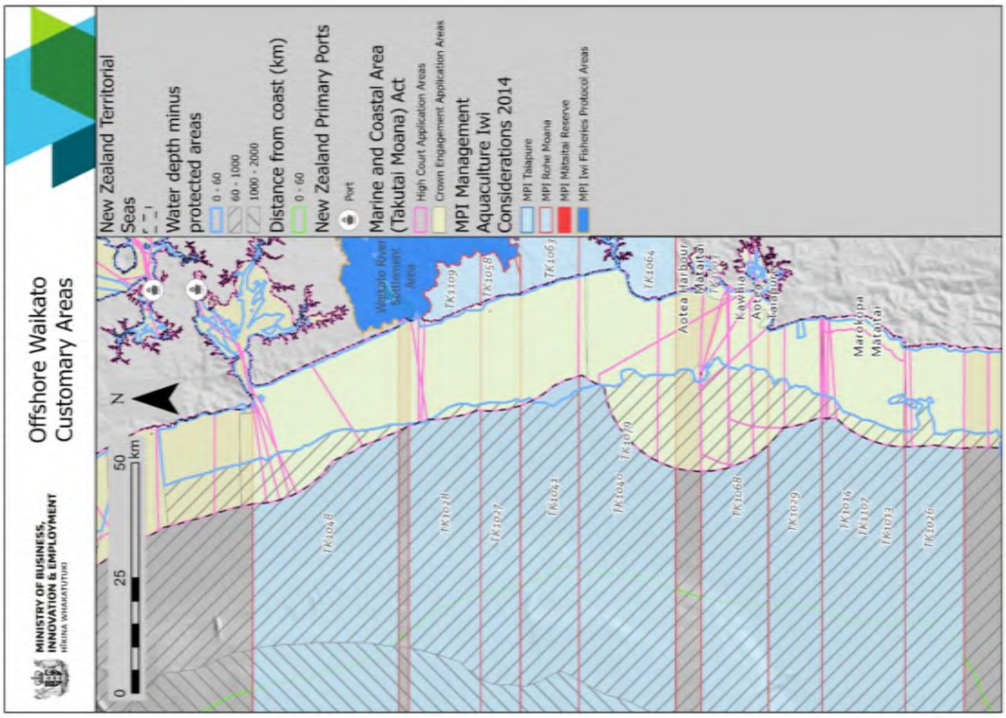


Figure 8

[4] https://maca-nds.maps.arcgis.com/apps/MapSeries/index.html?appid=1ed9665a8d2c4d38b4f9ddcb2d186f1b
[5] https://maps.mpi.govt.nz/templates/MPIViewer/?appid=96f54e1918554ebbaf17f965f0d961e1

Figure 9 shows the fishing intensity annually averaged commercial catch (kg/ha) from all fishing methods (except freshwater fishing) reported to the Ministry for Primary Industries (MPI) from 2007 – 2019.[xxviii] It can be seen that the highest levels of activity are along the continental shelf edge and slope, in water depths greater than 100 m. It should be noted that there are two submarine cable and pipeline protection zones on the map: a large zone to the north of the area and a small near shore zone just south of the Albatross Point headland.

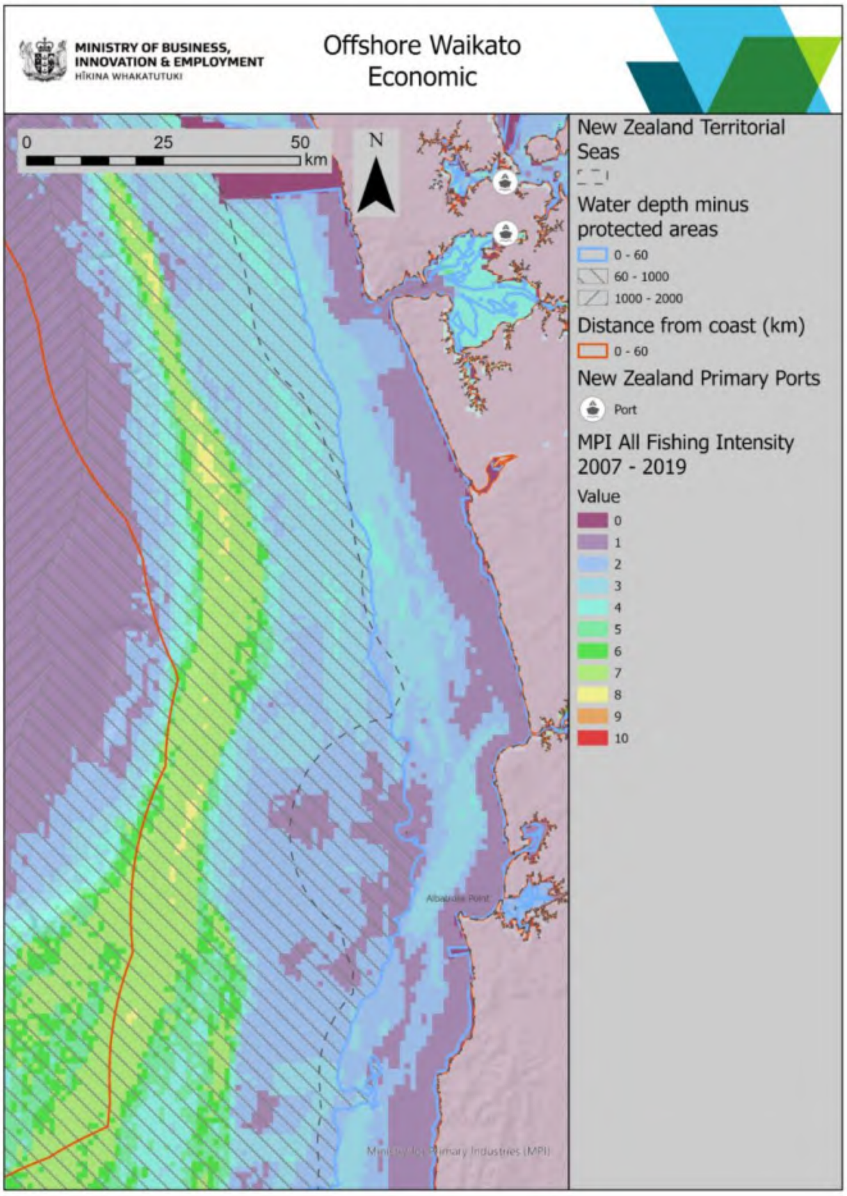


Figure 9

Figure 10 shows the extent of the Marine Mammal Sanctuary, which in this area is congruent with the Territorial Sea boundary (12 nautical mile). Within the extent of the map, Marine Reserves are limited to the inner Waitematā Harbour.

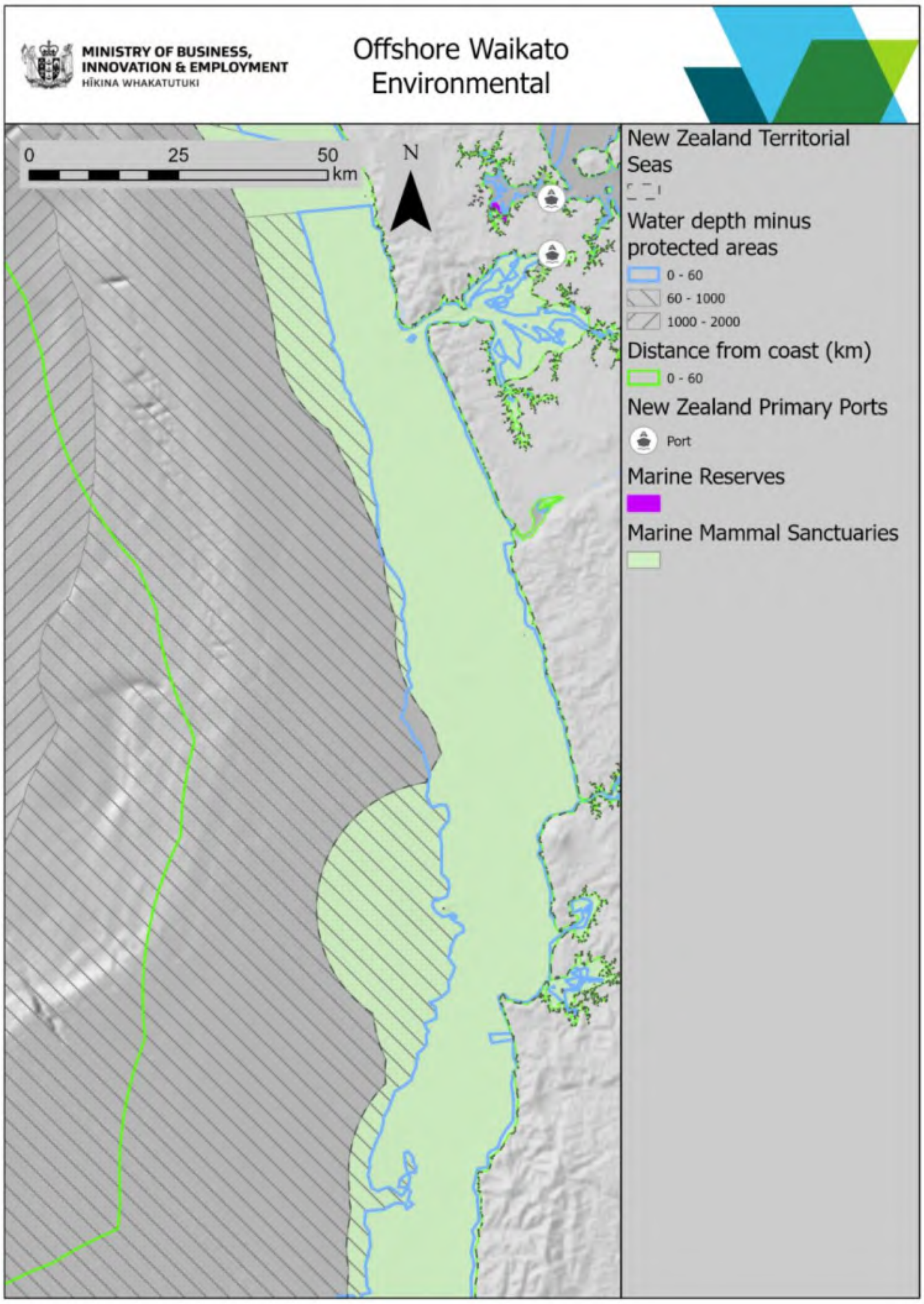


Figure 10

Figure 11 shows the reported position of vessels (of types noted in legend) operating an Automated Identification System (AIS) transponder for the year 2019. Higher density of vessel tracks indicates frequently used shipping "lanes". [xxix]

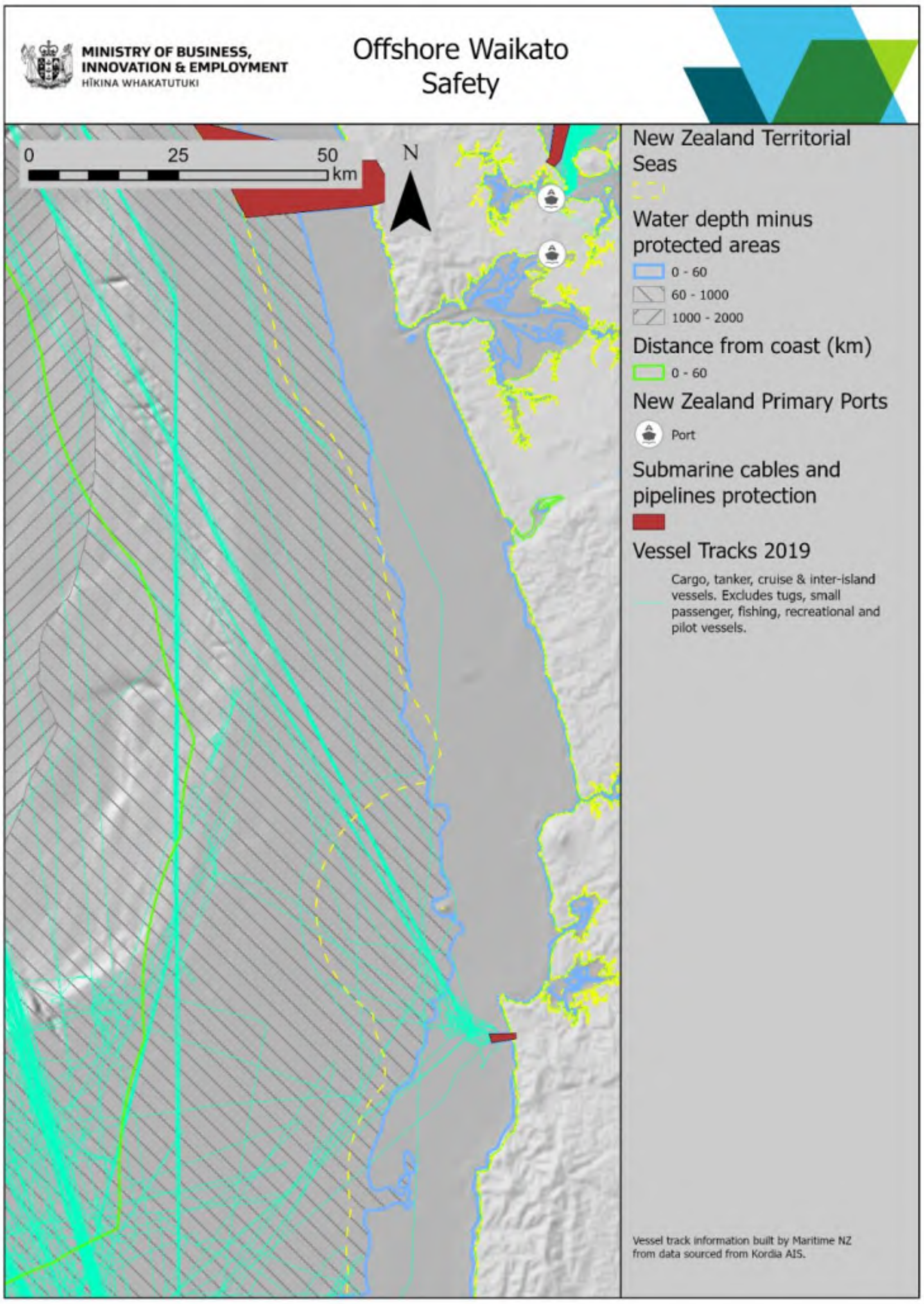


Figure 11

Figure 12 shows the distribution of recreational fishing activity, based on the aerial survey conducted by the Ministry for Primary Industries. Activity is effectively fully contained within the Territorial Sea (12 nautical mile) limits.

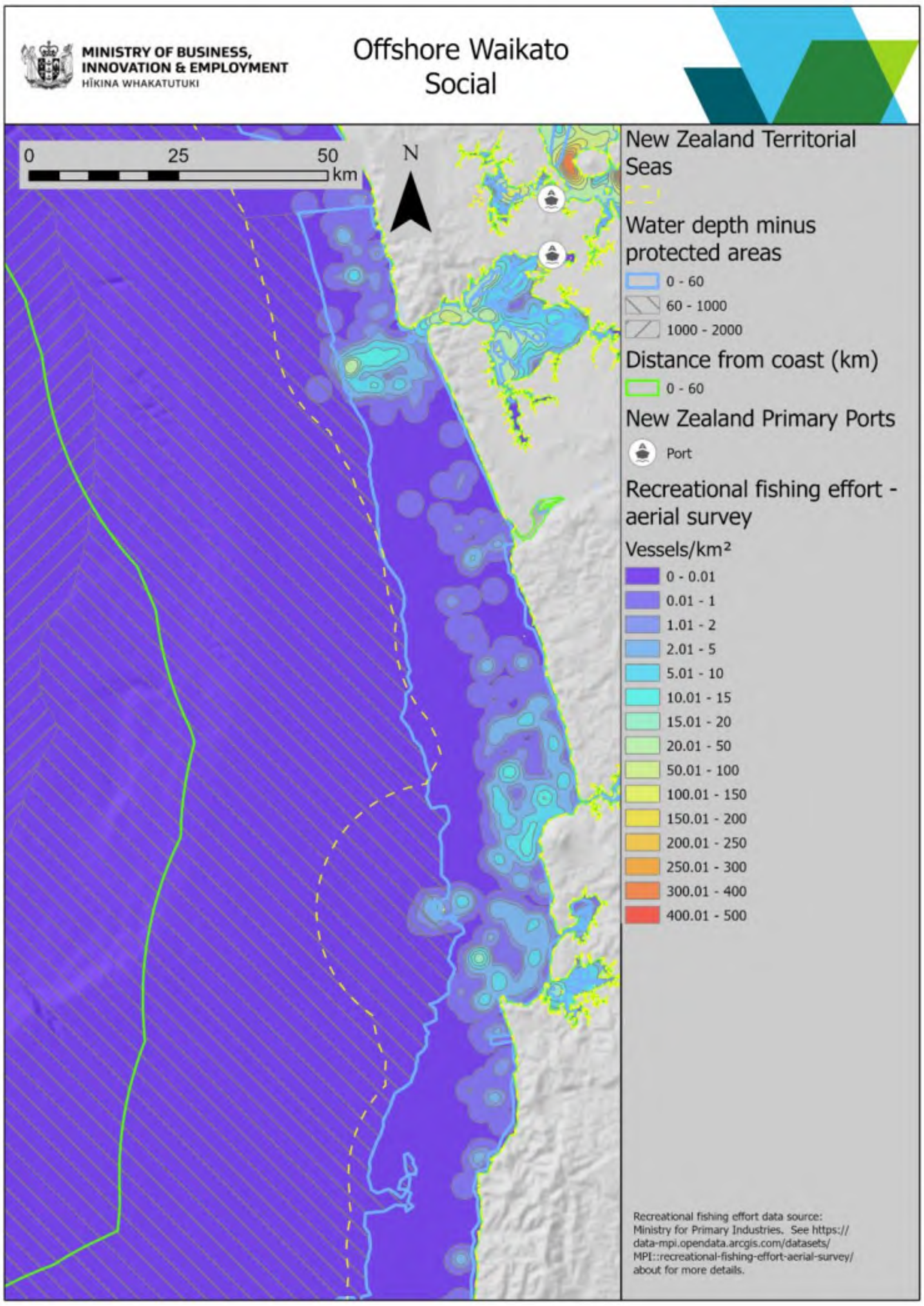


Figure 12

Uses, interests and values of relevance in Taranaki

Figure 13 shows the areas of customary rights and applications. As there is considerable overlap of areas, particularly within the Territorial Sea, readers are advised to consult individual information sources such as Te Kete Kōrero a Te Takutai Moana Information Hub and the Ministry for Primary Industries NABIS web map. Rohe Moana areas from Kaimoana Customary Fishing Notices are labelled in italics starting with TK and generally extend seaward from the coast, however some extend onshore. Rohe Moana areas from Notification of Tāngata Kaitiaki/Tiaki for Area/Rohe Moana of Te Tai Hauāuru labelled in bold red font.

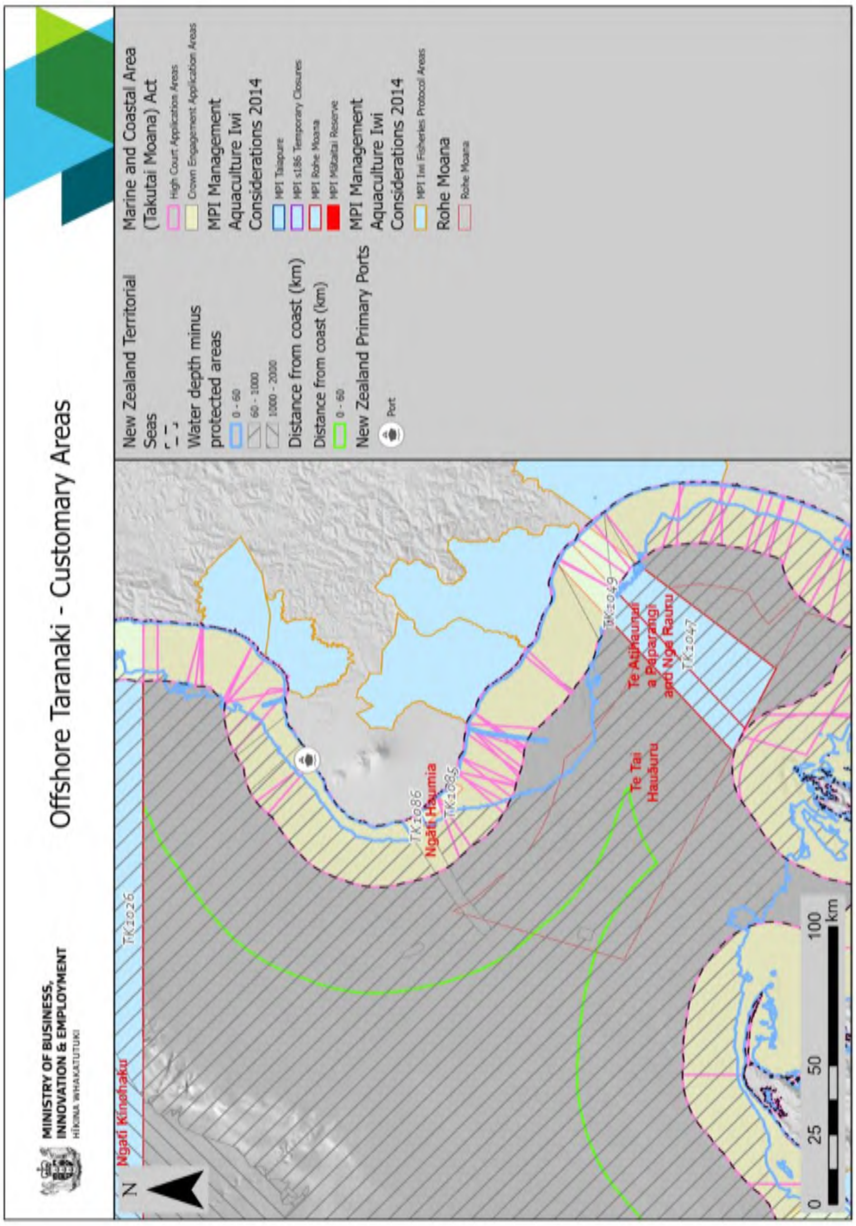


Figure 13

Figure 14 shows the fishing intensity annually averaged commercial catch (kg/ha) from all fishing methods (except freshwater fishing) reported to the Ministry for Primary Industries (MPI) from 2007 – 2019.[xxx] It can be seen that the highest levels of activity are on the continental shelf of the South Taranaki Bight, generally in water depths greater than 90 m.

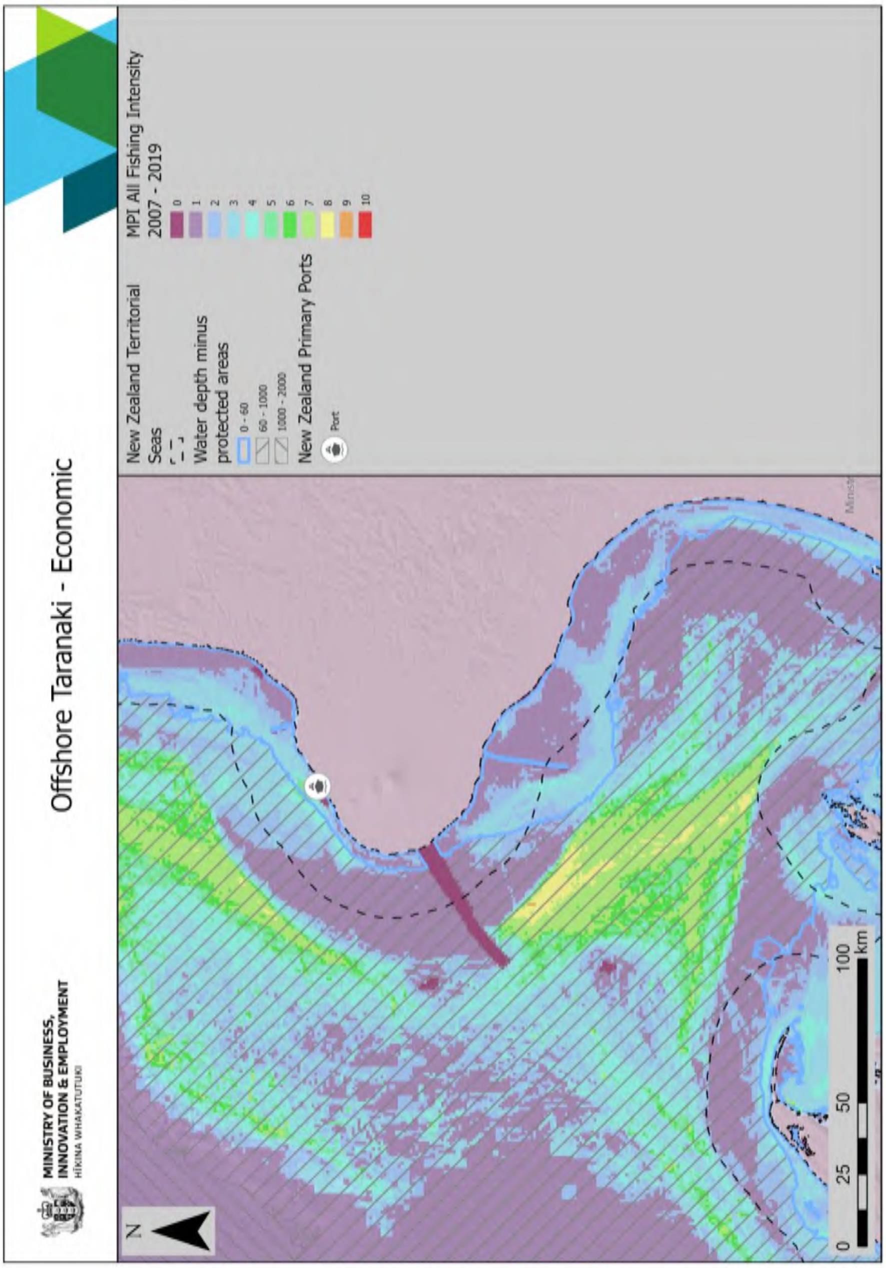


Figure 14

Figure 15 shows the extent of the Marine Mammal Sanctuary, which in this area is congruent with the Territorial Sea (12 nautical mile). Within the extent of the map, Marine Reserves are limited to the northern Taranaki coast and top of the South Island.

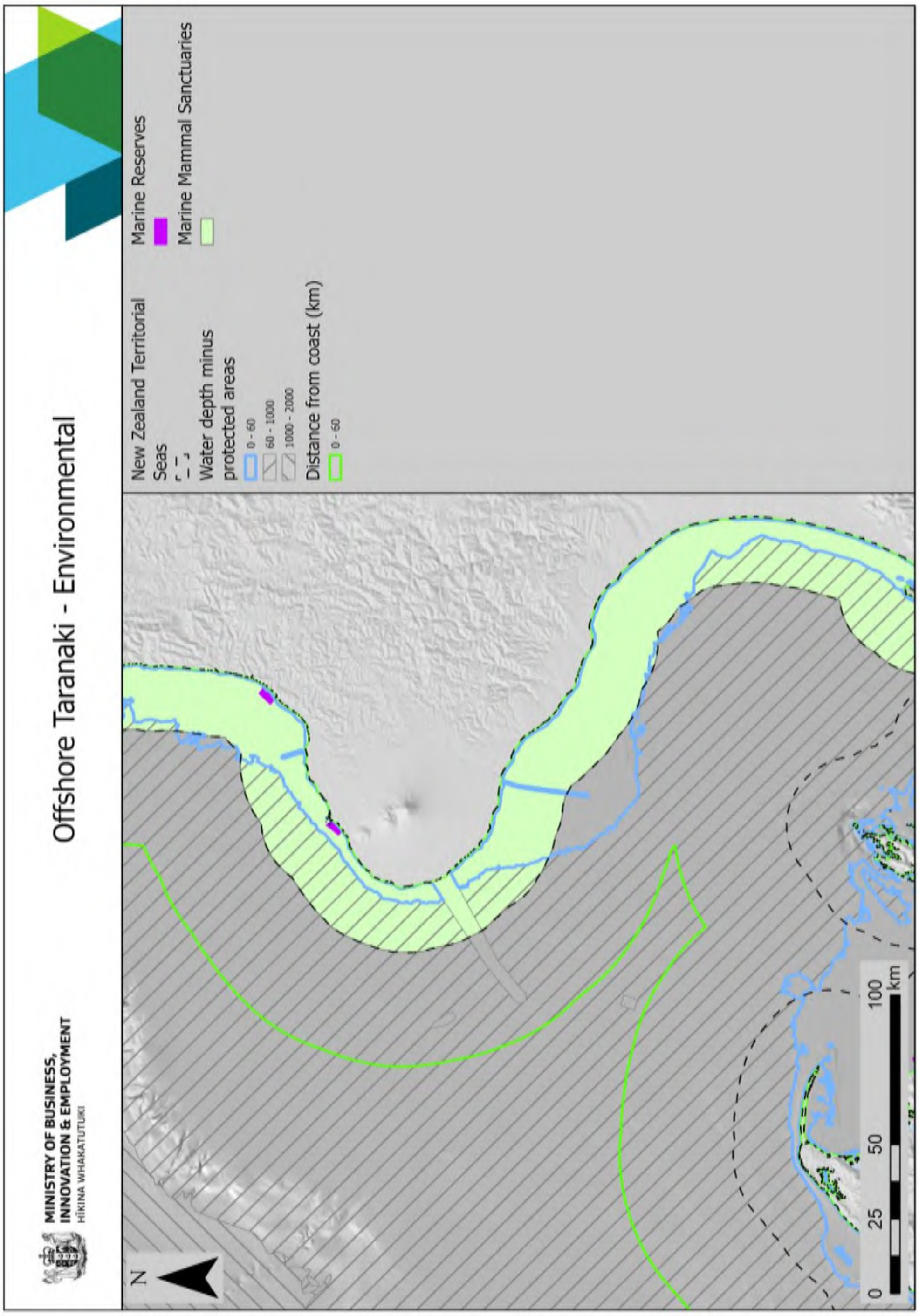


Figure 15

Figure 16 shows the reported position of vessels (of types noted in legend) operating an Automated Identification System (AIS) transponder for the year 2019. Higher density of vessel tracks indicates frequently used shipping "lanes". Note the correlation between vessel density and fishing activity shown in Figure 10. [xxxi]

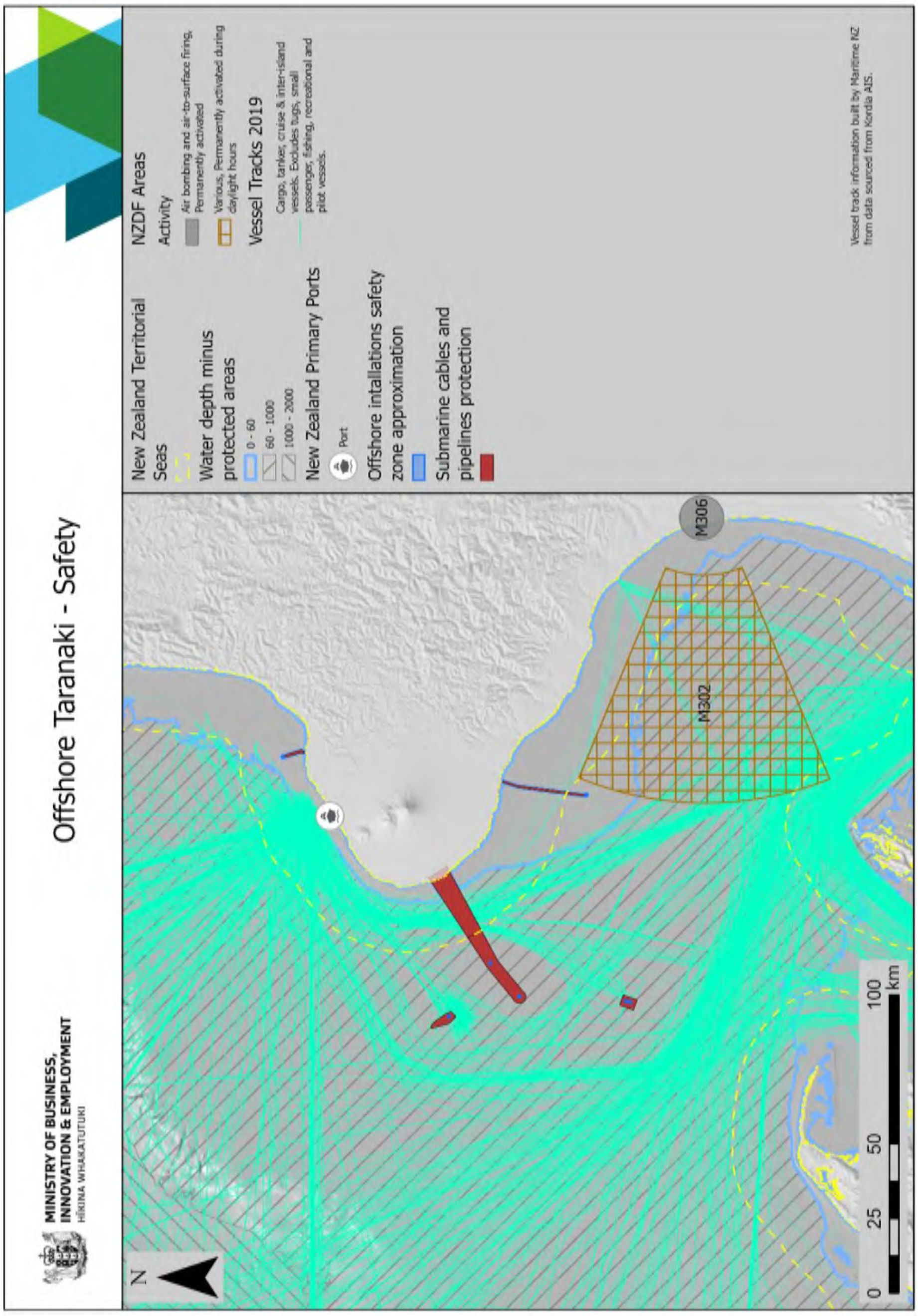


Figure 16

Figure 17 shows the distribution of recreational fishing activity, based on the aerial survey conducted by the Ministry for Primary Industries. Activity is effectively fully contained within the Territorial Sea (12 nautical mile) limits.

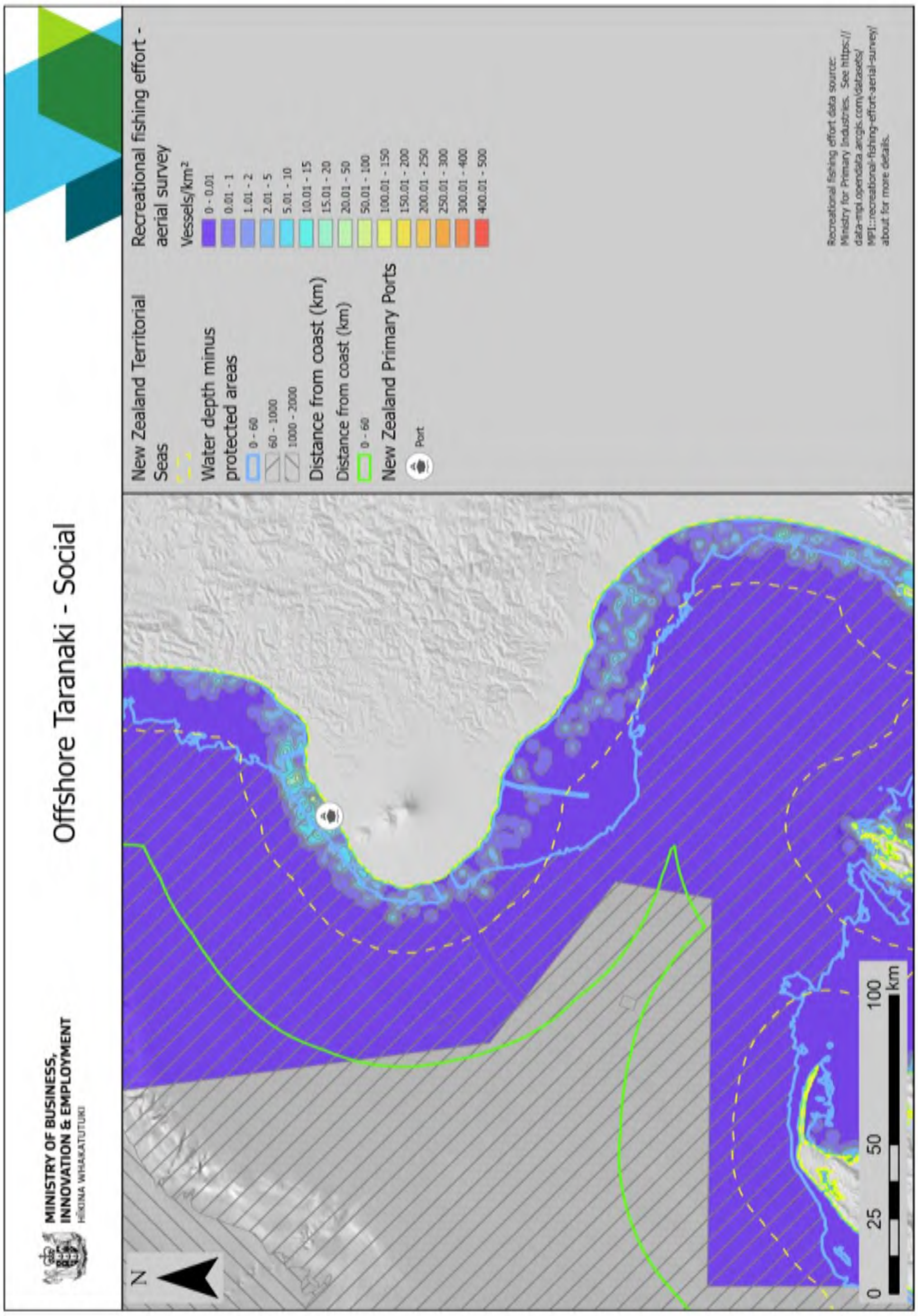


Figure 17

Uses, interests and values of relevance in Southland

Figure 18 shows the areas of customary rights and applications. As there is considerable overlap of areas, particularly within the Territorial Sea, readers are advised to consult individual information sources such as Te Kete Kōrero a Te Takutai Moana Information Hub and the Ministry for Primary Industries NABIS web map.[xxxii]

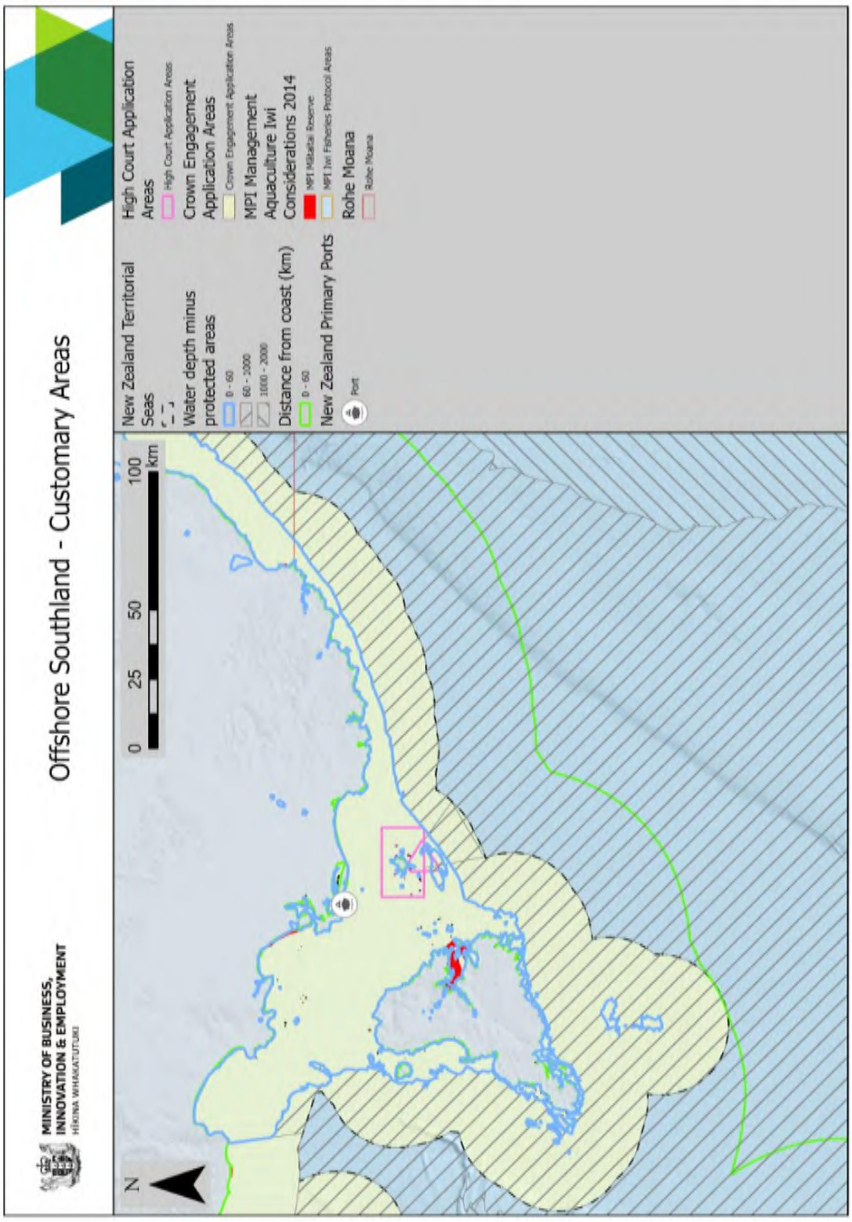


Figure 18

Figure 19 shows the fishing intensity annually averaged commercial catch (kg/ha) from all fishing methods (except freshwater fishing) reported to the Ministry for Primary Industries (MPI) from 2007 – 2019.[xxxiii] It can be seen that the highest levels of activity are within Foveaux Strait, just outside the territorial sea boundary and along the outer continental shelf and slope. Marine farms are predominantly contained within Big Glory Bay on Rakiura / Stewart Island, and Bluff Harbour.

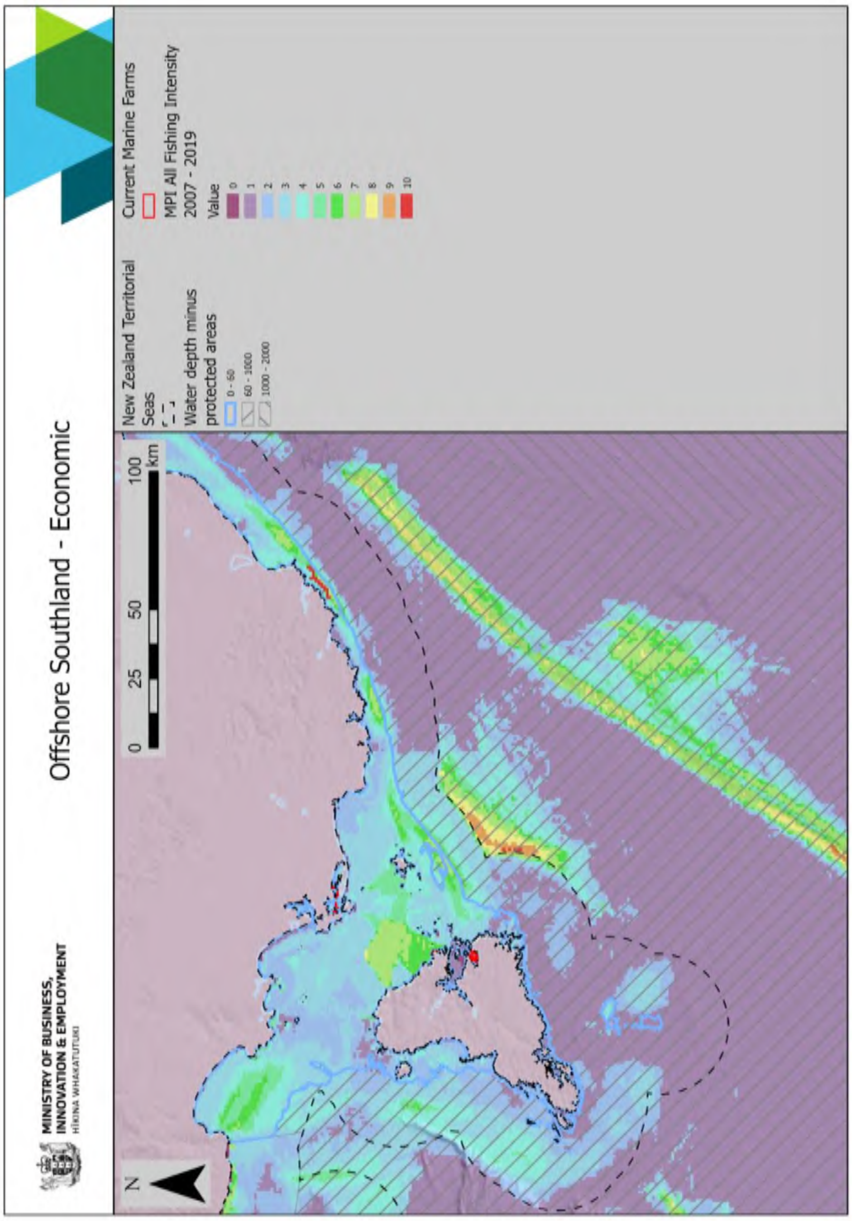


Figure 19

Figure 20 shows the extent of Marine Mammal Sanctuaries. Within the extent of the map, Marine Reserves are limited to Te Whaka a Te Were / Peterson Inlet.

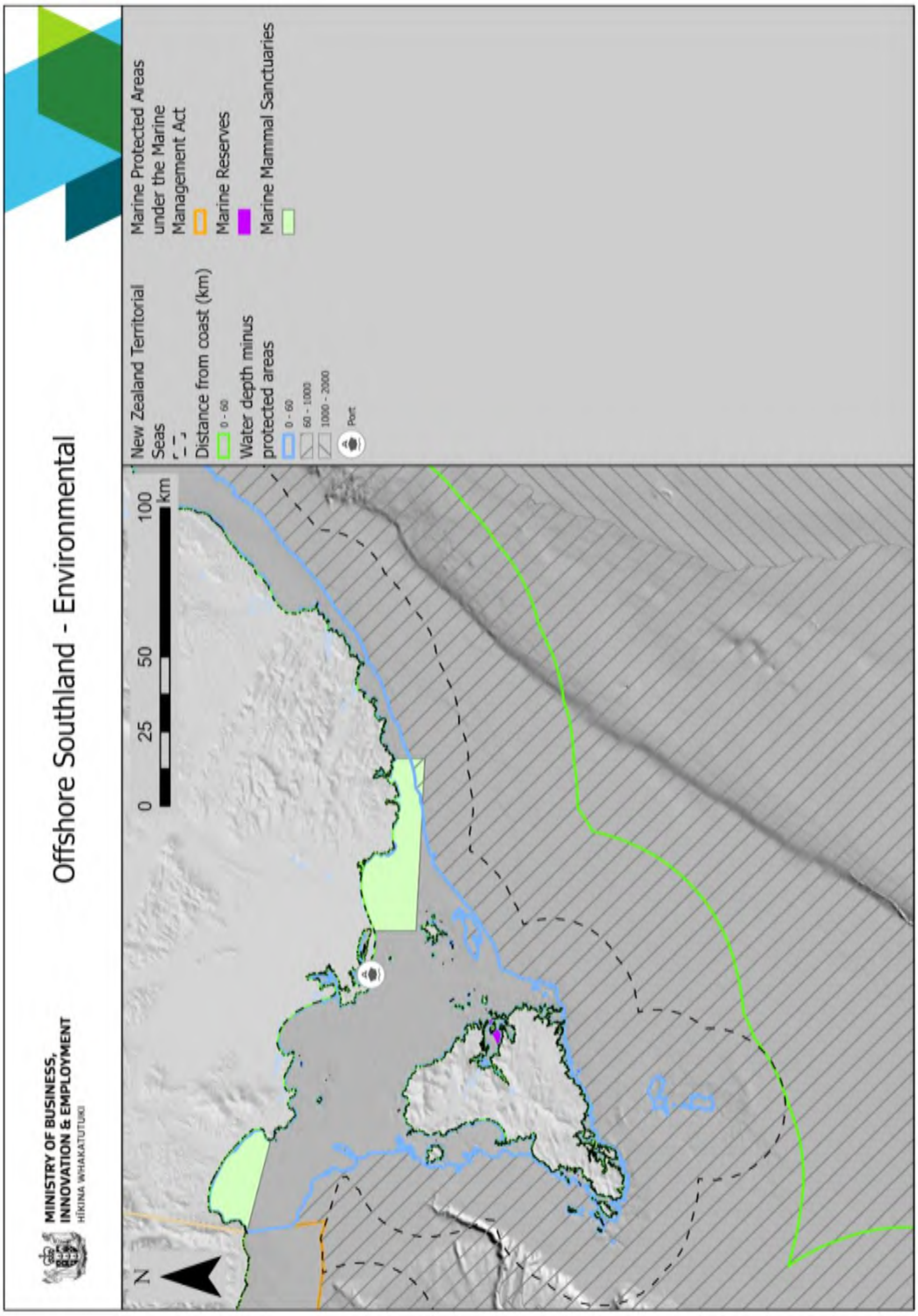


Figure 20

Figure 21 shows the reported position of vessels (of types noted in legend) operating an Automated Identification System (AIS) transponder for the year 2019. Higher density of vessel tracks indicates frequently used shipping “lanes”.[xxxiv]

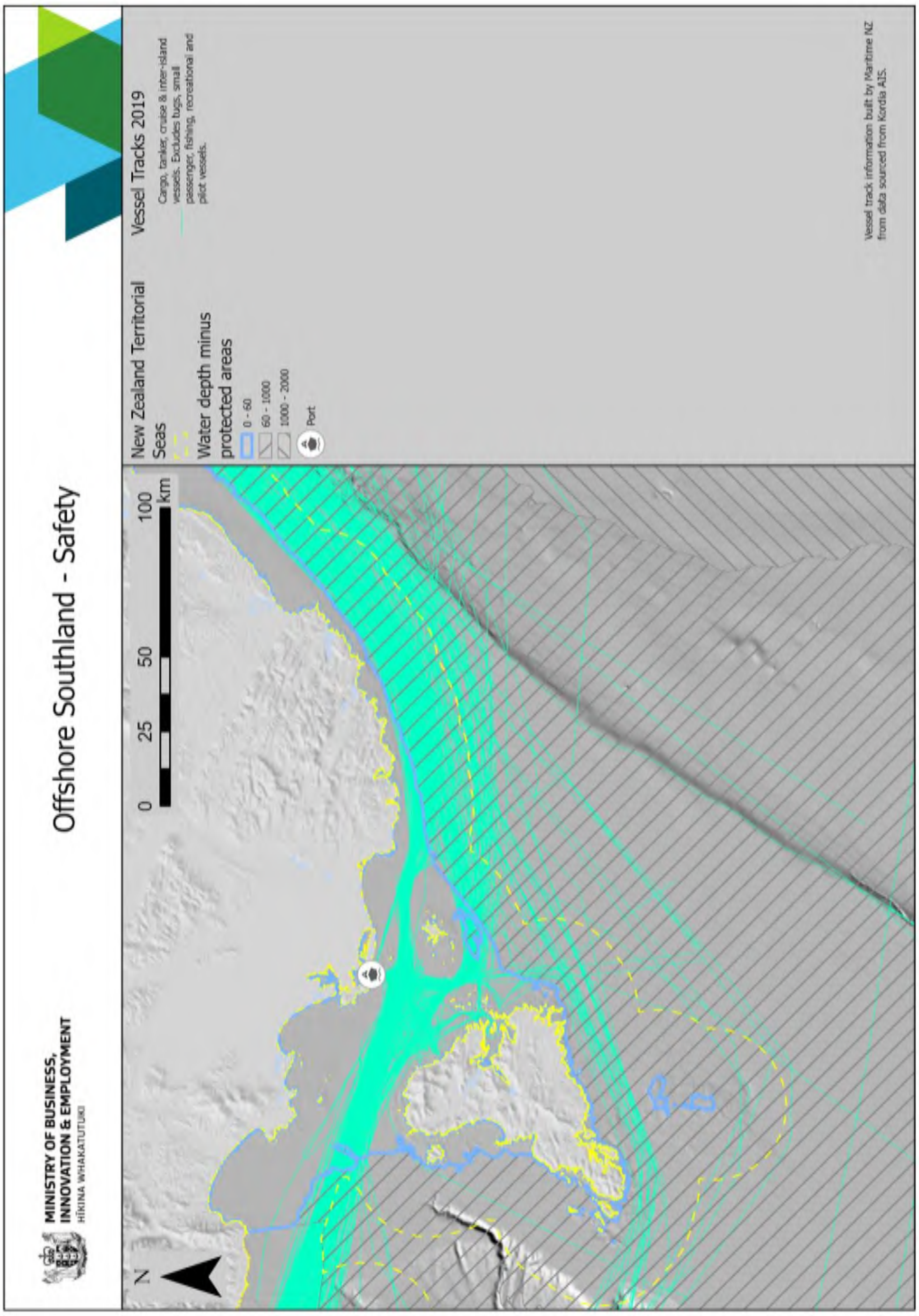


Figure 21

The recreational fishing activity survey conducted by the Ministry for Primary Industries does not extend to the Southland region. Figure 22 is included for completeness only.

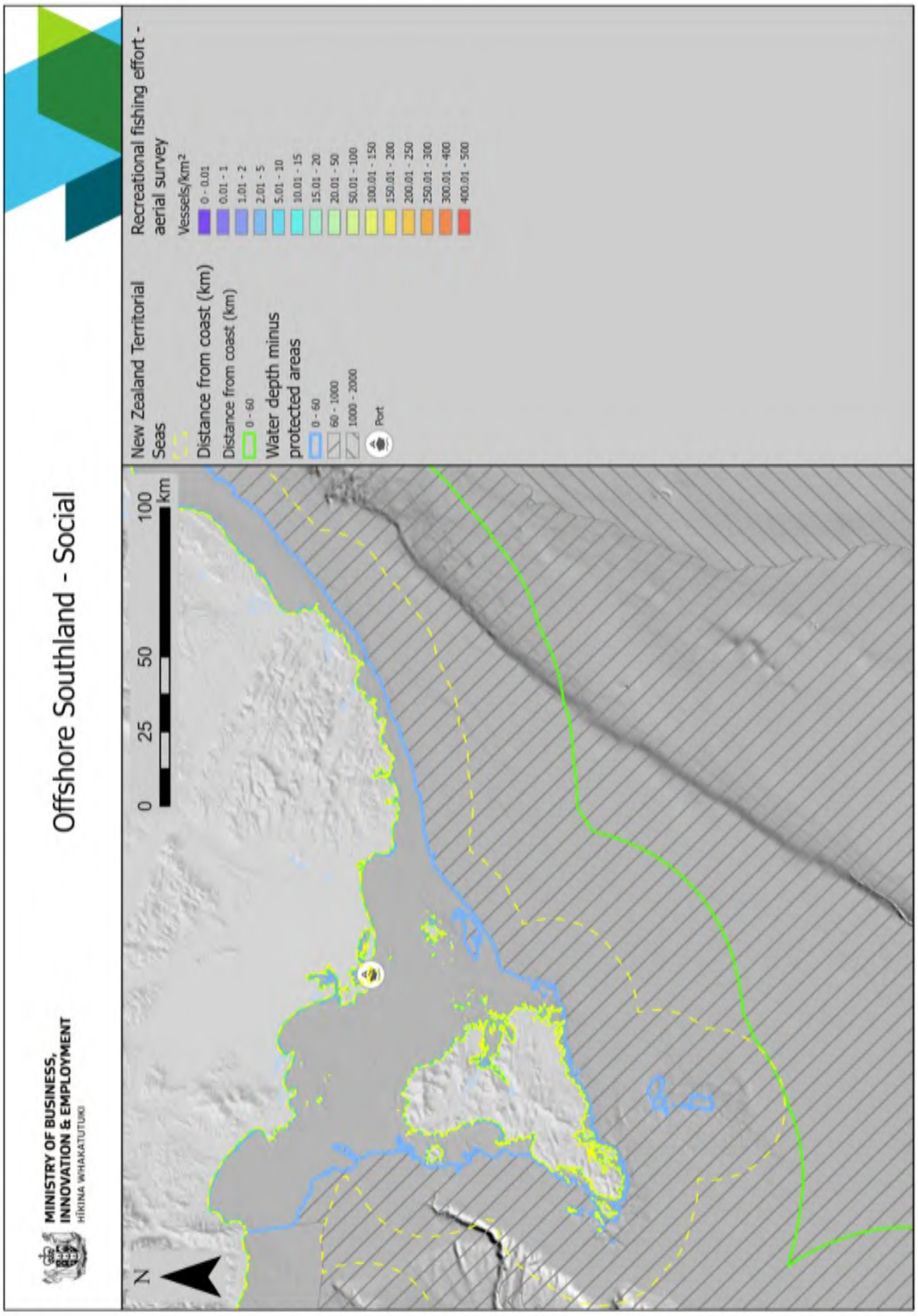


Figure 22

References

[i] For more information on the New Zealand Energy Strategy and its Terms of Reference, see https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand/new-zealand-energy-strategy/#:~:text=It%20has%20committed%20to%20reaching,100%25%20renewable%20electricity%20by%202030.

[ii] For European offshore wind projects online and under construction, see https://windeurope.org/intelligence-platform/product/european-offshore-wind-farms-map-public/.

[iii] New Zealand Infrastructure Commission Te Waihanga, *Technical paper: Leveraging our energy resources to reduce global emissions and increase our living standards*, accessed at https://www.tewaihanga.govt.nz/assets/Uploads/Leveraging-our-energy-resources.pdf.

[iv] Chapter 11 Energy and Industry of *Aotearoa New Zealand's first emissions reduction plan*, accessed at https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/energy-and-industry/

[v] Chapter 11 Energy and Industry of *Aotearoa New Zealand's first emissions reduction plan*, accessed at https://environment.govt.nz/publications/aotearoa-new-zealands-first-emissions-reduction-plan/energy-and-industry/

[vi] See https://www.mbie.govt.nz/building-and-energy/energy-and-natural-resources/energy-strategies-for-new-zealand/new-zealand-energy-strategy/#:~:text=It%20has%20committed%20to%20reaching,100%25%20renewable%20electricity%20by%202030.

[vii] Ministry of Business, Innovation and Employment, *Electricity demand and generation scenarios: Scenario and results summary*, July 2019, accessed at https://www.mbie.govt.nz/dmsdocument/5977-electricity-demand-and-generation-scenarios.

[viii] Transpower, *Whakamana i Te Mauri Hiko - Empowering our Energy Future*, March 2020, accessed at Whakamana i Te Mauri Hiko - Empowering our Energy Future | Transpower.

[ix] He Pou a Rangi Climate Change Commission, *Ināia tonu nei: a low emissions future for Aotearoa*, accessed at https://www.climatecommission.govt.nz/our-work/advice-to-government-topic/inaia-tonu-nei-a-low-emissions-future-for-aotearoa/

[x] International Renewable Energy Agency Offshore, *Offshore innovation widens renewable energy options: Opportunities, challenges and the vital role of international co-operation to spur the global energy transformation*, 2018, accessed at https://www.irena.org/publications/2018/Sep/Offshore-innovation-widens-renewable-energy-options.

[xi] See https://www.woodmac.com/press-releases/major-energy-exporters-race-to-lead-in-global-hydrogen-trade/

[xii] IRENA (2019), Future of wind: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation paper), International Renewable Energy Agency, Abu Dhabi.

[xiii] Ministry of Business, Innovation and Employment, *Discussion Document: Accelerating renewable energy and energy efficiency,* December 2019, accessed at https://www.mbie.govt.nz/assets/discussion-document-accelerating-renewable-energy-and-energy-efficiency.pdf

[xiv] International Energy Agency, *Offshore Wind Outlook 2019*, https://iea.blob.core.windows.net/assets/495ab264-4ddf-4b68-b9c0-514295ff40a7/Offshore_Wind_Outlook_2019.pdf

[xv] New Zealand Infrastructure Commission Te Waihanga, *Technical paper: Leveraging our energy resources to reduce global emissions and increase our living standards*, accessed at https://www.tewaihanga.govt.nz/assets/Uploads/Leveraging-our-energy-resources.pdf.

[xvi] IRENA (2019), Future of wind: Deployment, investment, technology, grid integration and socio-economic aspects (A Global Energy Transformation paper), International Renewable Energy Agency, Abu Dhabi.

[xvii] IRENA (2020), Fostering a blue economy: Offshore renewable energy, International Renewable Energy Agency, Abu Dhabi.

[xviii] Key Factors for Successful Development of Offshore Wind in Emerging Markets, pg.8.

[xix] C.A. Ishwar; I.G. Mason (2019), Offshore Wind for New Zealand, Proceedings of the EEA Conference and Exhibition, 25-27 June 2019, Auckland, NZ.
[xx] World Bank Group, *Key Factors for Successful Development of Offshore Wind in Emerging Markets*, 2021, p.52.
[xxi] The Treasury, *Guidance Note: Foreign Investment Policy and National Interest Guidance,* June 2021, accessed at https://www.treasury.govt.nz/sites/default/files/2021-06/for-invest-pol-nat-interest-guidance-jun21.pdf
[xxii] Dutch Offshore Wind Guide https://www.rvo.nl/sites/default/files/2021/10/Dutch%20Offshore%20Wind%20Guide%202022.pdf
[xxiii] https://publications.jrc.ec.europa.eu/repository/handle/JRC93792
https://wetten.overheid.nl/BWBR0036752/2015-07-01#Hoofdstuk2
https://European Offshore Wind Farms - A Survey for the Analysis by Developers of Offshore Wind Farms (pnnl.gov)
[xxiv] See Part 2 of the Offshore Electricity Infrastructure Act 2021 (legislation.gov.au)
[xxv] Consultation hub | Offshore renewable energy infrastructure area proposal: Bass Strait off Gippsland - Department of Industry, Science, Energy and Resources
[xxvi] Marine Users and Interests Gippsland, Victoria (storage.googleapis.com)
[xxvii] World Bank Group, *Key Factors for Successful Development of Offshore Wind in Emerging Markets*, 2021, p.49.
[xxviii] For more information see https://data-mpi.opendata.arcgis.com/maps/mpi-all-fishing-intensity-2007-2019/about
[xxix] See https://www.imo.org/en/OurWork/Safety/Pages/AIS.aspx for more details on AIS.
[xxx] For more information see https://data-mpi.opendata.arcgis.com/maps/mpi-all-fishing-intensity-2007-2019/about
[xxxi] See https://www.imo.org/en/OurWork/Safety/Pages/AIS.aspx for more details on AIS.
[xxxii] Te Arawhiti – The Office for Māori Crown Relations, Te Kete Korero a Te Takutai Moana Information Hub, accessed at https://maca-nds.maps.arcgis.com/apps/MapSeries/index.html?appid=1ed9665a8d2c4d38b4f9ddcb2d186f1b
and Ministry of Primary Industries, National Aquatic Biodiversity System, accessed at https://maps.mpi.govt.nz/templates/MPIViewer/?appid=96f54e1918554ebbaf17f965f0d961e1
[xxxiii] For more information see https://data-mpi.opendata.arcgis.com/maps/mpi-all-fishing-intensity-2007-2019/about
[xxxiv] See https://www.imo.org/en/OurWork/Safety/Pages/AIS.aspx for more details on AIS.

Te Kāwanatanga o Aotearoa
New Zealand Government

BRM 9036

AGENDA
Policy & Planning

Date 7 February 2023

Subject: **Offshore Subtidal Rocky Reef Habitats on Pātea Bank, South Taranaki**

Approved by: AJ Matthews, Director - Environment Quality

S J Ruru, Chief Executive

Document: 3138071

Purpose

1. The purpose of this memorandum is to provide the Committee with an overview of an Envirolink-funded report: *Offshore subtidal rocky reef habitats on Pātea Bank, South Taranaki*, commissioned by Taranaki Regional Council (the Council) and produced by NIWA.
2. A copy of the report accompanies this memorandum, and is available via the Council's website. This item will be accompanied by a brief presentation.

Executive summary

3. The South Taranaki Bight (STB) is a unique ecological area. Within this area, rocky reefs are known to exist at unusually far distances from shore; occurring on the relatively shallow, yet wide continental shelf (known as the Pātea Bank). These reefs provide important habitat for a range of marine species.
4. Although the STB has received some attention in recent years in relation to resource consent applications for sand mining, there is still much to be discovered regarding offshore seafloor habitats and associated biological communities.
5. In early 2020, following discussions with the Project Reef citizen science team, NIWA became interested in the uncharted reefs on the Pātea Bank, and decided to incorporate this area into a wider research project that was already underway.
6. In June 2020, NIWA travelled to the Pātea Bank with the R.V. Kaharoa to carry out high-resolution seafloor bathymetry surveying of a number of reef locations that had been provided by the Project Reef team and other local fishers and divers. A 250 km long track of seafloor was surveyed, covering a total of 61.5 km^2, and taking 30 hours to complete. Of the total survey area, 9.3% (or 5.7 km^2) was considered likely to be rocky reef, based on benthic terrain modelling. Reef topography varied from scattered, low relief patch reefs and knolls, to extensive linear ridges extending for kilometres in length.
7. In March 2021, NIWA returned to the Pātea Bank with the R.V. Ikatere in order to 'ground truth' a subset of the reef structures, and document the associated biological

communities. This survey component was carried out over three days using a towed underwater video sled, and baited fish traps.

8. A very large data-series was collected during these two surveys; the analysis and reporting of which was beyond the scope of NIWA's original research programme. To advance this work, Taranaki Regional Council (the Council) applied for an Envirolink advice grant in order to fund the analysis of the entire data-series, thereby ensuring full value was attained from the original surveys. Funding this report also ensured that the information would be accessible in a consolidated and useful format for the Council and Taranaki community.
9. The 'ground truth' surveys verified the presence of rocky reef habitat at all fourteen target sites. Median reef depths ranged from 17.3 to 35.5 metres, and reef geologies included mudstone/papa, sandstone and limestone. A range of biogenic habitat features were identified, including kelp forests, sponge gardens, macroalgal meadows, and bryozoan fields. A total of 39 different sponge species and 30 fish species were identified across the fourteen reef sites. Evidence of blue cod nurseries was present at four sites.
10. The report demonstrates that subtidal reef habitat is much more common and widespread on the Pātea Bank than previously documented in the scientific literature. Furthermore, the reefs were found to be associated with extensive areas of important biogenic habitat and abundant reef fish assemblages.
11. This report provides a valuable resource for Council and the community. The information it contains will support informed and effective decision making by Council in relation to the Taranaki Coastal Marine Area (CMA), and improve our understanding of these important habitats.
12. Another 324 km² of seafloor has since been surveyed in North Taranaki in order to update the navigational charts. This data presents an opportunity to identify potential features such as rocky reefs and important biogenic habitats in that area, following a similar approach to the methods of this report.

Recommendations

That the Taranaki Regional Council:

a) receives the report *Offshore subtidal rocky reef habitats on Pātea Bank, South Taranaki*

b) notes the findings of the report.

Background

13. Offshore seafloor habitats and associated biological communities in the Taranaki Coastal Marine Area (CMA) are poorly understood due to the lack of detailed survey data. This is largely owing to the significant cost and resourcing associated with seafloor habitat surveying, as well as the challenging west coast sea conditions.
14. Although this knowledge gap is not unique to Taranaki, it is one that needs to be addressed in order to enable informed and effective management of the CMA.
15. Although receiving some attention due to the resource consent applications for sand mining in recent years, the South Taranaki Bight (STB) is an area where further investigations are especially warranted.
16. The STB is a unique ecological area for a number of reasons. With regards to seafloor habitats, rocky reefs are known to exist at unusually far distances from shore; occurring

on the relatively shallow, yet wide continental shelf in the STB (Figure 1). This area is also referred to as the Pātea Bank.

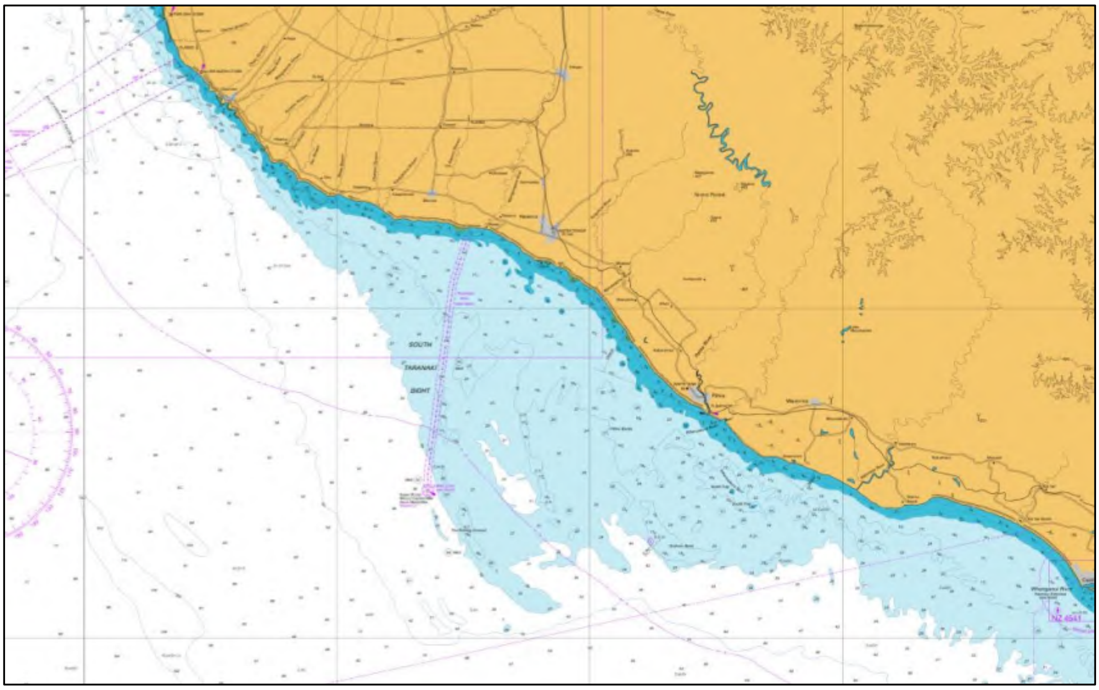


Figure 1 South Taranaki Bight, from LINZ Chart 45. Dark blue area shows 0 – 10 m water depth, light blue area shows 11- 30 m water depth, white area shows > 30 m water depth, CMA boundary (12 nm) shown with thin pink line.

17. The Pātea Bank provides a 'goldilocks zone' where there is still enough light at the seabed to support microalgae and seaweeds, whilst being far enough from the coast that the impacts of sediment from rivers and coastal erosion are reduced. Under optimal conditions such as these, rocky reefs provide a stable and enduring habitat, which can support diverse and thriving biological communities.
18. There is a wealth of local, anecdotal knowledge on numerous rocky reefs on the Pātea Bank. However, to date there has been a lack of scientific research carried out to formally document and support this knowledge.
19. The North and South Traps are perhaps the most well-known reefs on the Pātea Bank. These reefs are scheduled as an Area of Outstanding Coastal Value in the Proposed Coastal Plan for Taranaki, due to their unique physical characteristics and the abundant and diverse biological communities that they support.
20. More recently, a local citizen science project, Project Reef, has embarked on a project to survey and document another reef on the Pātea Bank. The work carried out by this group has highlighted the abundance and diversity of macroalgae, seafloor invertebrates (e.g. sponges, bryozoans, anemones) and reef fish found at 'Project Reef' (Figure 2). The Council was a science partner with the Project Reef team at its inception back in 2016, through the Curious Minds Participatory Science Platform funded by the Ministry for Business, Innovation and Employment (MBIE). Sufficient evidence was compiled through this project for the reef to be scheduled as an Area of Outstanding Natural Character in the Proposed Coastal Plan for Taranaki.

Figure 2 A Scarlett Wrasse swimming above a diverse assemblage of sponges and red algae on Project Reef.

21. Given what is known about the reefs on the Pātea Bank that have been subjected to scientific investigation, there is an obvious need to learn more about the remaining reef systems. However, the vast majority of rocky reefs on the Pātea Bank remain uncharted. Due to their low relief (not rising far from the seabed), and scattered nature, previous navigational chart surveys have detected very few reefs in this area. Therefore, acquisition of high-resolution bathymetry data (seafloor maps) is a critical first step for scientific mapping and investigation of these reefs.
22. In early 2020, the Project Reef team contacted a marine ecologist from NIWA to share the information they had been collecting from Project Reef. NIWA became interested in Project Reef, and decided to incorporate the reef into a wider MBIE-funded research project, which was investigating juvenile blue cod habitats.
23. In June 2020, the R.V. Kaharoa travelled to the Pātea Bank to carry out high-resolution seafloor bathymetry surveying of the Project Reef and several other locations nearby that had been provided by local fishers and divers (Figure 3). A 250 km long track of seafloor was surveyed, covering a total of 61.5 km^2, and taking 30 hours to complete. The survey found a number of low relief reef fields (<2 m in height), and a couple of taller and more extensive reef structures. Interestingly, based on the survey data, the Project Reef was one of the more subtle seafloor features detected.
24. In March 2021, the R.V. Ikatere travelled to the Pātea Bank in order to 'ground truth' a subset of the reef structures, and assess the associated biological communities. This survey component was carried out over three days using a towed underwater video sled, and baited fish traps. Council staff joined NIWA and the Project Reef team on board the R.V. Ikatere during one of the survey days.
25. A very large data-series was collected during these two surveys; the analysis of which was beyond the scope of the original MBIE-funded research programme (most of the seafloor bathymetry coverage, and multiple video tows). Therefore, the Council applied for an Envirolink Medium Advice Grant (MAG) in order to fund the analysis of the entire data-series, thereby ensuring full value was attained from the original surveys. The funding meant that the data, its analysis, interpretation and discussion could all be

included in a single report, ensuring that the information would be accessible in a consolidated and useful format for the Council and Taranaki community.

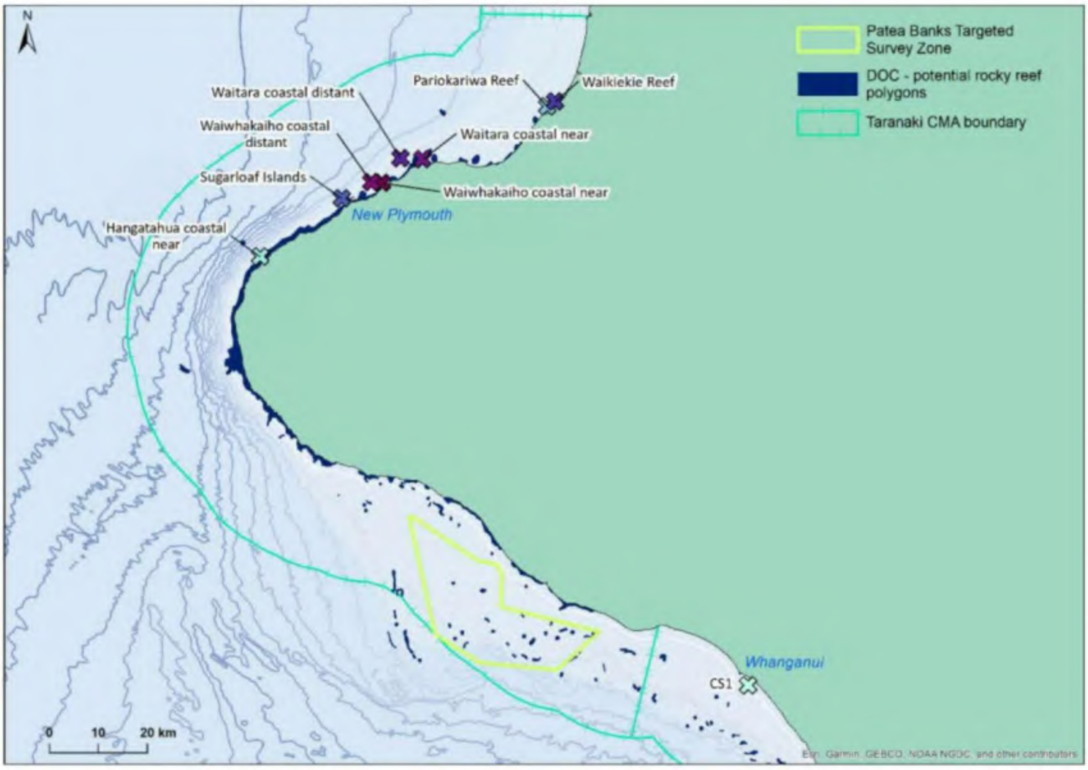


Figure 3 Targeted survey on the Pātea Bank, shown within the light green polygon (figure from report).

Discussion

26. The report analyses and interprets the data in a number of sections. First, the seafloor bathymetry data, collected in June 2020, is analysed. Next, an overview of the 'ground-truth' towed camera data collected in March 2021 is presented. Project Reef survey results collected by the Project Reef team are then summarised. Finally, complete site descriptions are reported for the reef sites where the 'ground-truth' towed camera surveys were carried out.

27. Because it was not possible to re-visit and 'ground truth' the entire survey area, a Benthic Terrain Model was used to determine likely rocky reef habitat, based on the characteristics of the bathymetry data that was collected in June 2020. Analysis of the data identified numerous features throughout the survey area that were likely to be rocky reefs. Of the 61.5 km² surveyed area, 9.3% (or 5.7 km²) was considered likely to be rocky reef. Reef topography varied from scattered, low relief patch reefs and knolls, to extensive linear ridges extending for kilometres in length.

28. The 'ground truth' surveys verified the presence of rocky reef habitat at all fourteen target sites (Figure 4). Median reef depths ranged from 17.3 to 35.5 metres, and reef geologies included mudstone/papa, sandstone and limestone. A range of biogenic habitat features were identified, including kelp forests, sponge gardens, macroalgal meadows, and bryozoan fields. A total of 39 different sponge species and 30 fish species

were identified across the fourteen reef sites. Evidence of blue cod nurseries was found at four sites.

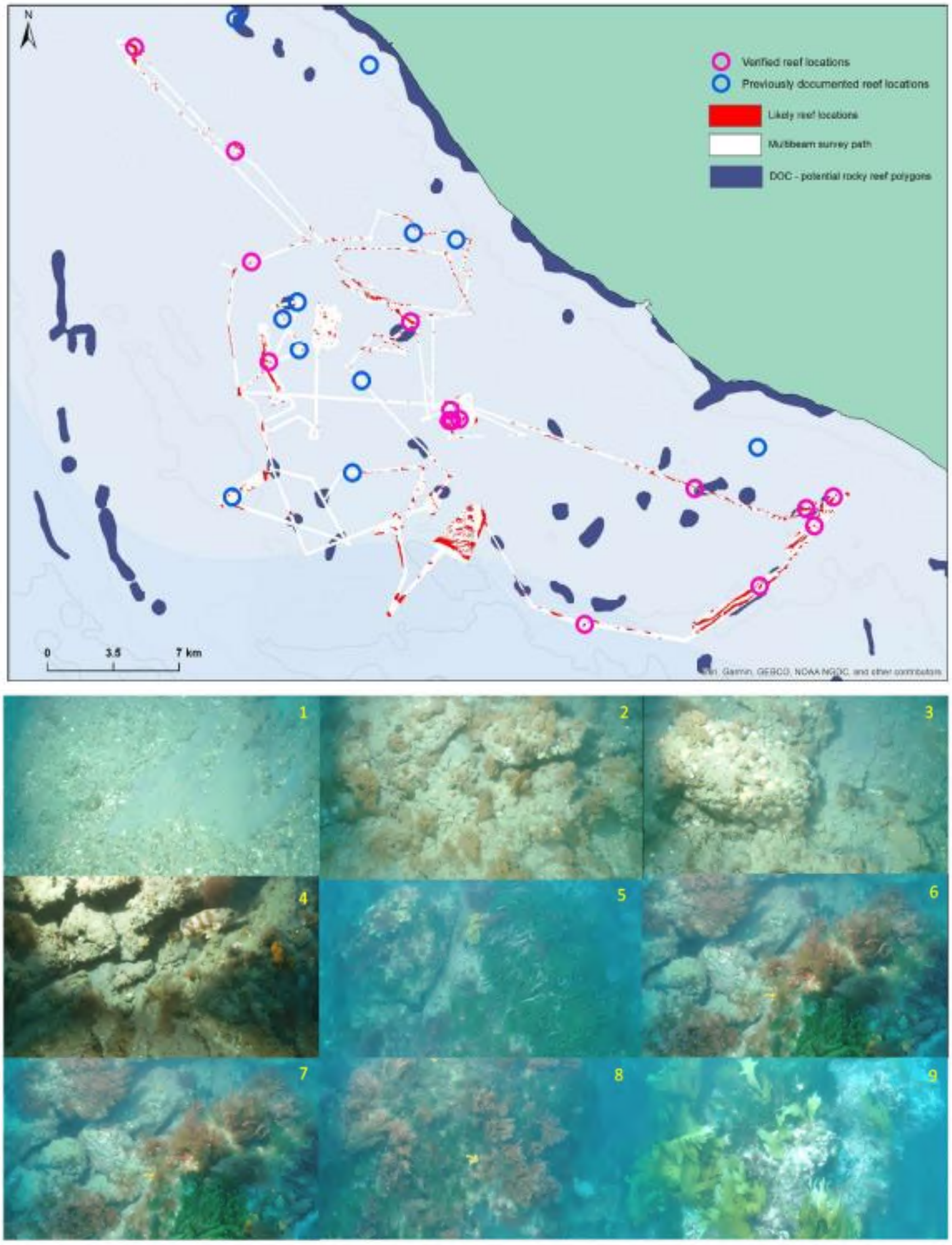


Figure 4 Top: Verified and likely reef locations from the targeted survey on the Pātea Bank, Bottom: Images captured with NIWA's CoastCam tow camera system at one of the verified reef locations (figures from report).

29. The findings are also compared to previous subtidal reef surveys carried out in the Taranaki CMA, highlighting differences and similarities in physical and biological characteristics.

30. The report demonstrates that subtidal reef habitat is much more common and widespread on the Pātea Bank than previously documented in the scientific literature. Furthermore, the reefs were found to be associated with extensive areas of important biogenic habitat and abundant reef fish assemblages.
31. It is important to note that only a small, albeit targeted, area within the STB was surveyed as part of this investigation. The remaining seafloor is yet to be surveyed and as such there are likely many more reefs that are yet to be mapped.
32. The report shows that these rocky reef habitats are unevenly distributed, with a relatively smaller footprint compared to the surrounding seafloor, yet they support biological communities with disproportionately high species abundance and diversity. The efficacy of the methods employed in this investigation highlights the importance of a targeted and stratified survey design for adequately sampling such habitats.
33. The information in this report supports a number of provisions in the Proposed Coastal Plan for Taranaki (which gives effect to the Resource Management Act 1991 and the New Zealand Coastal Policy Statement 2010). Objective 8 and Policy 15 of the Plan relate to the protection of areas of significant indigenous biodiversity. This report will support informed and effective decision making by Council that aligns with these planning provisions.
34. This report also supports a number of Methods of Implementation within the Proposed Coastal Plan for Taranaki. Methods 5, 6 and 8 relate to gathering information, developing spatial planning (including identifying sites with significant values), and supporting research into coastal management. This report is consistent with the implementation of these methods.
35. Spatial planning and mapping sites of significance was an important matter raised by the Department of Conservation (DOC), and Royal Forest and Bird (RFB) during the Coastal Plan hearing process. The Council's position on this at the time was that it would be prohibitively expensive to indiscriminately survey and map the entire Taranaki CMA, however, that we would take a strategic approach and capitalise on research and surveying opportunities as they arose. This report is consistent with that approach.
36. It should be noted that when compared to the total cost of the two field surveys carried out in 2020 and 2021, this Envirolink MAG (covering the analysis and reporting costs) has provided high value for money.
37. A number of recommendations for further research are also presented in the report. Some of which involve further analysis of the data, and others involve further survey effort to map more seabed and identify additional habitats.
38. There are opportunities to analyse the data in greater detail, in order to understand the relationship between physical features identified in the bathymetry surveys, and the associated biological assemblages. This could eventually inform a predictive model, whereby the location of certain biological assemblages could be predicted based on bathymetry information alone; improving Council's ability to appropriately manage the wider coastal environment.
39. With regards to opportunities for further seafloor mapping, it is worthwhile noting that an area defined as the 'Approaches to Port Taranaki' was recently surveyed in 2021 as part of Land Information New Zealand's (LINZ) HYPLAN work programme. This survey covered 324 km² of seafloor between Okato and Waitara (Figure 5). This data is publically available and could be used to identify potential features such as rocky reefs

and important biogenic habitats, following a similar approach to the methods of this report.

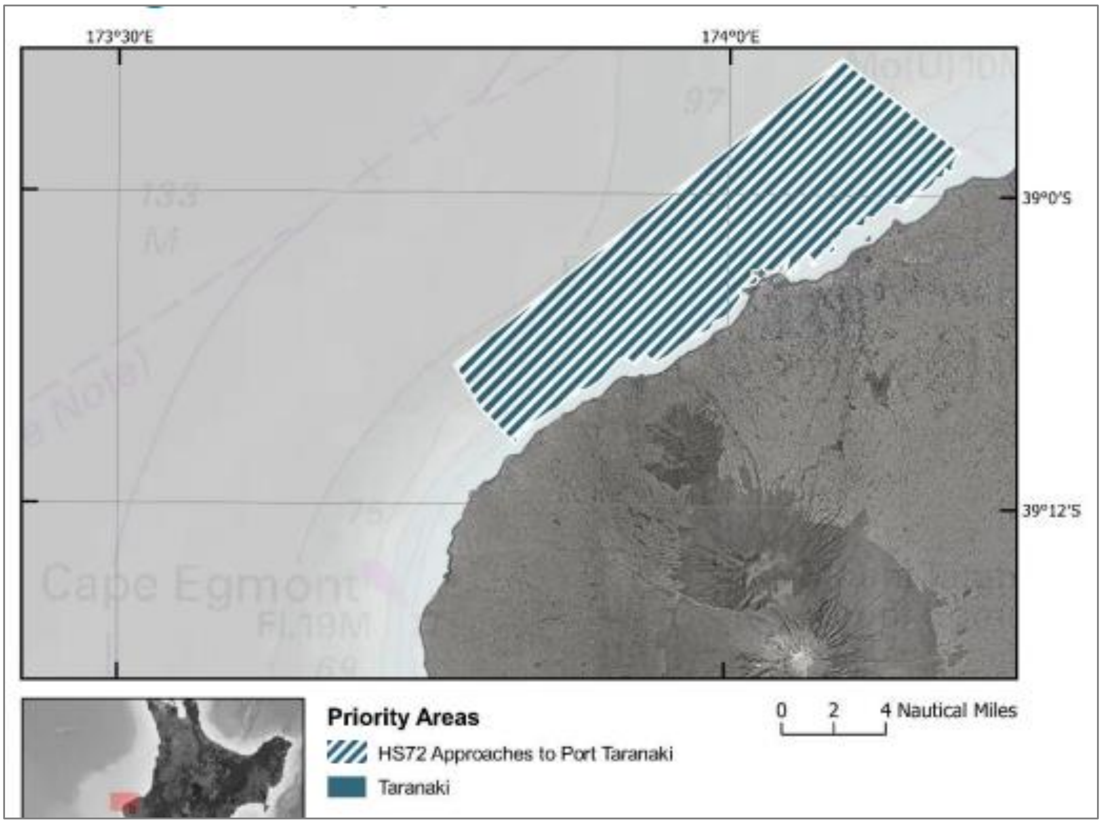


Figure 5 Approaches to Port Taranaki survey area from the LINZ HYPLAN (August 2022).

40. The Council would like to thank NIWA for this valuable report, and also acknowledges the important role that the Project Reef team played in initiating this research. This report, and the information it contains, is another accomplishment for Project Reef.

41. By extension, the Council also acknowledges the value of having access to MBIE's Curious Minds Participatory Science Platform in Taranaki. Project Reef was one of its earliest projects to receive funding, and it has since gone on to successfully engage the community in science, and produce important environmental information that has real-world application.

Financial considerations—LTP/Annual Plan

42. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

43. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987.*

Iwi considerations

44. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted long-term plan and/or annual plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

45. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

46. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

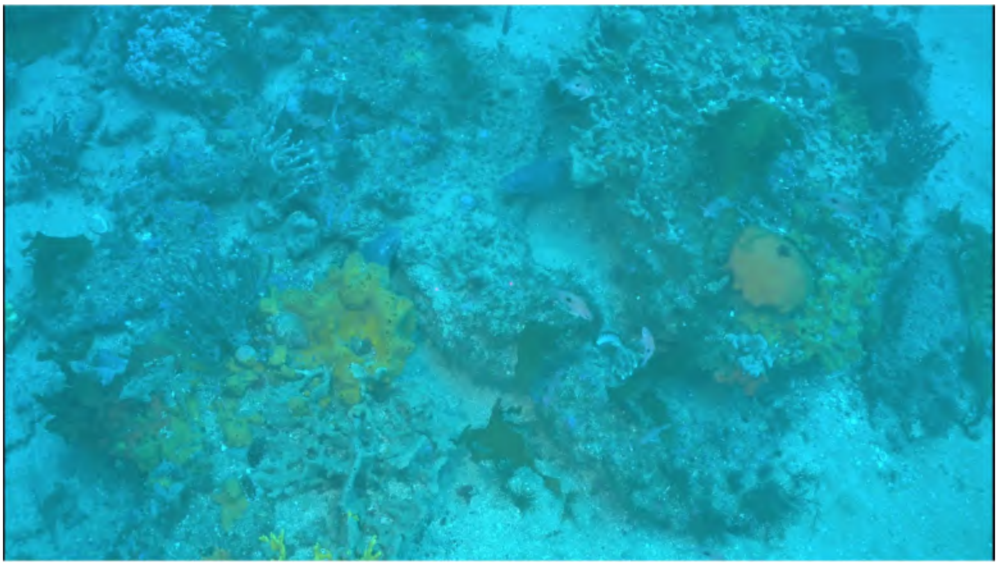
Appendices/Attachments

Document: 3135016 Envirolink Report – Offshore subtidal rocky reefs of Pātea Banks

Offshore subtidal rocky reef habitats on Pātea Bank, South Taranaki

Prepared for Taranaki Regional Council

September 2022



Climate, Freshwater & Ocean Science

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Contents

Tables

Figures

Executive summary

The Taranaki Regional Council engaged NIWA to undertake an analysis and classification of existing survey data on sub-tidal rocky reef habitat in the South Taranaki Bight. Presently, the coastal marine area of South Taranaki is poorly understood. There is a need to identify and characterise subtidal reef systems in the South Taranaki Bight to provide Council and the community with a good inventory of habitats and species present. This will in turn inform decision-making around both land and coastal management where activities may impact South Taranaki sub-tidal reefs.

A targeted selection of subtidal reefs of Pātea Bank, South Taranaki, were surveyed using a two phase approach.

In 2020, a multibeam sonar mapping route was created for the survey region, crossing over as many potential reef sites as possible. Likely reef sites were identified using local divers/fishers knowledge, DOCs (putative) reef polygon coverage, and the local chart. Time was also allowed for the mapping of patch reefs to either side of the survey route as practical. A route track of more than 250 km was achieved, mapping 61.5 km^2 of seafloor. Numerous reefs were revealed across the entire survey area, ranging from small knolls and patches, through to extensive linear ridges several kilometres long. Application of Benthic Terrain Modelling, which uses seafloor bathymetry to identify a range of topographic features, returned nine feature classes likely to be reefs. Collectively, these covered 9.3 % of the mapped area (corrected to remove some likely soft sediment bedforms in the deeper south-west of the survey region). Fault-lines were evident for several of the reefs.

In 2021, 14 of these reef features were sampled using a towed video camera system (NIWA's CoastCam), using the multibeam sonar maps to direct video transect placement. Those video transects were processed to provide detailed spatial estimates of reef geomorphologies, biogenic habitat covers, and invertebrate and fish species counts/abundances. A diverse landscape of reef and reef-associated species was found. Reef geologies included mudstone/papa rock and sandstone/limestone, with mudstone reefs having demonstrably lower biodiversity than sandstone reefs. Macroalgae dominated the habitat cover of most sandstone reefs, including narrow *Ecklonia radiata* (kelp) forests running for potentially kilometres along the reef ridgelines, and extensive meadows of the fleshy green algae *Caulerpa flexilis* covering step terrace reefs. Some of these *C. flexilis* meadows were closely associated with a low 'pillow ridge' reef form, aligned as long linear rows, and what appeared to be carbonate ridges (30 x 30 cm scale). These have not been seen elsewhere. Sponge-rich habitat clusters were present on the boundaries of some reefs, as patches in association with rock tells (limited rock just at or before sediment surface) and as a relatively large patchy sponge garden at the deepest site surveyed (30–33 metres). This deeper site also held high densities of juvenile blue cod, consistent with it providing important nursery habitat for this species. Several other smaller nursery habitat areas were discovered on the edges of some reefs.

In addition to macroalgae, 39 sponge species were identified as present across the reefs, as well as 30 fish species. Blue cod dominated the fish assemblage and were often abundant over habitat mosaics and at the reef/soft sediment boundaries. Other abundant fish species were scarlet wrasse, butterfly perch, leatherjacket, and tarakihi. Mobile invertebrates were uncommon, but kina were relatively abundant at two sites, where they formed urchin barrens. Valuable finer scale data and observations were available for one reef site through the local citizen science Project Reef team and were incorporated to provide additional insights into seafloor composition, blue cod dynamics (2016–2021), and local-scale fish occurrences over time using a novel in-situ camera.

These 14 Pātea Banks reef sites were compared to the wider subtidal reef information available for North and South Taranaki. North Taranaki reefs were found to differ in their composition, being volcanic boulder or bedrock based. The most northern Taranaki reef, Pariokariwa Reef, appeared to have a similar mudstone geology as some of the South Taranaki reefs, but was dominated by sponge garden assemblages not seen in South Taranaki. There appeared to be significant differences in the habitats and fish assemblages of North and South Taranaki, although these remain to be formally tested with suitable data.

This report demonstrates that subtidal reefs are in fact common on Pātea Bank, with many more awaiting discovery by multibeam sonar mapping. Associated with these reefs are extensive areas of biogenic habitat, dominated by macroalgae (notably *Ecklonia* forests, *Caulerpa* meadows, mixed macroalgal meadows, and soft bryozoan fields), as well as areas of sponge garden (areas of higher sponge cover more than 5 metres in width). The associated fish assemblages are abundant, dominated by blue cod, scarlet wrasse, butterfly perch, leatherjackets and tarakihi, with other fisheries species likely to be common (e.g., snapper, trevally, kingfish, and kahawai). The unusual distance of these reef systems from shore, occurring on a wide shallow continental shelf, makes them relatively unique in the New Zealand context, and may have protected them (in part) from land-based impacts seen elsewhere around New Zealand. They are worthy of careful management by the TRC, and other governance entities.

1 Introduction

The Taranaki Regional Council (TRC) has management responsibilities for the territorial sea area (out to 12 nautical miles; 22.22 kilometres) of the South Taranaki Bight, including Pātea Bank. This report provides a detailed quantitative narrative on recent 2020–2021 mapping and ecological survey work targeting subtidal rocky patch reefs on Pātea Bank. This new knowledge is put within the context of existing knowledge of other subtidal reef systems within TRC's management region (territorial sea). This new knowledge helps fill in major fundamental gaps around coastal habitats and associated ecological assemblages, which fall under TRCs management responsibilities.

1.1 General background

The South Taranaki Bight (STB) covers an extensive seafloor area (12,500 km^2) and is in part characterised by an extensive shallow continental shelf, extending to over 40 km offshore of the Taranaki coast. Its inner shoals cover around 1,700 km^2, including Pātea Bank and the area known as the "Rolling Rounds"; with a further 1,100 km^2 of shoals further offshore. At the national scale, it is unusual in holding extensive areas of relatively shallow water away from the coast proper, which has consequences for light climates at the seafloor. An estimated 612 km^2 (4.9 % of the STB) of its seafloor extent is estimated to receive sufficient light to support microalgae growth (Pinkerton 2014).

The coastline is well known to be erosion prone, with the main sources being sediment delivery to the coast from its catchments via rivers, and more directly, cliff falls of sediment as the cliffs retreat from sea-driven erosion. Suspended Sediment Concentrations (SSC) show a strong gradient from inshore to offshore. From the coastal edge to 10 km offshore, average SSC is 1.4 grams per cubic metre (m^3) of seawater (exceeds 3 g m^{-3} 27% of the time); this drops to 0.2–0.7 g m^{-3} at distances of 10 to 40 km from the coast (exceeds 3 g m^{-3} <5% of the time) (Pinkerton 2014).

The STB is influenced by upwellings of nutrient rich water occurring off Cape Farewell, with these water masses being transported north by currents to the STB region. Zooplankton densities have been measured as sometimes exceeding four times that of other New Zealand continental shelf regions, and 6.5 times more than for the North Taranaki Bight (DOC 2006).

Knowledge of the inshore STB's seafloor habitats and ecological assemblages is limited, due to its often rough sea climate, limited land access points, and relative remoteness from research agencies and institutions (DOC 2006). Fisheries research trawl surveys of the west coast of the North Island have avoided the general Pātea Banks area due to the presence of uncharted/unknown subtidal rocky reefs. Paradoxically, there has been a wider general perception that subtidal reefs are rare in the region, and combined with the remote access and weather issues, this region has been one of the least studied coastal regions of New Zealand. For example, the national scale shallow reef macroalgae and invertebrates survey by Shears et al. (2007) did not include any sites in South Taranaki, while the national scale assessment of reef fish distributions by Francis (2003) listed no reef-fish studies for this area. An exception to this was a short DOC-funded drop camera survey of the North and South Traps (two large reef complexes on the southern Pātea Bank) by ASR Ltd, which was later analysed in more detail by Bombosch (2008). Local retired commercial fishers were also interviewed in 2011/12 for their Local Ecological Knowledge (LEK) as part of an MPI-funded study, to help assess what biogenic habitats might be present in this region (and across 13 other regions around New Zealand) (Jones et al. 2016).

This data-poor situation was bought into sharp focus when a company (Trans-Tasman Resources (TTR Ltd.) applied for resource consent to mine large volumes of seafloor soft sediments for iron-sands. As part of this process, TTR Ltd. conducted a comprehensive suite of investigations into the STB environment, and modelling to predict the likely effects of the proposed mining operation. Included was extensive ecological sampling of the seafloor area around the proposed project area, focused on an area on/adjacent to the northern Pātea Bank area (Beaumont et al. 2015). That work sampled 145 sites in 2011, and fundamentally advanced our ecological knowledge of some of Pātea Bank's soft sediments areas. However, multibeam sonar seafloor mapping was not part of the ecological work, and sites were placed haphazardly. Just seven of the 145 sites were associated with rock/rocky reefs. A second smaller 2013 survey sampled a further 36 sites closer inshore and more broadly along the coast, of which five were rock-associated sites (independent of the 2011 sites) (Anderson et al. 2015).

Concern from the local community about the sand-mining proposal, and a desire to gain more knowledge on the reefs of the region, prompted the South Taranaki Underwater Club (STUC) to seek and gain funding for a marine project from the Ministry of Business, Innovation and Enterprise (MBIE)'s Curious Minds Fund in 2015 (one of the first funded by that fund). On the suggestion of one of the STUC members, a small reef observed by divers to support rich fish life and abundant reef cover was adopted as the project's focus, and unofficially came to be known as 'Project Reef'. The Project Reef citizen science group was created, with iwi partners (Ngā Rauru, Ngati Ruanui), and outreach initiatives to work with local high school students. The Taranaki Regional Council also provided support in the earlier years as the project's science partner. The Project Reef is around 3,000 m^2 in extent, and located 11 km offshore of Pātea, in 23 metres water depth. The Project Reef team has investigated the reef from 2016 to the present day; while the Taranaki Regional Council has listed the site in its 2021 interim Coastal Plan in Schedule 1 as having outstanding value, and in Schedule 2 as an area of Outstanding Natural Character (ONC)

The North Taranaki coast has received more focus on its subtidal reef systems, largely driven by the presence of the Sugarloaf Islands (Ngā Motu) complex and associated subtidal reefs immediately adjacent to New Plymouth. In December 1986, the Sugar Loaf Islands Marine Park was created using the Fisheries Act 1983, with the then Ministry of Agriculture and Fisheries (MAF) setting regulations to control recreational and commercial fishing within the Park. Protection was strengthened in 1991 with the passing of the Sugar Loaf Islands Marine Protected Area Act 1991, with the area's seabed, foreshore, waters, and islands being protected; and fisheries resources managed by the Ministry of Fisheries. Limited fishing was (and continues to be) allowed within the Sugar Loaf Islands Marine Protected Area (SLIMPA), except for the area around Waikaranga/Seal Rocks, which was totally protected (except for trolling for kingfish and kahawai). In 2008, the Tapuae Marine Reserve was established, encompassing 1,404 ha (14.04 km^2) of the Taranaki coast from the Tapuae Stream north of Ōakura, to Herekawe Stream, New Plymouth. It overlaps around one-third of the SLIMPA area, and protects all marine life, including pelagic fish.

Research work in the SLIMPA/Tapuae Marine Reserve area has included quantitative monitoring surveys of invertebrate, macroalgae, and fish assemblages from 2001–2003 (Millar et al. 2012, Miller et al. 2005, respectively); Baited Underwater Video (BUV) monitoring of fish assemblages (2011, 2013, 2015, DOC unpubl. data), side-scan sonar mapping in 2011 (DOC/UoW, undated), and multibeam sonar mapping in 2021 (DML 2021).

Slightly further north, the coastal Pariokariwa Reef and surrounding area was first broadly mapped in 1992 using a conventional echo-sounder at 1 km intervals along the shore (transects out to sea) to quantify seafloor bathymetry, with spot diving to validate seafloor types (Coffey & Williams 1992). In

1997, the reef was fully side-scan sonar mapped (DOC 1998). In 2006 the Parininihi Marine Reserve was created, covering 1800 ha (18 km^2), encompassing the Pariokariwa reef and extensive areas of adjacent silty sediment. In 2014, both Pariokariwa Reef, and the smaller separate Waikiekie Reef immediately to the north-east, were fully multibeam sonar mapped (Sturgess 2015).

The first ecological survey of Pariokariwa Reef was completed in 1995, with one day of diving survey focussed on its sponge assemblages (Battershill & Page 1996). In 2007, an invertebrate survey of these reefs (and the Sugarloaf Islands) was undertaken, but the sampling details, data, and draft report produced have not been able to be located (quoted as an 8-page draft report (Smith 2007) in Sturgess 2015). Also in 2007, attempts were made to survey the fish assemblages of Pariokariwa Reef and the adjacent smaller Waikiekie Reef (MetOceans Solutions 2007). Initially, a drop camera was deployed across both reefs, with sites selected by placing a grid over the 1997 side-scan map and retaining all those intercepts falling on reef as drop camera sites (117 and 20 sites respectively). These video observations were then used to select 30 fish count sites to be surveyed by divers. Only 10 of these sites were subsequently successfully surveyed (one day of diver fish counts), due to poor underwater visibility. The drop video data were never reported on, though the video files were later utilised by Sturgess (2015) to help direct sampling strategy. Sturgess (2015) collected limited additional drop camera video of Pariokariwa Reef, as well as new diver-collected data from the north-eastern side of the reef. DOC undertook Baited Underwater Video (BUV) monitoring of the reefs fish assemblages in 2011, 2013, and 2015 (DOC, unpubl. data).

1.2 New Pātea Banks survey knowledge and application

Outreach collaboration between NIWA's MBIE-funded 'Juvenile fish habitat bottlenecks' CO1X1618 research programme, and the Taranaki-based citizen science Project Reef group (see https://www.projectreefsouthtaranaki.org/, https://www.youtube.com/watch?v=QX_eAeyZgTE) led to two field sampling events in 2020 and 2021, to search for potential key juvenile blue cod habitats/nurseries on Pātea Bank. This field work targeted subtidal rocky reefs, using a combination of multibeam sonar mapping, high resolution towed video, and fish traps with attached Go-Pro cameras. Local ecological knowledge of fishers and divers was used to identify potential reef locations and drive the spatial design of the multibeam sonar survey in 2020. The subsequent seafloor maps were used to inform the placement of fourteen ground-truthing sites and associated ecological survey in 2021. Collectively, these methods revealed an extensive mosaic of individual reefs and associated rich ecological assemblages (fish, invertebrates, and macroalgae).

These rich ecological systems are of particular interest to TRC with respect to their management responsibilities for the coastal ecosystem in a region that has been poorly sampled. To help address this fundamental knowledge gap, an Envirolink project was secured by TRC to help complete analysis of video footage, integrate these and the other data components into a quantitative narrative on what exists on Pātea Bank's offshore subtidal rocky reefs; and compare these reef systems to others at the wider Taranaki scale. These new survey data (2020–21) are collectively presented and narrated through summary maps, plots, and tables. Formal statistical data analyses are beyond the scope of this report but future work is planned to undertake such analyses and progress their publication in the primary science literature. As these data and the methods that created them are reported here for the first time and not documented elsewhere, a detailed account is given of the field methodology, as well as the post-processing data extraction approaches used. Additional data created by the citizen science Project Reef group between 2016–2021 is also incorporated proving a valuable finer-scale detailed view of the Project Reef; set against the broader scale surrounding subtidal rocky reef systems.

2 Methods

2.1 Identification of potential subtidal reef sites

To maximise the number of patch reefs likely to be detected, a range of information sources were collated and spatially plotted. The Project Reef location was provided by the Project Reef team, and other South Taranaki Underwater Club members and local divers kindly provided in confidence several known/likely reef sites from their diving and fishing activities. Additionally, a GIS shapefile of small polygons likely to be rocky reef was available from the Department of Conservation (DOC). Working at the national scale, DOC had used old faring sheets to identify potential reef locations around New Zealand, in the 0 to 100 metres depth range. Abrupt shifts in bathymetry were used as a proxy for likely reef presence, and polygons created around these depth features. The positions of the seven rock-associated sites of Beaumont et al. (2015) were also included. Collectively, these geospatial data were plotted over the South Taranaki nautical chart, allowing the collective points/polygons likely to indicate reef/rock presence to be visually assessed against charted bathymetric features.

2.2 Multibeam sampling

The multibeam survey was conducted in August 2020, with approximately 30 hours of on-site vessel time (NIWA's RV Kaharoa, a 28 m research trawler) available for the multibeam survey. Using an anticipated 6 knot vessel speed, a network route was drawn across as many reef/rock targets as possible, while maximising the geographic (north/south) and depth (to 50 metres) spread of targets and allowing sufficient time to map out patch reefs when encountered. The route ran directly over sites represented as latitude/longitude points, and through the central mass of DOC putative reef polygons.

The effective swathe width of the multibeam sonar was 4x the water depth. When the vessel passed over a likely reef target (raised elevation, topographic features, backscatter change), it turned back and mapped the seafloor on either side of the transect to capture the full extent of the reef, where practical. Several interesting and unusual soft sediment bedform features encountered were also mapped in some of the deeper areas. Not all putative reef features encountered were able to be mapped, with the trade-off being completing the mapping route, versus mapping out as many reef targets as possible when detected.

2.3 Video imagery (NIWA's CoastCam)

In March 2021, NIWA's R.V. Ikatere (14 m) spent three days sampling a subset of the rocky reef locations revealed through the multibeam sonar mapping, working out of Whanganui each day. Using the multibeam sonar data (bathymetry and backscatter), twenty sites were selected for potential sampling. Site selection was based on achieving a good spatial spread from north to south, encompassing an on-shore/off-shore depth gradient, and encompassing a range of putative reef geo-morphologies, including long ridges, terraces, patches, and indeterminate mixes of rock and soft sediments. Each target site was assigned a unique letter as its identity, starting from A, and ordered from north to south. At each selected site, a single continuous towed video transect was carried out, passing over the different putative seafloor reef elements as shown in the multibeam sonar data. Turns within some transects were included to maximise capturing as much local reef variation as practical. Transect length (and associated survey times) varied from site to site depending on putative reef extent and complexity, with an average time target of 30 minutes; set as a pragmatic trade-off between the number of sites surveyed, versus collecting sufficient video footage within each site.

NIWA's 'CoastCam' towed video system was used for the sampling. This system has two high-resolution video cameras and one high-resolution still image camera. One of the videos faces forward at an angle to the seafloor (circa 35 degrees), and the second faces down to the seafloor. The stills camera also faces directly down to the seafloor and takes images at programmed intervals (here every 15 seconds). The stills cameras field of view is smaller than that of the video cameras. Lighting is used to illuminate the seafloor for both the video (continuous) and still cameras (flash). Two parallel scaling lasers (here 20 cm) were used as seafloor object/field of view distance measures. The CoastCam was flown at approximately 1.5 m altitude at a speed of approximately 0.6 knots. Altitude/height above the seabed was controlled using a remotely-controlled winch, with the winch operator using real-time video feeds to watch for changing water depth and water clarity/field-of-view, and to avoid seafloor obstacles.

The CoastCam system was designed to primarily quantify seafloor habitats, rather than fish. Fish must remain in front of the system as it approaches for the 35 degree camera to detect them and remain in the field of view as CoastCam passes over them for the downward facing cameras to detect them. Only the 35 degree camera footage was formally used for scoring both fish and the seafloor, so that as many fish were detected as possible with their associated seafloor habitat. More mobile fish species that may occur further off the seafloor (e.g., snapper, kahawai, kingfish) are known to be poorly detected with CoastCam, while more directly demersal species (e.g., blue cod, scarlet wrasse) are better quantified. To provide some background on whether larger mobile fish might be evading detection during this survey a forward-facing low-light camera was also attached to the CoastCam frame, without direct lighting or scaling lasers (as it was angled to the horizon). That footage has not been formally analysed but opportunistic viewing of some of the footage did not reveal additional fish individuals (aside from a specific instance at site V, which is discussed in that sites narrative).

The R.V. Ikatere's GPS was used to continuously record vessel position, and by extension, the location of the camera. It was not possible in this project to attach a tracking device on the actual camera system, to calculate the true camera position. Spatial error in the cameras plotted position includes GPS inherent error, distance from the GPS units' position on the vessel to the stern (6 metres) and the camera's cable layback from the vessel (which increases with water depth). Added caveats include the camera not always being directly behind the vessel, due to effects of currents, swells, and wind push on the camera/vessel; as well as during occasional vessel turns.

Days 1 and 2 completed pre-planned transect paths. On Day 3, sea conditions began to move towards being marginal for deploying the CoastCam. A three-metre and rising long swell restricted the safe directions in which CoastCam could be towed, with the tow direction having to run with the swell, to avoid putting excessive abrupt strains on the towing wire, winch drum, and camera unit. The planned gently zig-zagging transect paths to work along long reef ridges were not workable, as they sat at right-angles to the swell direction. Tows therefore were restricted to simple straight paths that ran with the swell and crossed these reef features across their narrowest extents.

It is important to remember that the three field survey days were exploratory and aimed to cover as much overall reef complexity and variation within the survey extent as possible, rather than investigate any individual reef in greater depth. The video transect placements were not random, in that they were placed to traverse as many habitat features as possible per transect; and there was no transect replication within any of the sites. The one exception was Site K (the 'Project Reef'), where it's small spatial extent (around 130 x 150 metres), and key focus for the Project Reef citizen science programme, attracted a placement of multiple parallel video transects nominally 10-metres apart, encompassing the full reef. The various seafloor %cover estimates presented in this report represent the transect footprint, rather than the full reefs. Nevertheless, they are likely to generally be a good first approximation of seafloor covers across the different reefs.

2.4 Baited fish traps

To provide additional data on the fish assemblages of the reefs, including species known to avoid towed cameras (e.g., snapper), a limited number of baited fish traps with attached Go-Pro cameras were deployed adjacent to a subset of the towed video sites. Umbrella traps, each with eight entrances, were baited with circa 300 grams of pilchards. Go-Pro cameras were mounted on a side pole extension, which positioned the camera one metre out from the trap, at 40 cm above the seafloor, and facing the trap. This provided a fixed field of view encompassing the trap (90 cm diameter) and a 90 cm strip to each side of the trap. Traps were left to fish for a minimum of one hour, before being retrieved. The caught fish were identified and measured down to the nearest mm fork/total length, and then released alive. The Go-Pro video was downloaded and stored on portable hard drives.

Originally the target was 4 replicates per trapping site (a subset of CoastCam transect sites), but time lost waiting for fuel in Whanganui Port reduced the time available to set traps (CoastCam transects being the key priority). More traps than expected were also lost to the reefs, along with their cameras and associated data (video/catch) for that set. That, and the subsequent camera pool reduction, further reduced the replication achieved.

2.5 Project Reef team methodology

2.5.1 Reef composition

The seafloor composition of the Project reef was assessed by SCUBA divers in 2017, 2018, and 2020 (Project Reef Citizen Science group). In 2017 (29 October–23 November), five 30-metre long transects were haphazardly deployed across the reef, starting from the survey vessel's anchor point due to safety reasons (the site is subject to often high currents and/or reduced underwater visibility). For each transect, a diver swam out a 30 metre measuring tape along a pre-determined random compass direction. A second diver, equipped with an underwater camera fixed to a 50x50 cm (0.25 m^2) sampling frame, followed along the tape, and took a seafloor photograph at one metre intervals. Collectively, this returned 30 images per transect, and 150 images overall.

In 2018 and 2020 the methodology changed to deploying a singled fixed transect, and the photograph sampling frame changed to 80 x 65 mm (0.52 m^2).

2.5.2 Blue cod population structure assessed by rod fishing

To assess blue cod population structure at the Project Reef over time, standardised rod and reel fishing was deployed from a small boat. The number of hours fished, and rods used, was recorded for each event. The fish catch was identified to species and measured for length (down to the nearest mm). All fish were returned alive to the sea.

2.5.3 Baited Underwater Video (BUV)

Three successful BUV deployments were made, using a downward facing camera over a baited burley pot set within a metal frame with scale bars (the same standardised system used by DOC). The BUV unit was deployed on the reef for 30 minutes, and then retrieved using the units attached surface float and dropline.

2.5.4 In-situ video camera monitoring

The Project Reef team developed an in-situ video camera system, able to be deployed for multiple weeks at a time. Equipped with lights for night operation, and a programable intervalometer, the camera was programmed to record 30 seconds of video, every 20 minutes. This system was deployed at a fixed location at the Project Reef, over eight discrete deployments between 2017 to 2020, with video footage recorded both during the day and at night.

2.6 Data processing

2.6.1 Multibeam sonar data

NIWA's standard approach to grooming and cleaning multi-beam sonar data sets were applied to the raw data to remove artefacts and errors (for instance, the removal of 'false' seafloor detections from features such as fish schools). This created final bathymetry and backscatter data-sets, with a 1-metre pixel resolution. The bathymetry data was then analysed using the Benthic Terrain Model (software), to cluster local-scale depth pixels into landscape-level bathymetric features such as ridges, slopes, depressions, and knolls. Such an approach is especially well suited to more rugged three-dimensional seafloors such as those of patch reefs; but is less informative for 'flat' bathymetries. Backscatter data were plotted as a visual backdrop in map plots to help with the assessment of the sampled reef sites. All the processed data outputs were loaded into ArcMap/ArcGIS Pro software for plotting and the production of maps.

The extent of each video-surveyed reef was estimated by manually drawing a polygon over the multi beam sonar bathymetry, tracking around the reef/s boundary. This was at the scale of the full reef, with a reef defined as a continuous elevated surface relative to the surrounding seafloor (as seen in the GIS ArcMap using sunlight illumination). Reef depth range was taken from the shallowest depth recorded in the multibeam sonar data (the top of the reef) to the lowest depth value associated with the reef boundary polygon (the reef-sediment boundary).

2.6.2 Towed video (CoastCam) processing

Geomorphologies

Biogenic habitat and geomorphology occurred as complicated spatial mosaics at different scales along the video. To address this, the video footage was divided into twenty second sequential intervals, and each treated as the base sampling unit. On average the video camera travelled 6.2 metres in distance in a twenty second period. Time was chosen as the unit of measure, as video time elapsed was able to be seen directly on the videos, was easy for the video analyst to keep track of and allowed each second that passed to be a good proxy for 5% of the video segment having been viewed. The alternative of using a fixed distance travelled as the base unit of measure was also considered (as a better statistical unit) but was found to be problematic for the video analysts (re, keeping track of when each individual segment started/stopped, and in calculating associated percent covers).

To estimate percent cover of the geomorphology classes, each 20 second video segment was viewed by the video analyst, and visually scored for the % cover of each class present. Class intervals of 5% were used, with rarer elements being classed in 1% bins up to 5%. This was considered to match the likely visual estimation accuracy achievable by the analyst. The combined percent cover was required to add to 100%. Each segment was viewed as many times as necessary to estimate the geomorphology covers present, with the estimates noted manually on paper. The start and end positions of each segment was determined using OFOP.

To generate a scoring scheme for reef and soft sediment geomorphologies, all video was initially viewed, and a broad classification scheme developed to categorise the features and bottom type's present. Broadly speaking, this was arranged in order of increasing 'object size', using the Wentworth particle approach for sediments, and rugosity and 'patchiness' for harder substrates. For example, soft sediment types ranged from sands through gravels to shells; while harder seafloor types ranged from cobbles, boulders, flat basement reef, gutters, and low reef, through to high relief reef. Rock type was divided into putatively mudstones (known regionally as Papa rock) and sandstones.

To help provide some potential future guidance (beyond this current report) on quantitively reducing the spatial offsets between the very spatially accurate multibeam seafloor maps and the less accurate towed video positions, when a significant vertical wall/terrace feature, or abrupt transition between reef and soft sediments was passed over squarely by the camera, a spatial position point record was made. These abrupt features are also well captured in the multibeam sonar seafloor maps, and a comparison between the two datasets (also including water depth as a proxy for camera cable length deployed) may allow for the camera's positional accuracy to be improved for future formal statistical analyses; through the application of new offset adjustments.

Biogenic habitat classes

The analysis of percent cover of biogenic habitat classes was handled in a similar fashion. Each habitat class was assigned a percent cover estimate, with class intervals of 1% up to 5%, 5% bins up to 10 % and then in intervals of 10%. These % cover classes were broader than those for geomorphology. Ten percent bins were thought to reflect the likely accuracy of visual cover estimates. There was no requirement for the biogenic classes to sum to 100%, as large extents and patches of seafloor did not have biogenic habitat cover. During analysis it was noted that small, new, *E. radiata* recruits (less than 10 cm in size, no stalk/stipe) could be reliably seen and counted, so a count of these per 20 interval was also included.

A range of habitat forming taxa were not amenable to being scored as individuals, including macroalgae and soft bryozoans, due to their close packed and often species mixed context, small size, variable resolution ability across and within the video footage, and tentative-only formal species identification by taxonomists. To allow for this, broader level classes were used, using general morphology and colour to create classes that could be consistently applied across the different situations encountered. These biogenic habitat classes were scored as percent cover. Bryozoans were recorded as either calcified (hard) or uncalcified (soft) species forms. Species able to be consistently scored as clearly monospecific covers (e.g., *E. radiata*, the two *Caulerpa* species) were identified to species.

To keep scoring classifications as consistent as possible with other New Zealand studies, the shallow-reef classification scheme of Shears et al (2004) was used as a base framework. Shears et al. validated a previously informal shallow rock reef habitat classification which was developed for north-eastern New Zealand but is broadly considered to hold for the North Island. Their summary table is reproduced here (Table 1). We note that this classification was developed for reef systems in shallower water (0 to 12 metres) than those encompassed in this Pātea Banks survey (12 to 38 metres; one shallow reef top to 9 metres). Several of Shears et al. (2004) habitat classes were not seen (e.g., *Carpophyllum*-dominated classes), along with new ones being encountered (e.g., soft bryozoan fields).

Table 1: Shears et al. (2004) shallow reef habitat classification [Note: "*Figures in the descriptions are indicative only. Habitats were determined by subjective assessment of dominant species*") (Source: table 1, Shears et al 2004).

Habitat	Typical depth range (m)	Description
Shallow Carpophyllum	<3	Dominated by high abundances (≥20 adult plants m^{-2}) of Carpophyllum maschalocarpum, Carpophyllum plumosum, and Carpophyllum angustifolium. Ecklonia radiata and the red algae Pterocladia lucida, Osmundaria colensoi, and Melanthalia abscissa also common. Sea urchin Evechinus chloroticus occurs at low numbers and generally occupies crevices.
Ecklonia forest	>5	Generally monospecific stands of mature Ecklonia form a complete canopy (≥4 adult plants m^{-2}), occasional C. flexuosum plants. Urchins at low numbers (<1 exposed urchins m^{-2}) and usually occupy crevices.
Carpophyllum flexuosum forest	3 to 12	C. flexuosum plants dominate (≥4 adult plants m^{-2}), on sheltered reefs plants are large and associated with high levels of sediment. On more exposed reefs plants are short and generally associated with Evechinus.
Mixed algae	2 to 10	Mixture of large brown algal species. No clear dominance of one particular species, usually only partial canopy (≥4 adult plants m^{-2}) and urchins may also occur at low numbers (<2 exposed urchins m^{-2}).
Red foliose algae	2 to 9	Substratum predominantly covered (>40 %) by red foliose algae such as P. lucida or O. colensoi. Low numbers of large brown algae (<4 adult plants m^{-2})
Turfing algae	3 to 12	Substratum predominantly covered by turfing algae (e.g., articulated corallines and other red turfing algae) (>30 % cover). Low numbers of large brown algae (<4 adult plants m^{-2}) and urchins may be common.
Caulerpa mats	2 to 12	Green algae, usually Caulerpa flexilis, form dense mats over the substratum (>40 %). Urchins and large brown algae rare.
Urchin barrens	3 to 9	Very low numbers of large brown algae present (2 exposed urchins m^{-2}), substratum typically devoid of macroalgae. Usually associated with grazing activity of Evechinus (>2 exposed urchins m^{-2}), which leaves the substratum relatively devoid of macroalgae. C. flexuosum and Sargassum sinclairii may occur
Cobbles		Reef comprises cobbles (c. <0.5 m 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
Encrusting invertebrates		Usually vertical walls, substratum predominantly covered by community of encrusting ascidians, sponges, hydroids, and bryozoans. Large brown algae rare.
Sponge flats	> 10	Sponges visually dominant, high cover of sediment. Usually occurs on the reef-sand interface. Low numbers of Ecklonia may be present (<4 adult plants m^{-2}).

The geomorphology and biogenic habitat class cover estimations were made by two independent video analysts respectively, as the two tasks could not be done simultaneously. This by default also prevented between-observer variability being present within each of the two groups estimations.

Individual species counts

The CoastCam's forward-facing camera was used for all video analysis. To create a master list of species present, the video files were initially viewed and multiple screen-grabs taken of all the different putative species present that could be reliably and consistently identified (broadly speaking, >4cm in size). Technical field issues with the still camera's focus and resolution limited use to largely just video being used for this process. Invertebrates including sponges, ascidians, sea-slugs (nudibranchs), hydroids, molluscs (bivalves, gastropods), echinoderms (urchins, starfish) and calcified bryozoans were identified to species where practical, while soft bryozoans were treated as a single Operational Taxonomic Unit (OTU) as distinguishing between species from video is problematic. Macroalgae included kelp species (e.g., *Ecklonia radiata*, *Carpophyllum maschalocarpum*) and a range of smaller species (e.g., *Caulerpa flexis*, *Caulerpa gemmata*, other green, red, and brown algae). Fish included all species seen (excluding triplefins). Selected invertebrate and macroalgae species imagery was distributed to a range of expert taxonomists, who identified these to species level where possible, or higher group levels if not. All species that were thought to be potentially identifiable from the video imagery were included in this process, including species already well known to the project team, to ensure a consistent approach. External expert opinion was sought for fish species that were well outside their normal national distribution (e.g., a porae), or relatively rare tropical stragglers (e.g., a red morwong). Triplefins were excluded due to their small size and highly variable detection rates using towed video. These identifications were used to generate a species scoring list for the video analysts to use, along with an informal visual species guide.

Each video file was loaded into the Ocean Seafloor Observation Protocol (OFOP) software, along with the matching GPS file recorded at the time of sampling. The GPS files were cleaned before input using a splining approach, which smooths out (removes) any spurious abrupt-short spatial deviations/jumps from the track-line that can occur when the GPS occasionally loses satellites and suffers spatial accuracy degradation. OFOP matches the timestamps of the video and the GPS files, to assign a spatial position to each observation scored by the video analyst. Using the pre-defined species master list loaded into OFOP, the video analysts scored each fish and invertebrate individual seen as a discrete point observation. Different video analysts scored the fish and invertebrates separately. This single scorer approach enabled each analyst to analyse all sites and thus removed inter-observer scoring variability (a form of processing error).

For invertebrates both individual and colonial species were present. An 'individual' was defined as either a single true individual (e.g., kina, sea-slugs, gastropods), or a colonial species that occurred as a discrete singular colony (e.g., finger and ball sponges, and hydroid trees) or as a discrete 'patch' that could be visually defined as a discrete object spatially distinct from other nearby patches (e.g., massive sponges such as *Ecionemia alata*, or patch formers such as *Crella incrustans* and Family Chondropsidae (*Psammoclema* sp. indet or *Chondrosia* sp. indet.) species 2. The video analyst used their best judgement to consistently score the number of patches/individuals present; colonies less than 5 cm in size were not scored.

Attraction of fish to the camera, and more specifically the lasers, was an issue for blue cod and to a lesser extent scarlet wrasse. A protocol was used to minimise the potential for overestimating fish abundance through fish being attracted into the field of view and following the lasers and being counted more than once in the video. Only fish entering the field of view from the upper half of the video field-of-view were counted; those appearing from the lower sides and the bottom of the field-of-view were ignored. Fish that were counted, and then continued to follow the lasers and remain in the field of view, were excluded from being re-counted. To provide more information on the size distributions of blue cod, individuals were assigned to length bins of <13 cm, 13–20, 21–30, and 30+ cm. The <13 cm length bin was further subdivided into juvenile blue cod still in their black and white coloration (recent recruits have a light white body and horizontal black stripes colouration), versus putatively older juveniles that had changed their coloration to ‘brown phase’. The twelve cm break was selected after viewing several videos and looking for the length at which the 0+ and 1+ age juvenile blue cod cohorts were clearly separated in size (0+ refers to fish from 0 to 1 year in age, 1+ as fish from between 1 to 2 years old, and so on). Tarahiki and snapper were also assigned into the same length bins, but with a 10 cm rather than 12 cm length break.

At thirty second intervals a screen-grab was taken, and the fixed distance scaling lasers bottom intercepts used to estimate the field of view. Issues of being unable to discern the lasers in some of the footage became apparent, with 393 estimates successfully made. The average estimated width of view was 225 cm, and this average was used across all the video transects. Further improvements for future formal data analysis (beyond this report) are possible through estimating missing values using interpolation calculations from those successfully estimated and applying these within and between transects.

Towed video data integration

To combine the four data streams (fish, invertebrates, geomorphology, and habitat classes), the 20 second video intervals were treated as the basic sampling unit (hence referred to as a segment). Code written in Python and R was used to take the OFOP geomorphology text files and extract the start and end spatial coordinates of each sequential 20-second segment, and within each of these, manipulate and re-order the geomorphology classes and associated percent cover estimates to create a flat table matrix (text) file. In this file, each 20 second interval was recorded as a single data line, with geomorphology classes as variable types along the top of the table, and percent cover estimates as data in the actual table. The biogenic habitat classes and associated percent cover estimates were added to this flat table, using time stamp matching to add these data to their respective unique video segments.

The fish and invertebrate records, scored in OFOP as individual point records, were assigned to the respective 20-second video segments that they fell within, again using time-stamp matching to assign them correctly. These were added to the master flat table as summed counts per species/identity per video segment.

The spatial start and end positions of each segment were used to calculate the distance covered by each video segment. The mid-point of each segment was used to plot bubble maps for selected species. The final master flat table consisted of 1,886 20-second segments (some of lesser time, if at the end of a given video run), with each segment being represented as a single data line with all its associated spatial information.

Each 20-second video segment was assigned a unique sequential number (range 0–1,874) and those numbers used as a spatial position index for the percent cover and species counts plots and maps. Where used in an individual site section to highlight areas of particular interest along the video transects, they are given as an index range prefaced by the symbol #; to avoid clutter, the associated figure is not referenced.

Each site section also presents a range of seafloor images, with each image assigned a unique sequential number within that site section (e.g., Site A has 18 seafloor images, numbered 1 to 18). Within a given site’s section, these are referred to without an associated figure number, to avoid clutter.

2.6.3 Fish traps with Go-pro cameras

Each Go-Pro video associated with a fish trap was viewed and scored for the maximum number of individuals able to be seen in one frame shot, for each of the fish species present. This metric, known as Nmax, is an estimate of the maximum density of fish present (by species), and avoids issues of double-counting individuals. Fish suitably aligned to the camera (e.g., not head/tail on/at a sharp oblique angle) were also estimated for length, using known distances between elements of the fish trap as a scale measure. It should be noted that the use of a single camera returns length estimates subject to greater measurement error than systems that use dual stereo cameras.

2.6.4 Project Reef team sample post-processing

Reef composition

The photo-quadrat images were loaded into the open license software PhotoQuad, and each image analysed for percentage cover, using 100 random point intercepts placed across the image. Each point intercept was assigned to one of the following seafloor classes

- Encrusting plants and animals – identified to phyla/taxa group
- Reef conglomerate – including bare rock and cobble mixes
- Biogenic habitat – mixed species cover of small algae, sponge, ascidians, bryozoans, and other encrusting organisms that could not be resolved to individual species at the level of resolution available
- Turfing algae – mixture of small species
- Shell hash – broken and intact dead shell cover
- Sand – excluding very light dustings on the reef surface
- Unknown – unidentifiable point intercepts, largely because of poor image quality and/or varying depth of field.
- Frame artefact – in the 2020 survey, a small part of the camera frame fell within the image field, obscuring the seafloor

Several individual images that were of too poor quality were excluded from analysis. All of the successfully processed images were treated as quadrats sampled along a transect, and the average of the quadrats along the transect presented as the base sampling unit. Error estimates were not calculated, as two of the three surveys contained only a single sampling unit (one transect).

Blue cod population structure assessed by rod fishing

Blue cod caught by line fishing, over measured time periods, were standardised to a Catch Per Unit Effort (CPUE) metric, expressed as fish caught per rod per hour fished. As each event was a single fishing trip, there was no replication, and error estimates were not able to be calculated.

Baited Underwater Video (BUV)

As with the Go-Pro trap cameras, each 30 minute video recorded was viewed, and Nmax for blue cod estimated. As one BUV deployment was made in each of the years sampled (two in 2020), there was no replication, and error estimates were not able to be calculated. Fish were not measured for lengths.

In-situ video camera monitoring

Formal counts/time present estimates of fish species from the in-situ camera deployments have not been made, but Project Team members viewed many of the 20-second video segments, and recorded narratives of what was seen.

3 Results

3.1 Multibeam sonar mapping

Around 30 hours of multibeam sonar mapping was achieved, over a route track of more than 250 km, and with an overall seafloor coverage of 61.5 km^2 (Figure 3-1) Numerous areas of rocky reef were encountered, and a number of these mapped out to a larger extent to each side of the initial transect. Large soft sediment bedforms were also observed in several areas, ranging from sand/gravel waves, through to large raised bedform features, which remain to be ground-truthed. All the locations identified through local fishing/diving knowledge held reefs. Many additional reef (complex local bathymetry) locations were identified, both adjacent to/around the local knowledge sites, and more broadly across the survey extent. The putative DOC rocky reef polygons were less often found to hold reefs, except for the South Trap, and the long raised NE/SW ridge features of the most south-eastern area.

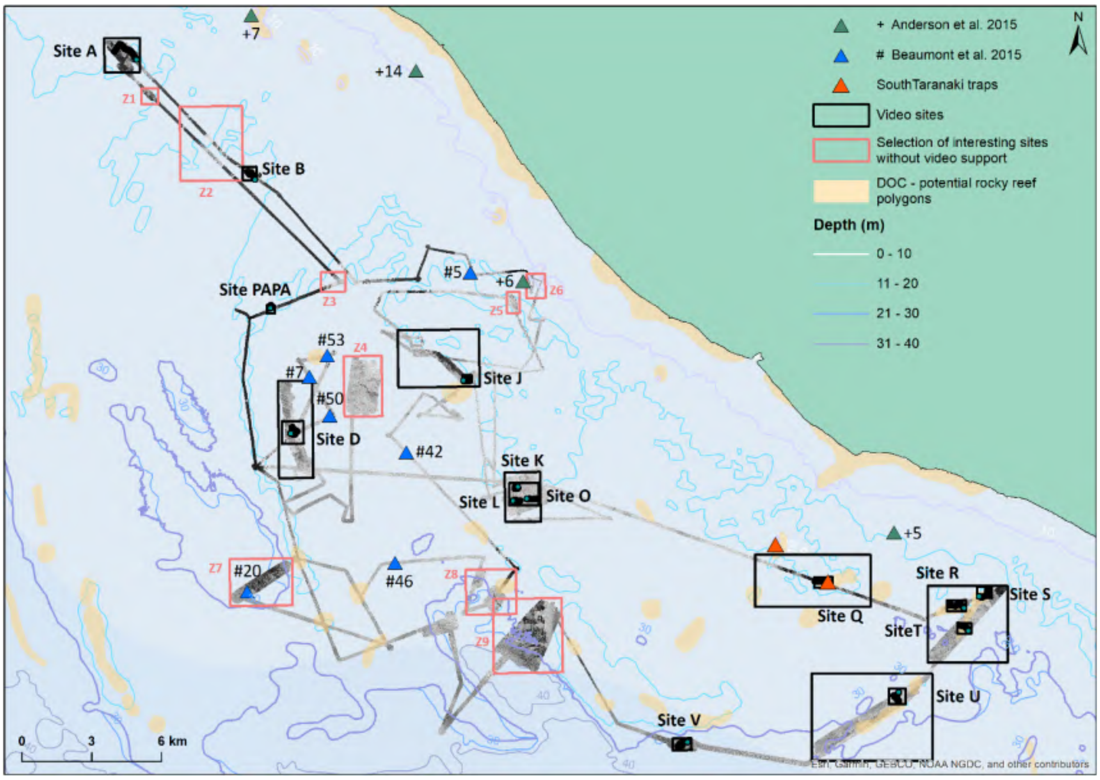

Figure 3-1: The multibeam sonar route (backscatter displayed) and the 14 site locations successfully sampled, and ground-truthed, using the towed camera system (CoastCam) are shown.

Target sites that were not able to be visited due to time constraints in the field are not shown. The black boxes show the sites sampled by video; where the reef sites fell within a larger reef complex, two scales are marked – one at finer scale focused on the video transect, and one at larger scale to illustrate the wider reef system. The pink boxes (Z series) indicate other particularly interesting sites, some reef focussed and some soft sediment, that were not able to be sampled with the CoastCam due to logistic constraints (see Appendix B for close-up images of backscatter and bathymetry). Many additional rock/reef features were also mapped but not marked up here. DOCs putative reef polygons are shown in yellow. Ten-metre depth contours are shown. Local knowledge sites are not shown to respect the information generously shared with us. To help protect the exact spatial coordinates of sites, latitude and longitude markers are not provided, the coastline is displayed at relatively low resolution, and geographic names are not included. Rock/reef sites encountered by Beaumont et al. (2015) and Anderson et al. (2015) are also shown.

Application of the Benthic Terrain Model (BTM) to the bathymetry data characterised the seafloor landscape into 14 feature classes (Figure), with flat plains being the dominant 'base background' within which the other 13 classes occurred. Of these 13 classes, eight were indicative of reefs for this region

- Steep slopes
- Scarp/cliff
- Rock outcrop highs, narrow ridges
- Local ridges/boulders/ pinnacles on slopes
- Local ridges/boulders/pinnacles on broad flats
- Local ridges/boulders/pinnacles in depressions
- Flat ridge tops

For finer spatial representation, multibeam data was split into six blocks for the calculations of percent putative reef (Table 2, Figure 3-2). These six spatial blocks are shown in greater resolution in Appendix A.

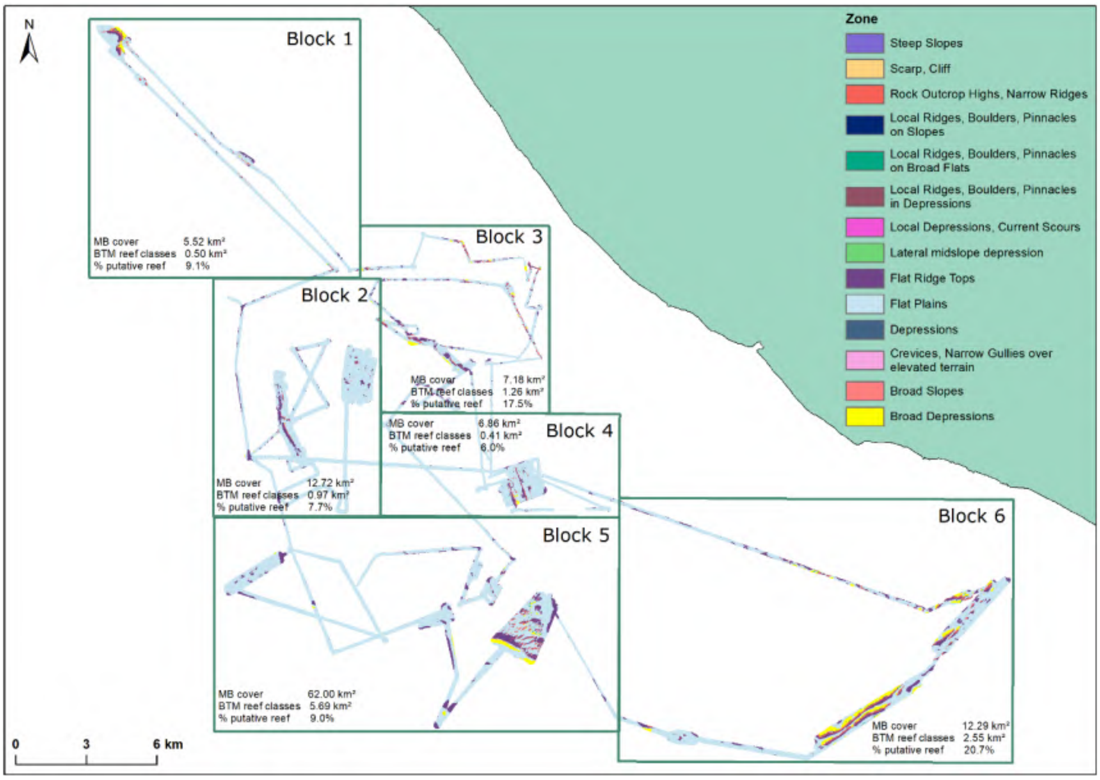

Figure 3-2: BTM classification of the multibeam bathymetric data, and conservative estimates of reef extent. Most of the possible reef categories shown in Block 5 are more likely to be large scale soft sediment features, although it is possible that reef components are present and contributing to the formation and presence of the soft sediment bedforms. Larger scale maps are given in Appendix A.

Table 2: Areal extent of seafloor mapped by multibeam sonar by sub-area; probable rock/reef extents and % contributions.

Block	Area mapped (m^2) All	Area mapped (m^2) Reef-associated classes	% likely reef
1	5,521,336	500,572	9.1%
2	12,719,137	973,833	7.7%
3	7,179,593	1,259,662	17.5%
4	6,859,173	411,216	6.0%
5	16,961,169	2,600,423	15.3%
6	12,285,293	2,547,834	20.7%
Total	61,525,701	8,293,539	13.5%
	Corrected for Block 5	5,693,116	9.3%

Across the six blocks, the seafloor extent mapped with multibeam sonar ranged from 5.52 to 16.96 km^2, with the percent reef estimates ranging from 6.0 to 20.7% (0.41 to 2.0 km^2), and an overall percent reef estimate of 13.5% (Table 2). A caveat to this estimate is that the raised bathymetry features of Block 5 were highly likely to be soft sediment bedform features (based on their repeated patterns, and orientations to each other), rather than reef; though some reef elements may also have been present in these structures (e.g., site #20, Figure , identified as 'low relief outcrop partially buried' by Beaumont et al. 2015) . No ground-truth video data was collected from Block 5. The backscatter data, while showing the Block 5 complex raised features to be highly reflective (often a characteristic of reefs), was not informative here. Visual examination of the backscatter data across the overall survey region showed that reefs were not consistently distinct from non-reef soft sediment habitats in their backscatter signal strength, with rock and coarse sand often having the same backscatter response. In some sub-areas, the coarse sand returns had a stronger acoustic return than rock seafloor.

Excluding the Block 5 percent reef estimate as being largely (but not completely) attributable to seafloor bedforms other than reefs, reduced the combined six block percent reef estimate to 9.3% of the surveyed area. This estimate is likely to be conservative, as the BTM classes were driven by bathymetric variations; flat rock/reef extents on a wider flat seafloor background were effectively 'invisible' to detection by BTM. There is evidence of this for some CoastCam sites, where flat rock-based seafloors as seen on the video transects did not always map onto BTM classes indicative of reefs.

The topographies of the reefs encountered are covered in more detail in later sections. Briefly, the presence of long narrow rock ridges, some extending for kilometres, was notable in Blocks 2, 3, 4, and 6 (Figure). Smaller scattered patch reefs and knolls were dominant in Block 1, along with the larger raised reef complex in the north (Four-Mile Reef). Numerous patch reefs were also present in the shallower north-eastern quadrant of Block 3, though these may have in part been components of larger ridge systems. This is hinted at by the linear orientations of these patch reefs, their boundaries extending outside of the narrow multibeam sonar transects (due to the shallow water depths), and the presence of such large ridge features in the south-west quadrat of the same block.

3.2 Towed camera data

Thirteen out of 20 potential target sites were successfully sampled using the CoastCam, covering as much of the multibeam sonar bathymetric and backscatter variation present as practical. One additional site was also added in the field, targeting a soft mudstone 'terrace' site discovered by local divers in 2021 (after the multibeam sonar survey). That site was assigned the name identifier 'Papa', in recognition of the soft mudstone nature of the reef. The site fell just north of part of the multibeam mapping route transect (Figure 3-1).

The video survey results section of this report is split into two parts. In the first section, the classes generated for the biogenic habitats and geomorphology are presented across the 14 sites sampled collectively, along with the fish and invertebrate data. In the second section, each site is looked at individually. Later in this report, these data and the new knowledge gained from them are set within the context of other previous work on Taranaki reefs

3.2.1 Geomorphology

The initial visual assessment of the fourteen transects revealed a series of complex seafloor geo-morphologies, often with many changes over short spatial differences, and the presence of habitat mosaics. Repeated viewing of the video transects resulted in a set of consistent visual geomorphology classes being created, that could be reliably used by the video analyst to estimate the percent cover contributions of those classes present in any given 20-second video segment.

Table 3 provides a summary of the geomorphology classes developed and used; Figure a selection of visual examples of the different rock-based geomorphology classes, and Table 4 the percent contributions of these and soft sediment classes at the site (video transect) scale.

Table 3: Rock-based geomorphology class descriptions (created for this project).

Rock habitat class	Description
Bare grey river stones	Round smooth light grey stones, that appear to be of a harder rock type, are not colonised by epifauna/flora, and are usually present in drifts and piles. They are strikingly similar in appearance to stones seen in some large, braided rivers; and may have had an origin as river-eroded stones.
Mixed irregular cobbles	Irregularly shaped cobbles, often flat and rectangular, of various sizes, often occurring embedded in a mix with soft sediments
Tell	Flat rock, or the slight bumps on otherwise flat rock, that is almost entirely covered with a soft sediment veneer, and just barely emerges as very small, exposed elements (< $1m^2$), or is shown to be present by the attachment of small clumps of hard-substrate sponge species, although the actual rock cannot be visually seen. The actual rock surface may be quite extensive, but most of it is covered by soft sediment veneer, making it unviable for attachment/use by reef-dwelling species. Sand/soft sediment movements may bury/expose these tells over time, as evidenced by varying covers of epifauna/flora, and situations where sessile fauna such as sponges are seen partially buried.
Bare raw rock	Recently exposed ‘new’ mudstone/papa rock surface, that is flush with or slightly depressed, relative to surrounding soft sediments. Likely to have been exposed by sediment scouring, and often seen adjacent to the base of reefs. Its newly exposed status is suggested by flat, smooth, and unblemished surfaces, devoid of animal burrows and other biological marks. Often also fractured as thin cracked slabs (cm’s thick) in part, probably from wave/swell action.
Boulder	Discrete rocks, that may sit as discrete objects on rock surfaces, or be sitting in soft sediments. When in soft sediments, they are visually distinguished from patch reefs by having a clear rounded/square-edged appearance, and/or not possessing under-hangs or ledge-type elements.
Flat basement	Flat rock with little topographic variation at the local scale. This does not mean that the rock surfaces are necessarily flush with the surrounding seafloor. For instance, the stepped flat terraces seen at some sites were scored as flat basement, along with the short walls/scarps. Each terrace was at different depth than its neighbours, but all were higher than the surrounding seafloor. They are also not necessarily flat in the sense of being horizontal; sloping uniform rock surfaces were also included in this class. A visual quirk of using the CoastCam over bathymetrically varying seafloor was that the camera was constantly being adjusted using the remote-controlled winch to maintain a relatively constant height above the seafloor. These fine-scale continuous adjustments often removed the visual signals (in post-processing) that the seafloor was not horizontal, but rather sloping. This effect was ‘invisible’ to the video analyst working on the video imagery back in the office; where some rock surface appearing to be horizontal but were sloping. Combining video data with fine-scale multibeam derived variables such as slope and rugosity , addresses this issue in formal statistical analyses.
Low patch reef	Low relief small discrete raised patches of rock, surrounded by soft sediment. Generally, less than 5 metres in width, as seen along the video transect
Low broken rock	Low broken rock, that extends over distances of more than 5 metres, often as long expanses of reef. Included in this class are situations where low-relief rock outcrops are present within irregular cobble fields.

Rock habitat class	Description
High broken rock	Like low broken rock, but higher in height at the local scale of view (generally around 1 to 2 metres variation), with high local visual topographic variability including walls, channels, knobs, and outcrops at the multiple metres scale
Pillow ridges	Low 20–30 cm semi-parallel rows of 'pillowed' rock, alternating with shallow troughs at the sub-metre scale, that form local 'fields'. Always associated with *C. flexilis* cover.
Fallen slabs (mudstone only)	Large mudstone rock slabs, immediately adjacent to scarp faces, that appear to be produced by eroding and retreating scarp faces. Only found at site Papa
Rock fingers/gutters	Alternating narrow rock fingers and gutters, all aligned in the same compass direction. Only found at Site Q (South Trap). Some other sites held localised 'lattice' reef forms that might be a similar erosion process of the same rock type, but those small areas were hard to determine boundaries for and were included in the high broken rock class.

Across the survey region, twelve rock-based geological classes were visually identifiable in the soft sediment seafloor areas (Table 3, Table 4, Figure). Arranged in increasing average particle size order, they included light and dark coloured sands (the latter probably due to higher iron content), fine gravels, shell dominated sediments ranging from loose shell though to shell armoured bottom and drifts of dead whole dog cockle shells (deepest site V only). These soft sediment classes collectively surrounded the reefs, and often were present at the start and end of the transects (transects started and ended on soft sediment where practical), so that the reef-soft sediment boundaries were included in the video imagery. Soft sediment patches were also often interspersed amongst and between reef outcrops and ridges. The dark (iron) sands were geographically constrained to the northern half of the survey region (sites Papa to J, limited cover at K), while lighter coloured sands were more broadly distributed (sites Papa, K, Q, and U). Gravels were largely limited to the southern sites (sites T, U, V). Shell based soft sediments (excluding dog cockles) occurred in varying proportions across most sites (J being an exception), with small whole shells being a major contributor at sites D, K and L. Within some sites, transitions occurred between some of the soft sediment classes, ranging from relatively abrupt boundaries through to diffuse change gradients.

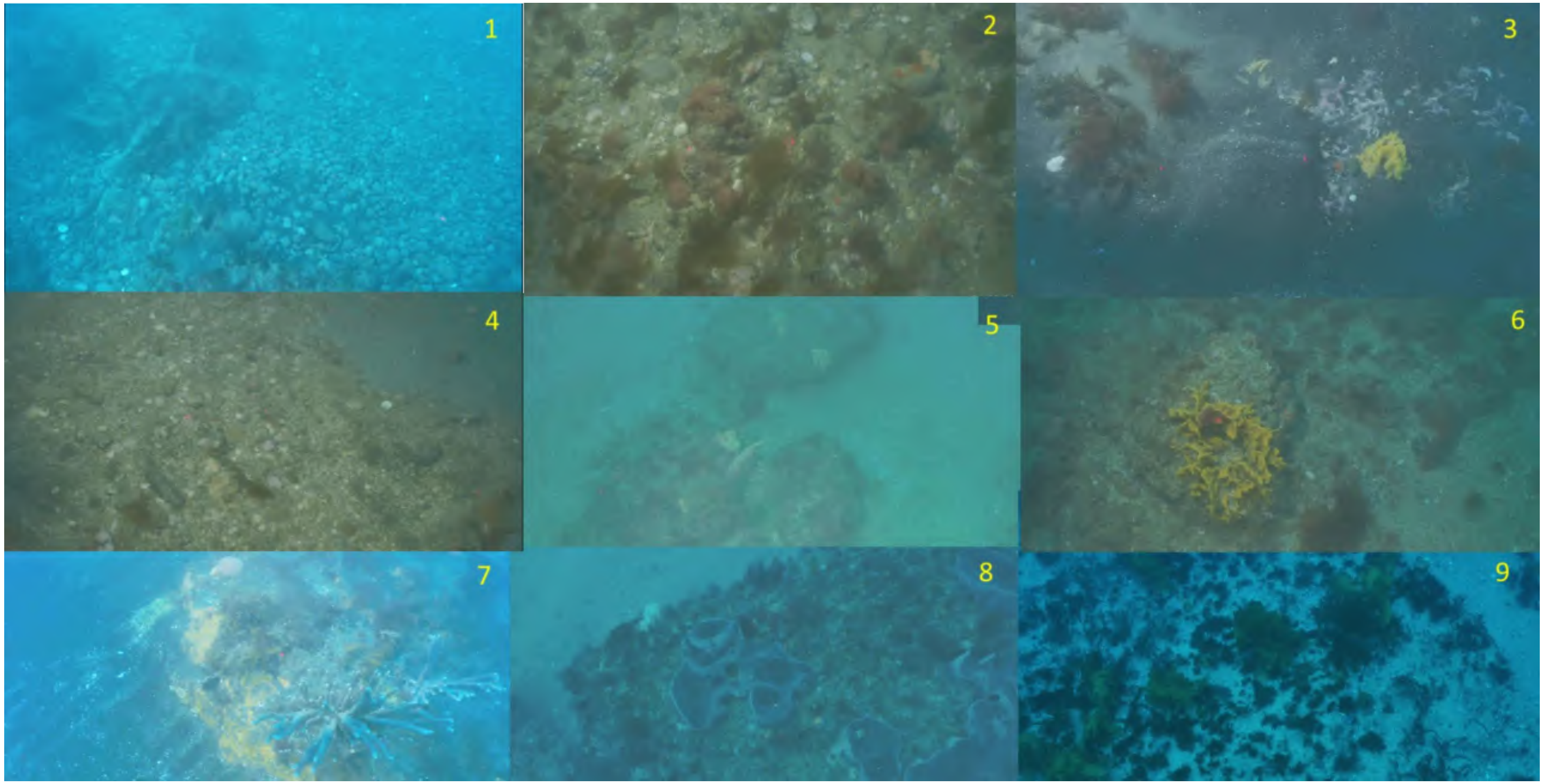

Figure 3-3: Geomorphology class examples 1) smooth grey stones; 2) irregular cobbles; 3) rock tells; 4) bare raw rock; 5) boulders on soft sediment; 6) boulder on flat basement; 7) low patch reef, 8) high patch reef (high slab); 9) flat basement.

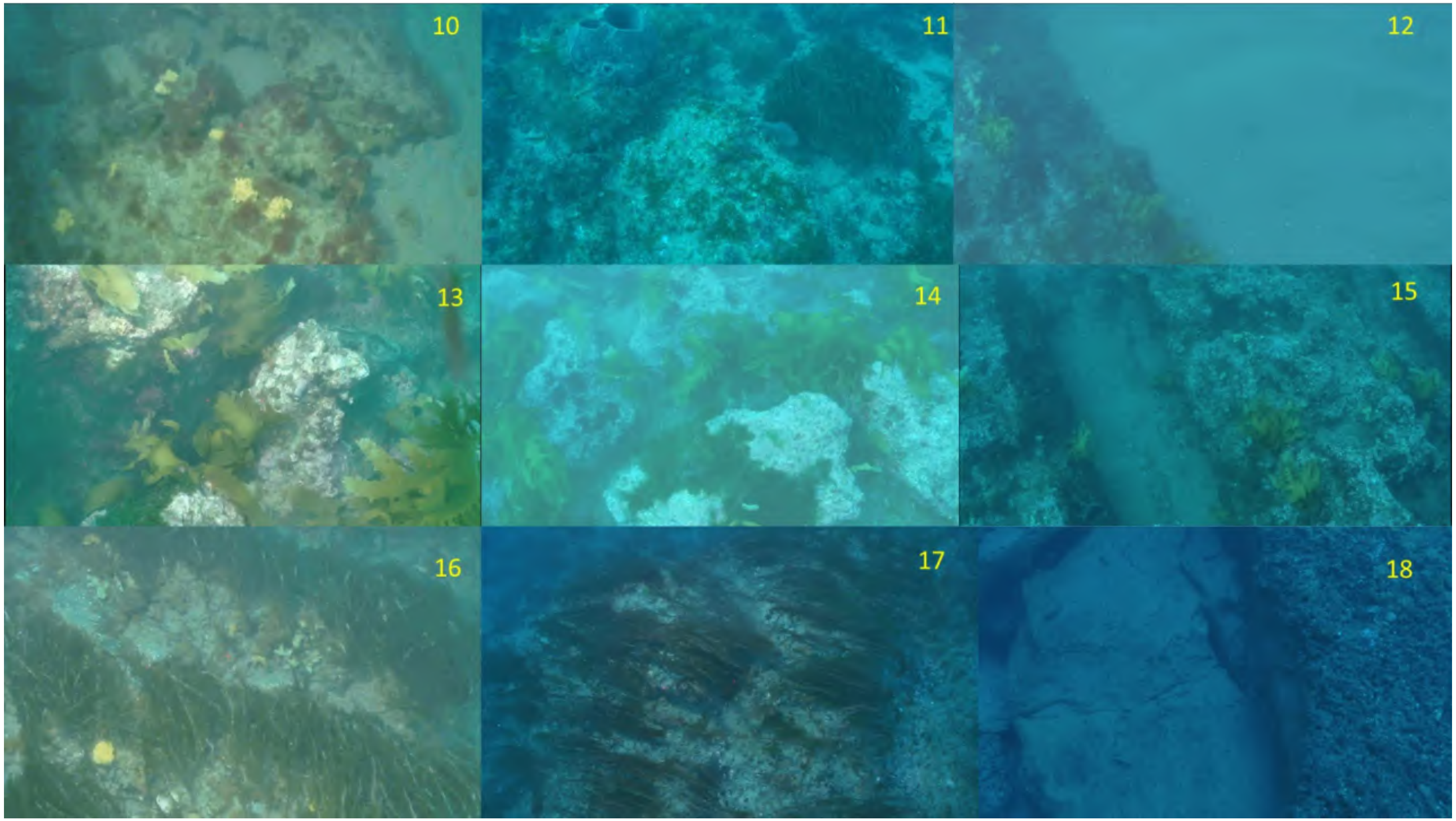

Figure 3-3: continued. Geomorphology class examples 10–11) low broken rock; 12–14) high broken rock (showing lattice form); 15) rock finger and gutter complex; 16–17) pillow ridge reef, 18) fallen slabs (site Papa only, mudstone/papa rock).

Table 4: Geomorphology classes and % contributions at the video transect/site. While not differentiated within the table, sites Papa and D were composed of a different rock type (mudstone, known as Papa) than the other sites, which were composed of harder sandstones/limestones (and site V appeared to be breccia rock). Their associated values are underlined, and their site name marked with a *, to draw attention to this difference. Each video segment within a given transect is given equal weight; individual segments have not been standardised to true area (distance covered, multiplied by the field of view).

														Site
Soft sediment habitats	A	B	Papa*	D*	J	K	L	O	Q	R	S	T	U	V
Sand			31.7			6.6		<1	2.7				12.6	
Dark sand (iron)	23.2	21.1	48.5	37.0	53.4	4.2	-	-	-	-	-	-	-	-
Gravel	-	0.8	-	-	-	<1	-	-	<1	0.9	-	81.2	11.5	59.7
Shell/broken shell mix	2.9	1.8	-	14.6	0.3	9.4	3.6	0.9	-	-	-	-	-	-
Poorly sorted shell/sand	-	-	2.7	1.0	-	4.3	-	3.7	-	6.6	3.2	-	25.8	2.1
Small whole shell	<1	1.8	-	21.2	-	26.8	22.9	6.3	-	-	-	-	-	-
Coarse shell armour	-	-	<1	-	-	-	-	-	-	-	-	-	-	2.9
Large gravel/stones and shells	-	1.3	-	<1	-	4.4	<1	<1	4.7	3.1	<1	-	-	5.9
Dog cockles scattered	-	-	-	-	-	-	-	0.6	-	-	-	-	-	2.0
Dog cockle shell drift	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4

Table 4: Continued.

	Site													
Rock/reef habitats	**A**	**B**	**Papa***	**D***	**J**	**K**	**L**	**O**	**Q**	**R**	**S**	**T**	**U**	**V**
Rock habitats														
Bare grey river stones	2.5	-	-	-	-	-	-	-	-	-	-	-	-	-
Mixed irregular cobbles	7.5	16.8	-	<1	36.8	35.8	64.4	84.9	-	<1	33.7	-	-	-
Tell	<1	0.9	0.6	1.1	1.5	0.8	0.9	-	2.1	0.6	<1	1.1	3.3	3.5
Bare raw rock	<1	-	<1	-	-	-	<1	<1	-	<1	2.3	-	-	-
Boulder	0.1	1.7	1.3	<1	<1	<1	-	-	-	1.9	1.4	<1	-	0.6
Low patch reef	0.7	0.9	1.6	0.6	2.0	3.0	0.8	1.2	3.3	5.7	9.7	2.9	16.1	3.9
Flat basement	7.8	47.3	7.1	18.6	1.2	0.6	-	-	2.3	8.2	11.1	13.8	-	11.3
Low broken rock	23.9	4.4	1.8	-	4.6	3.5	7.1	1.7	12.2	35.0	10.3	1.0	-	0.6
High broken rock	13.6	1.3	< 1	-	-	-	-	-	16.6	8.7	-	-	-	-
Rock fingers/gutters	-	-	-	-	-	-	-	-	55.7	-	-	-	-	-
Pillow ridge reef	16.5	-	-	-	-	-	-	-	-	28.5	27.0	-	-	-
Fallen slabs (mudstone only)	-	-	-	5.6	-	-	-	-	-	-	-	-	-	-
Video track distance (m)	1,683	852	323	1,078	313	1,258	348	470	653	823	669	483	640	757
Area sampled (m^2)	3,787	1,917	726	2,426	705	2,831	784	1,057	1,469	1,852	1,505	1,087	1,441	1,703

At several sites, small-scale ripples, and wave bedforms were associated with some of the soft-sediment seafloor types (and can be seen in various figures in this report); these were not quantified. Sand/shell wave bedforms were also quite noticeable in the multibeam sonar bathymetry at some areas, scales ranging from metres to tens of metres.

Harder seafloor substrates (rock-based) were present at all fourteen sites sampled. These included stones, cobbles, boulders, rock buried under fine veneers of soft sediment, low rock basement, and raised complex rock topographies. Table 3 provides a description of the rock-based geomorphology classes used to classify observed seabed features. Based on visual observation, at least two underlying rock types were present. A light brown mudstone (papa), which appeared very erosion-prone and 'crumbly' and often pitted with small holes/burrows, formed reefs at two neighbouring sites. Mudstone was dominant at the Papa site, present as broken rock piles and low terraces. At site D it formed a low terrace drop, structured as a sharp vertical scarp/s of 1–3 metres, that ran for several km in length. These scarp faces were often directly adjacent to large rock slabs, that could be a result of the scarp face eroding and retreating over time. It is possible that wave and current actions erode the base of the scarp at a differential rate, and as the base ceases to be able to support the rock weight/mass above it, the scarp calves off akin to glacier wall collapses, and ends up as large slab blocks at the scarp base. This topography was only seen at site Papa. It is possible that site Papa is an older reef site than D and shows the final stages of eroded mudstone scarps, with low boulder piles, and very low terraces.

The second rock type was classed as sandstone and was much more widespread throughout the survey. Without direct physical collection it was not possible to definitively identify all rock types observed, so for simplicity we refer to all reefs in this report (except the mudstone at Papa and D) as being sandstone. Sandstone was light coloured but appeared more 'robust' than the mudstone of sites Papa and D, was not burrowed, and formed both low and high-relief reefs. Some of the rocks seen may have been limestone. Additionally, site V appeared to be a rock type prone to forming large flat or slightly raised slabs, with bumps on the rock, suggesting some form of breccia (coarse rock fragments held together by cement or a fine-grained matrix).

Sandstone reefs occurred throughout the survey region in various topographic configurations. Two notable examples of variability in the reef topographies formed from this sandstone were extensive low 'pillow' reef fields; and alternating narrow rock finger and gutter complexes. The pillow reef feature was present at sites A, R, and S, and consisted of low 20–30 cm high parallel rows of 'pillowed' rock, alternating with shallow troughs, at the sub-metre scale. This topographic feature was always closely associated with dense and extensive green macroalgae (*Caulerpa flexis*) meadows, which grew on the rock pillows (but not in the shallow troughs). Small bryozoans and sponges were also co-associated. The nature of these fauna/flora associations and the appearance of the rock suggest a potential biological basis for these rows, through perhaps some form of carbonate production.

The narrow rock finger and gutter complexes consisted of alternating narrow rock fingers and gutters, all aligned in the same compass direction, with multiple alternations. This complex was clearly visible in the multibeam bathymetry, with the gutters/fingers being 1 to 2 metres deep/tall, with vertical walls, and relatively flat finger tops and gutter bottoms. This very visual topography was largely restricted to site Q (South Trap) where it contributed 56% cover. However, other reefs also hinted at the same rock type and process in parts, with short distance 'lattice' forms seen (Figure , images 13–14) on some reef tops. As they only occurred over short distances and had indeterminate boundaries, these were included in the high broken rock class.

At some sites, it was evident that soft sediment movement had uncovered small extents (cm – metres scale) of 'new' rock recently exposed to the water column (smooth, flat, unblemished). This rock was largely papa mudstone and seen just adjacent to the bottom edge of some reef sites, as small patches flush with or slightly depressed in depth, relative to the surrounding soft sediment. The rock was dark grey in colour and flat, and visually identical to that seen terrestrially in the Whanganui region when papa rock is found recently exposed and water saturated (Morrison, pers. obs.). A number of these patches showed recent erosion impacts, with the presence of thin fractured/cracked slabs (cm's thick) in situ, probably created by wave/swell action.

Irregularly shaped cobbles, of mixed sizes and densities, were a common seafloor element at seven sites, ranging from 7.5 to 84.9% cover. These could be the result of erosion of sandstone bedrock, with wave and storm action moving them to more sheltered areas where they accumulate.

Site A held a unique rock cobble class, in the form of smooth rounded light grey stones. These appeared visually very similar to the stones seen in braided river systems and were labelled as 'smooth bare grey stones' to distinguish them in this report. Largely devoid of attached fauna/flora, they occurred as small piles and accumulations within local mosaic landscapes of low rock and soft sediments. It is suggested that these stones are mobile and move around during rough sea conditions

3.2.2 Biogenic habitats

Initial assessment of the video imagery revealed a range of biogenic habitat forming species, which occurred at sufficient densities to form biogenic habitat covers. The biogenic classes used, modified from Shears et al. 2004 (see Table 1), are given in Table 5. Urchin (kina) barrens were present at sites Q and U but to keep geomorphology (innate objects) and the species counts / densities / biogenic habitats (living organisms) data series separate, these were not included within the biogenic habitat categories. Examples of the classes "*Ecklonia* forest", "red foliose algae", "turfing algae", "*Caulerpa* mats", "*encrusting invertebrates*", and "*sponge flats*" are given in Figure . New habitat classes not included in Shears et al. (2006) included soft bryozoan patches and fields, and green 'lawn' algae (Table 5, Figure).

Table 5: Biogenic habitat classes used and their descriptions Modified from Shears et al. 2004 (table 1) to better represent observed biogenic habitats.

Biogenic habitat class	Description
Wiry green filamentous algae	Green algae with a 'wiry' morphology appearance, Species unknown
Filamentous green algae	'Green' algae that is filamentous, but not visually 'wiry'. However, algal taxonomists think these are brown algae (despite their colouration).
Yellow-red blade algae	An algae with broad ribbon like blades, with a low number of individual blades. Usually associated with the reef/soft sediment boundary.
Green (brown) shrubby algae	A low dense shrubby algae that appears dark green in colouration but is probably a brown algae. Probably *Zonaria,* along with other brown algae such as *Cladostephus hirsutus, Microzonia*, and *Dictyota* species
Green 'lawn' algae	A very fine filamentous algae, that formed low flat mats, often in a form that strongly resembles Astro-turf lawn
Filamentous red algae	Red algae that is filamentous, very likely to include a range of different species

Biogenic habitat class	Description
Spikey red algae	Red algae that is ‘spikey’ in appearance, and sometimes seen in close association with sponges. Likely to include several species
Red foliose algae	Red algae that is foliose/feathery in appearance, and almost certainly includes several different species. Includes *Plocamium*.
Carpophyllum maschalocarpum	Solitary individuals, or two to three plants immediately adjacent to each other. Patch and forest scale aggregations (see *Ecklonia*) absent. Uncommon
Caulerpa geminata	Small patches of this matt forming algae, never a dominant biogenic habitat cover. Some limited patches may be misidentified *Halopteris* (a brown algae known as Sea Flax Weed)
Caulerpa flexilis	Large patches and continuous meadows, often the dominant biogenic habitat species when present
Ecklonia single plants	Single plants at low densities, that are spatially discrete from each other.
Ecklonia patches	Aggregated patches of multiple plants that form small discrete aggregations, but do not form semi-continuous/continuous cover across the video segment (and cannot occupy more than 50% of the video segment)
Ecklonia forest	Semi-continuous/continuous plant cover, across some/all the video segments. A defining feature is that some of the video frames must be fully occupied by plants, for a distance of at least 3 to 5 metres. Kelp forests in the context of these reefs appears to often occur as very narrow forests, 5 to 10 metres wide, on the top of reef ridges, which may extend for kilometres as a very narrow band.
Soft bryozoans	All soft (uncalcified) bryozoan species
Small anemones	*Anthothoe albocincta*, patches only (individuals not part of patches ignored)
Sponge, ascidian, other cover	The summed cover of sessile fauna, except for bryozoans.
Calcified bryozoans	Bryozoan species that have calcified frames, contributing species included *Diaperoecia purpurascens*, *Celleporina grandis*, and *Celleporaria agglutinans*

Multiple macro-algal species were present as sparse-to-dense patches and meadows, both as single and mixed species assemblages. Seven morphology/colour groups were created (Table 5) that lumped species into groups that could be reliably and consistently visually identified in the video footage, over the varying resolution conditions present across the videos. Two species was kept as a putatively single species classes: ‘green lawn algae’, as it was distinctive, and at times formed a significant cover; and ‘yellow-red blade algae’, which was present largely on rock surfaces at reef/soft sediment boundaries (a preferred juvenile blue cod zone) and was quite distinctive.

Shears et al. (2004)’s ‘*Caulerpa* mats’ class was split into two separate single species classes; *Caulerpa geminata*, and *Caulerpa flexilis*. Their “*Carpophyllum flexuosum forest*” class was not seen in the survey, but solitary and two-to-three plant groupings were present. A class *Carpophyllum flexuosum* was created to keep this important habitat forming species visible in the data sets as a specific identity. “*Ecklonia radiata* forest” was present, and used as a class, although it was defined using percent cover and local spatial extent, rather than Shears et al.’s “*complete canopy (≥4 adult* *plants* m^{-2}*)*" (Table 1 definition). Additional new classes of '*Ecklonia* single plants' and '*Ecklonia* patches' were created (Table 5), as *E. radiata* was often present at the reef sites in spatial configurations that were not forests (Figure).

Biogenic habitat forming faunal groups that occurred in sufficient densities to form biogenic habitats were combined into four classes. A soft bryozoan's class was created, inclusive of all soft bryozoan species (Family Catenicellidae), with several species likely to be present (D. Gordon, bryozoan taxonomist, pers. obs.). Calcified frame-building bryozoans were also present, and scored as a collective species class, although they were quite uncommon and did not reach densities/extents that provided significant seafloor cover. The small anemone *Anthothoe albocincta* occurred as both solitary individuals and as occasional visually obvious patches, depending on site. Too numerous to individually count, this species was enumerated as a biogenic habitat class cover when it was present as visually obvious clusters (solitary scattered individuals were ignored). All other sessile invertebrate biogenic habitat forming species (including hydroids) were collectively assessed together as the class 'Sponge, ascidian, other cover', equivalent to combining Shears et al.'s "*Encrusting invertebrates*" and "*Sponge flats*" classes. They were classed in this way to keep the geomorphology and biogenic habitat classes as separate entities.

Figure 3-4: Biogenic habitat class examples: 1) filamentous green (brown) algae; 2) dark shrubby algae; 3) yellow-red blade algae; 4) green 'lawn' algae; 5–6) filamentous red algae (image 5 is from the CoastCam still camera); 7) spikey red algae; 8–9) red foliose algae. See Table 5 for habitat descriptions.

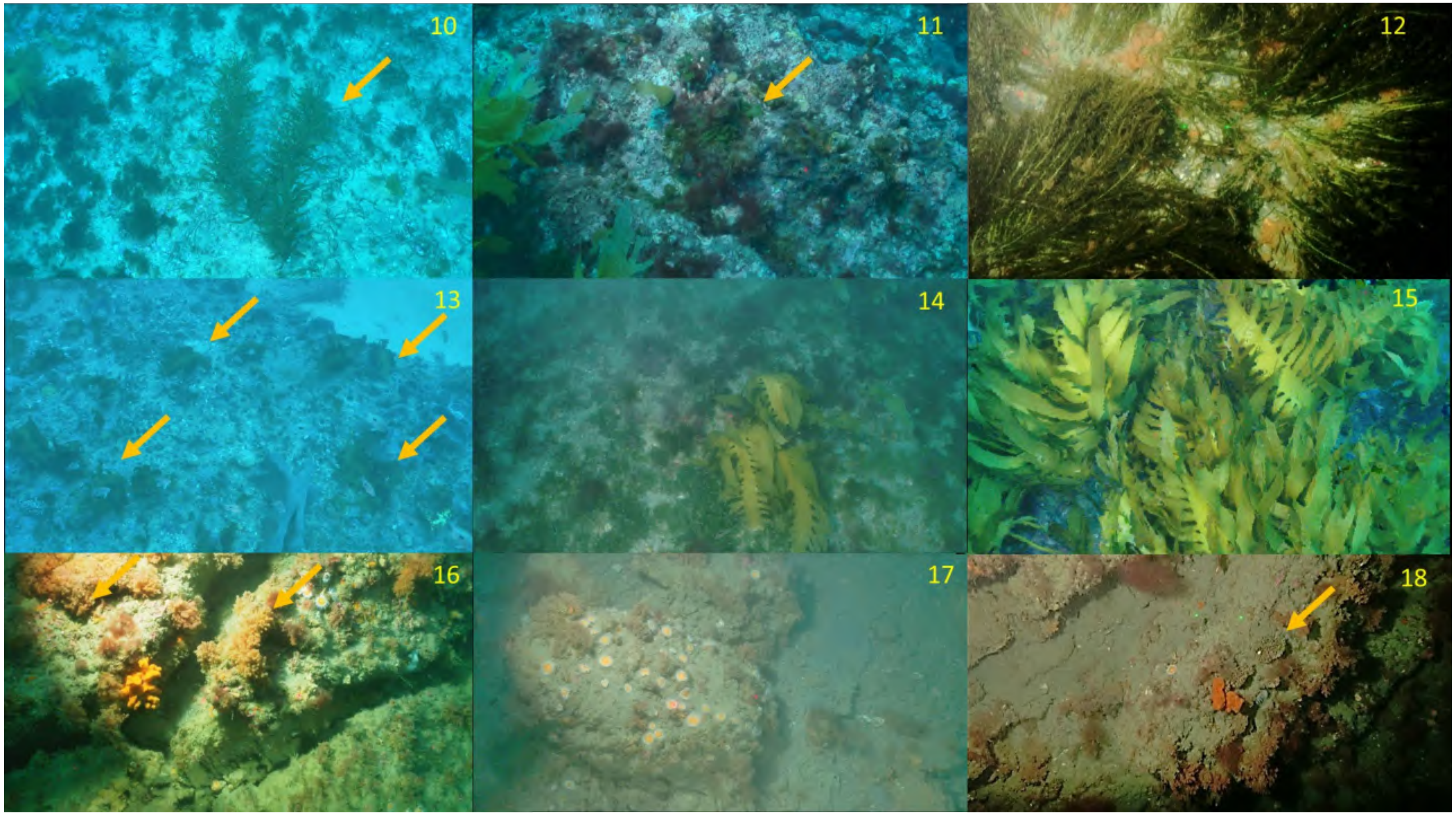

Figure 3-4: **continued.** Biogenic habitat class examples: 10) *Carpophyllum maschalocarpum*; 11) *Caulerpa geminata*; 12) *Caulerpa flexilis*; 13) *Ecklonia* single plants; 14) *Ecklonia* patch; 15) *Ecklonia* forest; 16) soft bryozoans; 17) Small anemone patch (*Anthothoe albocincta*); 18) calcified bryozoans. See Table 5 for habitat descriptions.

Table 6: **Percent cover of each biogenic habitat class at each site.** Reef containing sites only (see Table 5). Area of reef present (m^2) estimated as the summed area of all video segments containing one or more rock-based geomorphology classes. Percent cover estimates are of the whole video segment/transect including soft-sediment areas

Biogenic Habitat Class	Site													
	A	B	Papa	D	J	K	L	O	Q	R	S	T	U	V
Wiry green filamentous algae	-	-	-	-	-	0.54	-	11.38	-	-	-	-	0.01	-
Filamentous green algae	1.60	0.03	-	-	2.92	0.65	0.29	0.05	0.36	0.33	0.49	0.10	0.21	-
Green (brown) shrubby algae	0.07	-	-	0.02	2.58	1.24	2.96	-	0.07	0.25	0.07	0.20	5.87	0.01
Yellow blade algae	0.00	-	-	-	0.20	-	-	-	-	0.00	0.01	-	-	-
Green 'lawn' algae	-	-	-	-	0.02	-	-	-	9.02	0.51	0.16	0.92	0.01	-
Filamentous red algae	2.88	34.07	0.01	-	0.05	1.26	3.19	0.17	0.38	0.59	0.29	0.25	0.18	1.10
Spikey red algae	-	-	-	-	-	-	-	-	-	-	0.02	-	-	0.02
Red foliose algae	0.98	-	-	-	-	-	-	-	0.11	1.16	-	1.68	-	-
Caulerpa gemmata	0.18	0.01	-	-	0.11	0.18	0.70	0.36	0.85	0.23	0.19	1.35	0.01	-
Caulerpa flexilis	15.83	0.03	-	-	-	-	-	-	0.51	13.50	7.31	0.46	2.30	-
Ecklonia radiata all	1.44	0.01			0.02	4.96	4.21	1.43	10.03	10.73	0.95	0.72	11.11	1.00
Ecklonia (single plants)	*0.30*	-	-	-	*0.02*	*1.85*	*1.06*	*0.26*	*1.81*	*0.54*	*0.07*	*0.43*	*0.60*	*1.00*
Ecklonia patches	*0.54*	*0.01*	-	-	-	*2.37*	*1.60*	*0.15*	*1.30*	*0.74*	*0.81*	*0.29*	*2.93*	-
Ecklonia forest	*0.60*	-	-	-	-	*0.74*	*1.54*	*1.02*	*6.92*	*9.45*	*0.07*	-	*7.58*	-
Sponge, ascidian, other cover	0.41	2.94	0.01	2.20	0.79	2.55	3.81	4.56	0.66	0.59	0.42	0.49	0.52	5.57
Small anemones	0.01	0.02	-	-	0.01	-	-	0.02	0.03	-	0.05	0.04	-	-
Soft bryozoans	0.01	0.04	-	-	-	-	0.04	0.01	0.04	0.61	1.22	0.45	0.02	-
Calcified bryozoans	-	-	-	-	-	-	-	-	0.01	-	-	-	-	0.17
% Biogenic habitat	23.40	37.15	0.02	2.23	6.70	11.37	15.20	17.98	22.07	28.50	11.38	6.66	20.39	7.87
Reef area (m^2)	3,486	1,715	296	1,241	453	1,993	689	955	1,452	1,813	1,478	443	1,379	943

Soft sediments contributed an average 39% (range 8–83%) of the area of seafloor surveyed (Table 4). To focus specifically on rock-based habitats, all purely soft sediment video segments were excluded from calculations presented in Table 6, while all video segments that held one or more of the nine rock-based geomorphology classes were included. This retained virtually all observations of biogenic habitat except for some dog cockle shell drifts at site V (with occasional small sponges), and a coarse sediment flat at Site U supporting low density macroalgae cover. This filtering approach retained all video segments that were a mixture/mosaic of rock and soft-sediment classes, including those with rock tells and patch reefs that often had high biogenic habitat covers. Estimates of reef area (m^2) were calculated using the distance travelled for each video segment (measured using the start and end coordinates of each segment), multiplied by the average camera width of view (2.23 m); and summed at the transect scale.

Overall biogenic habitats covered 0.02 to 28.50% of video transects (Table 6). The two lowest values were for the mudstone sites Papa (0.02%) and D (2.23%). This low biogenic cover may be a consequence of the highly erodible nature of the rock and the low height profiles observed (except for the 3–4 m high scarp present at Site D) making much of the rock habitat susceptible to being covered/uncovered with soft sediments. Site Papa was largely bare, aside from the presence of occasional filamentous algae, some rock-boring sponges, and ascidians. Site D supported a low percent cover of sponges and ascidians, largely concentrated on the top of the scarp; on the narrow flat rock pavement present before the scarp drop, to where soft sediment started to overlay the rock surface. Of note, the mudstone/papa reef surfaces were often highly pocked and burrowed, suggesting that a substantial infaunal burrowing animal assemblage was present.

The highest biogenic cover (37.15%) was seen at Site B, where meadows of filamentous algae (34.07%) were associated with extensive irregular cobble fields. Sponges made a smaller contribution (2.94%), associated with small low rock outcrops (<0.5 m height, metres width) and several larger rock knolls (3–4 m height, 10s of metres in width).

Macroalgal biogenic habitats dominated the sandstone reefs of the survey region (all sites except Papa and D). Small macroalgal species (browns, reds, and greens) occurred as both discrete patches and as larger meadows, with different species mixtures and dominances. Average percent cover across the 11 sandstone reef sites (excluding site B) was 5.12% (range 1.13–11.60%). While these were scored as nine classes (both single species and group based), many species were likely to be contributing. In some instances where the towed camera dropped very close to/onto the seafloor, the very close camera lighting and higher image resolution revealed a range of macroalgae colourations and fine morphologies suggesting a multi-species mix – although the enhanced details were still largely insufficient to make definitive species identifications. Of note, the 'green lawn algae' class was a dominant biogenic habitat cover (9.02%) at site Q (South Trap)

Caulerpa flexilis, a fleshy green algae with a growth form of horizontal stolons with upward facing foliose shoots, was common at sites A (15.83%), R (13.50%), and S (7.31%) where it formed extensive mono-specific meadows. It was often closely associated with the pillow reef geomorphology class, with co-associations of low density small sponges and bryozoans, and coralline algae plates (counted as individuals, see following sections). It was also common on flat rock terraces, with a co-association of occasional very large solitary *Ecionemia alata* sponges within the meadows. On more broken raised reefs, *C. flexilis* occurred as patches, often mosaiced with *E. radiata* kelp patches, as well as smaller patches of a second *Caulerpa* species, *Caulerpa gemmata*. *C. gemmata* was present at all the sandstone reefs except for the deeper reef at site V. At the transect scale it contributed only a small percent cover (0.4%) but formed localised patches on some reefs that made a much higher contribution in small areas.

Ecklonia radiata was the only common large brown kelp, and occurred on all the reefs surveyed, with the exceptions of sites Papa and D where only a few unattached drift plants were observed. The occurrence of kelp ranged from occasional single plants, through small plant clusters/patches, to continuous kelp forest (though 90–100% canopy cover was only observed twice). Overall cover (all classes summed) at the site level ranged from 0.1% at site B (concentrated on a single high rock knoll) and 0.2% at site J (concentrated on a low very limited extent rocky outcrop); to 10–11% on the higher relief complex reefs of Q, R, S, and U. At these three latter sites, *Ecklonia* forest contributed most of the cover (7–9%), rather than patches and individual plants. These forests were generally associated with raised reef features, including the extensive finger and gutter reef areas of site Q (South Trap) and narrow reef ridges (S, R, U). The limited *Ecklonia* forest extents found at sites A, L, and O (1.43–4.43%) were also closely associated with reef ridge tops (with the video transects passing across these ridges). These narrow ridge features extended for kilometres at some camera-surveyed sites; with ridges also a dominant feature of many unsurveyed reef sites (as mapped by multibeam sonar). It is highly likely that long, very narrow *Ecklonia* forests extend right along these ridges, with some being more than 4 km long. *Ecklonia* forest was absent from sites J and V.

Ecklonia patches were more widespread and were often found associated with small topographic reef variations, such as small ledges/terrace edges, and raised outcrops (metres scale). They contributed an average 1.1.% cover (range 0.01–2.37%) across the sandstone reefs (absent at sites J and V). The *Ecklonia* single plant class was present at all the sandstone reef sites except for site B, with an average contribution of 0.79% (range 0.02–1.85%).

All the *E. radiata* seen appeared to be in very good condition, with unblemished and 'vibrant' canopies, with no browsing damage evident, and uniform plant sizes with little variation at local spatial scales. Plants were estimated to be at most 50 cm high (on average shorter), with short stipes. No elongated stipe morphologies, as sometimes seen on deeper reefs in other regions such as the Hauraki Gulf where light levels are thought to be limited, were seen (at the deepest site V, single *Ecklonia* plants covered 1% of the reef, at depths of around 31–32 metres). Local knowledge observations are that *Ecklonia* cover comes and goes on the reef systems, related to the frequency and intensity of larger storm events. This would explain the size uniformity and very healthy condition of the *Ecklonia* seen, assuming that these populations are composed almost entirely of younger individuals, representing only one or two large recruitment events. Small *Ecklonia* recruits (<10 cm height, single blade, no thalli visible) were common across several of the sites and were seen in greatest densities adjacent to adult plant patches/forest (see following section)

Large brown kelp algae (aside from *Ecklonia radiata*) were rare, and only present at one site in sufficient cover to constitute biogenic habitat. At site U, *Carpophyllum maschalocarpum* adult plants were present as scattered individuals and occasional groups of 2–3 plants, on coarse sand and shell flats adjacent to the main reef (these video segments had no rock present and did not contribute to Table 6). Scattered single plants, and occasionally 2–3 plant patches were also seen on the reef structure, where they contributed 0.14% cover (not included in Table 6).

Biogenic habitats created by invertebrates were far less common than macroalgal ones. The combined biogenic habitat class of sponges, ascidians, hydroids and other epifauna occurred across all the sites, though virtually absent (0.01%) from the Papa site. Cover was higher at mudstone site D (2.20%), with the main contribution coming from several sponge and ascidian species that formed low covers on the rock and appeared to be rock-boring. Across the sandstone sites, percent cover ranged from 0.41 to 5.57%. Sponges (numerous species) were by far the dominant contributors, and in some localised areas of the video transects, were dense and species-diverse enough to be regarded as sponge gardens (sites O, V). These sponge gardens were found on the edge of the reef proper and were associated with localised extents of low exposed rock (Site O), or rock tells and small patch reefs partially covered by soft sediments (Site V). This association was also evident at sites where rock tells/small rock patches, adjacent to the reef proper, were present as occasional small, low density scattered features (e.g., at sites A, Q)

The faunal biogenic habitat classes of 'soft bryozoans' and 'small anemones' often occurred together, along with red filamentous algae, in the deeper sub-areas of the sandstone reefs, on rock substates that appeared more sedimented, and in areas with higher turbidity (and lower light). These biogenic habitats had low percent cover; soft bryozoans averaged 0.15% (range 0.1–0.64%), and anemones 0.02% (range 0.01–0.04%). Soft bryozoans were absent as a biogenic habitat class from sites J, K, and V; and small anemones were absent as a biogenic habitat from sites K and V.

The biogenic habitat class 'calcified bryozoans' was largely absent from the surveyed reefs, with only occasional small individuals observed (which did not qualify as biogenic habitat cover given their tiny footprint). For example, calcified bryozoans had an average percent cover of 0.01% and 0.17% at sites Q and V respectively. They are retained here as a biogenic habitat class as a contrast to further offshore on Pātea Bank in deeper water depths (50–70 m), extensive calcified bryozoan fields are common, co-occurring with dog cockle beds/shell drifts (Beaumont et al. 2015).

3.2.3 Invertebrate abundance

In total, 62 taxa were able to be consistently and reliably identified in the video footage, encompassing 39 sponge, 3 ascidian, 1 hydroid (*Solanderia* sp. 'trees'), 2 calcified bryozoans, 3 gastropods (Cook's Turbans, saw shells, and a general gastropod class), 1 urchin (kina), 3 starfish, 1 crayfish (red rock lobster), 1 large scale-worm, 1 ophiuroid, and 3 anemone taxa (Table 7, Figure). One algal taxa was also included, that of small discrete pink-and-white coloured coralline plates. The sponge taxa morphologies included finger, mound, cup, ball ridge, and low spreading forms; with a size range extending from small cm-scale golf-ball sponges (4 species), through to large, massive colonies of the grey sponge *Ecionemia alata* (metres in diameter) (Figure). Of the 11,221 sponges counted, one species contributed 5,258 individuals (47% of all sponge counted). This species is yet to be formally described but has a current working name of "Family Chondropsidae (*Psammoclema* sp. indet or *Chondrosia* sp. indet.) species 2" (hence referred to as "Family Chondropsidae species 2") based on previous specimens collected by the Project Reef team, and passed on to M. Kelly, NIWA sponge taxonomist. It has a low spreading form, with low narrow ridges that hold lines of oscules (filtering hole structures used by the sponge for feeding and excretion). The dominant colour is various shades of grey, although yellow ones were also observed, and treated as likely colour morphs. *Crella incrustans*, which occurred in yellow/orange broken ridges form, was the next most common sponge species (1,216 records, 11%), followed by the grey cone sponge *Stelletta conulosa* (890 records, 8%). A further 16 species were present as 100 or more individuals (3,572 total records, 32%), and 20 species with less than 45 individuals (285 records, 3%).

Sponges occurred at all 14 sites but had the lowest abundance and species diversity at the soft mudstone Papa site (Table 7). Site D, also formed of mudstone, also had low species richness relative to the sandstone sites. The other 12 sites supported a higher diversity of sponge species, and in some subareas formed small sponge garden habitats (see biogenic habitats section above). Coralline algal plates occurred at 11 sites but with highest abundances at sites R and S, where they were often found in association with *Caulerpa flexilis* meadows. Ascidians were largely represented by a small bright orange solitary species (identity not confirmed), which occurred sporadically within the reef habitats present, often in the lee of small topographic rock variations (cm to metres scale). Hydroid trees (*Solanderia* sp.) were observed at 11 sites, as solitary colonies, and occasional small clusters. This was the only hydroid species large enough to be reliably seen and counted on the video footage but many other smaller species were likely present. Calcified bryozoans, of sufficient size to be reliably seen on video, were uncommon and limited to larger colony-forming species (*Galeopsis porcellanicus*, *Adeonellopsis macewindui, Cinctipora elegans*). Other species seen occasionally when the camera was particularly close to the seafloor included *Diaperoecia purpurascens*, *Celleporina grandis*, and *Celleporaria agglutinans*). *C*. *agglutinans* is an important biogenic reef former in some parts of New Zealand, where it grows as large, very heavy colonies composed of ‘chimneys and plates’, and has been shown to support very highly abundant and diverse invertebrate communities (e.g., Rangitoto Islands, east D’Urville Island, Morrison et al., unpubl. data), as well as supporting juvenile fish nurseries. However, on Pātea reefs it was only present as occasional, small, solitary colonies.

Eleven species of mobile invertebrates were recorded, as well as a general gastropod class that included larger gastropods unable to be identified to species due to image resolution/eroded shell forms (including probably some Cooks Turban/saw shell individuals). Kina (*Evechinus chloroticus*) was the only urchin species recorded, with 1111 individuals counted across 7 sites. This was a conservative count, as many would have been ‘invisible’ to the camera, e.g., when passing over the rock finger and gutter complexes of site Q (South Trap), where the gutter walls closest to the camera were not observed. The highest abundances of kina were recorded at site Q (890 inds.), followed by site U (149 inds.). Densities varied from occasional individuals to more than 5 per square metre, well above the minimum urchin density threshold of 2 exposed urchins m^{-2} on open rock used to define ‘urchin barrens’ (Shears et al. 2004).

Two large gastropod species were commonly observed and counted. High abundances of Cooks Turban (*Cookia sulcata*), a large herbivorous gastropod, were recorded at sites Q and R, where they were concentrated on the higher, more rugose reef areas. The saw-shell (*Astrea heliotropium*) was less common and occurred in low numbers across a wider range of reef geomorphologies. The large sea-slug/nudibranch, *Aphelodoris luctuosa,* occurred at low densities across most of the reef sites, with a strong co-association with the dominant grey ridge sponge Family Chondropsidae species 2, on which it feeds. It was also recorded where this sponge species was absent. Three species of starfish were observed and counted. Herbivorous cushion stars (Family Asterinidae) were rare and restricted to sites S and T, where a few individuals were seen on the coarser soft sediments adjacent to the reefs. Two predatory starfish species were observed, the reef star *Stichaster australis*, and the 11-armed starfish *Coscinasterias muricata*. These two species were hard to separate in video footage, and so were grouped. *S. australis* was restricted to rock habitats, while *C. muricata* was present over both rock and soft sediments. *S. australis* was most common at site Q., while *C. muricata* had a wider distribution across sites (M. Morrison, pers. obs.). Three rock lobsters were seen, sheltering under structure on the top of outcrops that were observable by the towed camera; the majority of day-time rock lobster habitat (under overhangs/ledges, in crevices) was not amenable to sampling with towed cameras. A single large-bodied scale-worm (perhaps *Euphione squamosa*) and a single snake star (*Ophiopsammus maculata*) were recorded.

Figure 3-5: Taxa examples, 14 most common sponge species, starfish, and hydroid tree. Note that images vary in scale: 1–4) Family Chondropsidae species 2 (grey and yellow colour morphs); 5–6) *Crella incrustans* (orange and yellow colour morphs); 7) *Stelletta conulosa*, 8) *Aaptos globosa* (right) and Unid. Sp., order Haplosclerida/Poecilosclerida (left); 9) *Raspailia topsenti* (left), *Tethya bergquistae* (right).

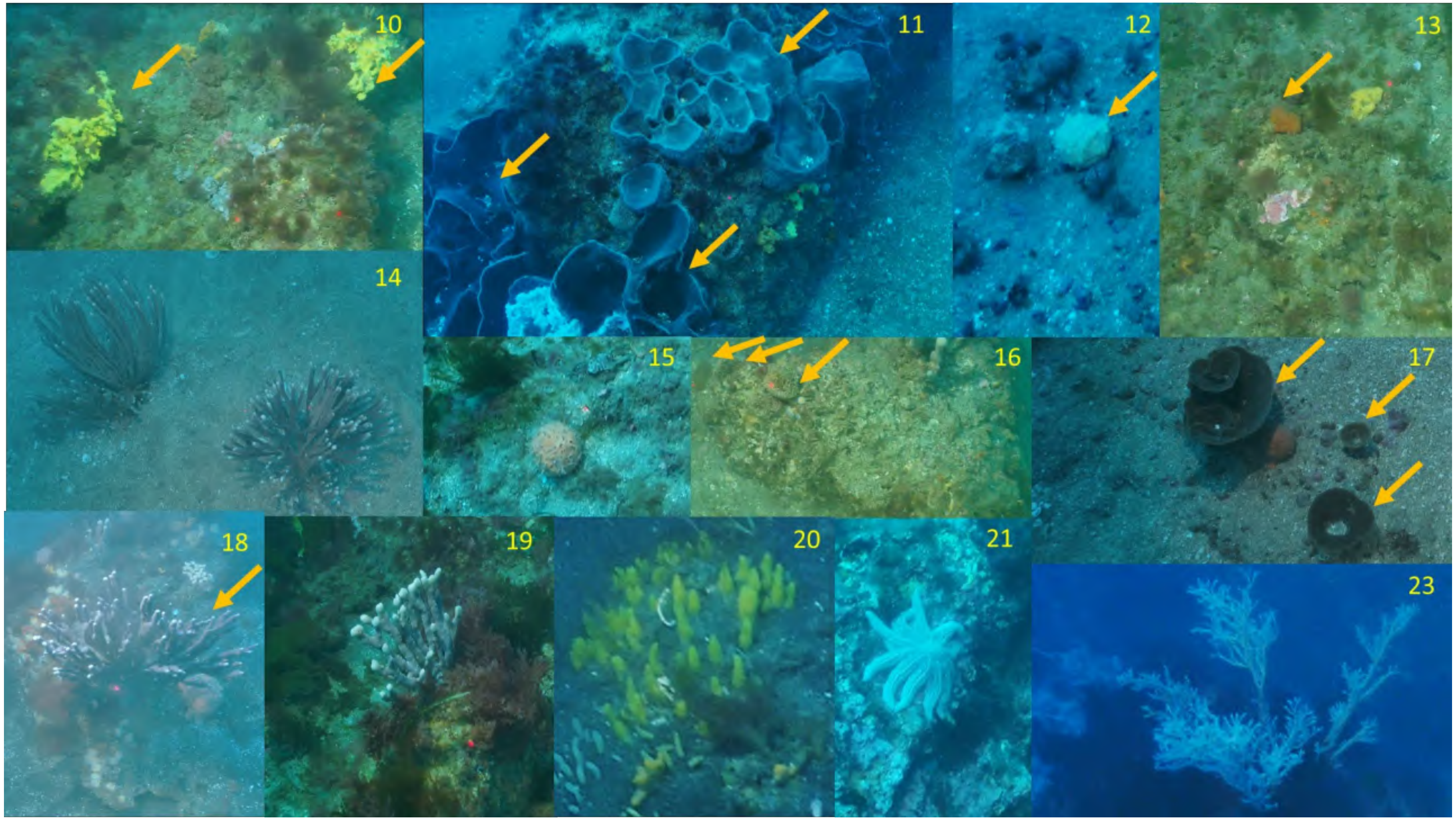

Figure 3-5a: continued. 10) *Darwinella oxeata*; 11) *Ecionemia alata* (grey colour variations); 12–13) *Tedania* sp. indet. (white and yellow colour morphs); 14) *Callyspongia ramosa* (*Callyspongia nuda*); 15) *Tethya bergquistae*; 16) *Cinctipora elegans* (calcified bryozoans); 17) *Cymbastela lamellata*; 18–19) *Dactylia varia*; 20) *Ciocalypta polymastia*; 21) *Stichaster australis* (starfish); 23) *Solanderia* sp. (hydroid tree).

Table 7: Summary of taxa identities and number of individuals recorded from CoastCam video footage at each site. Area of reef present estimated as the summed area of all video segments containing one or more rock-based geomorphology classes. Includes soft sediment where present in those video segments with rock elements. *, species sampled/photographed by Project Reef divers at site K (Project Reef), and identified by M. Kelly, sponge taxonomist, NIWA; but not seen in the CoastCam survey of site K. Additional species confirmed from the Project Reef are *Leucettusa lancifera*, *Stelletta columna*, and *Chalinulan* sp. (powder soft feathery bush)(Porifera, Haplosclerida, Chalinidae). Species occasionally seen by CoastCam when very close/on the seafloor included an anemone (white tentacles, purple body, Family Actiniidae), small white (*Cryptolaria* sp.) or golden (Sertulariidae) hydroids, the bryozoans *Diaperoecia purpurascens*, *Celleporina grandis*, and *Celleporaria agglutinans*, and the green top shell *Coelotrochus viridis*.

		Area of reef present (m²)		**3,486**	**1,715**	**296**	**1,241**	**453**	**1,993**	**689**	**955**	**1,452**	**1,813**	**1,505**	**443**	**1,379**	**943**
																	Site
Taxa group	**Description**	**Taxonomic name**	**Total**	**A**	**B**	**Papa**	**D**	**J**	**K**	**L**	**O**	**Q**	**R**	**S**	**T**	**U**	**V**
Sponge	Low flowing encrusting	Family Chondropsidae (Psammoclema sp. indet or *Chondrosia* sp. indet.) species 2	5258	443	691	51	261	49	854	410	330	533	750	223	140	213	359
Sponge	Yellow broken ridge form	*Crella incrustans* (Carter, 1885)*	1216	116	229	3	14	40	229	203	258	49	19	18	9	45	24
Sponge	Grey cone	*Stelletta conulosa*	890	37	116	-	-	10	174	66	74	154	111	32	25	74	27
Sponge	Orange/grey multi-stalk	*Raspailia topsenti*/*Axinella* sp. indet.	397	156	22	-	18	13	13	3	2	28	60	70	14	4	7
Sponge	Yellow foamy low sponge	*Darwinella oxeata* Bergquist, 1961*	388	43	17	7	44	8	7	11	10	41	54	88	13	14	39
Sponge	Massive colonies	*Ecionemia alata* (Dendy, 1924)	366	21	81	-	-	6	25	10	8	141	39	15	8	12	6
Sponge	Pale pink ball	*Aaptos globosa**	308	6	55	-	-	25	162	24	7	-	11	22	20	-	1
Sponge	Orange/yellow/grey ball	*Tedania* sp. indet.?*	228	9	22	1	-	-	39	1	7	4	7	21	1	-	116
Sponge	Bright yellow combs	*Ciocalypta polymastia**	226	80	14	-	22	3	40	20	20	1	1	3	-	4	21
Sponge	Slender purple finger	*Callyspongia ramosa* (*Callyspongia nuda*)	204	-	6	-	-	-	6	2	21	-	8	6	4	26	125
Sponge	Pale orange/pink ball	*Tethya bergquistae**	188	44	28	1	-	6	29	1	1	2	47	25	6	-	4
Sponge	Bright yellow flanges	*Raspailia topsenti**	185	55	24	1	2	5	5	3	3	2	36	40	7	5	2
Sponge	Thick purple finger	*Dactylia varia*	183	23	14	-	8	2	12	-	25	-	14	23	13	-	51
Sponge	Yellow, rock-boring	Unid. Sp., order Haplosclerida/Poecilosclerida*	181	5	4	3	63	4	6	5	8	3	1	69	3	5	6
Sponge	Dark grey spiral cup	*Cymbastela lamellata*	179	1	-	-	-	-	-*	-	-	-	-	-	-	-	178
Sponge	Orange top, oblong dull	Unid. Sp., order Poecilosclerida*, encrusting	155	-	-	-	-	-	-	4	7	-	-	141	3	-	-
Sponge	Orange fluffy mound	*Stylissa* sp. indet.	150	6	-	-	-	-	2	2	-	-	101	18	11	3	7
Sponge	Grey/white smooth foamy	Family Irciniidae (*Psammocinia* sp. indet.)*	127	23	3	1	5	-	3	2	1	8	43	26	3	2	7

		Area of reef present (m²)		3,486	1,715	296	1,241	453	1,993	689	955	1,452	1,813	1,505	443	1,379	943
																	Site
Taxa group	**Description**	**Taxonomic name**	**Total**	**A**	**B**	**Papa**	**D**	**J**	**K**	**L**	**O**	**Q**	**R**	**S**	**T**	**U**	**V**
Sponge	Dirty yellow encrusting	Family Halichondriidae, genus & sp. unid.*	107	-	-	-	-	-	-	-	-	4	102	1	-	-	-
Sponge	Reddish-pink/grey ball	*Aaptos rosacea*	45	-	-	-	-	-	-	-	-	-	-	39	5	-	1
Sponge	Grey branching finger	Order Axinellida genus and species indet.	35	-	4	-	1	-	-	-	1	-	5	11	2	-	11
Sponge	Bright yellow cone	*Stelletta crater* (Dendy, 1924)	33	1	15	-	-	-	9	1	3	-	2	1	-	1	-
Sponge	Pink-orange lumpy ball	*Tethya fastigata**	32	3	2	-	-	1	1	7	-	1	4	9	3	-	2
Sponge	Grey fuzzy football	*Polymastia* cf *massalis*	31	1	2	-	-	-	1	-	-	7	4	2	-	2	12
Sponge	White udon noodles	*Polymastia echinus**	19	3	-	-	11	1	-	1	-	-	3	-	1	-	-
Sponge	Grey-dirty tan ridge form	*Stryphnus ariena**	15	11	-	-	-	-	1	2	-	-	-	1	-	-	-
Sponge	Yellow foamy with holes	*Iophon minor**	14	1	5	-	-	-	4	-	1	3	-	-	-	-	-
Sponge	Yellow branching	Family Axinellidae genus and species indet.?*	13	-	-	-	-	-	-	-	-	-	9	3	1	-	-
Sponge	Low mound	*Biemna rufescens** (base colour, no maroon)	10	-	2	-	-	-	-	-	-	3	3	1	1	-	-
Sponge	Broken flange sphere	*Desmacidon mammilatum*	9	-	-	-	1	-	1	-	1	1	3	1	-	-	1
Sponge	Low mound	Family Chondropsidae (*Psammoclema* sp.*)	8	-	1	-	-	-	-	-	1	4	-	2	-	-	-
Sponge	Grey-white rough foamy	Family Irciniidae (*Psammocinia* sp. indet.), Family Chondropsidae (*Psammoclema* sp. indet or *Chondrosia* sp. indet.) species 1	7	1	4	-	-	1	-	-	-	2	-	-	-	-	-
Sponge	White pod cluster	Class Calcarea, possibly *Leucetta* sp. 2*	5	1	4	-	-	-	-	-	-	-	-	-	-	-	-
Sponge	Pink low ridges	*Haliclona venustina** or *Haliclona caminata**	3	-	-	-	-	-	-*	-	-	-	3	-	-	-	-
Sponge	Yellow half-buried tubers	Order Axinellidae genus & species indet.*	2	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Sponge	Grey, white oblong	Family Dysideidae, possibly *Dysidea* sp. indet. (rough surface) of class Calcarea (*Leucetta* sp. 1).	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Sponge	Grey brain-like mound	*Polymastia* sp. indet.*	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Sponge	Dull round, algae epibionts	Family Halichondriidae genus & species unid.*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Sponge	Dull yellow smooth	*Iophon proximum**	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Coralline	Coralline algae plate		1297	142	27	-	1	7	67	75	118	7	258	537	41	24	-

		Area of reef present (m²)		**3,486**	**1,715**	**296**	**1,241**	**453**	**1,993**	**689**	**955**	**1,452**	**1,813**	**1,505**	**443**	**1,379**	**943**
																	Site
Taxa group	**Description**	**Taxonomic name**	**Total**	**A**	**B**	**Papa**	**D**	**J**	**K**	**L**	**O**	**Q**	**R**	**S**	**T**	**U**	**V**
Ascidian?	Bright orange		839	180	93	6	21	9	46	16	17	8	141	230	53	13	15
Ascidian	Grey scraggly broken	*Didemnum* sp. indet.	89	2	2	9	57	-	4	1	-	-	1	10	1	-	2
Ascidian?	Ascidian?		4	-	-	-	-	-	-	-	-	-	-	1	3	-	-
Hydroid	White hydroid tree	*Solanderia* sp.	110	14	6	-	-	-	11	1	-	40	20	6	2	9	1
Bryozoan		*Galeopsis porcellanicus*	148	-	8	-	1	-	2	1	-	4	72	42	12	4	2
Bryozoan		*Adeonellopsis macewindui*	132	-	-	-	-	-	1	5	-	-	22	82	11	6	5
Uncertain	Encrusting, grey wax drip	(not a bryozoan)	20	-	-	-	-	-	-	-	-	2	15	2	-	-	1
Urchin	Kina	*Evechinus chloroticus*	1111	48	-	-	-	-	30	2	-	870	8	4	-	149	-
Gastropod	Cooks' turban	*Cookia sulcata*	226	-	-	-	4	-	9	3	-	159	39	3	-	7	2
Gastropod	General gastropod		51	1	2	4	2	-	2	1	-	4	5	-	-	7	23
Gastropod	Saw shell	*Astrea heliotropium*	42	-	-	-	-	-	1	1	1	7	14	1	1	15	1
Nudibranch	Sea slug	*Aphelodoris luctuosa* (Cheeseman, 1882)	117	1	4	4	19	-	-	-	-	8	58	12	8	1	2
Starfish	Reef/eleven-armed star	*Stichaster australis/Coscinasterias muricata*	52	-	-	-	-	-	1	1	1	30	3	2	11	3	-
Starfish	Cushion star	Family Asterinidae	11	-	-	-	-	2	-	-	-	-	-	9	2	-	-
Crayfish	Rock lobster	*Jasus edwardsii*	4	-	3	-	-	-	-	-	-	-	-	1	-	-	-
Worm	Scale worm	Polynoidae, perhaps *Euphione squamosa*	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Ophiuroid	Smooth armed snake star	*Ophiopsammus maculata*	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Hermit crab	Hermit crabs in gastropod		4	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Dead shell	Dead paua shell		4	-	-	-	-	-	-	-	-	1	1	2	-	-	-
Anemone	Small white and yellow	*Anthothoe albocincta (patches only)*	188	10	18	-	-	3	1	-	8	18	10	110	10	3	-
Anemone	Jewel anemones	*Corynactis australis (patches only)*	4	-	-	-	-		-*	-	-	2	-	1	-	1	-

3.2.4 Fish abundance

Twenty-six fish species were observed on the towed video transects (Table 8, Figure). Blue cod were the most abundant and were present at all 14 sites. Blue cod sizes ranged from 0+ juveniles (black and white colouration) through to large adults; with 0+ fish contributing 19% of blue cod counted. While blue cod were abundant, there did not appear to be a strong component of large (>45 cm) fish in the population/s. Site V had the highest number of 0+ fish, with 231 seen (59% of blue cod counted), strongly associated with sponge assemblages on rock tells and small patch reefs off the main reef (Figure), and dog cockle shell drifts. The 0+ juveniles counted at other reef sites were also concentrated on the reef/soft sediment interfaces. Larger, older blue cod were predominantly seen on and around the lower reef edges and were not common up on the reefs proper. The two mudstone reef sites (Papa, D) held relatively high numbers of blue cod, in strong contrast to the counts/covers of invertebrates and biogenic habitat covers on this reef type.

Butterfly perch were the next most common species, often occurring as small schools of adults in the water column (Figure), associated with abrupt bathymetric changes such as ridge tops, knolls, and terrace drops. Juveniles were also frequently seen, and at some sites in association with *C. flexilis* meadows and/or sponges (Figure). Site V had the highest butterfly perch count and was notable for a small area of reef that held a mixed schooling fish concentration of butterfly perch and tarakihi with a lower density background contribution from leatherjackets, goatfish, and blue moki (e.g., Figure).

Scarlet wrasse were ubiquitous across most of the 14 sites (aside from only a single individual being seen at Site J) and were present across most reef habitat types. Juveniles (<10 cm) were seen associated with *C. flexilis* meadows in small loose schools; as single individuals with some *Ecklonia* kelp locations; and at some sponge patch areas on/adjacent to reef edges. Leatherjackets were also seen often across all reefs except site Papa's bare mudstone low outcrops and boulder piles. Sites D, Q, and U held higher numbers, with leatherjackets being one of the species more commonly observed in association with *Ecklonia* forest and patches. Tarakihi were observed at five sites but were most common at Site V (65% of the 107 fish counted), where they occurred as several small schools. Two smaller juveniles (10–20 cm) were seen at the mudstone reef at site D.

Twenty further fish species had recorded abundances of 100 individuals or less, the most numerous being goatfish, sweep, red moki and spotty with abundances ranging from 11 to 54 fish. Spotties (the wrasse *Notolabrus celidotus*) were surprisingly uncommon (11 individuals), as a species that is regarded as ubiquitous on shallow reefs and other structured habitats around New Zealand. However, as true for most reef fish species in New Zealand, we have a rather poor understanding of most species depth range and how densities are distributed over that range. Those ranges are also likely to vary with factors such as water temperature. For instance, tarakihi are seldom (if at all) seen on shallow reefs in northeastern New Zealand by divers but become progressively more commonly seen on shallow reefs with increasing latitude. The depth range of this present survey (12–34 metres) may have been deeper than the main depth distribution of spotties in this region.

Small sharks and rays (elasmobranchs) were only occasionally seen; five carpet sharks, two rig, one stingray and one eagle ray. All were sitting inert on the seafloor, on or between rocky sea-floor. Two 'tropical straggler' species were seen. A magpie perch (*Cheilodactylus nigripes*) at Site K (the Project Reef), one of a resident pair often seen at the reef by Project Reef divers (both fish – the pair – were seen on Coast-Cams second video camera). A red morwong (*Cheilodactylus fucus*) was seen at Site S. One porae (*Nemadactylus douglasii*) was recorded. The STB is outside this species normal distribution along the north-eastern coast of New Zealand (warm temperate waters).

The remaining sixteen species had total counts ranging from 1 to 5 individuals. Snapper were only seen once (a single individual), which was expected as this species is seldom seen on day-time towed video).

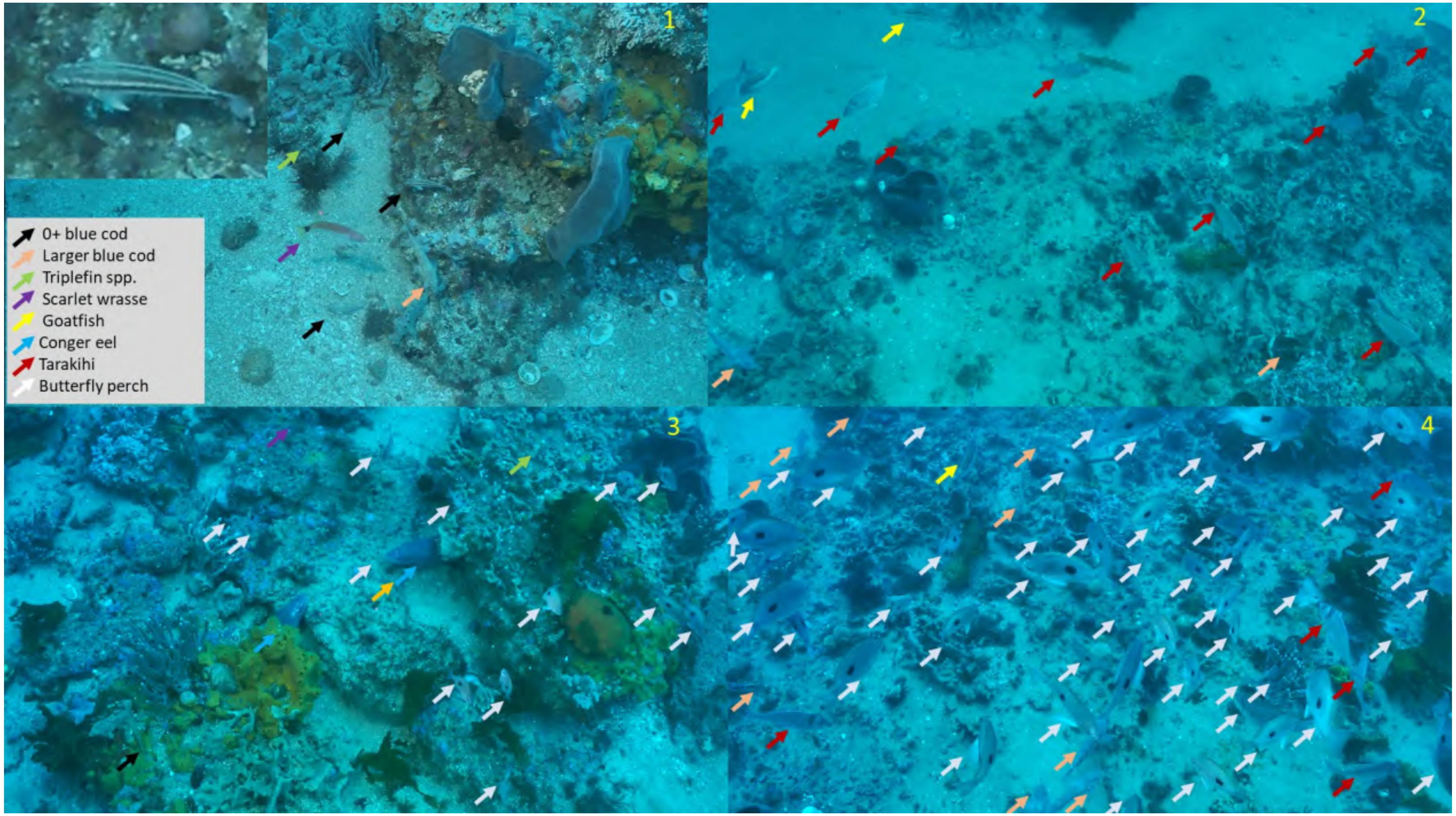

Figure 3-6: Fish examples from Site V, for reef #V1, 32 metres water depth Individual species are marked by coloured arrows: 1) soft sediment to reef boundary with sponge biogenic habitat, and 0+ juvenile blue cod (insert: close-up of 0+ black & white colouration), blue cod, triplefin, scarlet wrasse; 2) reef and soft sediment channel with sponge biogenic habitat, tarakihi school, goatfish, blue cod (an adult blue moki is out of shot); 3) reef/sand mosaic area with sponge and E. radiata biogenic habitat, 0+ blue cod, conger eels, scarlet wrasse, triplefin, and juvenile butterfly perch (school on moving video); 4) rock platform with sediment, sponge and E. radiata biogenic habitat, school of adult butterfly perch, tarakihi, goatfish, and tarakihi.

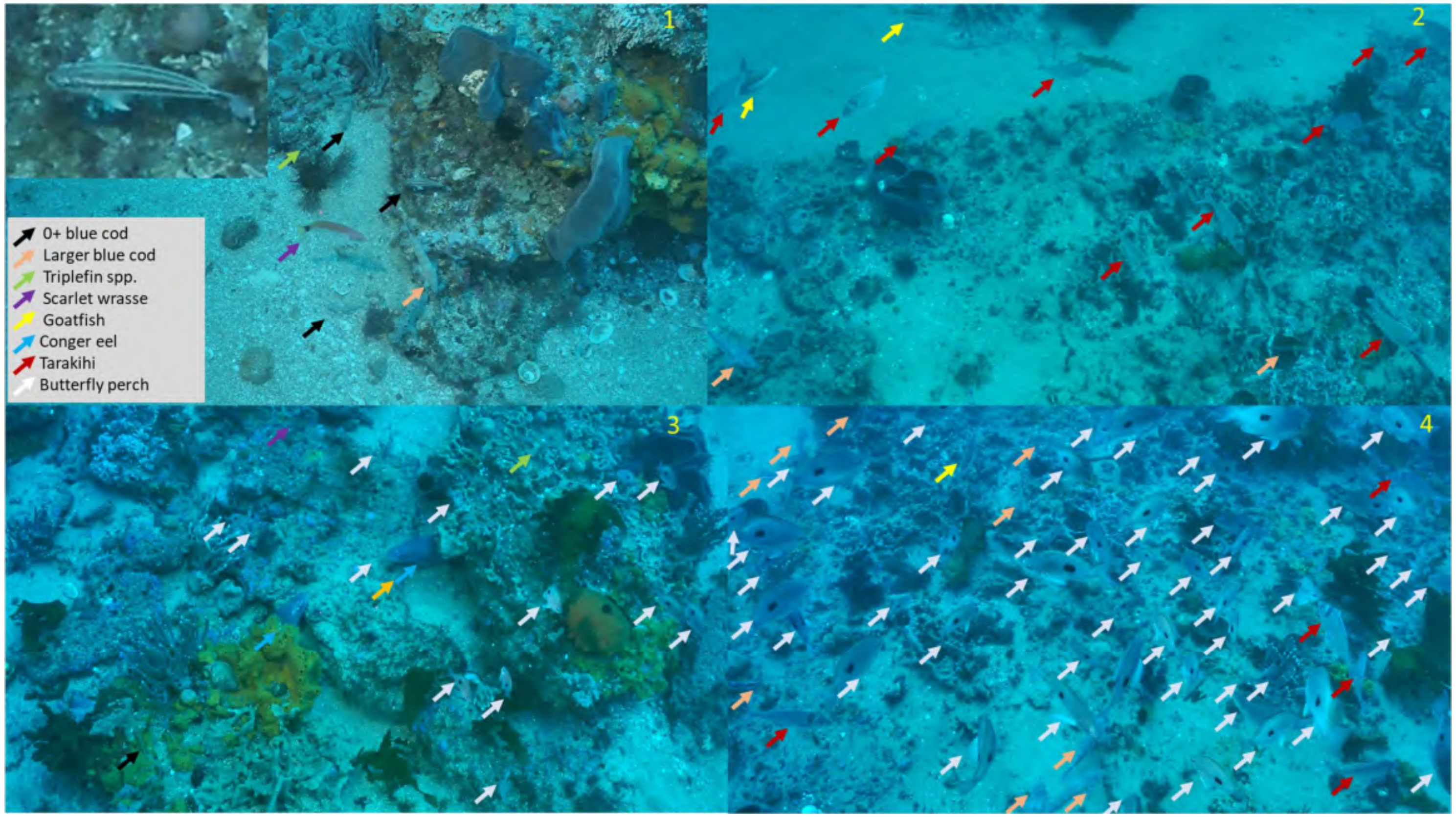

Figure 3-6: Fish examples from Site V, for reef #V1, 32 metres water depth Individual species are marked by coloured arrows: 1) soft sediment to reef boundary with sponge biogenic habitat, and 0+ juvenile blue cod (insert: close-up of 0+ black & white colouration), blue cod, triplefin, scarlet wrasse; 2) reef and soft sediment channel with sponge biogenic habitat, tarakihi school, goatfish, blue cod (an adult blue moki is out of shot); 3) reef/sand mosaic area with sponge and E. radiata biogenic habitat, 0+ blue cod, conger eels, scarlet wrasse, triplefin, and juvenile butterfly perch (school on moving video); 4) rock platform with sediment, sponge and E. radiata biogenic habitat, school of adult butterfly perch, tarakihi, goatfish, and tarakihi.

Table 8: Summary of fish counts recorded from CoastCam video footage. Note that triplefin species were difficult to see due to their small size and cryptic nature and so were excluded from formal counting. However, any incidental observations that were made have been included here.

	Area of reef present (m^2) >>	**(see Table 7) >>**	**1,715**	**296**	**3,486**	**1,241**	**453**	**1,993**	**689**	**955**	**1,452**	**1,813**	**1,505**	**443**	**1,379**	**943**
																Site
Species	**Taxonomic name**	**Total individuals**	**A**	**B**	**Papa**	**D**	**J**	**K**	**L**	**O**	**Q**	**R**	**S**	**T**	**U**	**V**
Blue cod all sizes	*Parapercis colias*	2200	98	73	146	218	16	115	105	76	53	44	45	30	256	391
Blue cod (0+ B&W)		*405*	*9*	*2*	*10*	*39*	*2*	*21*	8	*19*	*1*	-	-	-	*63*	*231*
Blue cod <12cm not B&W		*35*	-	*1*	-	-	-	-	-	*1*	-	-	*8*	*5*	*19*	*1*
Blue cod (13-20cm)		*615*	*54*	*36*	*75*	*82*	*1*	*39*	35	*28*	*13*	*21*	*25*	*18*	*99*	*89*
Blue cod (21-30cm)		*387*	*24*	*27*	*40*	*56*	*8*	*26*	34	*17*	*25*	*21*	*4*	*7*	*53*	*45*
Blue cod (>30cm)		*224*	*11*	*7*	*21*	*41*	*5*	*29*	28	*11*	*14*	*2*	*8*	-	*22*	*25*
Butterfly perch	*Caesioperca lepidoptera*	931	5	97	-	21	11	88	3	-	52	71	90	36	208	252
Scarlet wrasse	*Pseudolabrus miles*	744	137	57	13	37	1	33	13	8	103	89	88	37	120	21
Leatherjacket	*Meuschenia scaber*	228	23	4	-	50	2	18	5	1	46	13	15	4	50	5
Tarakihi all sizes	*Nemadactylus macropterus*	107	-	4	-	15	-	1	-	-	-	-	17	-	-	70
Tarakihi (10-20cm)		*2*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-
Tarakihi (21-30cm)		*25*	-	*3*	-	*13*	-	*1*	-	-	-	-	-	-	-	*8*
Tarakihi (>30cm)		*80*	-	*1*	-	-	-	-	-	-	-	-	*17*	-	-	*62*
Goatfish (Red mullet)	*Upeneichthys lineatus*	54	-	1	1	7	-	1	1	-	3	1	-	-	19	21
Sweep	*Scorpis lineolatus*	23	3	-	-	-	-	-	-	-	20	-	-	-	-	-
Red moki	*Cheilodactylus spectabilis*	11	-	-	-	1	-	-	-	-	3	1	5	-	1	-
Spotty	*Notolabrus celidotus*	11	2	-	-	3	2	-	-	-	-	2	2	-	-	-
Carpet shark	*Cephaloscyllium isabellum*	5	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Blue moki	*Latridopsis ciliaris*	4	-	1	-	-	-	-	-	-	-	-	-	-	-	3
Southern conger	*Conger verreauxi*	4	-	-	-	-	-	-	-	-	-	-	-	-	-	4
Banded wrasse	*Notolabrus fucicola*	3	-	-	-	-	-	-	-	-	3	-	-	-	-	-

	Area of reef present (m²) >>	(see Table 7) >>	1,715	296	3,486	1,241	453	1,993	689	955	1,452	1,813	1,505	443	1,379	943
																Site
Species	**Taxonomic name**	**Total individuals**	**A**	**B**	**Papa**	**D**	**J**	**K**	**L**	**O**	**Q**	**R**	**S**	**T**	**U**	**V**
Sea perch	*Helicolenus percoides*	3	1	-	-	-	-	-	-	-	-	-	1	-	1	-
Marble fish	*Aplodactylus arctidens*	2	1	-	-	-	-	-	-	-	1	-	-	-	-	-
Rig	*Mustelus lenticulatus*	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Common roughy	*Paratrachichthys trailli*	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Butterfish	*Odax pullus*	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Copper moki	*Latridopsis forsteri*	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Magpie perch	*Cheilodactylus nigripes*	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Snapper (21-30cm)	*Chrysophrys auratus*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Red morwong	*Cheilodactylus fucus*	1	-	-	-	-	-	-	-	-	-	-	*1*	-	-	-
Red banded perch	*Hypoplectrodes huntii.*	1														
Porae	*Nemadactylus douglasii*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*
Porcupine fish	*Allomycterus pilatus*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*
Stingray (only partially in view)		1														
Eagle ray	*Myliobatis tenuicaudatus*	1														
Triplefin species																
Banded triplefin	*Forsterygion malcolmi*	26	3	5	1	-	-	1	-	-	4	3	1	1	5	2
Oblique-swimming triplefin	*Forsterygion maryannae*	10	-	-	-	-	-	-	-	-	10	-	-	-	-	-
Yellow and black triplefin	*Forsterygion flavonigrum*	4	-	-	-	-	-	-	-	-	-	-	-	-	4	-

3.3 Fish species counts from the baited fish trap video

Thirteen successful baited fish traps deployments were made across six sites. Note that fish traps were several hundred meters away from the CoastCam transects conducted at these sites. Given the low within-site replication and large variability, the data are presented in narrative form only.

Trap catch was low (28 blue cod, 6 scarlet wrasse, and 4 carpet sharks) but camera observations were much more informative. Table 9 gives the Nmax counts for the species seen (16 fish species, and the crayfish *J. edwardsii*), with a summed Nmax (all species) of 278 individuals. Blue cod dominated, contributing 47% of the individuals, with an estimated average fish length of 24 cm (range 13–43 cm, n = 131); trap catch lengths averaged 23 cm (range 13–35 cm, n = 28). Blue cod were present at all six sites, and in all 13 replicates. Average Nmax was 10 fish (range 1–20, all 13 trap sets treated as replicates).

Snapper were the second most common species, contributing 11% of individuals, with an average fish length of 32 cm (range 19–48 cm, n = 31). No snapper were caught in the traps. Fish were present at 5 sites, and in 8 replicates. Average Nmax was 2.5 fish (range 0–14).

Scarlet wrasse were the third most common species, contributing 10% of individuals, with an average fish length of 25 cm (range 20–30 cm, n = 28); trap catch lengths averaged 19 cm (range 14–21 cm, all from one single Q site trap). Average Nmax was 2.2 fish (range 0–14).

Trevally were the fourth most common species, contributing 10% of individuals, with an average fish length of 26 cm (range 25–30 cm, n = 27). No trevally were caught in the traps. Average Nmax was 2.1 fish (range 0–10.).

All other species had less than 15 individuals scored (sum of Nmax values). Eleven tarakihi (size range 30–33 cm) were seen passing by in the background at two sites (coming from behind the trap and passing to one side several metres behind the trap). Trevally had a similar behaviour but passed much closer to the trap (Figure). Kingfish, barracouta, and trevally were all seen in the baited trap videos but were absent from the CoastCam videos. These are all mobile species that are less likely to be observed on the seafloor. As with snapper (only one individual seen by CoastCam), they are likely to be towed camera adverse in general.

Table 9: Species Nmax counts from baited video An asterisk (*) indicates fish species not seen on the towed video transects. Replicates at sites D and S are labelled sequentially.

	Site/replicate >>	A	D1	D2	D3	D4	L	O	Q1	Q2	S1	S2	S3	S4	Total
Species	Taxonomic name														
Blue cod	*Parapercis colias*	8	5	1	13	11	16	14	7	15	7	7	20	6	130
Snapper	*Chrysophrys auratus*	3			14	2	5			1	3	1		3	31
Scarlet wrasse	*Pseudolabrus miles*	1					2	1	16		1			7	28
Trevally*	*Pseudocaranx dentex*		10		9				7	1					27
Spotty	*Notolabrus celidotus*	2						1	10				1		14
Tarakihi	*N. macropterus*				4		7								11
Leatherjacket	*Meuschenia scaber*	2					2	1	1				1	2	9
Carpet shark	*C. isabellum*						1	1	1	2		1	1	1	8
Sweep	*Scorpis lineolatus*								7						7
Kingfish*	*Seriola lalandi*				2	2			2						6
Barracouta*	*Thyrsites atun*	1											1	1	3
Long-tailed ray*	*Dasyatis thetidis*		1										1		2
Red mullet	*Upeneichthys lineatus*						2								2
Crayfish	*Jasus edwardsii*						1								1
Blue moki	*Latridopsis ciliaris*					1								1	1
Porcupine fish	*Allomycterus pilatus*												1		1
Totals		17	16	1	42	16	36	18	46	19	11	9	26	21	278

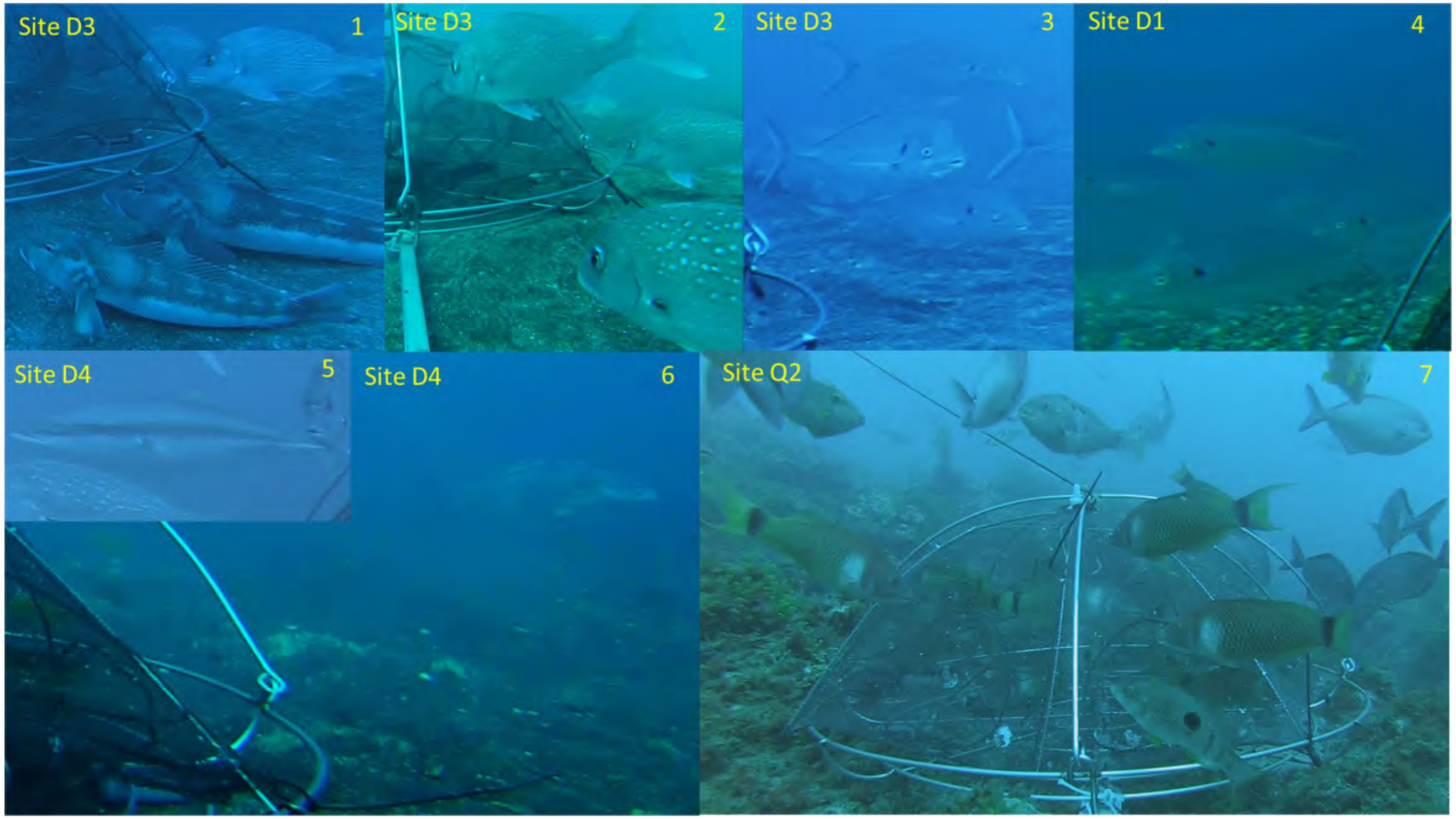

Figure 3-7: Fish species seen in baited fish trap video: 1) snapper and blue cod; 2) snapper; 3–4) trevally (part of wider dispersed schools of 10–20+ individuals); 5) kingfish (~70 cm), 6) blue moki (~60 cm); 7) scarlet wrasse, spotties, sweep, leatherjacket, and blue cod (in trap). Other species seen but not shown here are barracouta, short-tailed stingray, red mullet, porcupine fish, tarakihi, blue moki, and crayfish. Some imagery has been darkened to reduce 'washout' of fish against light background.

3.4 Project Reef (site K) diver-based photo quadrats (2017, 2018, 2020)

The results of the Project Reef diver-collected photo-quadrats, as percent cover, are given in Table 10. These still camera images were of higher resolution that the CoastCam video cameras. The 2017 survey was the most comprehensive, with 4 random transects; versus the 2018 and 2020 single fixed transects and so we have focused on the 2017 data.

Table 10: Seafloor %cover assessed by the Project Reef team. The classification scheme differs from that used for the CoastCam video transects. *, biogenic reef class was assigned to the most likely epifauna/epiflora classes in 2017, while in 2018 and 2020 it was left as a class.

Class	Sub-class	2017	2018	2020
Abiotic Material	Reef conglomerate	48.8	22.4	47.8
	Shell hash	9.0	7.4	11.1
	Sand	0.4	0.9	0.9
Encrusting Animals	Biogenic Reef	*	5.6	1.9
	Porifera	13.4	5.8	6.7
	Bryozoa	0.2	0.4	0.2
	Chordata	3.4	0.4	1.7
	Cnidaria	2.2	0.4	0.9
Mobile invertebrates	Mollusca	0.2	0.1	0.2
	Echinodermata	0.6	0.7	0.3
Macroalgae	Chlorophyta	3.6	2.4	4.4
	Rhodophyta	1.6	1.7	5.8
	Ochrophyta	6.6	6.3	7.1
Turfing Algae		9.8	43.5	9.1
Fish		0	0	0.2
Unknown		0.2	2.2	0.3
Sampling frame intrusion		0	0	1.5

Turfing algae had a percent cover of 9.8% of 2017 survey (43.5 % in 2018, 9.1% in 2020). This very low height, fine turf was not included as a class in the CoastCam video classification, as it was largely not able to be distinguished by the image scale and resolution used.

The Project Reef Citizen Science group (2017) informal report noted that while some small bryozoans, sponges, and various forms of macroalgae were known to be present (from finer-scale macrophotography taken outside the scope of this project), they were not distinguishable at the 0.25 m^2 image scale used here. *E. radiata* kelp plants were also noted to have obscured the seafloor beneath their blades, resulting in an underestimation of benthic cover on the seafloor proper.

Table 11 provides a detailed breakdown of taxon contributions (percent cover) of the seafloor from the 2017 photo quadrats to the finest practical taxa/species level. The higher resolution of images allowed the identification of three species not identified in the broader scale CoastCam video transect: the small gastropod *Buccinulum linea* (the lined whelk, endemic to New Zealand) the macroalgae *Polysiphonia* sp., and *Zonaria turneriana* (the latter could occasionally be identified to *Zonaria* sp. when the CoastCam system was unusually close to the seafloor).

Table 11: Taxa contributions (%cover) from the 2017 photo quadrats sampling the Project Reef.

Taxon group	Taxa/species	%cover	Sub-totals	All
Sponges	*Chondropsis* sp.	1.81%		
	Crella incrustans	1.36%		
	Unidentified sponges	1.22%		
	Ecionemia alata	0.61%		
	Stelletta conulosa	0.56%		
	Aaptos globosa	0.47%		
	Ciocalypta polymastia	0.22%		
	Tethya bergquistae	0.17%		
	Psammocinia perforodorsa	0.11%		
	Iophon minor	0.08%	6.61%	
Ascidians	*Didemnum* sp.	1.08%		
	Unidentified Ascidiacea	0.56%	1.64%	
Bryozoans	Unidentified Bryozoan	0.19%	0.19%	
Anemones	*Anthothoe albocincta*	0.86%	0.86%	
Mobile invertebrates	*Evechinus chloroticus*	0.31%		
	Unidentified mollusca	0.08%		
	Cookia sulcata	0.06%		
	Buccinulum linea	0.03%	0.47%	
Kelps/macroalgae	Unidentified turfing algae	9.72%		
	Ecklonia radiata	5.94%		
	Caulerpa geminata	4.06%		
	Polysiphonia sp.	3.00%		
	Coralline algae	2.08%		
	Unidentified Ochrophyta	0.86%		
	Unidentified Rhodophyta	0.75%		
	Unidentified Chlorophyta	0.19%		
	Zonaria turneriana	0.14%		
	Caulerpa flexilis	0.03%	26.78%	36.56%

The Project Reef team has also collected various video and still imagery of the reef (e.g., Figure). Their web page (https://www.projectreefsouthtaranaki.org/) has a range of high quality still and video imagery of the reef, together with their research on the reef, community engagement, and the history and activities of the group.

Figure 3-8: Project Reef imagery of the reef Top image), top raised edge of reef terrace with *Ecklonia* patches, soft bryozoans, *C. flexilis*, and various sponge species. Bottom image), the same reef , but taken about 3 metres further back, showing the terrace drop to soft sediment. The reef is formed from rock with a high fossil content, probably limestone.

3.5 Project Reef (site K) blue cod and fish assemblage

3.5.1 Baited Underwater Video (BUV)

Four single BUV drops were carried out on the Project Reef between November and March in 2017, 2018, 2019 and 2021. The respective Nmax numbers were 20, 30, 17, and 71. These numbers cannot be directly compared to the fish trap Nmax numbers due to the different methodological approach (e.g., vertical versus horizonal cameras, use of traps), but nevertheless have upper/higher values (Table 9). Other species were not counted, but included snapper, scarlet wrasse, tarakihi, and carpet shark; and three species not seen in either the CoastCam or fish trap videos: octopus, seven-gilled shark (*Notorynchus cepedianus*), and school shark (*Galeorhinus galeus*).

Two BUV drops were also made in 2020 but these were unable to be quantified (one too short, the other dragged in the current).

3.5.2 In-situ camera

Thirty-two species of fish were recorded in eight deployments of a fixed in-situ video camera were made, with the footage partially reviewed by the Project Reef team (Table 12). Seven of these species were not seen by any of the other sampling methods. These were southern bastard cod (*Pseudophycis barbata*), giant boarfish (*Paristiopterus labiosus*) (Figure), rock cod (a *Lotella* sp.), lantern fish (Family Myctophidae), slender roughy (*Optivus elongatus*), frostfish (*Lepidopus caudatus*), and piper (*Hyporhamphus ihi*). Other non-fish species recorded were shrimps, crayfish, octopus, a crab, a nudibranch, a sea cucumber, and a New Zealand fur seal (*Arctocephalus forsteri*). There was no obvious relationship between species richness and season (Table 12).

Across the four seasons (over four years), snapper were consistently present across all 8 deployments (two of which were in winter 2020). Blue moki, leatherjackets, scarlet wrasse and southern bastard cod were seen in 7 out of 8 deployments 8% (88%). Leatherjackets were seen in 73% of deployments; giant boarfish, butterfly perch, carpet sharks, common roughy, and oblique triplefins in 63% of deployments; and kingfish and trevally in 50% of deployments. Blue cod were only seen in 38% of deployments. Whether the fish seen were resident on the reef, or more transient seasonal or haphazard visitors, is unknown (though small-bodied species such as triplefins are likely to be resident at a fine scale).

Table 12: Species presence by season, from the Project Reef in-situ camera Number of 20-second video clips reviewed was 3,145. Fish species not seen by any of other methods marked with *.

	Month	Nov	Jan	Jan	Feb	Feb	Mar	June	July
	Year	17	20	18	19	20	17	20	20
	Season	Spr	Spr	Sum	Sum	Sum	Aut	Win	Win
	Fish species richness	15	16	8	20	11	11	17	21
% time	Species								
100%	Snapper	1	1	1	1	1	1	1	1
88%	Blue moki	1	1	1	1		1	1	1
	Leatherjackets	1	1	1	1	1	1		1
	Scarlet wrasse	1	1	1		1	1	1	1
	Southern bastard cod	1	1		1	1	1	1	1
75%	Goatfish	1	1		1	1		1	1

	Month	Nov	Jan	Jan	Feb	Feb	Mar	June	July
	Year	17	20	18	19	20	17	20	20
	Season	Spr	Spr	Sum	Sum	Sum	Aut	Win	Win
	Fish species richness	15	16	8	20	11	11	17	21
% time	Species								
63%	Giant boarfish	1			1	1		1	1
	Butterfly perch	1	1		1			1	1
	Carpet shark	1			1	1		1	1
	Common roughy	1	1		1		1	1	
	Oblique triplefin			1	1	1		1	1
	Tarakihi	1	1		1	1		1	
50%	Kingfish	1	1					1	1
	Trevally		1		1		1		1
38%	Black and yellow triplefin	1					1		1
	Blue cod		1			1			1
	Crayfish		1		1			1	
	Eagle ray			1	1	1			
	Rock cod			1	1			1	
	Sea perch	1						1	1
	Shrimps	1						1	1
25%	Conger eel				1		1		
	Copper moki		1					1	
	Eagle ray			1					1
	Lantern fish*						1	1	
	*Octopus**							1	1
	Slender roughy*				1				1
	Spotty	1							1
	Unidentified shark		1						1
13%	Banded triplefin		1						
	Crab				1				
	Frostfish*				1				
	Magpie perch								1
	New Zealand fur seal							1	
	Nudibranch			1					
	Piper*				1				
	Porcupine fish						1		
	Sea cucumber		1						
	Short-tailed ray				1				
	Sweep								1

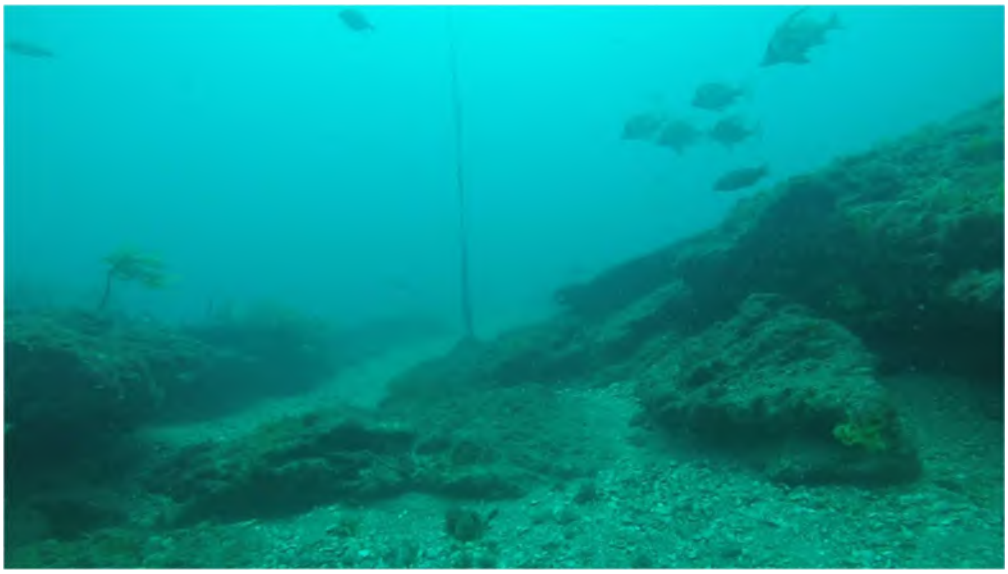

Figure 3-9: The fixed field of view of the in-situ camera The camera is bolted to a heavy permanently fixed base. The site is in a small notch feature/indent in the Project Reef's southern side and faces south onto the adjacent low rock and coarse sediments, as well as the reef edge (right side). Shown are a small school of giant boarfish (five individuals) which in this video spent some time sitting up on the reef wall facing into the current. Later, this group swam from behind the central mooring rope to pass the camera at close range on the left side. Also present are two scarlet wrasse and a leatherjacket.

3.5.3 Research rod fishing

Eleven separate fishing events were completed on the Project Reef between 2016 and 2021. Two of these were on the same day, and another two separated by only five days; these two pairs were each combined, giving nine fishing events overall. A total of nine fishing events occurred between 2016 and 2021. Figure (top graph) shows the sizes of all blue cod measured (n = 391), plotted by event. Fish ranged in size from 155 to 550 mm. Fitting of a simple linear regression found a very small but significant positive relationship between time and size (r^2 = 0.09). Predicted average fish size rose from 293 mm in 2016, to 334 mm in 2021 (a 40 mm increase). Re-expressing the same data as the proportion of legal-sized fish (330+ mm) caught, plotted against time (Figure 10, second graph), also showed a significant positive relationship (r^2 = 0.39). The predicted legal size fish proportion increased from 25% to 62%.

There are several possible reasons for this observed increase in the size of blue cod over the five year period, for the blue cod sampled population (nominally fish 155 mm and larger). New recruitment to the sampled population (juvenile fish growing larger than 154 mm) over time may have been less than previous years, resulting in an aging fish population (and, therefore, on average larger fish). Natural variations in fish population abundance and size compositions over time are normal. Little is known about natural blue cod recruitment dynamics over time, but it is highly likely that year class strength varies naturally between years (some spawning years are much more successful than others). An alternative possibility is that the Project Reef was experiencing some level of fishing removals prior to being adopted by the local (human) community; and that with the creation of Project Reef, this fishing pressure ceased/reduced as a voluntary response, allowing more fish to grow to a larger size.

Standardisation of the blue cod catches to a Catch Per Unit Effort (CPUE) metric, expressed as fish caught per rod per hour fished, is plotted in Figure (bottom graph). Sampling effort averaged 6.26 rod hours fished per event (range 3.2–12.2). There was a small but significant downward trend in CPUE over the five-year period (r^2 = 0.09), with a predicted 30% decline. This finding favoured the lower recruitment hypothesis for explaining the increase in average fish size seen over the same period.

Other species were caught in numbers too low to support numerical investigation; a catch summary is given in Table 13.

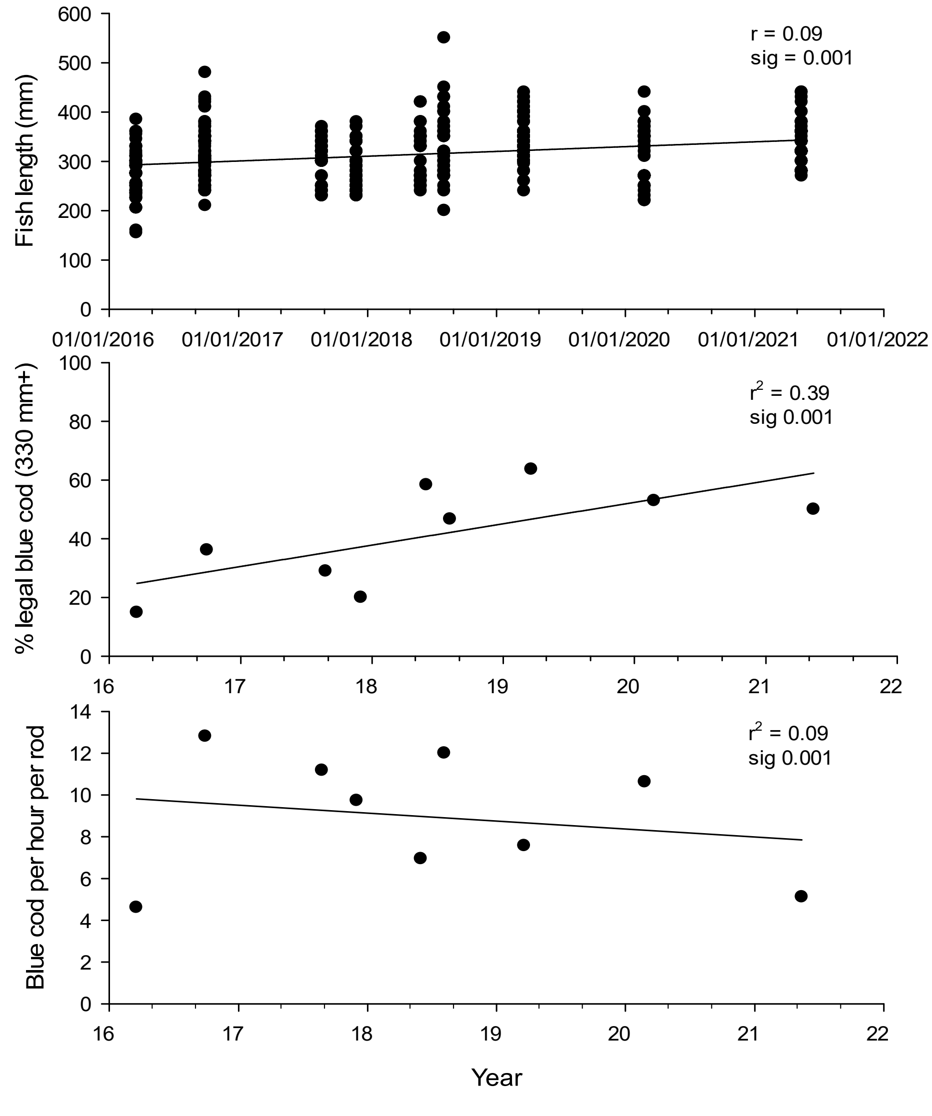

Figure 3-10: Fishing survey blue cod data from Project Reef top) fish lengths by event; middle) proportion of fish of legal size (300 mm and greater); bottom) CPUE, measured as fish per rod hour fished.

Table 13: Rod fishing catch summary of all fish species other than blue cod The maximum possible number of fishing events is nine. For snapper, 21 fish (57% of individuals sampled) were caught during one sampling event (1/06/2018).

Species	n	Av. Size	Range	No. of events
Snapper	37	37	27–79	5
Kahawai	8	64	50–56	3
Spikey dogfish	8	74	74–75	1
Scarlett wrasse	6	28	25–31	3
Trevally	4	49	46–54	1
Tarakihi	3	29	29–30	3
Sea perch	3	N/A	N/A	2
Carpet shark	2	100	-	1

3.6 Individual site descriptions (CoastCam)

This section describes each site in more detail.

As the various identity keys for graph plots take a lot of space, they are presented once below (Figure), to be referred to when viewing the figures below. In the graph plots for a site, all geomorphology and biogenic habitat covers are presented. As a broad overview of sponges, each video segment is plotted for its sponge count (sum of 'individuals' seen) and sponge richness (number of species present). Coralline algal plates, *E. radiata* recruits and hydroid trees are plotted as important / interesting species counts, summed by video segment. Mobile invertebrates are plotted for the five most common species/taxa, with kina represented by a red star symbol to help them stand out as a key habitat-structuring species. The five most abundant fish species are also plotted as summed counts per video segment, with blue cod and tarakihi further divided into size classes. 0+ juvenile blue cod are represented with stars, to help them stand out on the plots also.

For the maps in the individual sections that include the Benthic Terrain Model (BTM) classes, the BTM key is also not included on each individual map to save space. Figure provides the key to refer to, it is given as part of Appendix A. To avoid clutter, within an individual site section, seafloor images are referred to by number (1–32) without a corresponding Figure reference. Similarly, video segment numbers are referred to simply by their number, prefaced by a # to separate them from the seafloor image numbers.

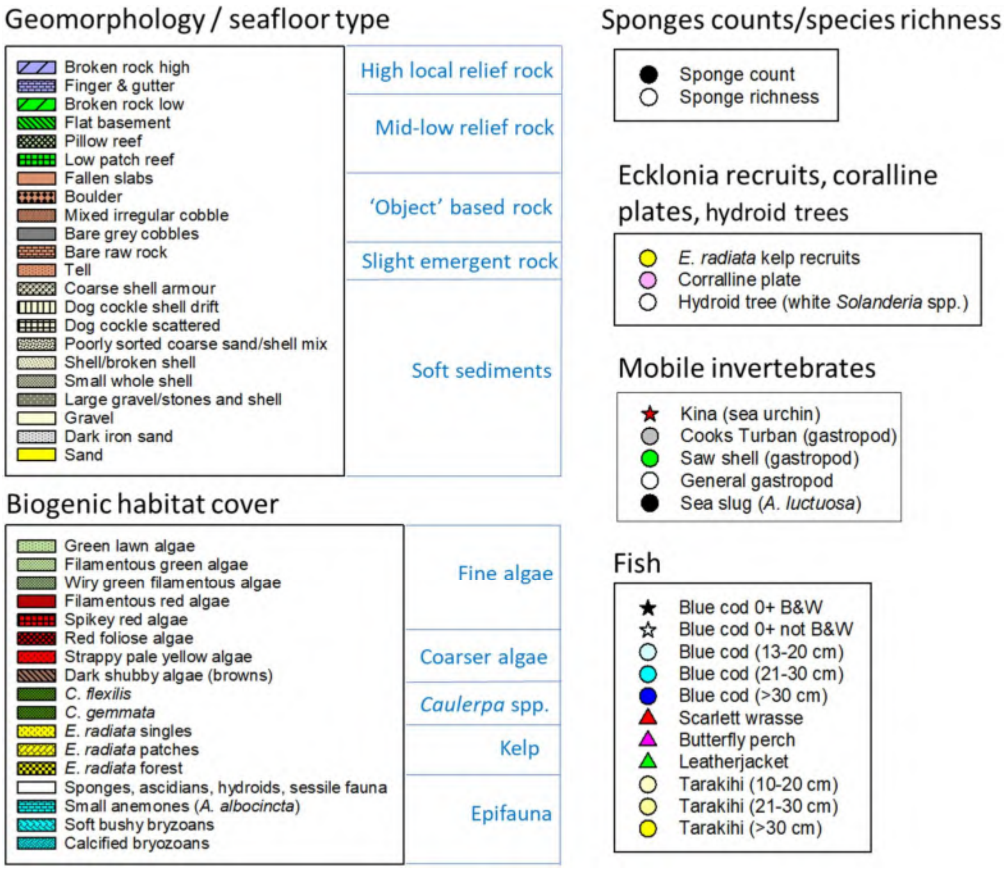

Figure 3-11: Master key for graphs in the individual sites section Geomorphology/seafloor type classes are ordered broadly by decreasing local topographic/height complexity and particle size. Biogenic cover is ordered for macroalgae by increasing form complexity/size, and for epifauna so that the general class of 'sponge, ascidians, hydroid' provide a clear visual break between epifauna and epiflora (macroalgae) classes where both are present. For the three plots of individual taxa abundance, most symbol colours were chosen to broadly match the organisms, with within-colour gradients used for blue cod and tarakihi to separate different size classes (lightest shade for smallest fish). Blue cod 0+ juveniles are shown as star symbols, to help likely blue cod nursery habitats/areas stand out clearly; kina are also shown as star symbols, given their potentially strong effect on structuring subtidal reef benthic assemblages.

3.6.1 Site A

Depth range. 13.9–24.8 metres **Reef size**: 425,000 m^2

Form. Low ridge/escarpment, composed of two main reef features. Discrete.

The larger northern part formed a low arcing bluff, extending 1,650 m along its axis (Figure 3-12). Cross-sectionally, the northern reef emerged from sand (18.4 m) on its south/west side, ramped up to a flat ridge top (shallowest area 13–14m), before dropping away more steeply and in more broken form on the north-east side, down to flat seafloor (22.9 m). The smaller southern reef, about 500 m along its axis, was similar in structure with an east-west orientation, but with less pronounced bathymetry, going from sand (19.4 m) to the reef top (18.5 m), then dropping away to the east (24.8 m).

BTM Divisions (east to west video transect): Flat Plains (sand) → Flat Ridge Tops → Rock Outcrops High/Narrow Ridges → Flat Ridge Tops → Broad slopes → Depressions → Broad Depressions (with some patches of Local Ridges, Boulders, Pinnacles in Depressions/on Broad Flats/on Slopes) (Figure 12).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-12 to Figure 3-14)

Geology: The reef was composed of a rock type that appeared hard but amenable to erosion (4,12), assumed to be sandstone with an additional component of smooth small grey stone drifts on the upper flanks of the ridge reef feature (4,9,10,12). On the deepest eastern side where the reef reached flat seafloor, small tell exposures of a flat grey basement rock (likely mudstone/papa rock) also appeared (17). Several clear geological NE/SW fault lines were present in the multibeam sonar data; but cannot be seen in the figures here, due to their small scale on the page.

On its southern side, the reef first appeared as small tells/rock patches surrounded by dark sand (1–2), then reef increased in cover going up the ridge flank as a mix of low broken rock, high patch reefs, and dark sand. Drifts of smooth, grey stone cobbles (4,10,12) were also apparent. These stones were intermixed with bedrock outcrops, occurring as patches and drifts, with the stones likely to be mobile during storm events. On the ridge top, high broken rock dominated (#725–762, #840–850), and the upper flanks/sides (#762–825) were composed of low broken rock, irregular mixed cobbles, and grey stone cobbles (9,11,12). Dropping away down-slope to the east, the transect crossed over alternating dominances of low broken rock and dark sand (#850–930), along with lesser contributions of mixed irregular cobbles and tells.

The reefs overall height was seven to nine metres, with local topography variability at metres scale. The exception was a limited area of larger rectangular reef blocks (6) (1–2 m high, 5–6 m long, 3–4 m wide) seen near the top of the ridge, surrounded by coarse sediment.

Biogenic habitats: On its west side, the reef emerged from a flat plain of dark sand (1) as small tells/patch reefs dominated by sponges, red filamentous, and yellow-bladed algae (2). As the reef increased in cover, patches of *C. flexilis* appeared (3), increasing to become the dominant reef cover (7,9,11). The very mosaiced nature of the reef (rock, cobbles, stones, soft sediments) limited *C. flexilis* to numerous patches (15–20% cover), rather than continuous dense meadows as seen on other reefs. Its dominance reduced in the eastern deeper area beyond the ridge top, where it forms a mixed biogenic habitat dominated by red filamentous algae (15–18), as well as patches of the green algae *C. geminata*.

E. radiata (kelp) occurred as intermittent single plants and small patches (7,13,16) across the transect, with kelp forest limited to the reef ridge-top, where it formed a dominant narrow habitat band (8) (10–15 metre wide). The transect passed over this narrow kelp forest band twice (separated by 450 m), strongly suggesting the existence of a long narrow kelp forest extending along the top of the ridge (750+ m). This forest may have been wider in the central area, where the flat ridge top widened to 50 m. Overall *E. radiata* cover was 1.44% (forest 0.60%). *Ecklonia* recruits were most abundant on the upper reef, near higher adult plant covers; as well as toward the transect end (#900+) (Figure 3-12).

Main invertebrate species: Sponges were the most common sessile invertebrates, with an overall low percent cover contribution across the video transect of 0.41% (Table 6). The dominant taxa were Family Chondropsidae sp 2, *Raspailia topsenti*/*Axinella* sp. indet., *Crella incrustans*, *Ciocalypta polymastia*, and *Tethya bergquistae*, as well as an unidentified bright orange ascidian. Sponge richness and abundance were highest on the tells/reef patches (2) at the transect start (<#700), as well as on the eastern side (>#850) as the reef dropped in depth as an alternating dominance mix of rock and soft sediments (15–18). Kina were present across the upper part of the reef, but in low numbers (48 counted) and never seen in groups of more than two to three. Other mobile invertebrates were rare (1 gastropod, 1 sea-slug) (Table 7).

Main fish species: Scarlet wrasse were the dominant species seen and were present across the reef. Blue cod were also common, with fish sizes dominated by larger juveniles and adults. Few 0+ juveniles were counted. Blue cod distribution was largely associated with reef/sediment boundaries, rather than on the reef proper. Leatherjackets were in lower numbers across the transect, while butterfly perch were uncommon (5 seen) compared to most other sites with similar sandstone rock types.

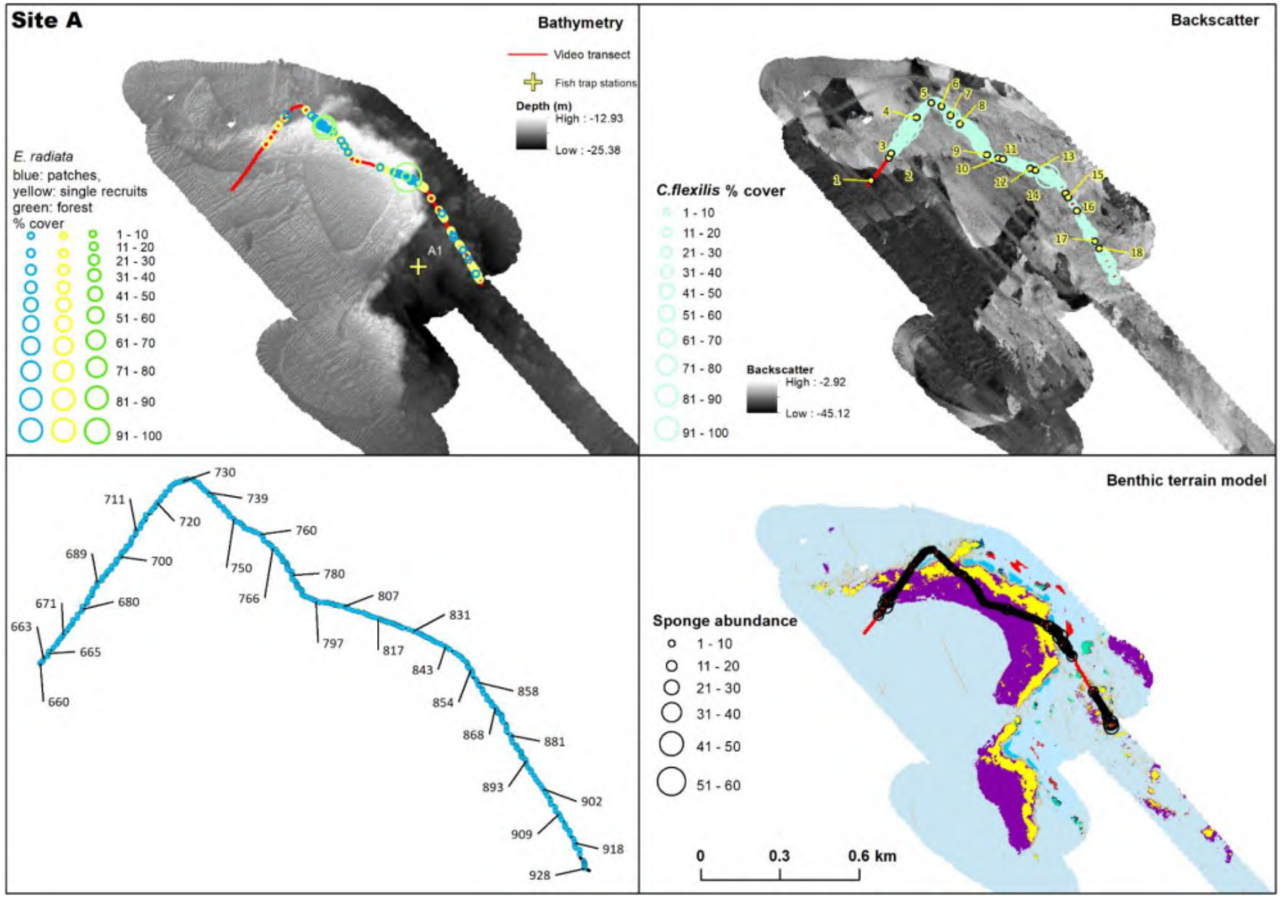

Figure 3-12: Maps of site A Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; bottom left) towed video transect with video segment sequential numbers; bottom right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

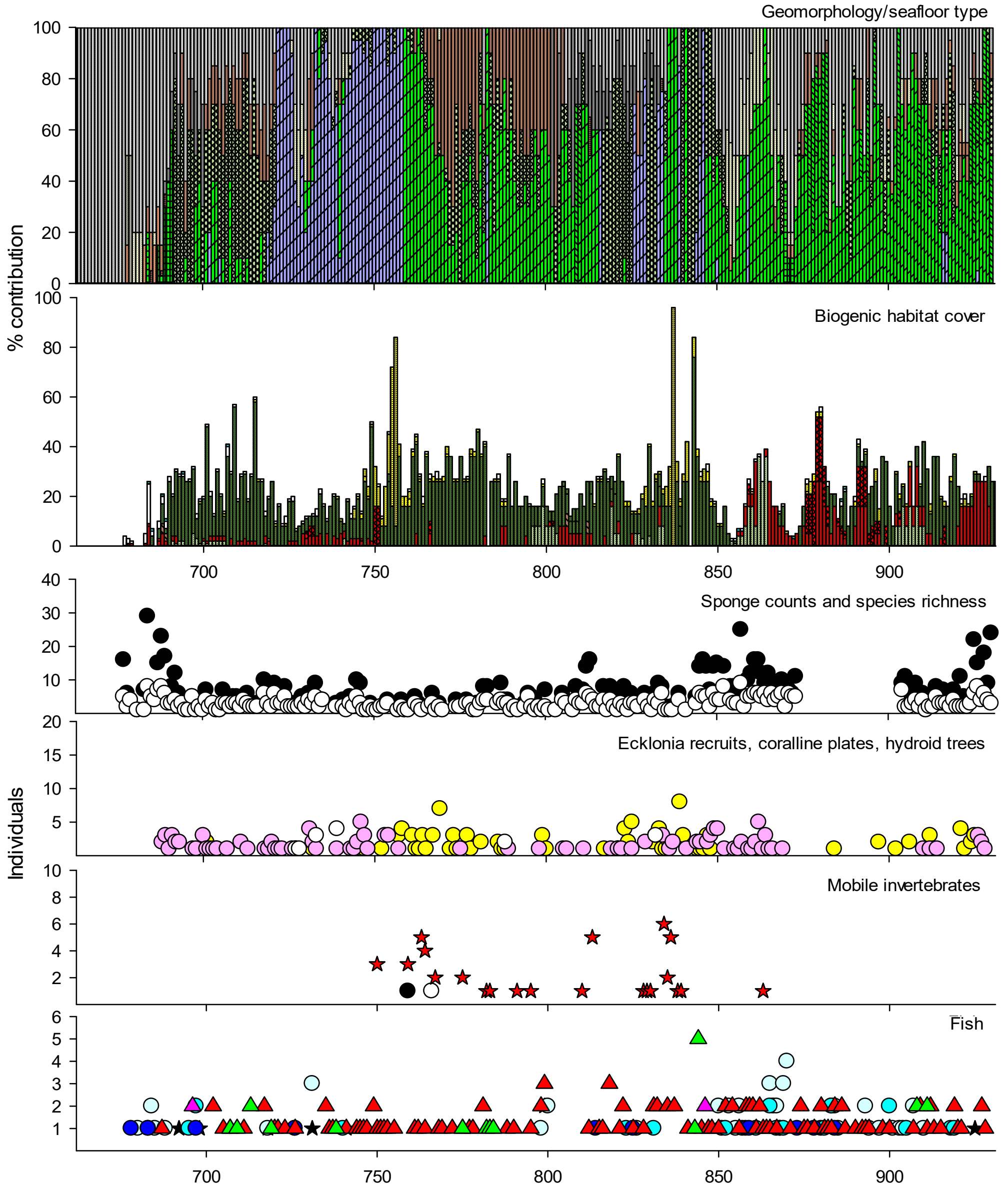

Figure 3-13: Site A CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. The data gap for sponge cover and richness (#825–900) is due to poor water visibility limiting resolution of sponge taxa. Class keys are given in Figure . The x axis plots the sequential spatial position index of the 20-second video segments, shown in map form in Figure 3-12.

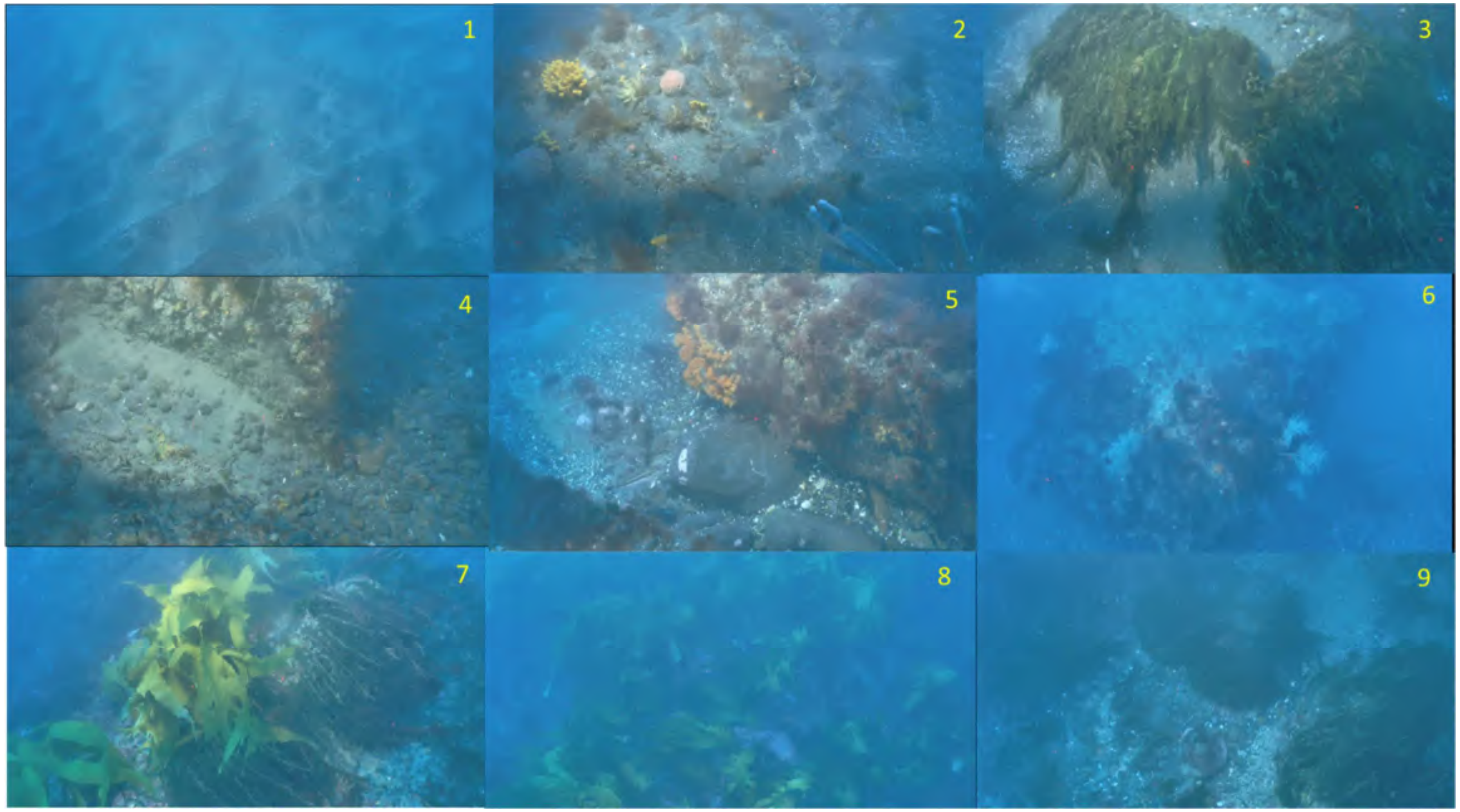

Figure 3-14: Site A seafloor images image numbers are plotted spatially in Figure 3-12 over multibeam sonar back scatter: 1) bare dark sand; 2) tells with sponges including; *R. topsenti*/*Axinella* sp. indet.; 3) *A. globosa*, *C. ramosa*) *C. flexilis* patches; 4) reef flanked by smooth grey cobbles; 5) small blue cod and sponge *C. incrustans* in mixed habitat (the small boulders may be a different rock type); 6) large rectangular reef block, with white hydroid trees (*Solanderia* sp.); 7) *Ecklonia* patch; 8) *Ecklonia* forest; 9) mixed reef and smooth grey cobbles habitat (the small boulders may be a different rock type).

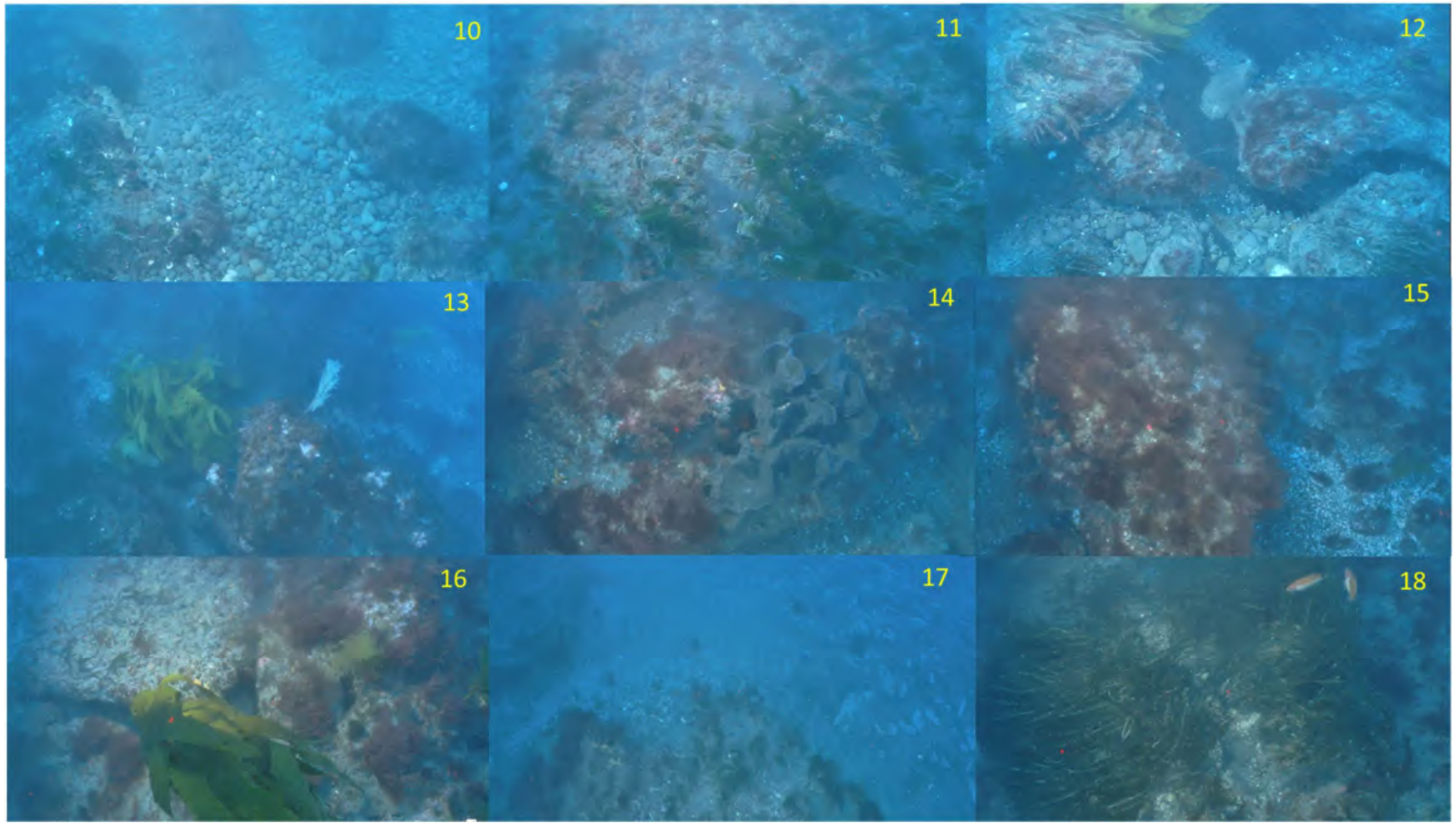

Figure 3-14: continued 10) smooth grey cobbles field; 11) flat basement reef with *C. flexilis*, off-white 'strings' are dead stolons); 12) mixed rock, smooth grey cobbles, dark sand; 13) low relied reef with *Ecklonia* patch and hydroid tree; 14) low relief reef with foliose red algae and the large grey sponge *E. alata*; 15–18); low relief reef, sediments, and bare rock class (17, thought to be mudstone/Papa rock); (18, two scarlet wrasse associated with *C. flexilis*).

3.6.2 Site B

Depth range. 21.2–25.9 metres **Reef size**: 211,957 m^2 (within overall MBES polygon)

Form. Extensive low mixed reef, cobble, and coarse sediment field, with several small rocky knolls and outcrops; adjacent to flat sand plain to the west. Figure shows the broader multibeam sonar block, which was used to calculate the area of reef.

This area was composed of a field/mosaic of low irregular basement rock, irregular cobbles, boulders, and coarse soft sediments. Occasional higher rocky knolls (3–4 metres height) were present within the field. This reef field was bordered by a flat sand plain, which also occurred occasionally inside the reef field. Additional low rocky knolls may be present within the flat sand plains, as indicated by multibeam sonar data. The dominant rock type was visually assessed as sandstone.

BTM Divisions (east to west video transect): Flat Plains (sand) → Broad slopes (sand/reef boundary) → Flat plains (low mixed reef) → Broad slopes (reef/sand/reef boundaries) → Local ridges Boulders, Pinnacles on Slopes (part of reef knoll) → Rock outcrops Highs/Narrow Ridges (reef knoll) → Broad slopes (reef/sand/reef boundaries) → Flat plains (mixed reef field) → Broad slopes → Scarp/cliff (side wall of reef knoll) → Rock outcrops Highs, narrow ridges (side of rocky knoll) → alternating Broad slopes and Flat plains → Broad depressions → alternating Broad slopes and Flat plains → some Rock Outcrop Highs, Narrow Ridges and Flat Ridge Tops towards end of transect (Figure 3-16).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-16 to Figure 3-18)

Geology: On the west side (start of video transect), a flat sand plain made an abrupt change into the reef field, associated with a bathymetry drop of 0.5–1 metres (1). This boundary drop was clearly visible in both the bathymetry and backscatter data and identified by BTM analysis as a very narrow 'broad slopes' feature delineating this boundary (Figure , 3-16). This BTM feature class ran as a largely continuous line north-west/south-east across the mapped block and was also visually obvious in the bathymetry and backscatter maps (Figure , 3-16). Smaller short segments of this feature class were also present both in the flat sediment plains and the rock field, suggesting smaller scale sand/reef patches in the extensive reef or sand dominated areas, respectively (Figure , 3-16). Most of the reef field transect was composed of a mosaic of flat basement reef (47.3%), mixed irregular cobbles (16.8%), low broken rock (4.4%), boulders (1.7%), and high broken rock (knolls). Several discrete rocky knolls were targeted by the transect (#950, 5–6; #982 and #1019, 10–12), which were defined by steep vertical slopes several metres high, which for the largest knoll were classed as cliff/scarp by the BTM analysis. Towards the end of the transect, further rock outcrops were identified by BTM, although they were just missed by the towed video/ not readily apparent in video footage.

Biogenic habitats: The bare sand plain habitat was devoid of fish, epifauna, and epifauna; this absence was consistent each time the transect passed over open sand habitat (Figure 3-16, 3-17). The mixed reef field was dominated by red filamentous algae (2–4,7,9,17), which covered 34% of the seafloor overall, (ranging up to >60% cover, depending on substrate). Within this dominant overall biogenic habitat were small patches of sponges, usually associated with small outcrops of basement reef (2,3,15), as well as occurring as solitary sponge individuals (16,17) (2.9% sponge cover overall).

The rocky knolls were in contrast dominated by relatively high sponge cover (5,6,10,11), especially of the grey sponges *E. alata* and *S. conulosa*, through the percent cover of red filamentous algae was also high. Several crayfish (*J. edwardsii*) were also seen sheltering under sponges on one of the rocky knolls (5, 6)

Main invertebrate species: The dominant taxa were the sponges Family Chondropsidae species 2, *R. topsenti*/*Axinella* sp. indet., *C. incrustans*, *S. conulosa, E. alata* and *A. globosa*, as well as an unidentified bright orange ascidian species. Overall percent cover of sponges and other encrusting invertebrates across the reef transect was 2.94%.

Sponge richness and abundance were highest on the tells/reef patches (2) at the transect start (<#700), as well as on the eastern side (>#850) as the reef dropped in depth as an alternating dominance mix of rock and soft sediments (15–18). Sponge richness was relatively constant through the reef field, with higher abundances often associated with the rock knolls and some low reef outcrops. Kina were not seen; other mobile invertebrates were limited to several general gastropod and sea slug individuals (Table 7, Figure).

Main fish species: Butterfly perch was the dominant species present (Table 8), largely as small school/s associated with the largest rocky knoll (10,11). Sub-adult and adult blue cod were the next most common species, but 0+ juveniles were rare (two counted). Scarlett wrasses were also common and distributed across the reef field (Figure). Other fish species were uncommon and included the only copper moki (*Latridopsis forsteri*) seen during the survey.

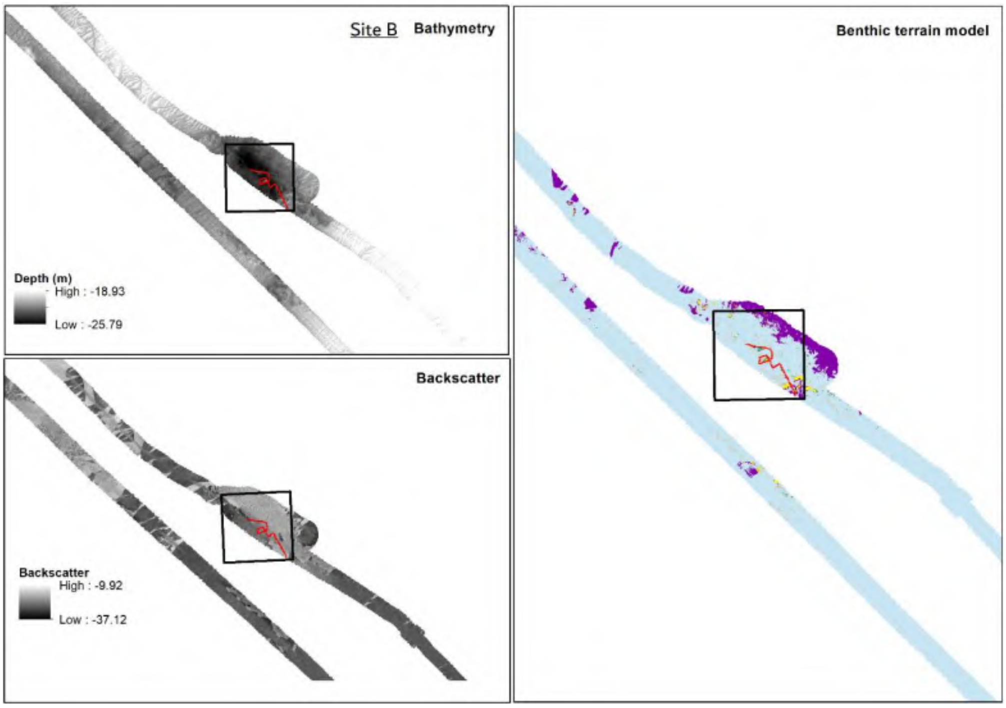

Figure 3-15: Broader extent maps of larger seafloor area mapped around site B upper left) multibeam sonar bathymetry; bottom left) multibeam sonar backscatter; right) BTM model classes.

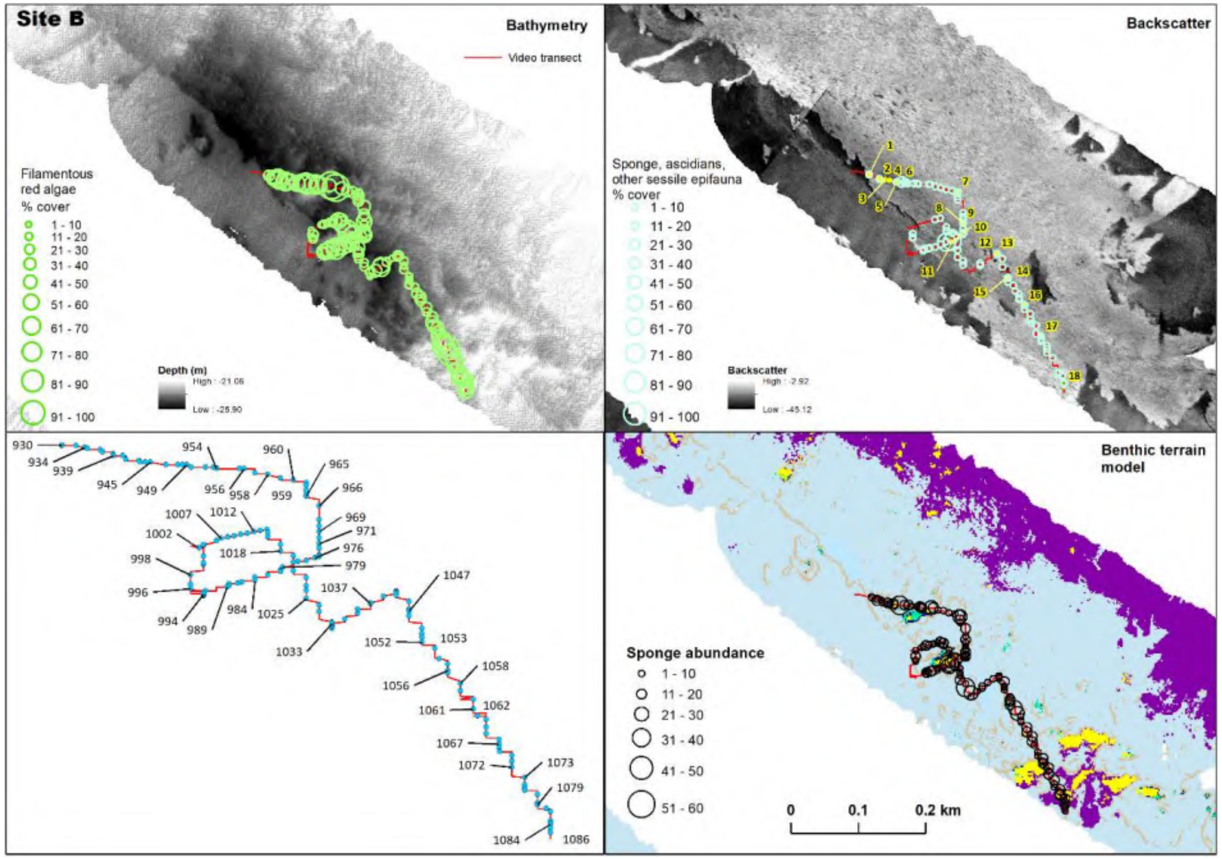

Figure 3-16: Maps of site B. Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment). Note that the reef knoll features are obscured by the bubble plots; refer to Figure 3-15).

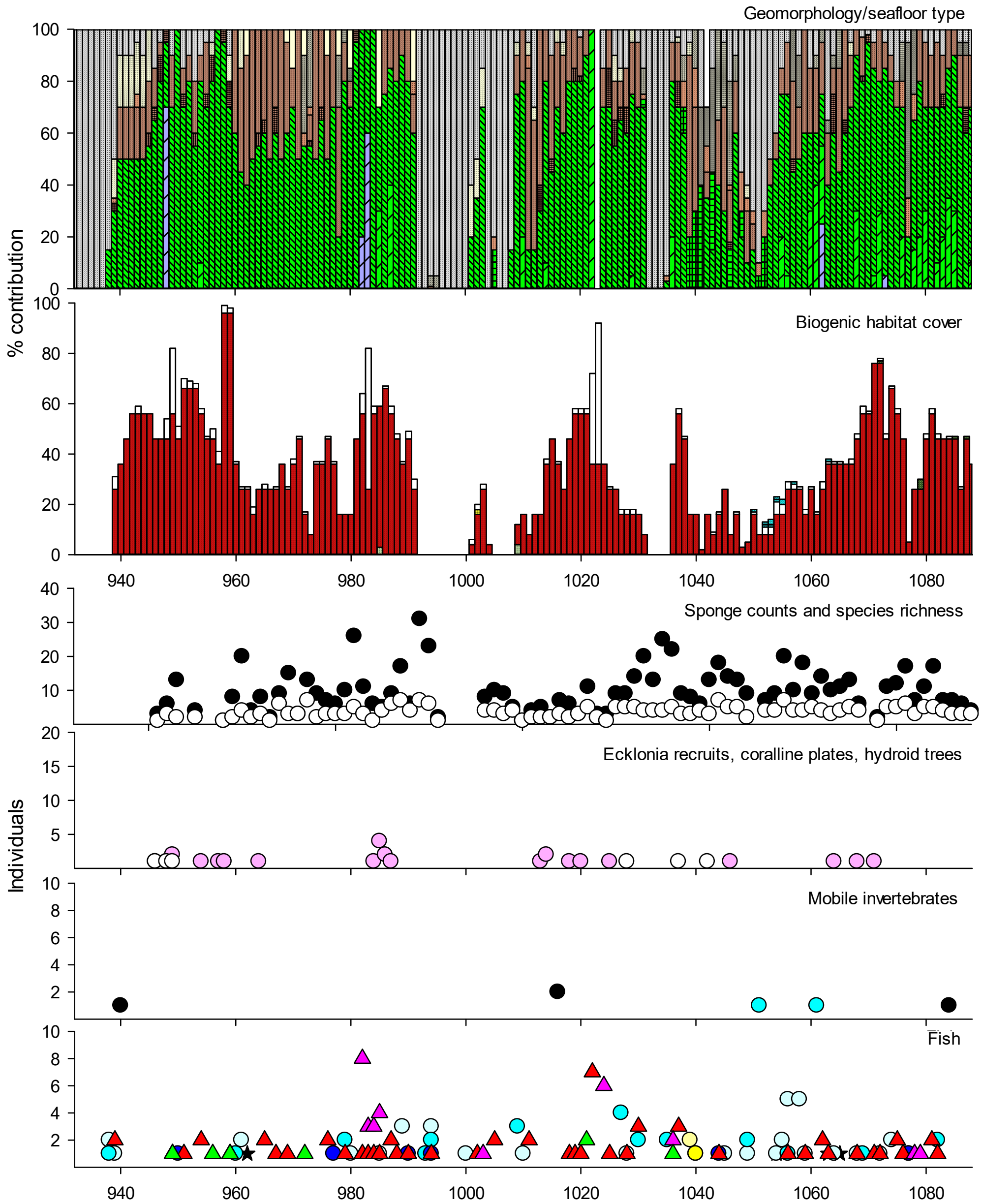

Figure 3-17: Site B CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish.Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-16

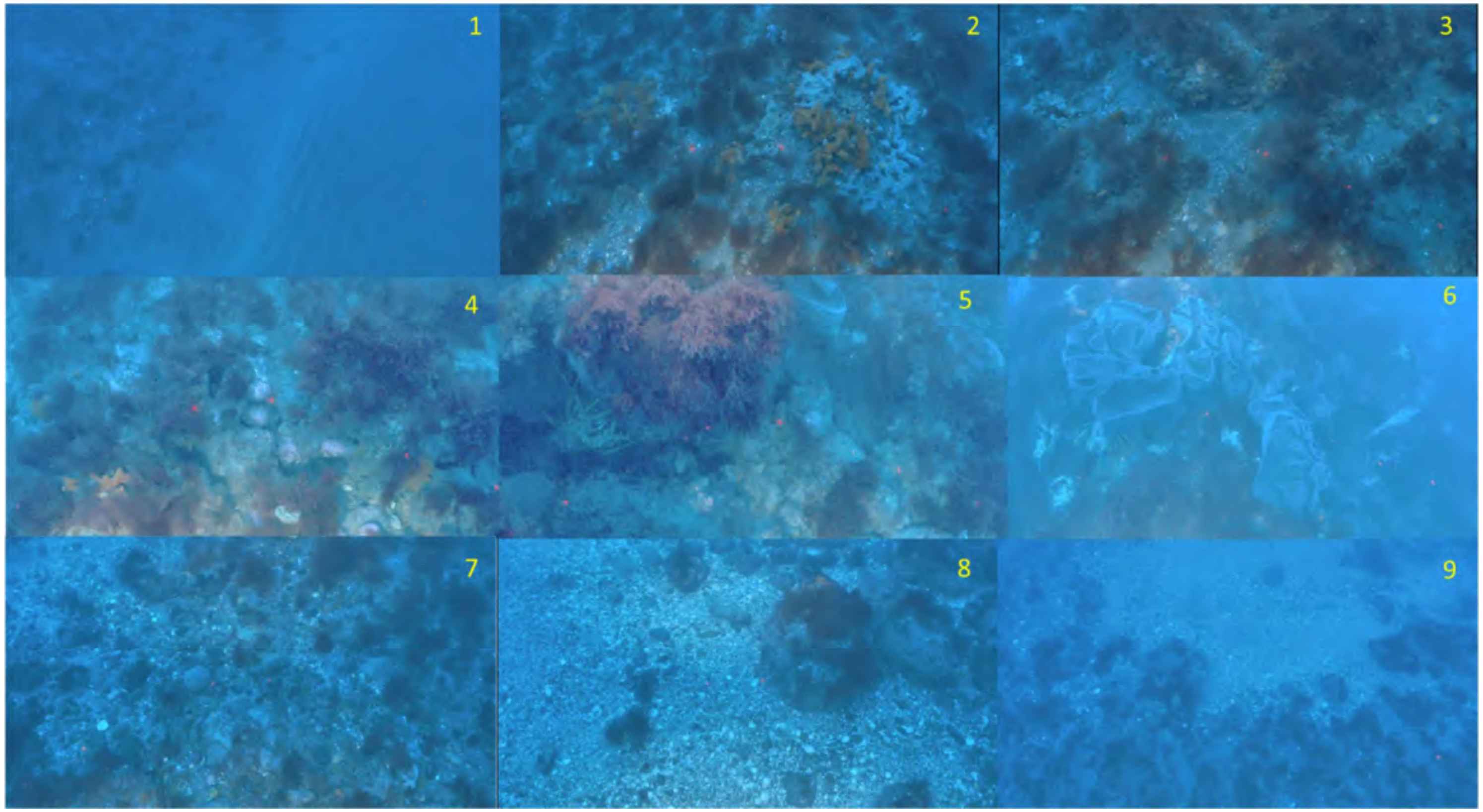

Figure 3-18: Site B seafloor images image numbers are plotted spatially in Figure 3-16 over multibeam sonar back scatter: 1) flat sand plain/reef field boundary; 2–4) low rock field, with sponges Family Chondropsidae species 2 (grey), and *C. incrustans* (orange); 5) crayfish associated with small reef knoll; 6) crayfish and grey sponge *E. alata* on small knoll; 7–9) reef field mixed substrates.

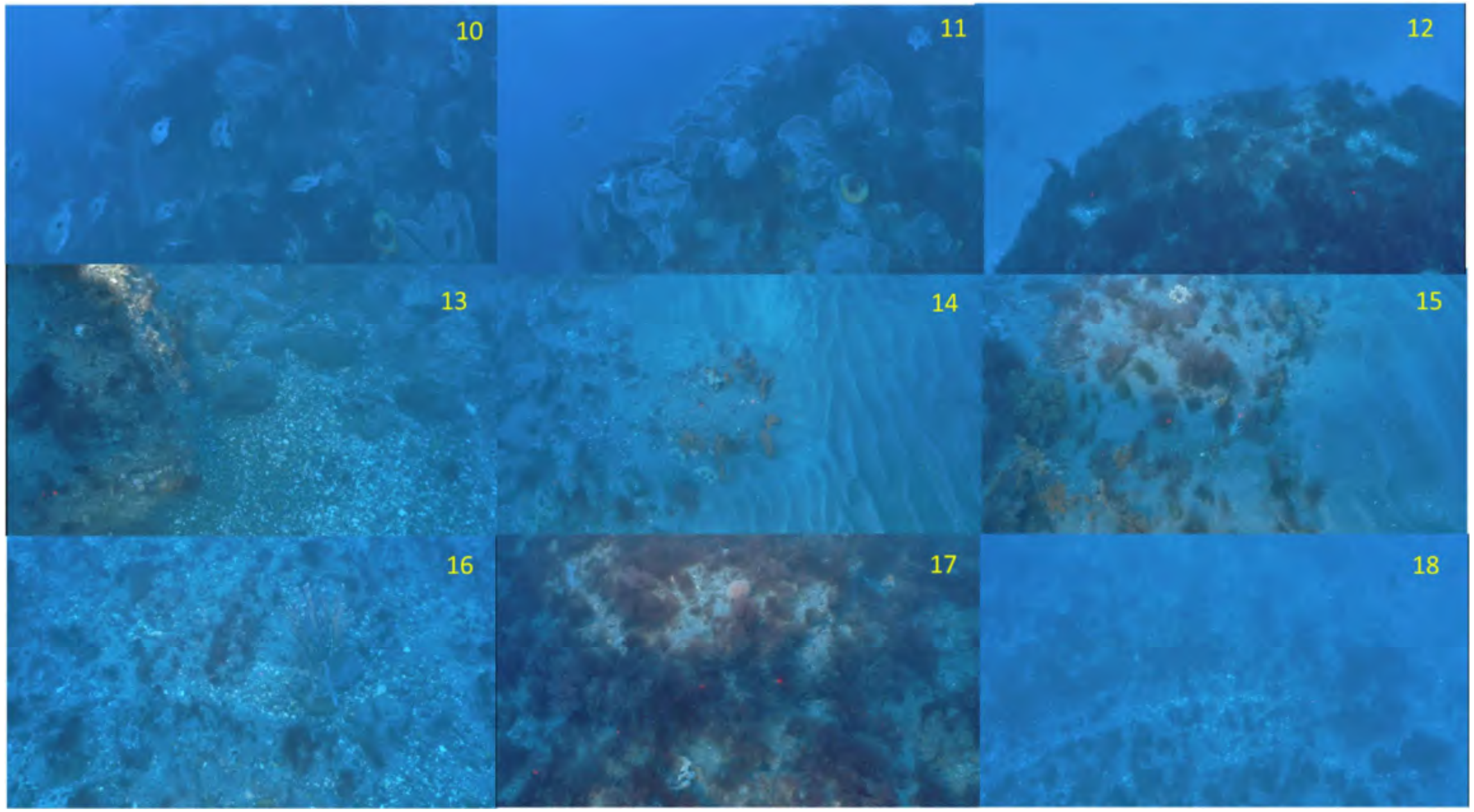

Figure 3-18: continued 10–11) butterfly perch sponges on the edges of the largest reef knoll); 12) drop-off of smaller rock knoll, 13) boulder patch (note the rock type may not be sandstone), 14–15) sand/reef boundaries, within the wider reef field; 16–18) reef field general views.

3.6.3 Site Papa

Depth range. 21.7–23.5 metres **Reef size**: Site mostly falls outside MBES mapped area

Form. Sparse patches of papa mudstone forming broken slabs/boulder piles and low basement outcrops, surrounded by flat sand plain. Some patches of flat grey tell partially covered by sand.

This unplanned site was added to cover a new reef and rock type (mudstone/Papa rock) discovered by local divers just prior to the survey. The site fell just north of one of the multibeam sonar lines, and has no underlying multibeam data, apart from the end where it extended into the mapped area. The looping nature of the transect was a result of trying to follow the reef features as they were encountered – which appeared to be very patchy and non-continuous.

This area was composed of an overall background of dark sand plain (1,6,7), with occasional low piles of broken boulders/slabs (4,5), low emerging basement terraces (3,8,9), occasional boulders (7), and tells (1) partially covered by sand. These reef features occurred both on their own, and in association with each other (2,3).

BTM Divisions (north–south along video transect): Most of the transect fell outside the BTM coverage. Towards the end of the transect where data were available, the pattern was: Broad depressions (sand) → Flat Ridge Top (flat basement rock) (Figure 3-19).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-19 to Figure **)**

Geology: Overall, this site was dominated by flat dark sand plain, within which sat scattered reef extents of broken boulders/slabs, low terrace, and occasional boulders. The rock type appeared to be papa mudstone, which was very bio-eroded (pitted surfaces with many tunnels/holes present). Low terraces (estimated 10–40 cm high) emerged at some spots, flanked by sands on either side (3,8), as well as standing clear as low outcrops (2,9). Piles of broken rock boulders were also seen (4,5), which are interpreted as low terraces breaking away under their own weight after being exposed by swell action over time (see site D for a much clearer example, where they form massive slabs). The occasional bare raw rock patches observed (1) were identical to those seen at site A, 12.5 kilometres to the north-west.

Biogenic habitats: The bare sand plain habitat was devoid of visually-obvious fish, epifauna, and epiflora. The papa rock was largely devoid of associated biogenic habitat-forming fauna and flora, aside from a few small patches of red filamentous algae and encrusting sponge/ascidian species (each contributing 0.01% cover) (Table 6). *E. radiata* and *Caulerpa* species were completely absent. The numerous burrows and holes evident in the rock suggest a richer reef infauna, probably including rock boring bivalves such as piddocks (Family Pholadidae), but the video resolution was not able to resolve any potential contributing species.

Main invertebrate species: The dominant taxa was the low encrusting sponge Family Chondropsidae species 2., which was present on some of the low terrace and boulder features (7,9) (Table 7, Figure). The few other sponge species occasionally present were also largely low encrusting/rock boring forms. The unidentified bright orange ascidian, and the low straggly ascidian *Didemnum* sp. indet., were also present in low numbers. Mobile marine invertebrates were rare, with four individual sea-slugs (*A*. *luctuosa*) and four gastropods seen (Table 7, Figure).

Main fish species: Blue cod were relatively common in association with the low reef features, with fish of all sizes present including some 0+ juveniles (Table 8, Figure). Scarlet wrasse were also present in low numbers (13 seen), along with a solitary goatfish.

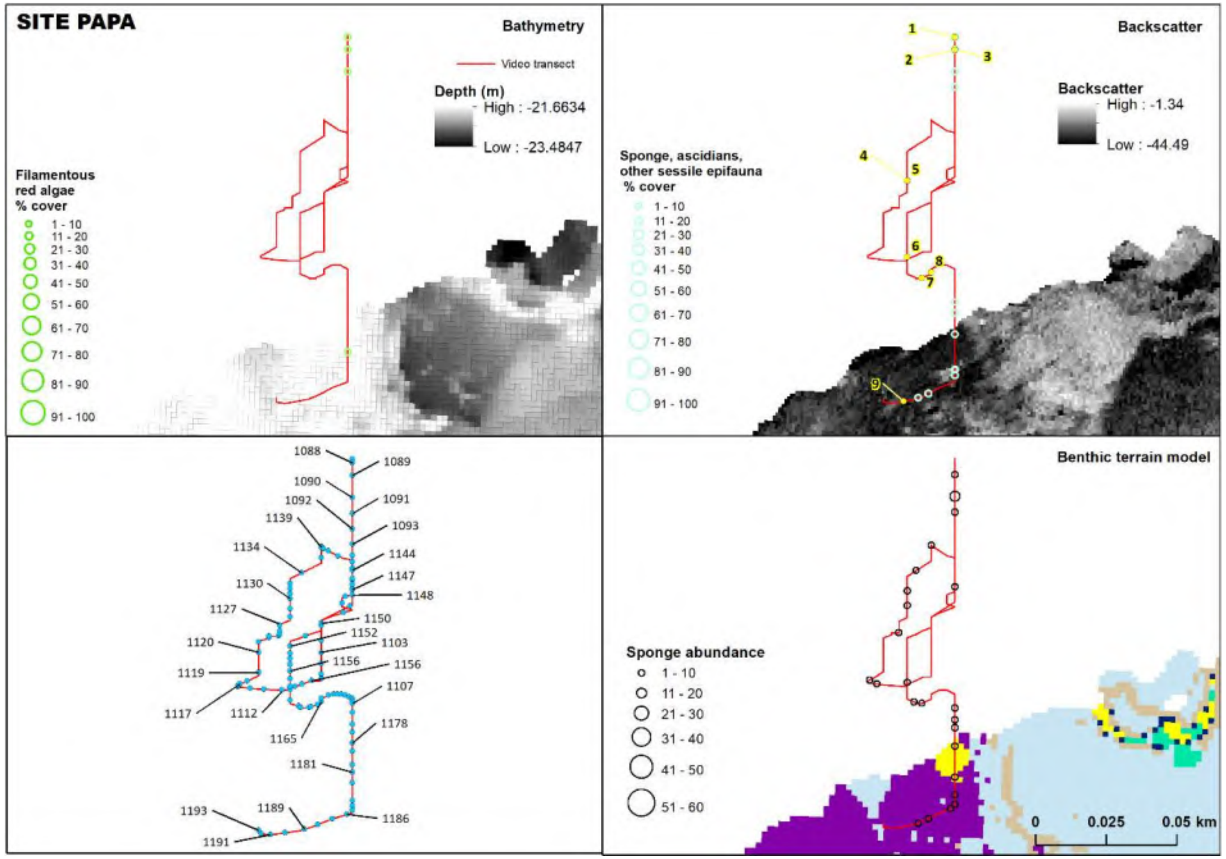

Figure 3-19: Maps of site Papa Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers (absent); top right) multibeam beam backscatter and 'Sponge, ascidians, other sessile epifauna' %covers (*C. flexilis* absent); lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

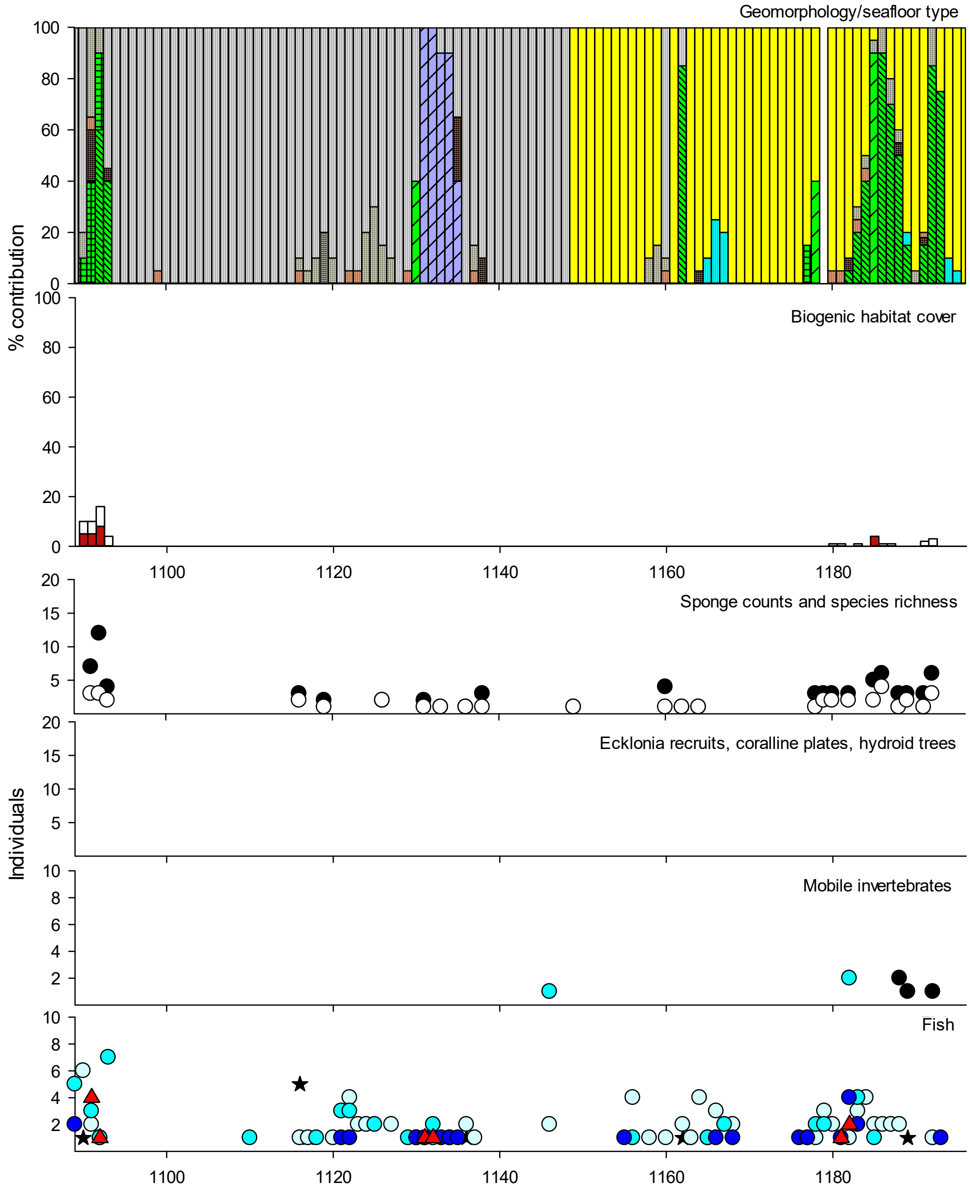

Figure 3-20: Site Papa CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish.Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-19.

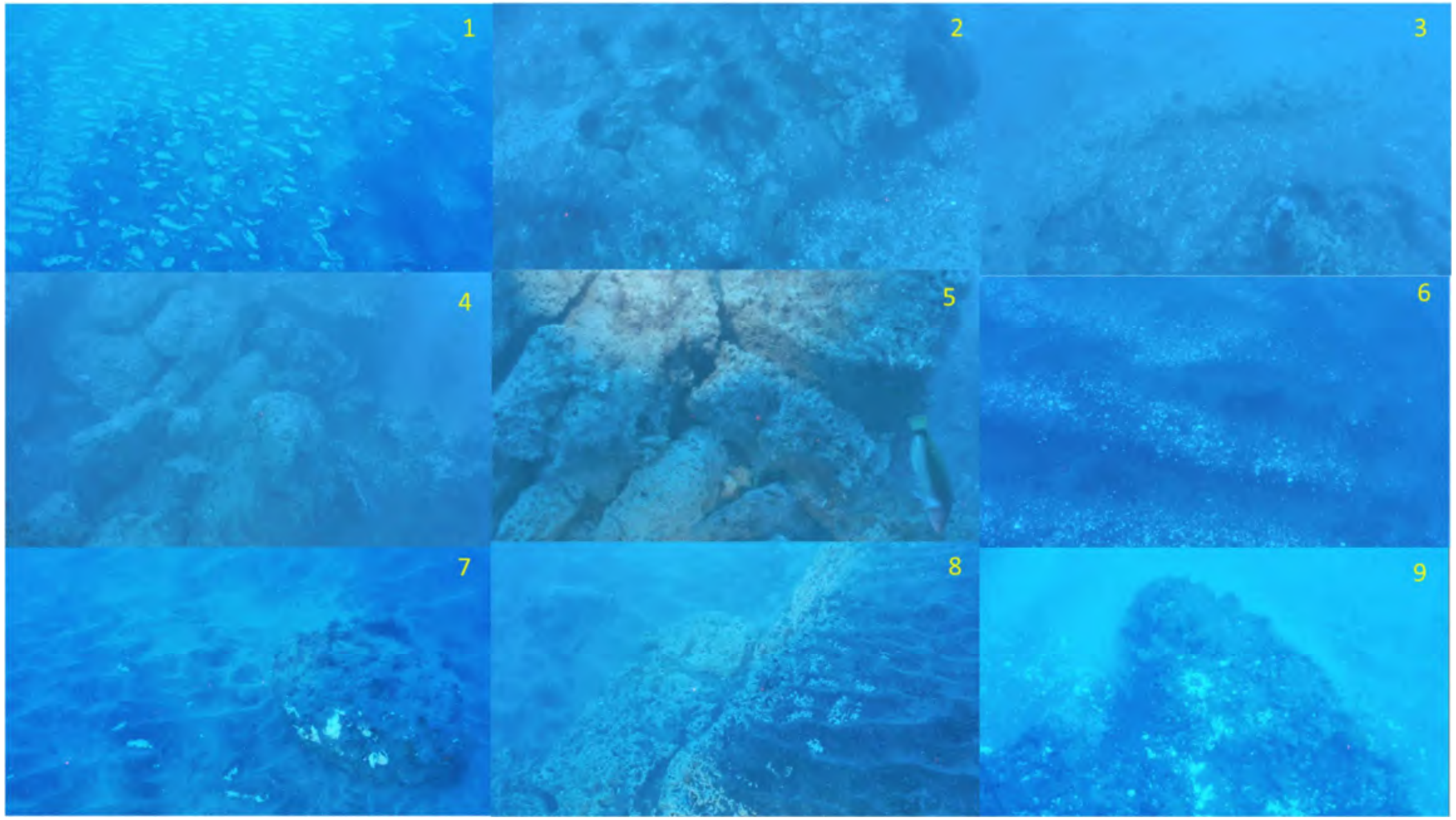

Figure 3-21: Site Papa seafloor images image numbers are plotted spatially in Figure 3-19 over multibeam sonar back scatter: 1) bare mudstone/Papa rock overlain with dark sands; 2) low outcrop; 3) low terrace (left) and boulder (right); 4–5) boulder piles with blue cod (4) and scarlet wrasse (5); 6) dark sand; 7) boulder with the ascidian *Didemnum* sp. Indet.; 8–9) low terraces (with an eagle ray in 8).

3.6.4 Site D

Depth range. 22.3–28 metres

Reef size: 399,750 m^2 within overall MBES polygon (excludes additional western structure/s)

Form. A long, largely continuous north-south reef terrace drop (scarp), running 3.45 km along its main axis (Figure). Includes several lesser terraces in some sections, a small eastern extension in the middle, and several incised 'bays' at its southern end. The main terrace wall ranged from 2 to 3 metres high, often with large broken sandstone slabs at the wall base. The terrace rock flats were narrow, and surrounded/overlain by soft sediments (sand, shell).

This area was composed of a rock type that looked soft, heavily bio-eroded, and which was visually identified as mudstone/Papa rock. It may be the same rock type as at Site Papa but appears to be less eroded. One possibility is that the rock has been exposed to the water column for a lesser time than site Papa.

BTM Divisions (north south along video transect): Set within a background of Flat Plains (sand, shell), the terrace drop was classified as Broad slopes for much of its length, along with components of Local Ridges, Boulders, Pinnacles on slopes, and Scarp/Cliff. The terrace proper was classed as Rock Outcrop Highs, Narrow Ridges, flanked by Flat Ridge Tops. In some sections, only the Flat Plains → Flat Ridge Tops transition was present. Some very limited areas of Broad Depressions occurred adjacent to the Broad Slopes component of the terrace wall (Figure , Figure 3-23).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-23 to Figure 3-25)

Geology: The video transect traversed both sides of the eastern reef extension mid-way down the overall terrace feature (Figure 3-23). Starting on a mixed sand and shell rippled seafloor (1), the reef first appeared as a series of low terraces surrounded by soft sediments (2,3) with low and wide stepped platforms apparent at some sections (4,5). Occasional fine scale structure was embedded in the rock, which might be indicative of fossils/or some past differential erosion process (5). The rock surfaces appeared quite bio-eroded and 'knobbled' in general. The terrace drop itself was first encountered as an undercut low wall (8) at the very narrow end of the eastern terrace extension. The transect then passed over a narrow (at this location) terrace top, then fell away to soft sediment again less than 10 metres on (9). The transect then followed along the terrace edge, revealing a vertical wall drop, flanked by large broken rock slabs (9–12). A number of these slabs appeared to be recently exposed, with smooth clear surfaces (10–12); as opposed to others that were pitted with bio-erosion and supported sponges (10–11). We suggest that this represents an actively eroding wall feature, where the wall is slowly undercut by swell and soft sediment erosion, and the low strength mudstone then collapses to form large heavy slabs. The overall terrace feature could be slowly eroding over time.

Further low terrace/step platforms re-appeared (13,14) later in the transect, as well as very occasional small patches of 'assembled' cobbles (15), possibly sourced from elsewhere through storm transport. The transect then moved onto bare dark sands (16) and shell gravel seafloor, with occasional very limited tells of darker rock. At the very end of the transect, the main terrace wall was again encountered (18).

Biogenic habitats: The bare sand/shell plain habitat was devoid of visually-obvious fish and invertebrate species, and this absence was consistent each time the transect crossed into bare sand habitat (Figure 3-23, Figure). The exception to this was the presence of small patches of green-lipped mussels (*Perna canaliculus*) (17), associated with some of the rock tells (<1 m^2 in size) seen in the second half of the transect, away from the terraces. These were very difficult to visually quantify from video, and so were not scored as biogenic habitat. However, these mussel beds were observed with close inspection of screen-grabs taken from video. Several small patches were also seen on the terrace reef itself (lower left, image 6, 'invisible' at the image scale shown), although the video resolution allowed for a putative species assignment only.

The terrace itself held a variable, low cover assemblage of sponges and other sessile species, most with low or rock-boring morphologies and covered 2.2% of the reef area (Tables 6, 7). Attached *E. radiata* was absent but a few drift plants were observed around the sandstone slabs. A few green/brown shrubby algae were seen (Figure 3-23) suggesting light levels were sufficient for macroalgal growth. The numerous burrows and holes evident in the rock suggested a possibly richer reef infauna, but the video resolution was not able to resolve any potential contributing species.

Main invertebrate species: The dominant taxa was the low encrusting sponge Family Chondropsidae species 2, followed by a yellow, rock-boring unidentified sponge species (order Haplosclerida/Poecilosclerida), the yellow foamy low sponge *D. oxeata*, the bright yellow *C. polymastia*, and the orange/grey multi-stalked sponge *R. topsenti*/*Axinella* sp. indet. (Table 7). The low straggly/broken-form ascidian *Didemnum* sp. indet. was also frequently observed (uncommon at other reef sites). Sponge and ascidians covered 2.23% of the (rock-associated) 20-second video segments. Mobile marine invertebrates were uncommon, except for the sea slug *A. luctuosa*, with 19 individuals counted, often in association with the sponge Family Chondropsidae species 2., on which they graze, and lay egg masses (there is a sea-slug cluster in the upper left of image 6). Four Cooks Turban (*C. sulcata*) and two other gastropods were also seen (one of which may have been a *Maurea* sp., also associated with a sponge) (Table 7). Kina were not observed.

Main fish species: Fish life was concentrated along the terrace wall and over and around the large sandstone slabs (Figure). Blue cod were relatively common around the reef features, with all size/age classes present, including 0+ juveniles (18% of the 218 individuals counted, Table 8). Leatherjackets (including juveniles), scarlet wrasse and butterfly perch were also present. Tarakihi were also seen, including the two smallest individuals seen across the survey (10–20 cm length). One common roughy (*Paratrachichthys trailli*) was counted. This is a nocturnally foraging zooplanktivore species and more fish may have been sheltering under the terrace wall and sandstone slabs (and possibility also other species such as slender roughy, which have been observed at the Project Reef (site K)).

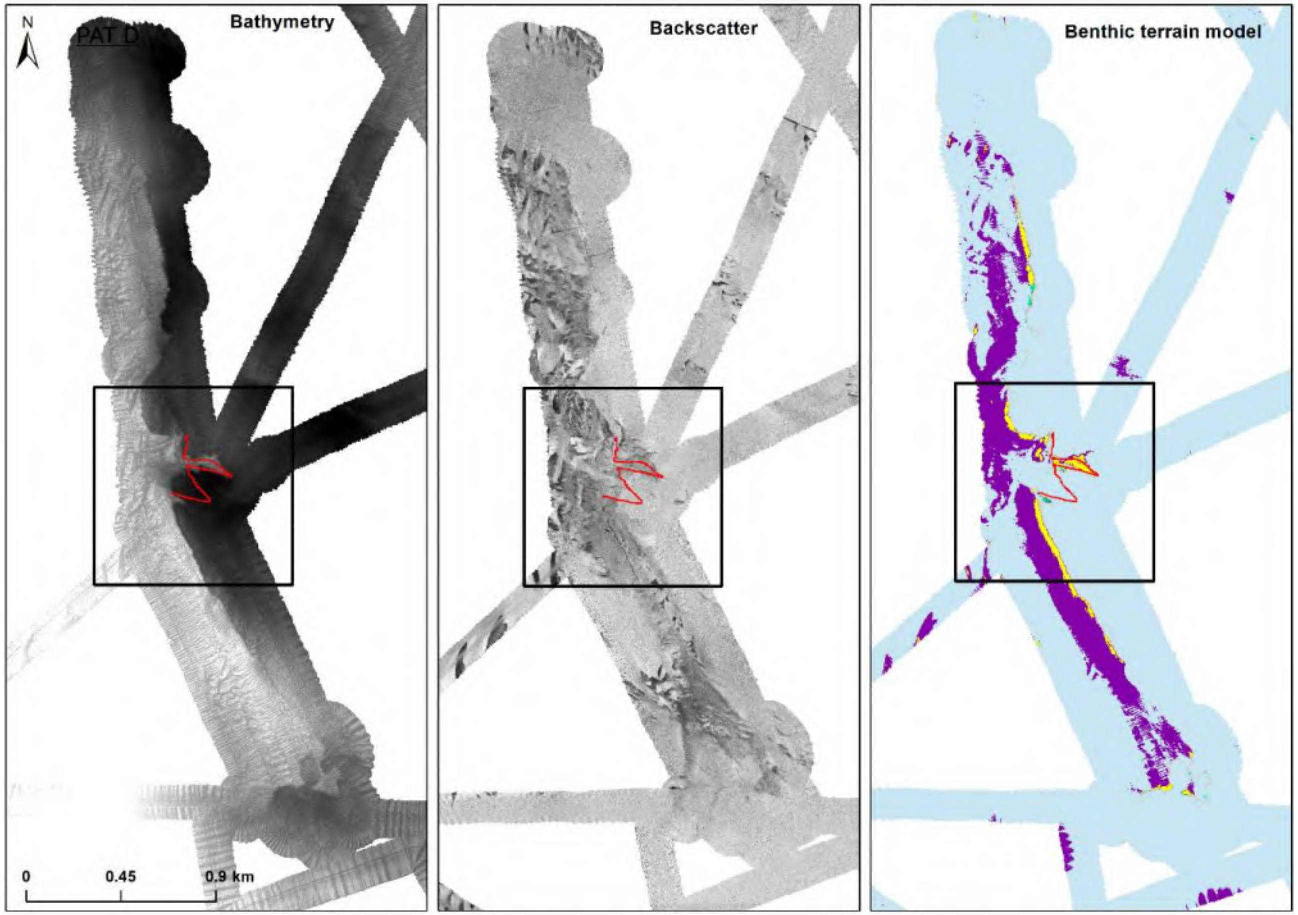

Figure 3-22: Broader extent maps of larger seafloor area mapped (a 3.5 km long terrace) around site D.

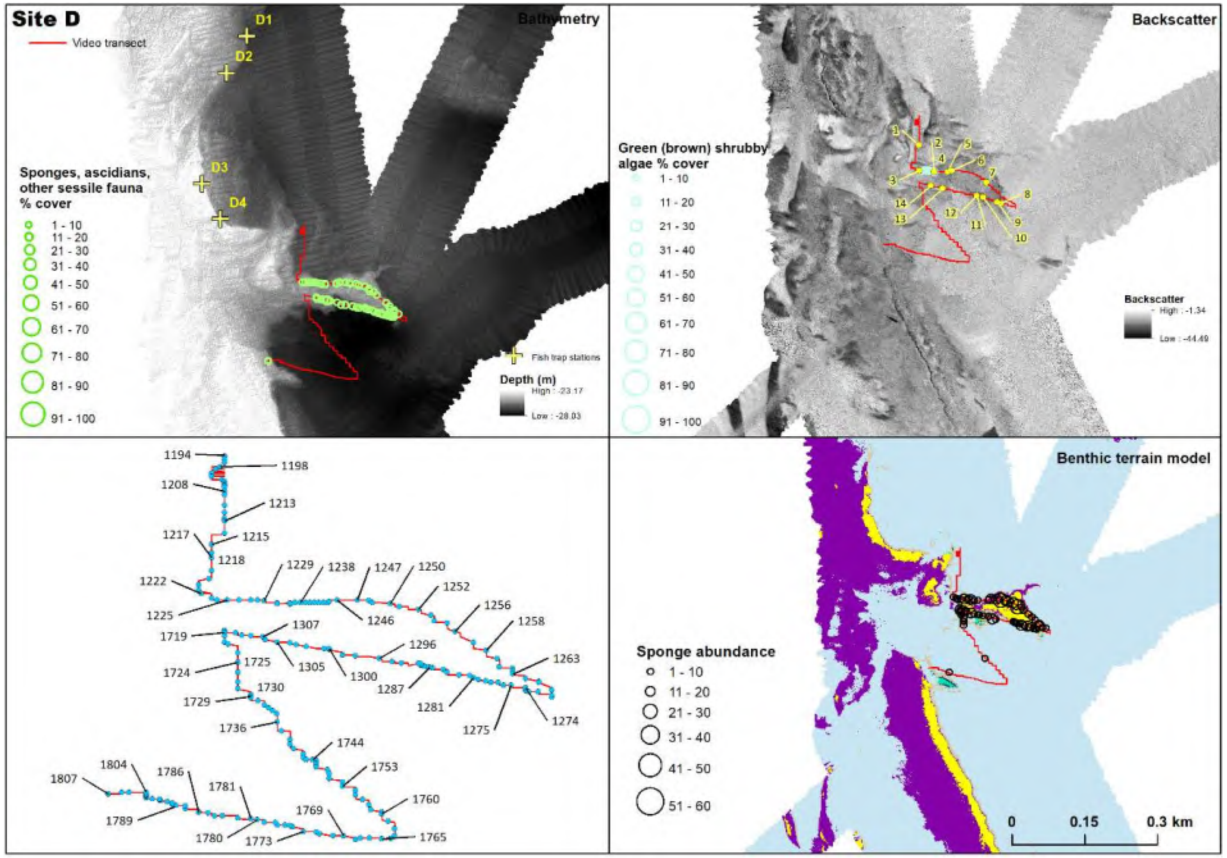

Figure 3-23: Maps of site D Top left) multibeam sonar bathymetry and sponge %cover (*E. radiata* kelp completely absent); top right) multibeam beam backscatter and brown shrubby algae cover (*C. flexilis* completely absent) %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

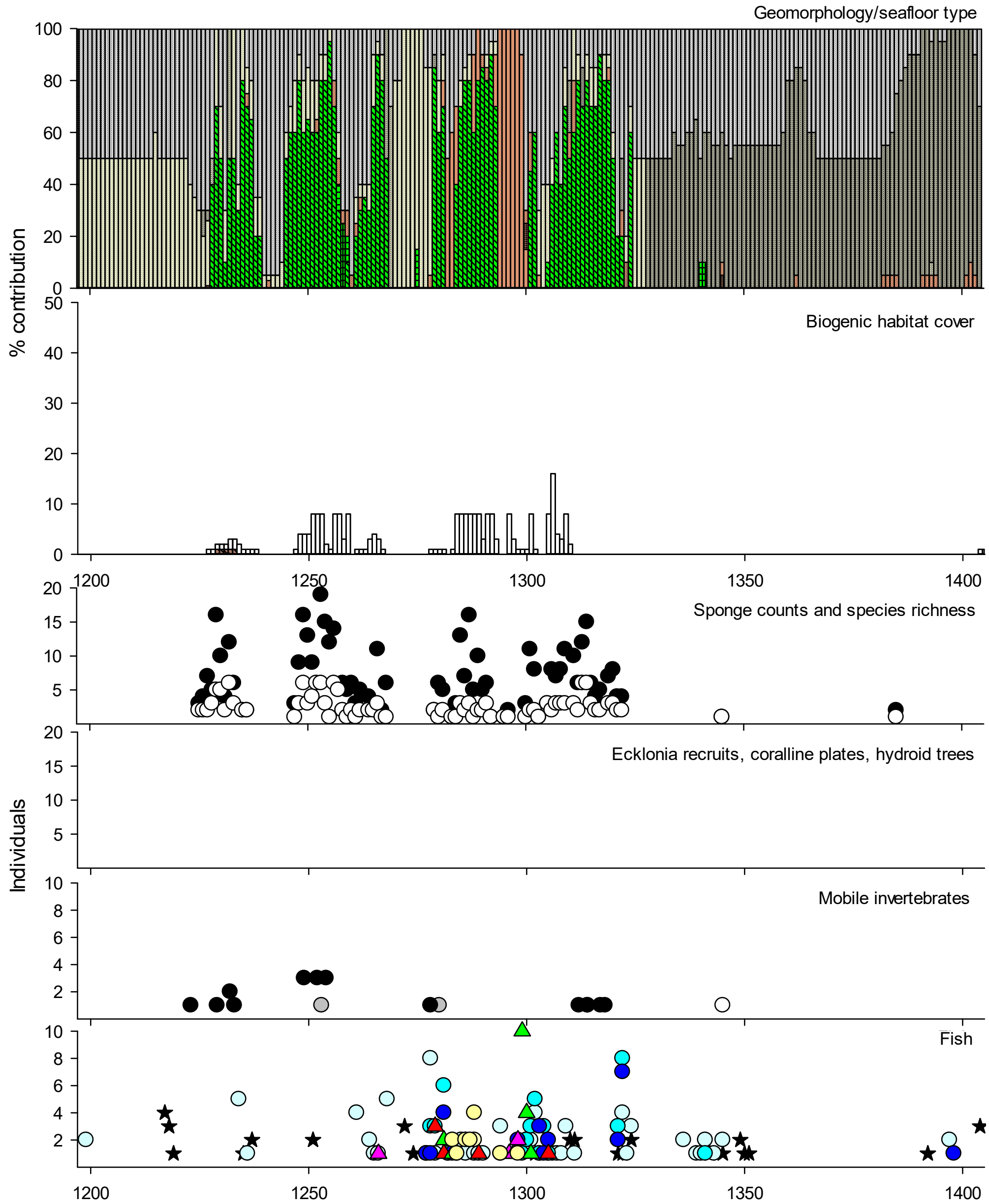

Figure 3-24: Site D CoastCam data: geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-23.

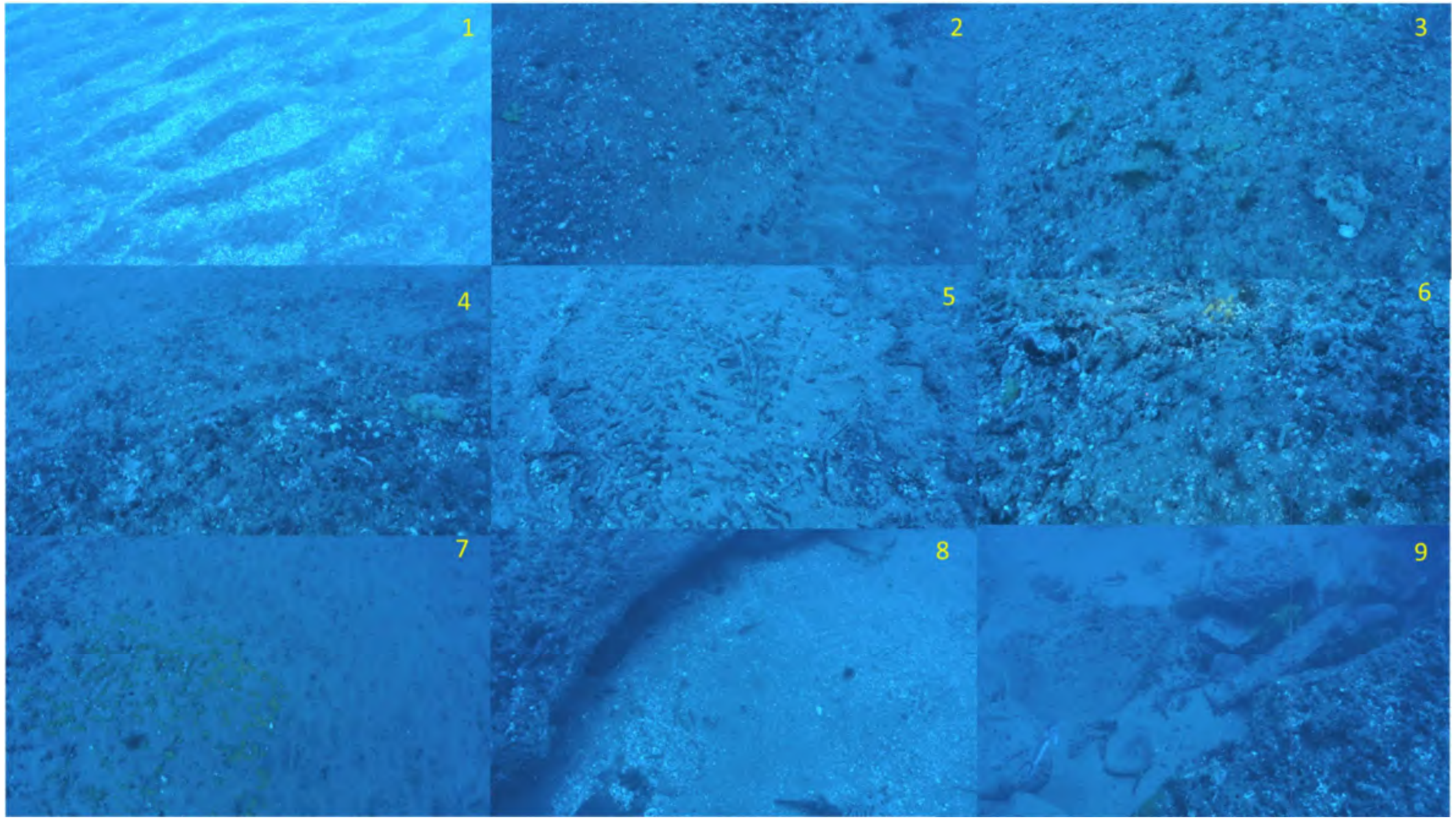

Figure 3-25: Site D seafloor images image numbers are plotted spatially in Figure 3-23 over multibeam sonar back scatter: 1) bare sediments; 2–3) low flat terrace; 4) multiple low stepped terraces dropping away from the camera; 5) terrace rock with embedded linear stick-like features (slightly embossed); 6) terrace rock; 7) terrace rock overlain with sediment; 8) low terrace drop at end of eastern extension; 9) looking down from the terrace onto large rock slabs adjacent to main terrace drop, and blue cod.

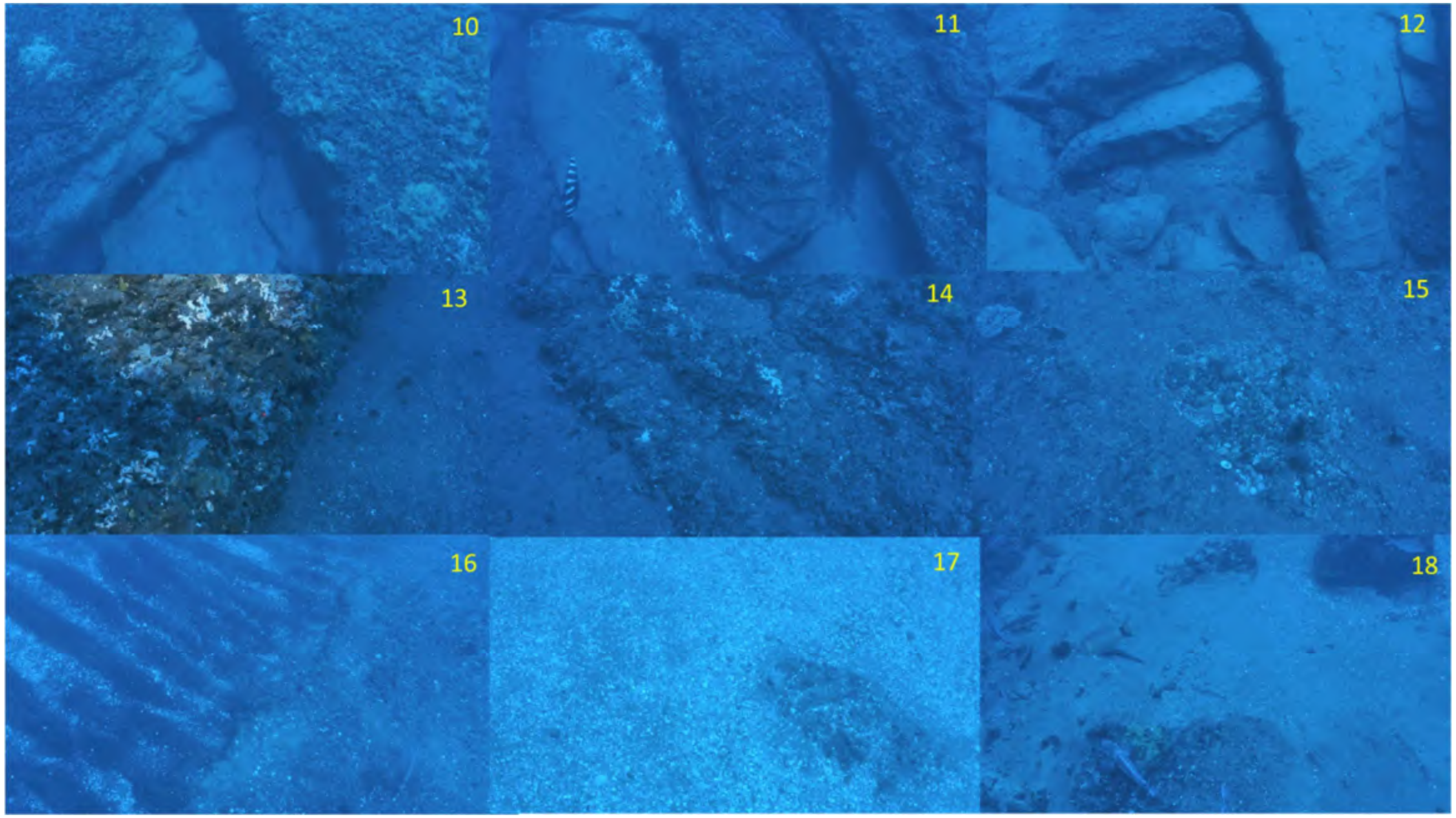

Figure 3-25: Continued 10–12) large rock slabs adjacent to terrace scarp (right side of image for 10–11; just off right of image for 12), and red moki (11); 13–14) higher cover epifauna areas on rock terrace/s; 15) cobble pocket; 16) dark sand; 17) small rock tell with attached, green-lipped mussel patches; 18) end of transect just adjacent to main terrace (just out of shot to left) with blue cod, scarlet wrasse, and tarakihi.

3.6.5 Site J

Depth range. 18.4–24.1 metres **Reef size**: 38,990 m^2

Form. Low broken ridge composed of low broken rock and irregular mixed cobbles. Part of much larger ridge reef complex that extends for 2.3 km (possibly even 4.6 km) (Figure).

This site crossed a small, low broken ridge feature, that extended for around 500 metres in a north-west/south-east orientation. It is part of a larger ridge feature, with a horizontal shear displacement of 80 metres between Site J and an adjacent larger ridge area to the north-west, strongly suggesting a geological fault. The two areas combined created a low ridge that is about 2.3 km long. Further exposed ridges occurred in the same orientation to the north-west; these may be separate ridge features, or part of the same overall feature (overall distance of 4.6 km) (Figure , Figure 3-27).

BTM Divisions (west to east along video transect): Flat Ridge Tops (sand) → Flat Plains → Broad slopes (1 pixel wide) → Rock Outcrop Highs, Narrow Ridges → Flat Ridge Tops → Broad slopes (1 pixel) → Flat Plains (Figure 3-27).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-27 to Figure 3-29)

Geology. The reef was composed of a rock type that appeared hard but amenable to erosion (3,4), that was assumed to be the same sandstone as site A. Other rock types may also be present (8). The ridge feature itself was narrow and broken, with a limited low broken rock contribution, overlain/dominated by a cover of irregular mixed cobbles (2–5) (Table 4, Figure 3-27). To the west, the broken rock was replaced by a mosaic of dark sand and irregular mixed cobbles dominated (6–8), with occasional low patch reef (9) and tells (not mudstone/Papa rock). Some flat basement reef was present at the end of the transect. To the east, the reef ridge was replaced by dark sand seafloor (1)

Biogenic habitats: On the east side of the ridge feature (<#1841), the bare sand/shell plain habitat was visually devoid of fish, epifauna, and epiflora. At the sand/reef ridge boundary, there was a narrow zone (about 9 m width) of relatively high cover (15.5%) of sponges, ascidians, and other sessile species (segment #1841, part of segment #1842). On the rest of the reef, this biogenic habitat class covered just 0.79% (Table 6, Figure) and was replaced with a mixed biogenic habitat of green (brown) shrubby macroalgae, green filamentous algae, and *C. geminata* patches (respectively 2.58, 2.92, and 0.11% cover). This biogenic habitat mix was associated with the ridge proper (~15% local cover) and was replaced with green filamentous algae cover once the ridge ended (#1851) and the substrate changed to a mixture of irregular cobbles and dark sand seafloor. This three-class biogenic habitat mix appeared again (in lesser cover) to the west, where low patch reef and irregular cobbles dominated. Yellow blade algae (0.20% cover) and filamentous red algae (0.05% cover) were also occasionally present.

E. radiata (kelp) occurred only as intermittent single plants (0.02% cover) and was limited to two 20-second video segments just west of the ridge proper (Figure 3-27).

Main invertebrate species: Sponges were the most common sessile invertebrates, dominated by Family Chondropsidae species 2, *C. incrustans, A. globosa, S. conulosa,* and *R. topsenti/Axinella* sp. indet. Ascidians were uncommon, with nine unidentified bright orange ascidians counted (Table 7). Mobile invertebrates were largely absent, with just two cushion stars observed. No kina were seen.

Main fish species: Blue cod and butterfly perch were both present, with 10 to 20 individuals recorded (Table 8), with the butterfly perch as an aggregation on the top of the reef ridge (Figure). A few leatherjacket, scarlet wrasse and a spotty were the only other fish counted.

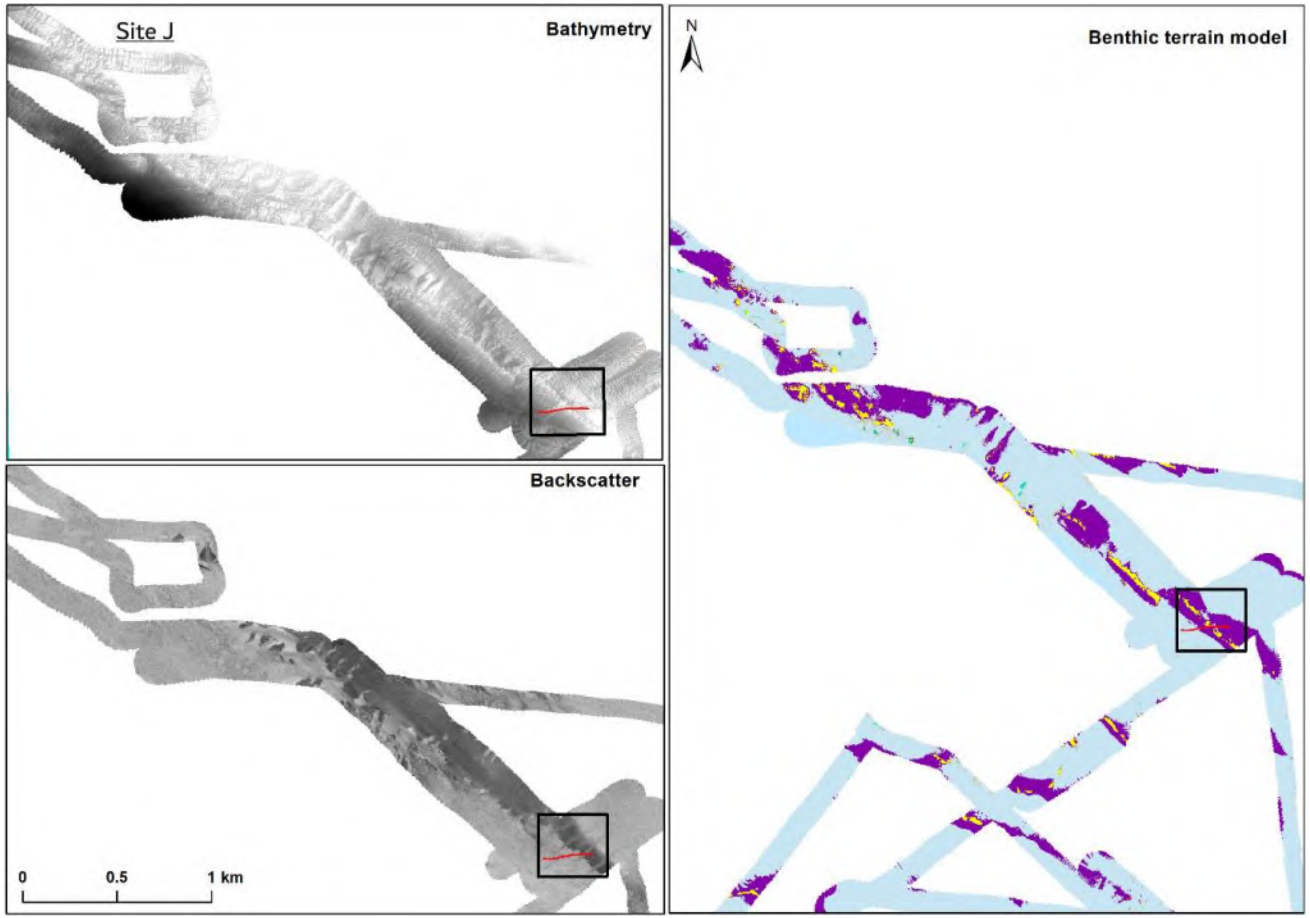

Figure 3-26: Broader extent maps of larger seafloor area mapped (a series of reef ridges) around site J.

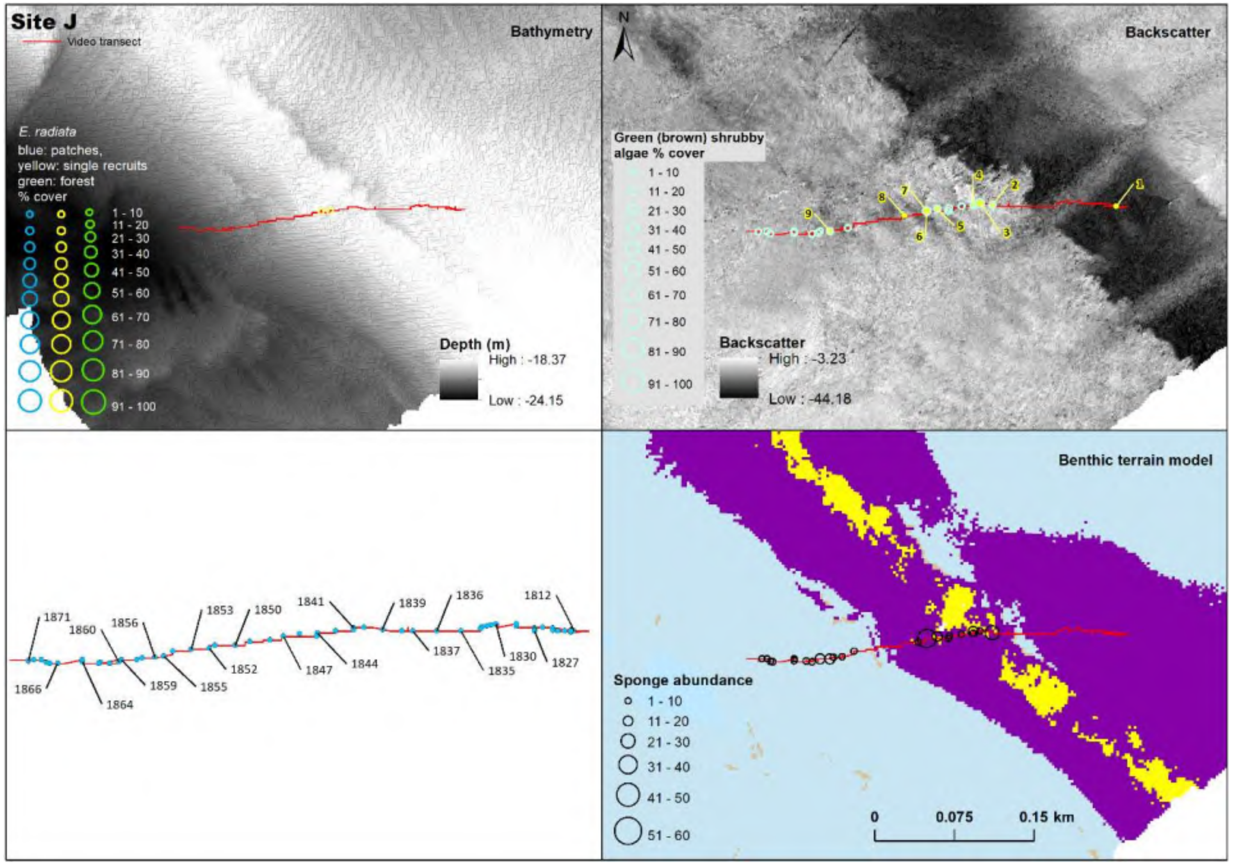

Figure 3-27: Maps of site J. Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers); top right) multibeam beam backscatter and green (brown) shrubby algae %cover (*C. flexilis* was absent); lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

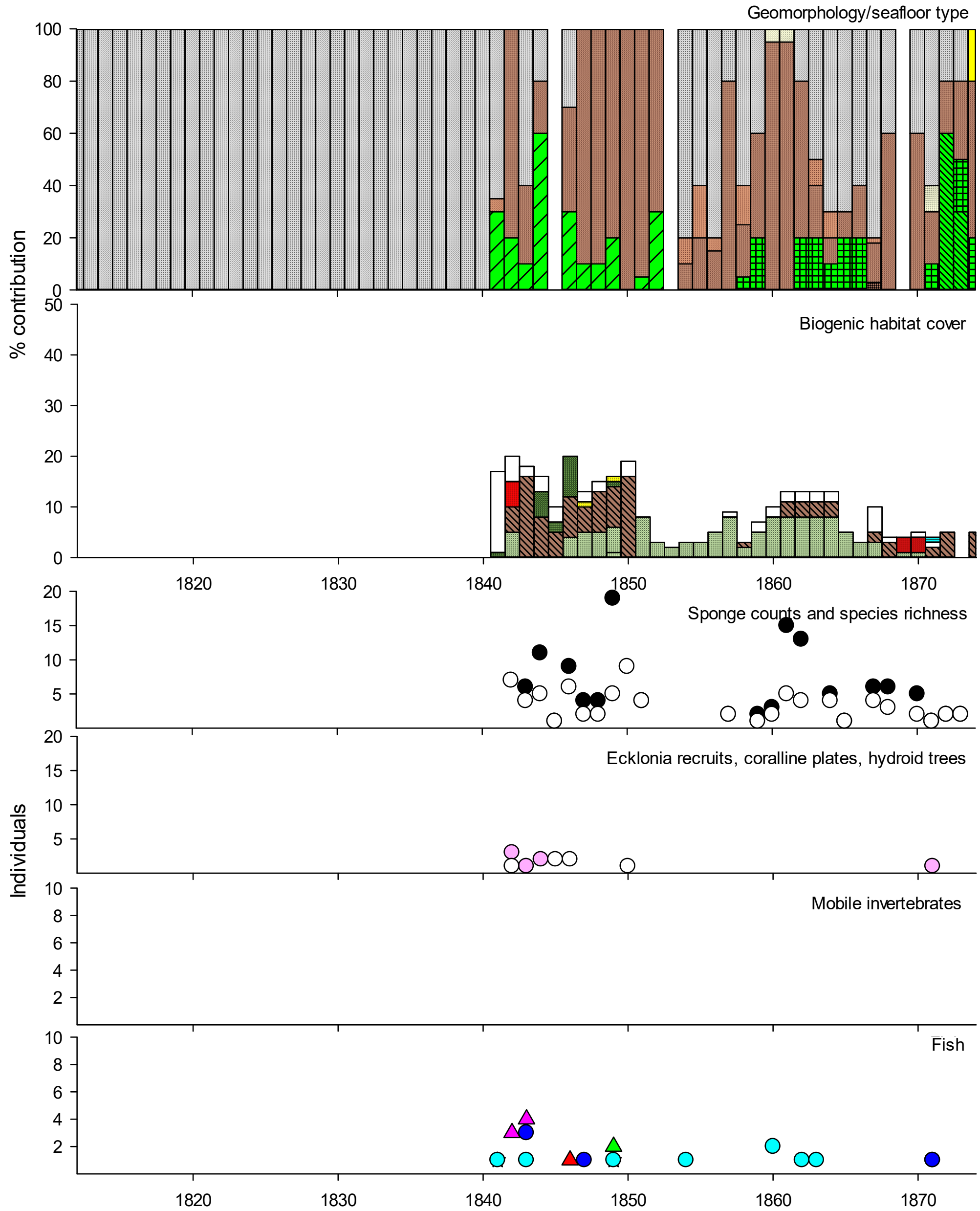

Figure 3-28: Site J CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-27.

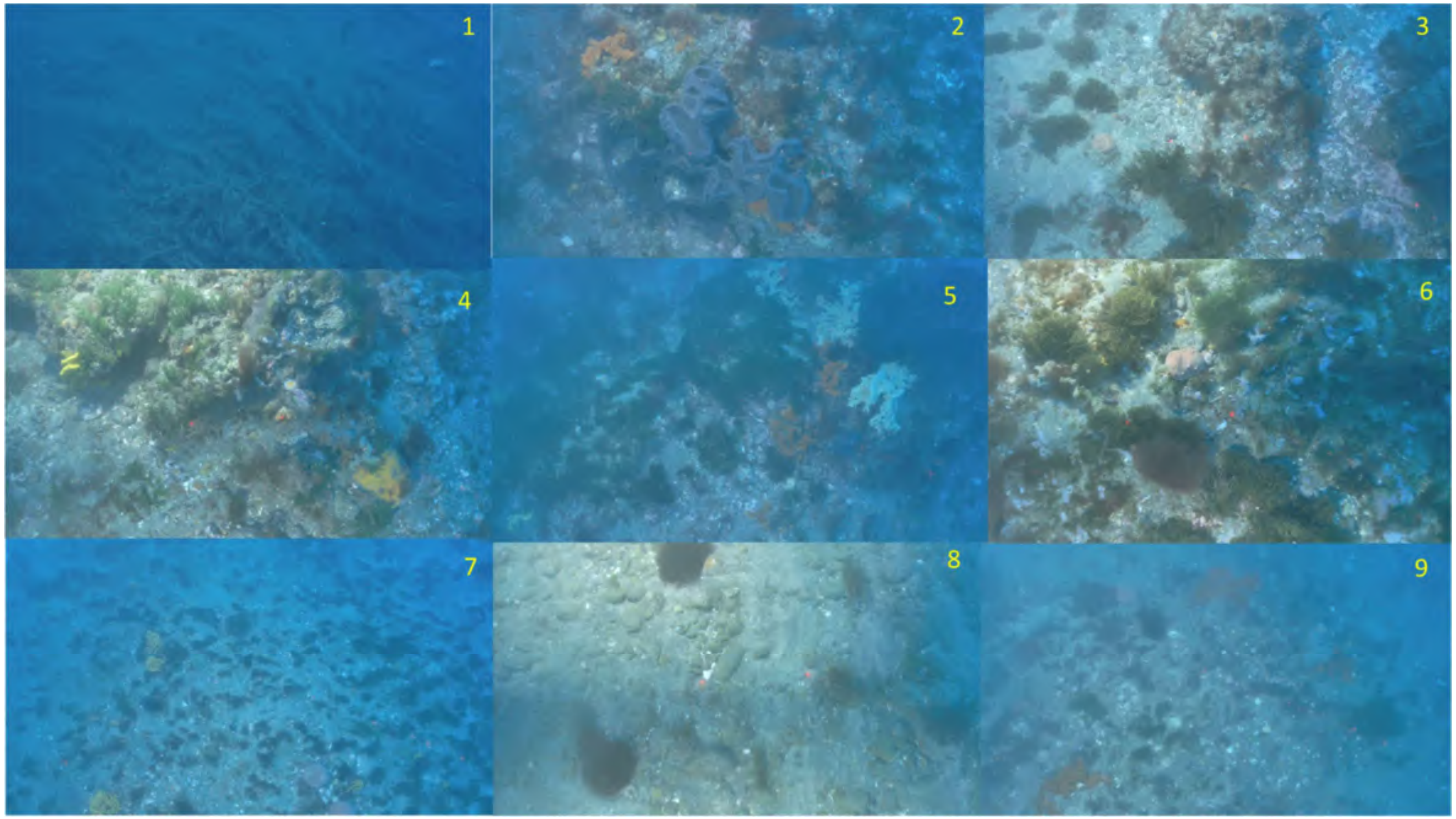

Figure 3-29: Site J seafloor images image numbers are plotted spatially in Figure 3-27 over multibeam sonar back scatter: 1) dark sand; 2) start of low ridge with higher sponge cover including grey *E. alata*; 3–5) low ridge seafloor; 7–9) mixed substrate seafloor to the west of the ridge feature.

3.6.6 Site K (Project Reef)

Depth range. 19.9–22.6 metres **Reef size**: 2,933 m^2

Form. Low mixed reef stack composed of low terrace rock, irregular mixed cobbles, and coarser soft sediments.

This is the Project Reef, monitored and observed by the citizen science Project Reef team since 2015. Numerous project dives have shown the raised terrace components (0.7–1.5 metres high) to be made of a hard fossil-abundant rock type, along with mixed irregular cobble patches, and various mixtures of whole shell, broken shell, and coarser soft sediment types. It sits within a much larger reef complex of long narrow ridges up to 1.9 km long but does not appear well aligned with those either in aspect or morphology (Figure). The Project Reef stands out quite clearly as a discrete bathymetric feature.

BTM Divisions (multiple east-west passes with video transect): Flat Plains → Broad slopes (1-3 pixels wide) → Rock Outcrop Highs, Narrow Ridges (the reef itself) → Broad slopes (1-3 pixels wide) → Flat Plains. Some reef edge pixels classed as Flat Ridge Tops / Steep Slopes / Local Ridges, Boulders, Pinnacles on Slopes (Figure 3-31).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-31 to Figure 3-33)

Geology. The reef terrace is known to be composed of a hard, fossil-rich rock (Figure), that forms the terrace features (8,10,16). The towed video transect passed over the reef itself seven times in an east-west orientation, with a nominal 9 metre transect spacing (Figure 3-31). Rough sea surface conditions at the time of sampling made the actual spacing more variable. The reef feature was classed as a mixture of low and high patch reef, and low broken rock (5–7,9,11–12, 14–15, 17–18), along with mixed irregular cobbles (2,4), which also extended beyond the reef. Various coarser grained soft sediment classes with variable shell contributions were also present around the reef (1,3,4,13), as well as sand.

Biogenic habitats: The reef held a mix of biogenic habitat classes, with the most common being *E. radiata* (4.7% cover), composed of single plants (5, 6, 11), patches (15,17), and one small 'forest' on the south-east edge of the reef. Sponge, ascidian, and other sessile fauna contributed 2.55% cover (6,9,12,18), along with filamentous red algae (1.3%) and green (brown) shrubby algae (11,18) (1.2%)(Table 6). *E. radiata* kelp cover was generally associated with high patch reef geomorphology, where it spanned several video segments at a time. Higher sponge and other sessile fauna cover also aligned with this reef type, but not where *E. radiata* dominated (this was not an artefact of kelp canopy obscurement). Filamentous red and green algae were patchily distributed, while green (brown) shrubby algae occurred in patches on the northern half of the reef, as well as off-reef to the east, where further rock habitat was present.

Main invertebrate species: Sponges were the most common sessile invertebrates, dominated by Family Chondropsidae species 2, *C. incrustans*, *S. conulosa*, and *A. globosa* (Table 7). Mobile marine invertebrates were uncommon, with kina the most often observed species (30 individuals), followed by Cooks Turban gastropods (9) (Table 7, Figure). The Project Reef benthic assemblage photo quadrats (2017) found a similar sponge species assemblage and dominance order (noting that finer-scale Project Reef work was done using point-based grid scoring of still camera imagery)(Table 11).

Main fish species: Blue cod were the dominant species, with 115 records, of which 21 were 0+ juveniles (Table 8, Figure) found on the reef edges (irregular cobbles). All size classes were relatively common. Butterfly perch were the second most observed species (88 individuals), followed by scarlet wrasse and leatherjackets. Five other species were seen as singletons only; tarakihi, goatfish, butterfish, and a magpie perch. The butterfish was the only one seen during the CoastCam survey, while the magpie perch was one of a resident pair often seen by Project Reef divers (the pair seen together on the second downward facing CoastCam camera).

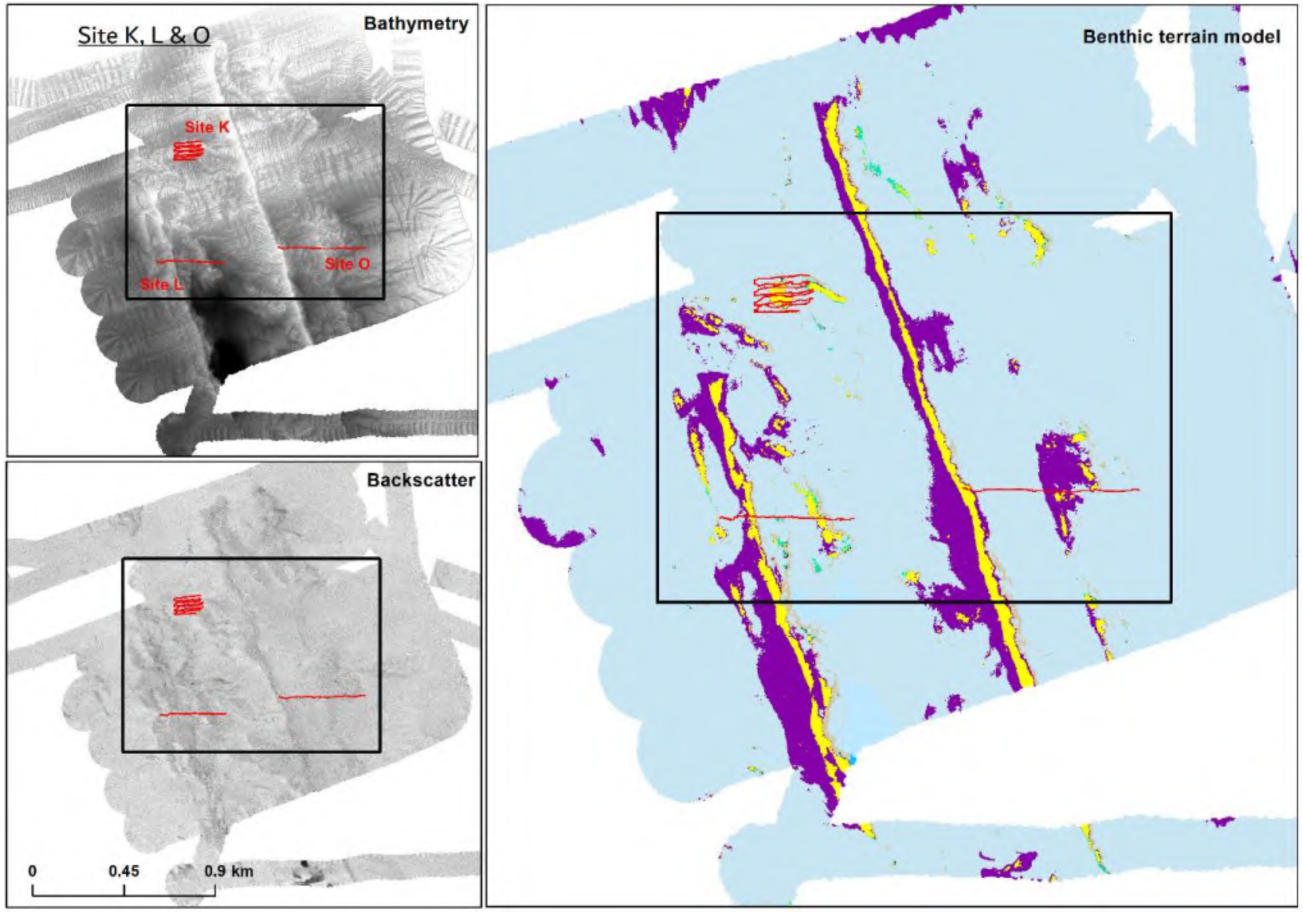

Figure 3-30: Broader extent maps of larger seafloor area mapped (a series of reef ridges) around sites K, L, and O.

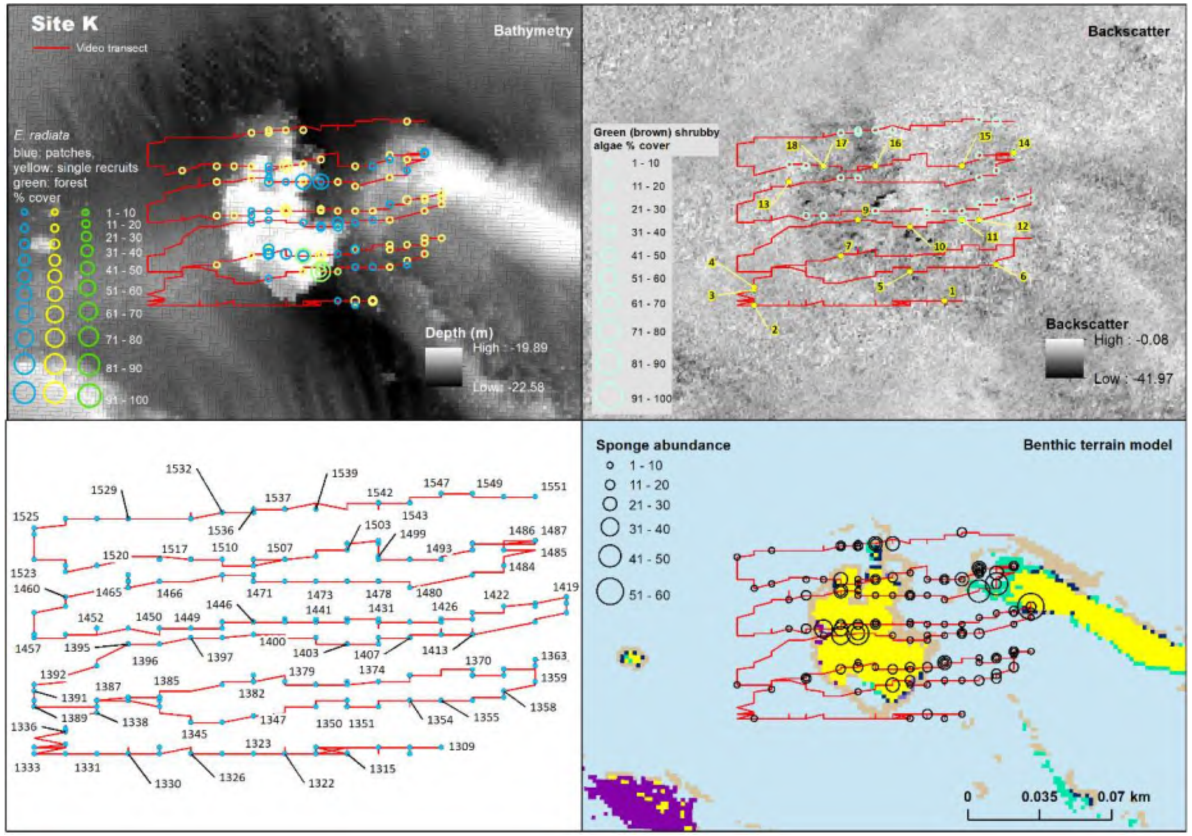

Figure 3-31: Maps of site K Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and green (brown) shrubby algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment). Image 10 marks the position of the Project Reef in-situ camera block. Images 5, 7–10, 16, 17, and 18 fall on the Project Reef; the other images are off-reef.

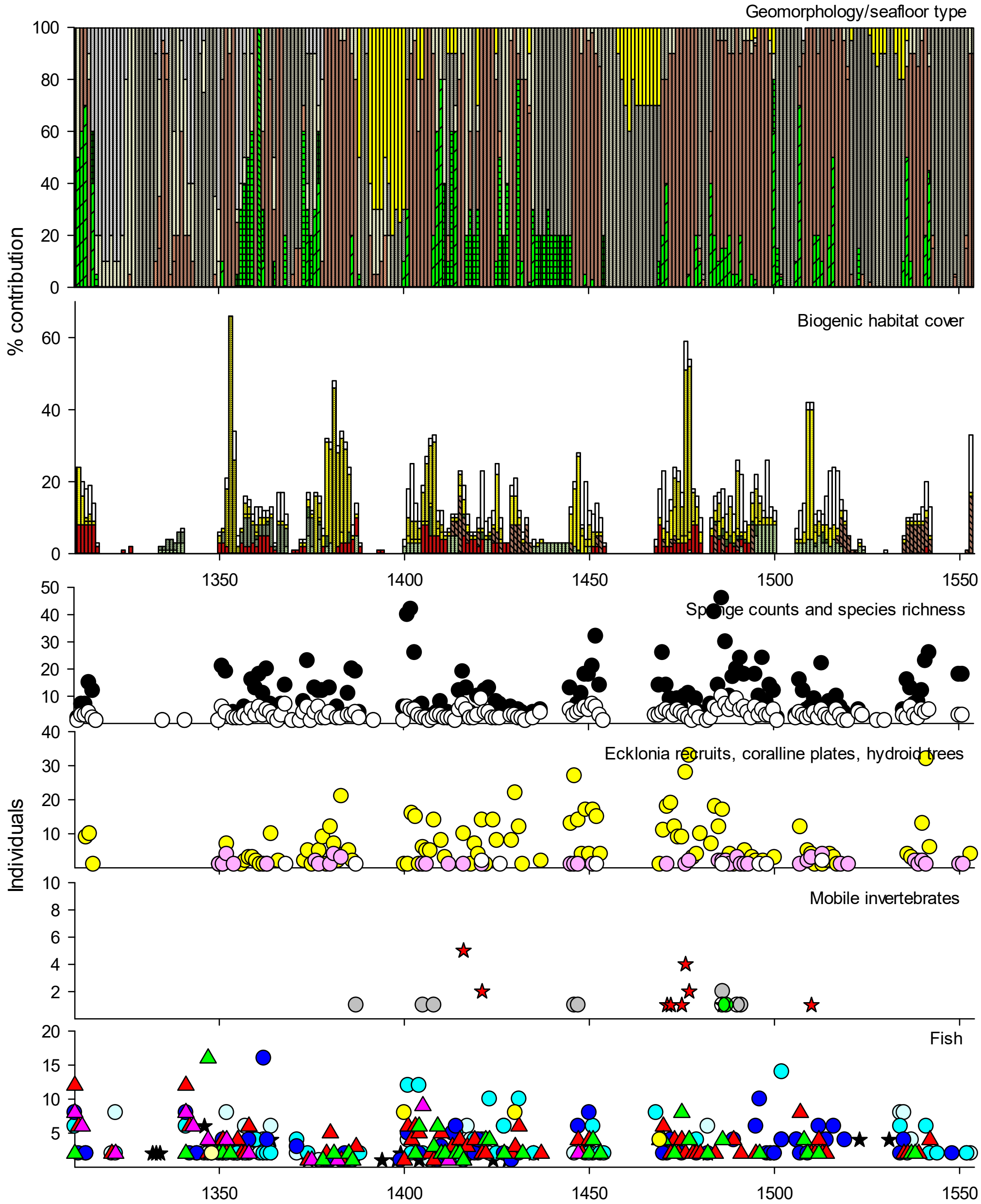

Figure 3-32: Site K CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-31.

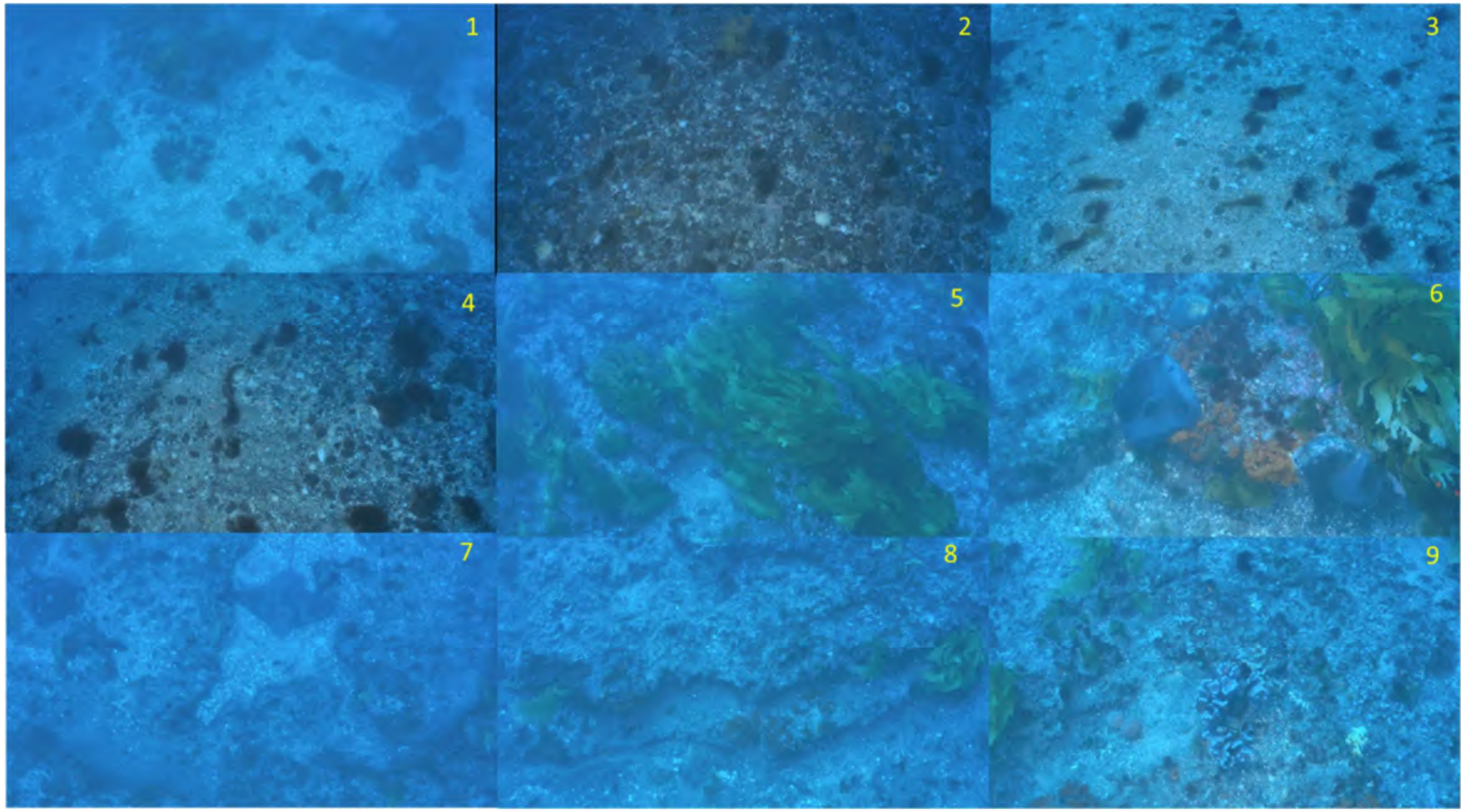

Figure 3-33: Site K seafloor images image numbers are plotted spatially in Figure 3-31 over multibeam sonar back scatter: 1–4) mixed soft sediment and small stones seafloor substrates off-reef; 5) *Ecklonia* patch on reef; 6) low small rock outcrop east of the reef, with a sponge cluster; 7) reef edge with resting eagle ray; 8) reef edge, with *Ecklonia* individuals and patch; 9) reef with the uncommon 'broken flange sponge' *Desmacidon mammilatum* (nine seen across the overall survey).

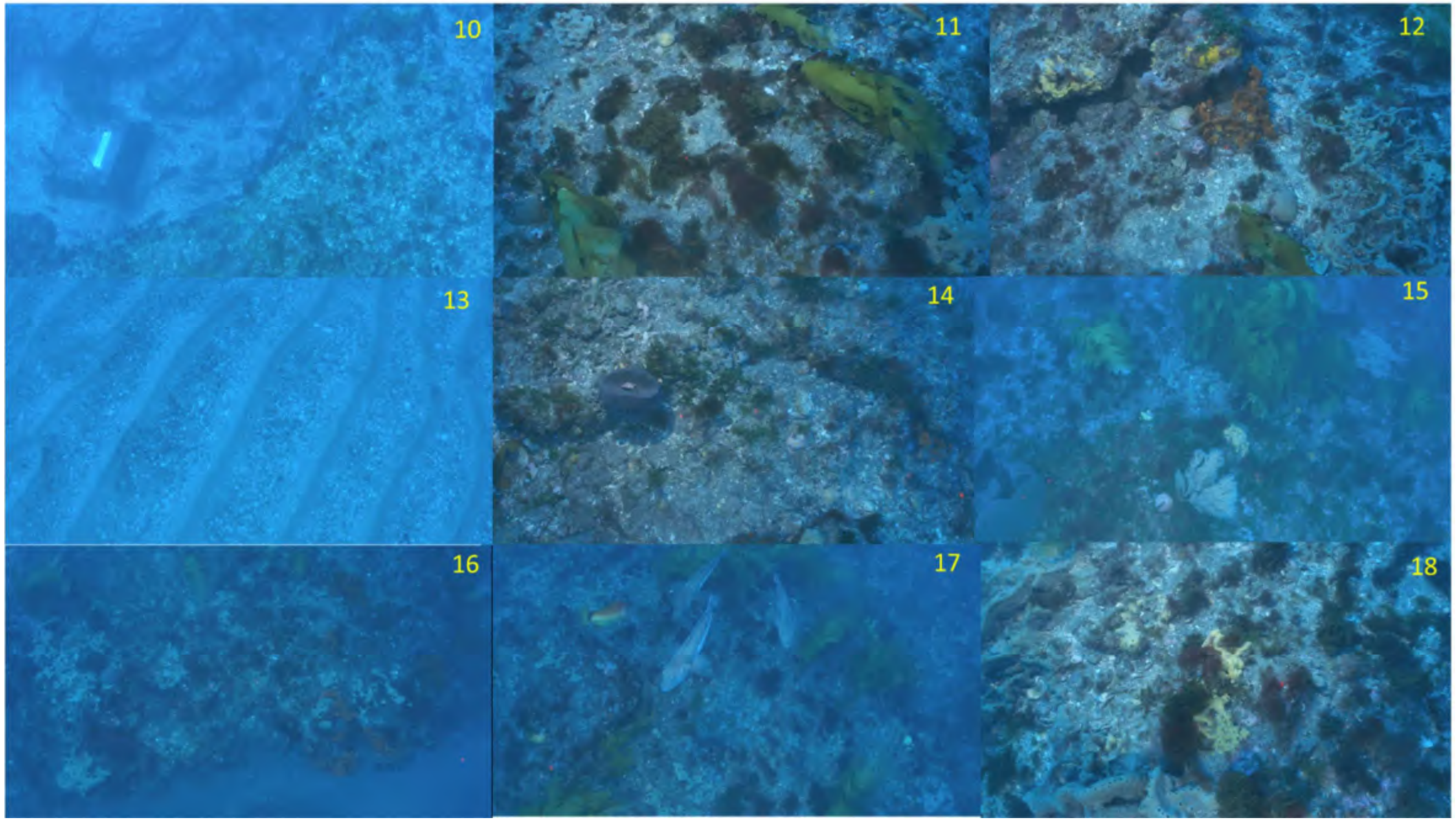

Figure 3-33: Continued. 10) the Project Reef in-situ camera site (in-situ camera not present); 11) green (brown) shrubby algae (off-reef); 12) small rock outcrop with sponges (off-reef); 13) soft sediments west of Project Reef; 14–15) small rock patch east of the Project reef, with sponges (unidentified gastropod sitting in sponge *S. conulosa* 'cone' in 14, and *Ecklonia* singles/patch in 15); 16) Project Reef north-east edge drop; 17) Project Reef blue cod and scarlet wrasse; 18) sponges, green (brown) shrubby and red algae on the Project Reef.

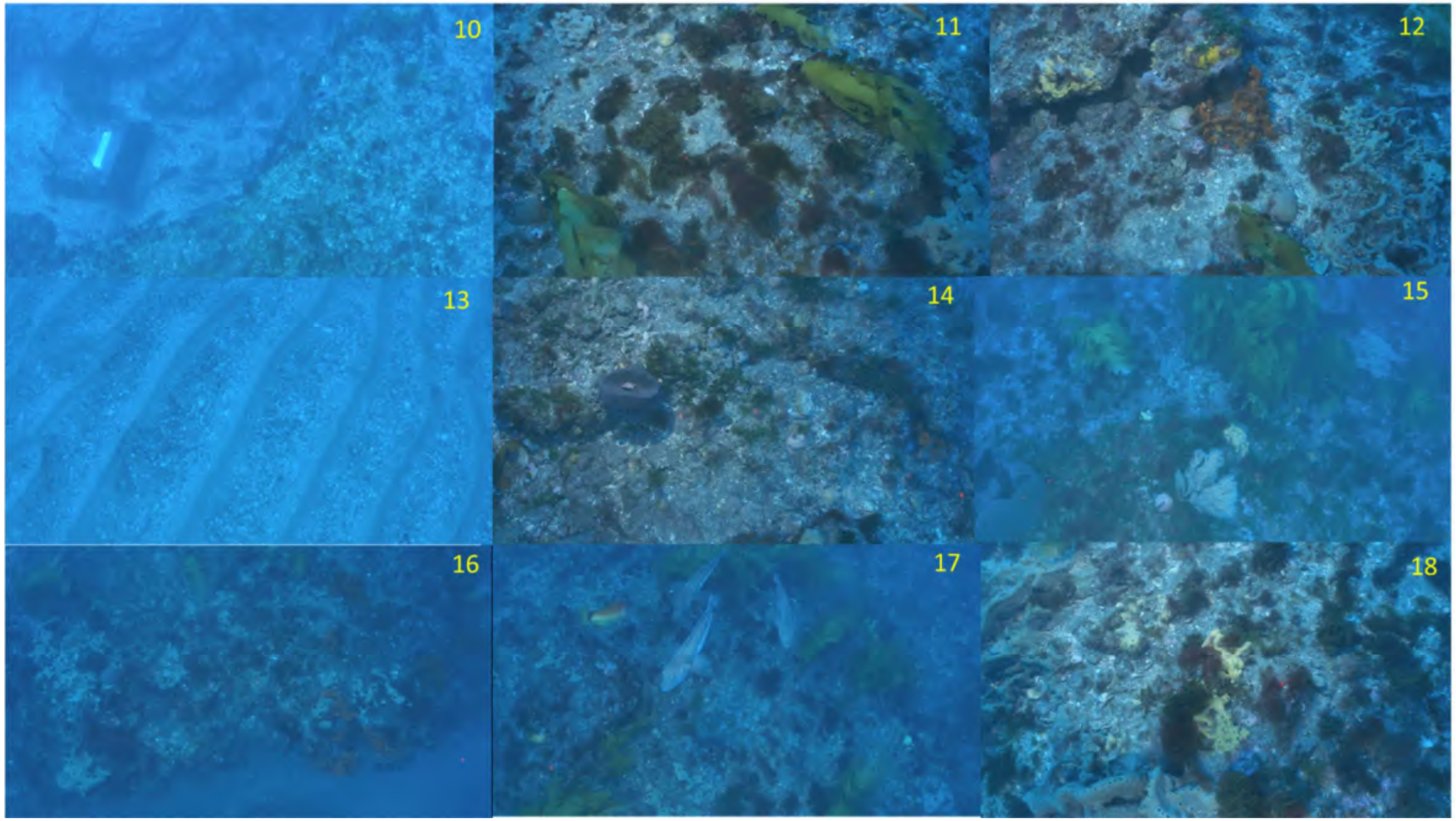

Figure 3-33: Continued. 10) the Project Reef in-situ camera site (in-situ camera not present); 11) green (brown) shrubby algae (off-reef); 12) small rock outcrop with sponges (off-reef); 13) soft sediments west of Project Reef; 14–15) small rock patch east of the Project reef, with sponges (unidentified gastropod sitting in sponge *S. conulosa* 'cone' in 14, and *Ecklonia* singles/patch in 15); 16) Project Reef north-east edge drop; 17) Project Reef blue cod and scarlet wrasse; 18) sponges, green (brown) shrubby and red algae on the Project Reef.

3.6.7 Site L

Depth range. 20.05–25.9 metres **Reef size**: 301,673 m^2 (full ridge feature)

Form. Long ridge feature approximately 1.17 km long, with flanking secondary shorter 'scalloped' ridges and reef depressions to the west and east (Figure).

The north-south ridge averaged around 300–330 m wide along most of its length, tapering to around 100 m width towards its southern end, and ending as a low 30 m wide ridge grading down into soft sediments. There were similar large ridge reef complexes to the east.

The video transect cut across the main ridge feature, and a secondary ridge to the east.

BTM Divisions (east to west along video transect): Flat Plains → Broad slopes → Rock Outcrops High/Narrow Ridges → Flat Ridge Tops → Flat Plains → Broad Slopes → Flat Ridge Tops → Rock Outcrops High/Narrow Ridges → Flat Ridge Tops → Flat Plains → Flat Ridge Tops → Flat plains (Figure 3-34).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-34 to Figure 3-36)

Geology. Most of the reef/rock extent was composed of mixed, irregular, cobbles (64.4%) (1–3), with low broken rock (7.1%) largely confined to the top of the ridge features (4,6,9,14). Various shell dominated soft sediments were present between the two ridge features, and on either end of the transect (2,11,18) (Table 4, Figure 3-34).

At the start of the video transect, on the eastern side of the reef, the seafloor was composed of irregular mixed cobbles and broken/mixed shell cover, which graded into 100% irregular mixed cobble (Figure). The secondary reef feature appeared as low broken rock (#1573–1582) covering up to 50% of the seafloor, along with irregular mixed cobbles. Cobbles again dominated as the transect moved off the ridge, were replaced by small-whole-shell soft sediment for a short distance (#1590–1597), before reappearing as the dominant seafloor cover (#1599 on). The main ridge feature had several short segments of low broken rock (#1612–1615) but was much less obvious than for the secondary ridge. Irregular broken cobbles extended right across the main ridge feature, until the bathymetry dropped down slightly to a depression in the west, with 100% seafloor cover of small-whole-shell soft sediment (#1621 on).

Biogenic habitats: On the eastern half of the transect, including to each side of the secondary ridge, biogenic habitat cover was largely dominated by green (brown) shrubby algae growing on cobbles, with occasional small contributions of sponge-ascidians-other-epifauna (Figure). Associated with the secondary ridge proper, and the main ridge (broken low rock) was a biogenic habitat class dominated by filamentous red algae, sponge-ascidians-other-epifauna, and some limited *C. geminata* and green lawn algae. This pattern was more 'diffuse' for the main ridge feature, where these classes extended more widely over the cobble as well as the rock seafloor (Figure).

E. radiata (kelp) occurred as small patches (4,6,9,14) across both ridge features and their flanks, although it had greater cover/extent on the main ridge, where it was also present as a narrow band (15) of kelp forest (6–10 metres wide) on the ridge-line proper (#1617–1618) (Figure 3-34). The distribution of *Ecklonia* forest, only on top of the reef ridge, was consistent with other reef ridge sites. It seems likely that this narrow *Ecklonia* forest ran right along the top of the 1.17 km ridge line (Figure). *Ecklonia* recruits appeared to be spatially associated with the presence of kelp patches and forest (Figure).

Main invertebrate species: Sponges were the most common sessile invertebrates, with a 3.8% cover contribution (Table 6). The dominant taxa were Family Chondropsidae sp 2, *C. incrustans*, *S. conulosa*, *A. globosa*, and *C. polymastia* (Table 7). Sponge richness and abundance were highest on and around the two ridge features, although there were clear negative associations with the narrow *Ecklonia* forest (as seen at other sites, not explainable as an artefact of kelp obscuring the seafloor) (Figure). Only two kina were observed (Figure). Other mobile invertebrates were rare (1 Cooks Turban gastropod, 1 starfish) (Table 7).

Main fish species: Blue cod were the dominant species seen and were present across the reef, with a few 0+ juveniles present (Table 8, Figure). Other species were less common, and included low numbers of butterfly perch, leatherjackets, and scarlet wrasse.

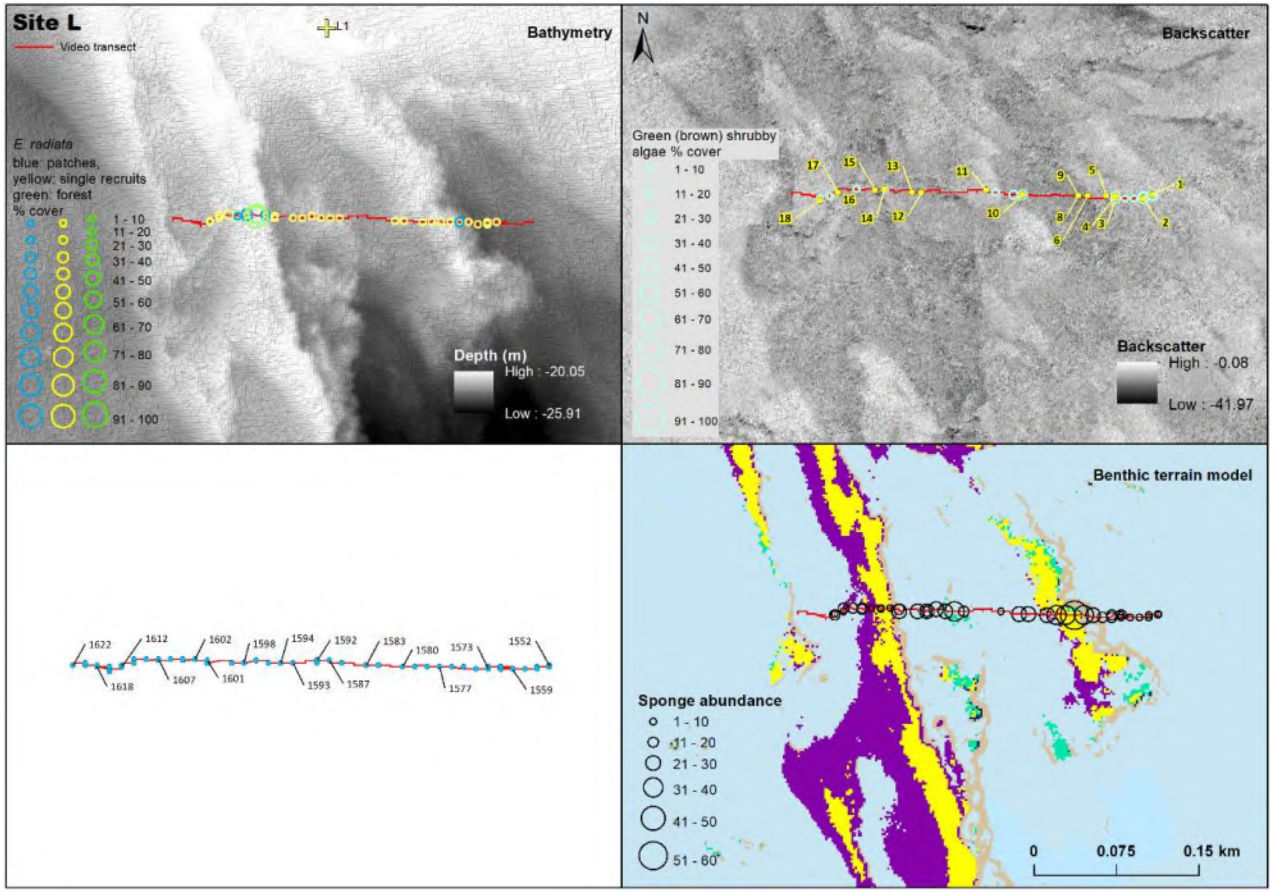

Figure 3-34: Maps of site L Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

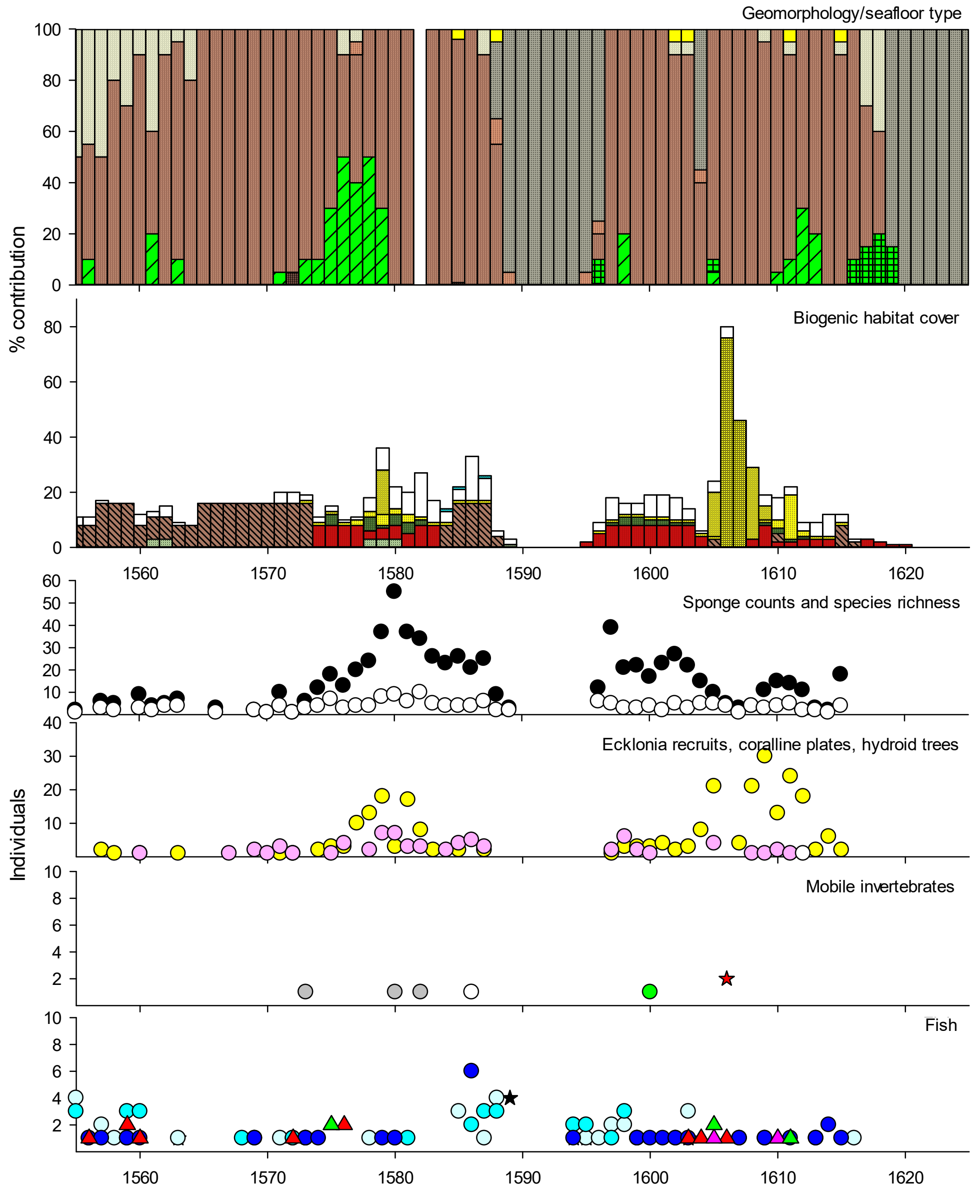

Figure 3-35: Site L CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, shown in map form in Figure 3-34.

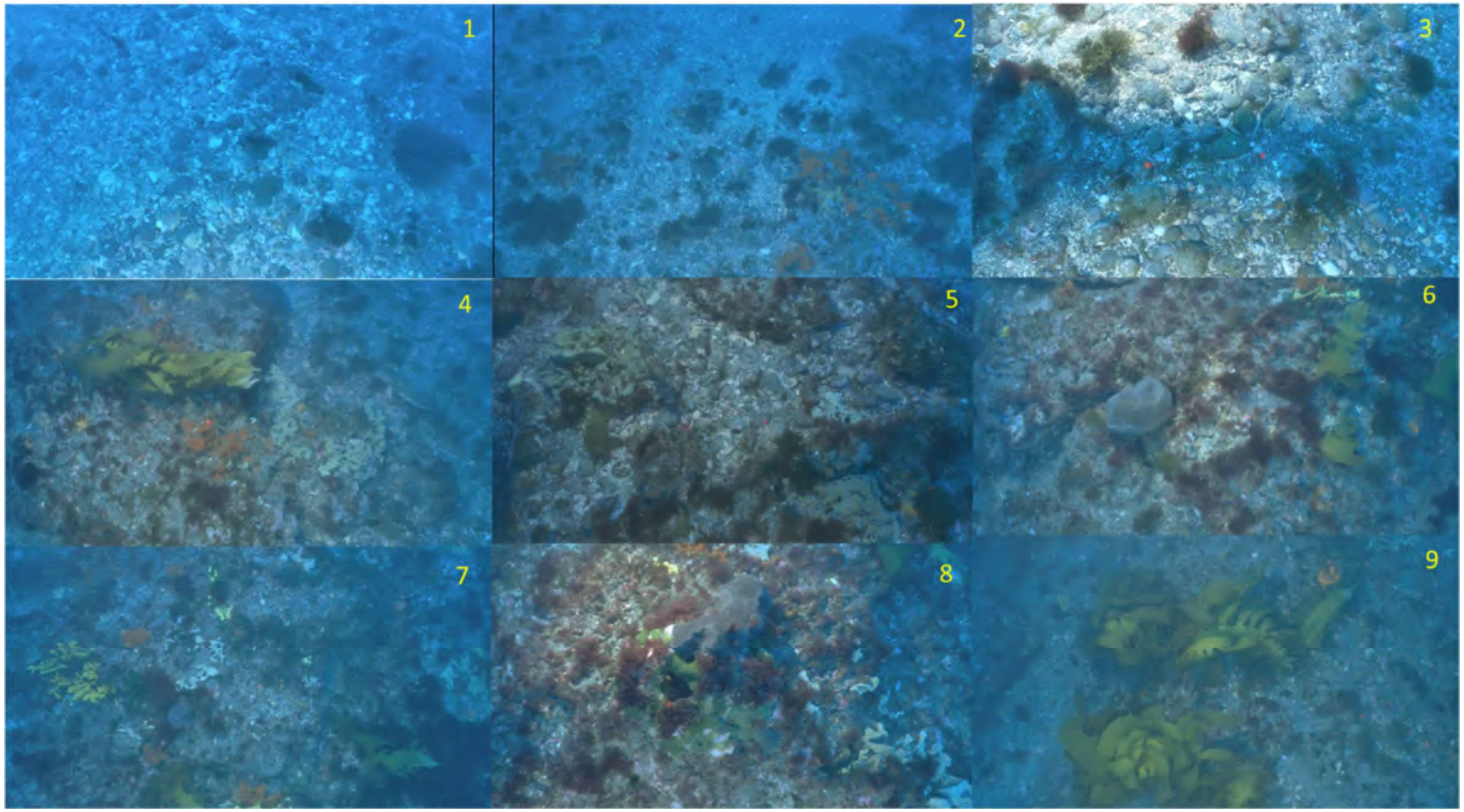

Figure 3-36: Site L seafloor images image numbers are plotted spatially in Figure 3-34 over multibeam sonar back scatter: 1–3) irregular cobbles field; 4–9) secondary ridge seafloor mixed rock substrates, and biogenic habitat covers of *Ecklonia* singles and patches, green (brown) shrubby algae, red algae, and sponge species.

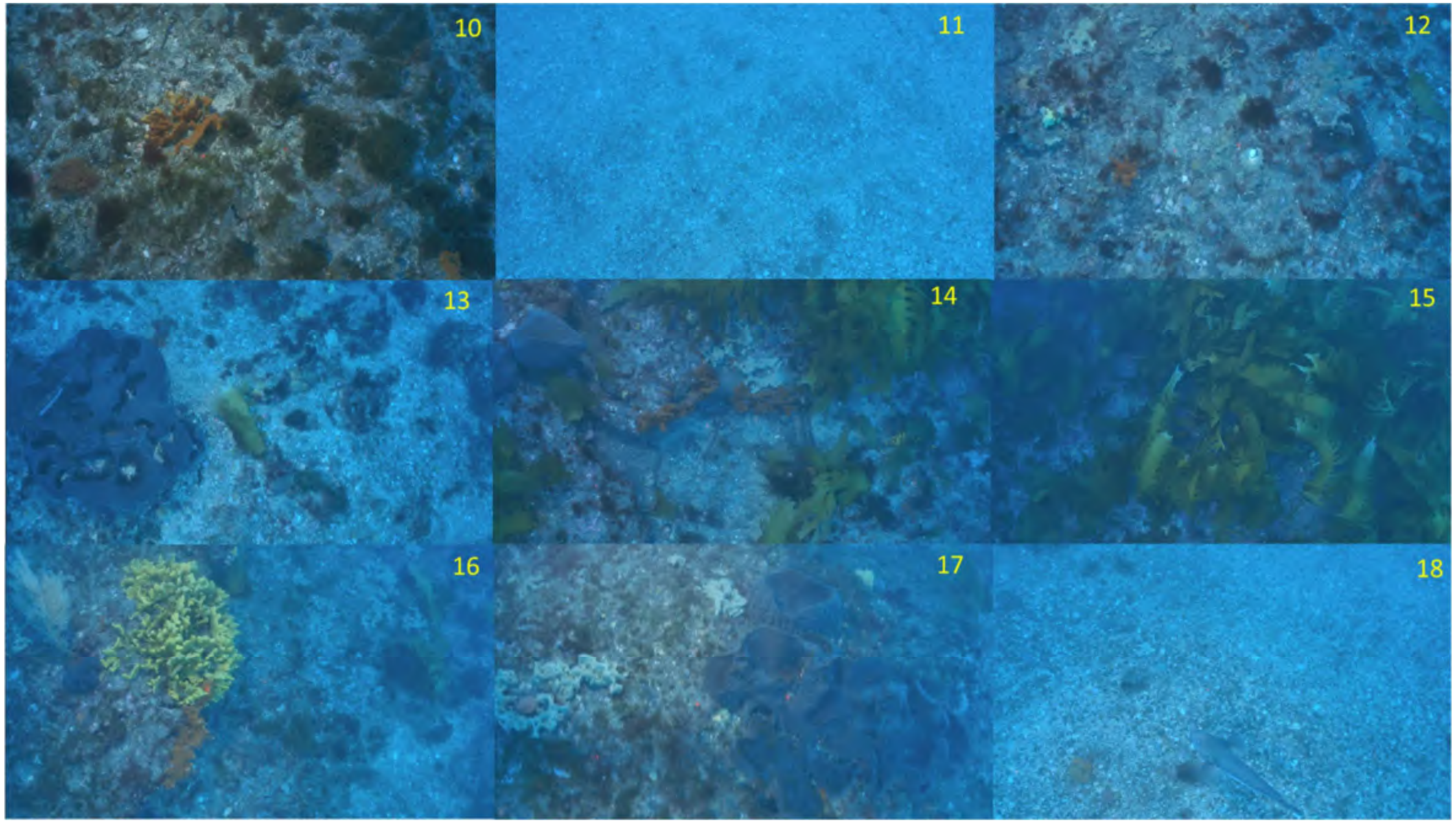

Figure 3-36: Continued 10) secondary ridge seafloor; 11) soft sediment seafloor; 12–17) main reef ridge seafloor, including grey sponge *E. alata* and blue cod (13), grey sponge *S. conulosa* (14), *Ecklonia* patches (14) and forest (15), yellow sponge *Crella incrustans* (16), grey sponge Family Chondropsidae species 2; (17) blue cod on reef edge; 18) gravel seafloor with blue cod.

3.6.8 Site O

Depth range. 19.6–25.4 metres **Reef size**: 109,994 (main ridge) + 66,698 m^2 (east reef)

Form. A ridge feature greater than 1.61 km long (southern end not mapped), with a second more broken and less starkly defined parallel ridge feature to the east (Figure). This east side reef started from the same north origin point as the larger ridge, ran out obliquely for 500 m south before disappearing, then re-merged from a soft sediment seafloor 500 m further south as a third ridge of broken reef (> 600 m long, southern end not mapped). This last ridge section had a large oblong reef extension extending to the east. A similar oblong reef feature was also present north-west of the main long ridge feature (slightly further south that the one on the east side).

These reef features were part of the wider complicated reef complex that also included sites K and L.

BTM Divisions (cross section along east to west transect): Flat Plains → Rock Outcrops High/Narrow Ridges → Flat Ridge Tops → Flat Plains → Broad Slopes → Flat Ridge Tops → Rock Outcrops High/Narrow Ridges (Figure 3-37).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-37 to Figure 3-39)

Geology. Most of the reef/rock extent was composed of mixed irregular cobbles (64.4%)(1–3), with very limited low broken rock (1.7%) largely confined to the top of the ridge features (4,6,9,14) (Table 4). Various shell dominated soft sediments were present between the two ridge features, and on either end of the transect (2,11,18) (Figure).

To the east, the seafloor was composed of broken/mixed shell cover (1), with occasional flat boulders (2) which graded into 100% irregular mixed cobbles (3). The secondary reef feature appeared briefly as low broken rock (4) (#1639–1642) covering up to 50% of the seafloor, along with irregular mixed cobbles. Most of the reef was irregular cobbles dominated with very occasional small rock patches (5). Moving off the reef feature, irregular cobbles continued to be dominant for the rest of the transect, to its western end. The main ridge feature had a few segments where low broken rock again appeared, but the ridge was covered by irregular cobbles (6,7). Soft sediments were present at the very western end of the transect (9) (Figure).

Biogenic habitats: On the eastern half of the transect, including to each side of the secondary ridge, biogenic habitat cover was largely dominated by wiry green filamentous algae growing on cobbles (3,4,6), with occasional small contributions of sponge-ascidians-other-epifauna (5,6) (Figure)

E. radiata forest was present as a narrow band on the western end of the transect (Figure 3-37, 3-38) associated with the top of the reef ridge feature. As with other ridge sites, this suggested a long narrow kelp forest extended along the >1.61 km long ridge top

Main invertebrate species: Sponges were the most common sessile invertebrates, but with a low percent cover (3.8%) cover contribution across the video transect (Table 6). The dominant taxa were Family Chondropsidae sp 2, *C. incrustans*, *S. conulosa, Dactylia varia*, *Callyspongia ramosa*, and *C. polymastia* (Table 7). Sponge richness was relatively constant, while sponge abundance was variable with no obvious seafloor-associated changes. Mobile invertebrates were rare, with one saw-shell (*A. heliotropium*) and one starfish (*Stichaster australis*/*Coscinasterias muricata*) being observed (Table 7).

Main fish species: Blue cod were the dominant (and largely only) fish species seen, distributed across the transect, with 0+ juveniles contributing 25% of the 79 individuals seen (Table 8, Figure). A few scarlet wrasse were counted, as well as one leatherjacket. Butterfly perch were conspicuously absent.

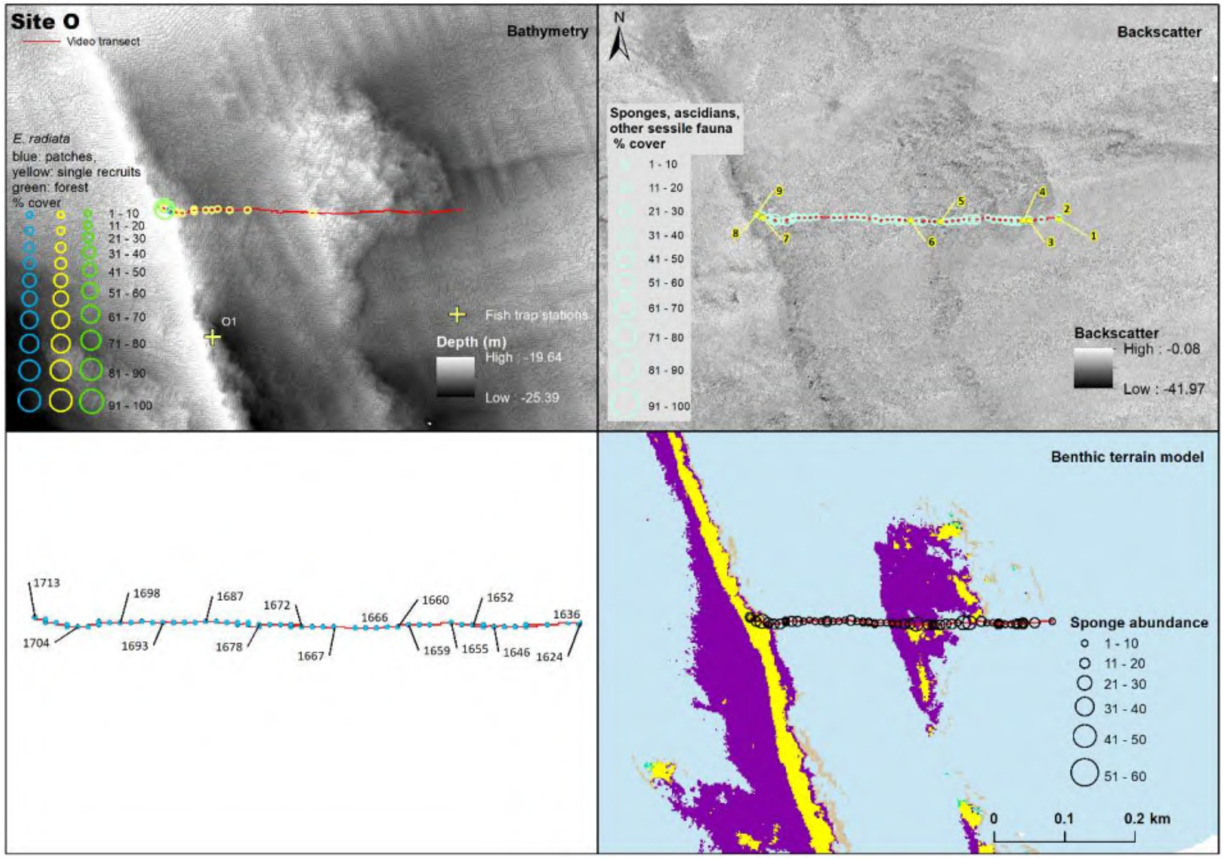

Figure 3-37: Maps of site O Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

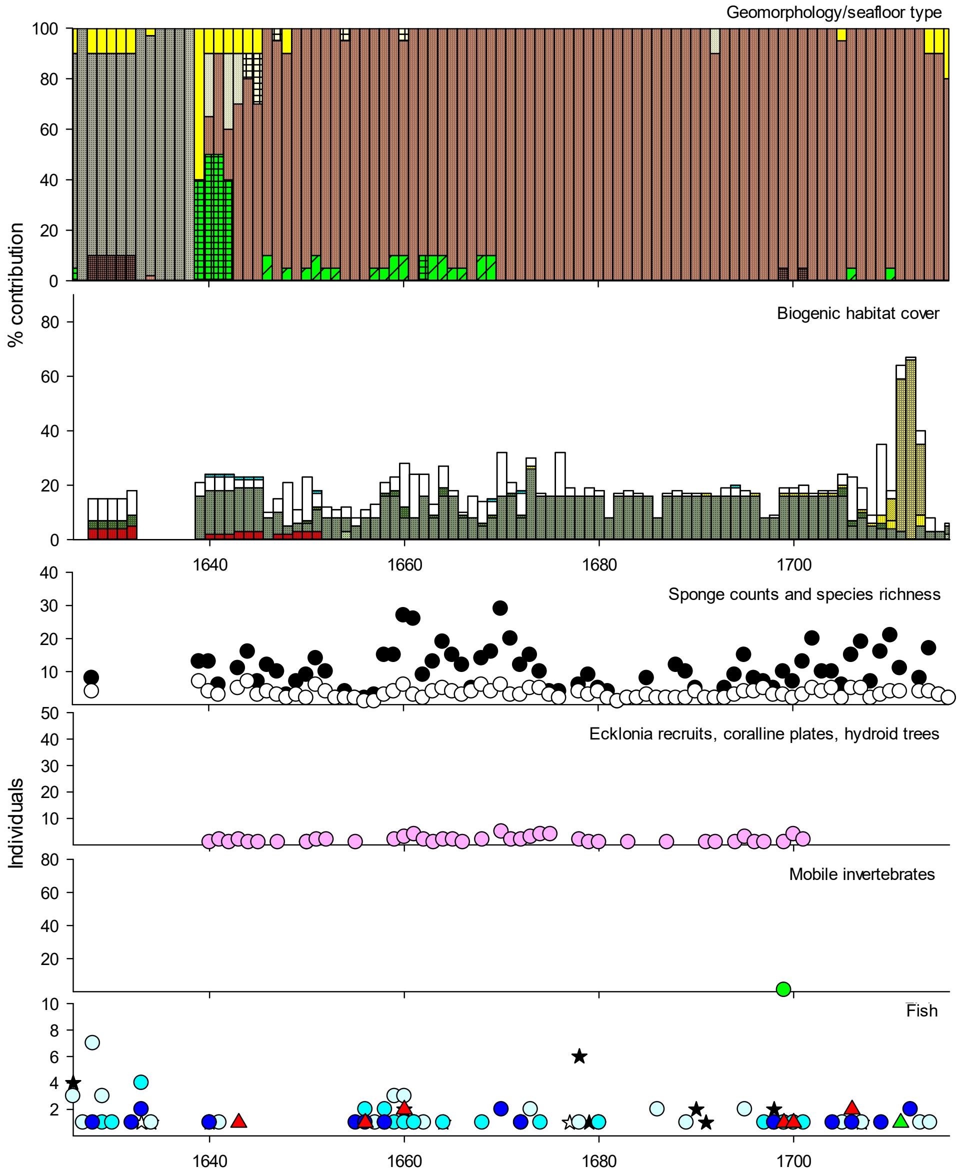

Figure 3-38: Site O CoastCam data Geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-37.

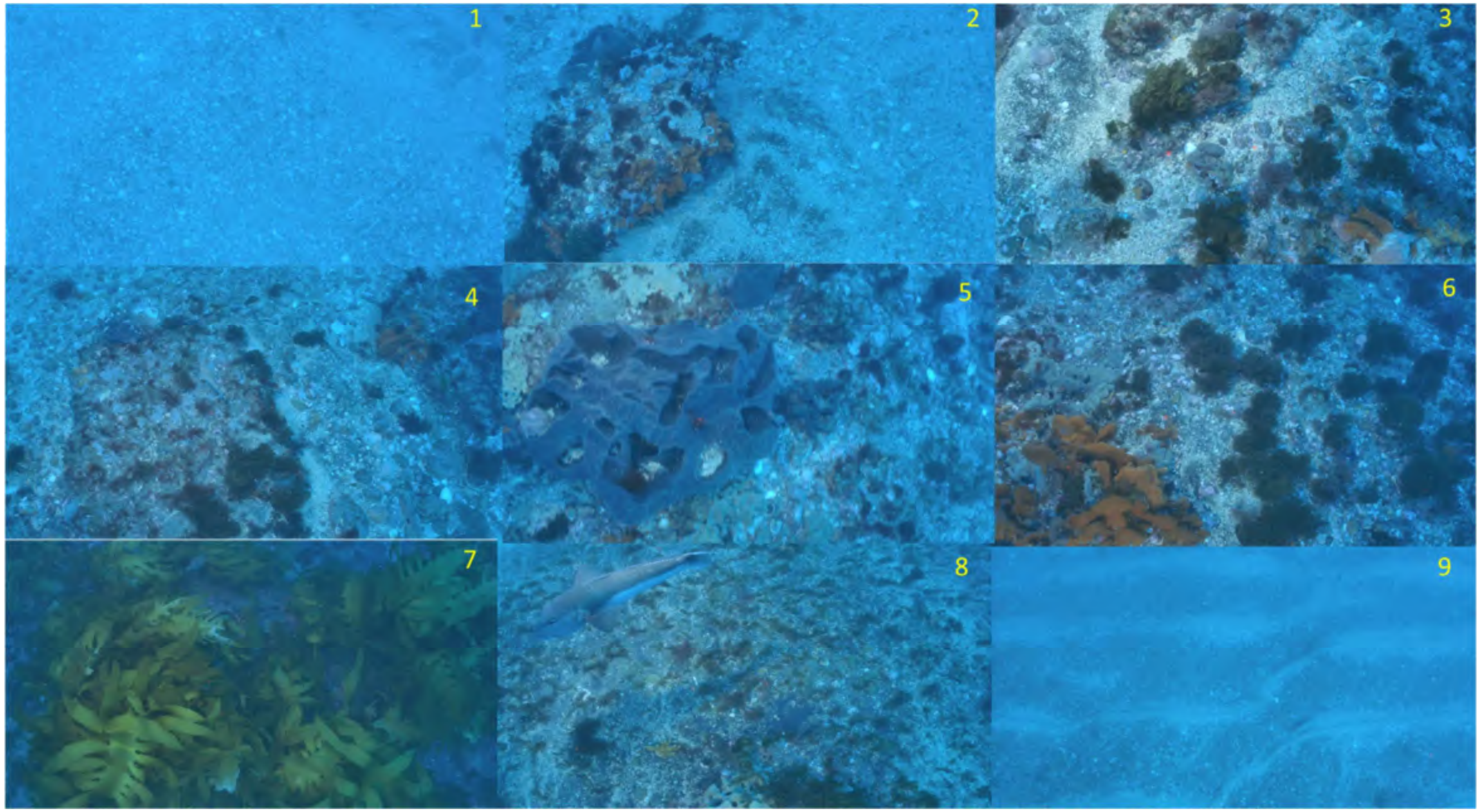

Figure 3-39: Site O seafloor images image numbers are plotted spatially in Figure 3-37 over multibeam sonar back scatter: 1) soft sediment seafloor; 2) boulder on soft sediment; 3) irregular cobble field; 4) low reef; 5–6) sponges *E. alata* and *C. incrustans*; 7) narrow *Ecklonia* forest; 8) blue cod; 9) soft sediments western end of transect.

3.6.9 Site Q (South Trap)

Depth range. 9.9–24.6 metres **Reef size**: 85,794 m^2 (MBES polygon extent only)

Form. Cross-section of a larger reef complex feature (South Trap), with long ridge and slope-platform features, composed of finer-scale finger-and-gutter reef morphologies, and more irregular rock. All features orientated north-east/south-west.

The reef was immediately flanked to the east and west by soft sediments.

A wider range of reef and other unknown seafloor features were present more broadly to the east and west (Figure), including the North Trap (see Figure 3-1), whose southern edge was just passed over by the multibeam sonar transect (see later Traps report section).

BTM Divisions (cross section along west to east transect): Broad Depression → Depressions → Lateral Mid-slope Depression → Steep Slopes → Flat Ridge Tops → Rock Outcrop Highs, Narrow Ridges → Flat Ridge Tops → Crevices, Narrow Gullies over elevated terrain → Lateral Mid-slope Depressions → Local Depressions, Current Scours → Lateral Mid-slope Depressions → Flat Ridge Tops → Rock Outcrop Highs, Narrow Ridges → Rock Outcrop Highs, Narrow Ridges/Flat Ridge Tops (Figure 3-41).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-41 to Figure 3-43)

Geology: Most of the 600 metre long video transect traversed reef habitat (93%), dominated by rock finger-and-gutter complexes (56%), with low broken rock (12%); and lesser contributions of low patch reef (3%), flat basement (2%) and tells (2%) (Table 4, Figure). Cobble habitat was absent. Soft sediments were present on the east side as gravel and stones interspersed with low patch reefs, and as sand patches towards the middle of the transect.

Biogenic habitats: On the west side, the transect started on soft sediments composed of large gravel/stones and shells (1), followed by low oblong patch reefs (2–4, 50% seafloor cover), orientated east-west on their longest axes (2). These patch reefs were in slab block form, with sharp right-angle edges, and elevated to around 0.5–1 m above the surrounding soft sediment. The initially patch reefs were dominated by large sponge cover (predominantly *E. alata*), which was quickly replaced by variable macro-algae contributions of filamentous green algae, green (brown) shrubby algae, and *C. flexilis* (5,6). This variable biogenic cover continued as the reef proper sloped up as a mixture of rock slab outcrops/stacks and flatter rock ledges (7,8) and associated low walls (8,9). Just before the ridge crest 'green lawn' algae biogenic habitat cover appeared as a dominant cover as well as scattered *E. radiata* plants (9). The reef from this point on was dominated by finger-and-gutter complexes, along with some short spans of broken rock, rock tells, and sand (10–18). Green lawn algae, and a lesser *E. radiata* contribution, covered up to 40–50% of the reef surface, before *E. radiata* forest became the dominant cover (10–15). In the latter part of the reef transect, the rock surface become more broken and less structured, and the *E. radiata* forest disappeared (16–18), with kina increasing in abundance. A lower cover of green lawn algae and filamentous red algae persisted.

Main invertebrate species: Sponges were the most common sessile invertebrates, with an overall low 0.7% cover contribution across the video transect (Table 6). The dominant taxa were Family Chondropsidae species 2, *S. conulosa*, *E. alata*, and *Darwinella oxeata* (Table 7). Sponge species richness abundance was negatively correlated with *Ecklonia* forest cover on the two ridge features (Figure 3-41). White hydroid trees (*Solanderia* sp.) were relatively common (40 individuals, 36% of animals surveyed). Kina were common (870, 78%), and appeared negatively correlated with *Ecklonia forest* (Table 7, Figure). Cooks Turban (herbivorous gastropods) were also relatively common (159, 70%), as were the starfish *Stichaster australis*/*Coscinasterias muricata* (30, 57%) (note virtually all *S. australis* seen in the survey were from this site, M. Morrison pers. obs.).

Main fish species: Scarlet wrasse dominated the fish assemblage and were recorded across the reef system (Table 8, Figure). Butterfly perch were present as small schools, usually associated with walls and drop-off features. Blue cod occurred in low numbers around the reef edges and broken rock. Sweep were also largely restrained to this site, with 20 of the 23 sweep (87%) seen (the other three from site A). This pattern was also seen in the baited traps video, where sweep were only seen at site Q1 (Nmax 7, Table 9, Figure). Banded wrasse were only seen at this site (3 individuals), as well as one of two marble fish seen across the survey (Table 8).

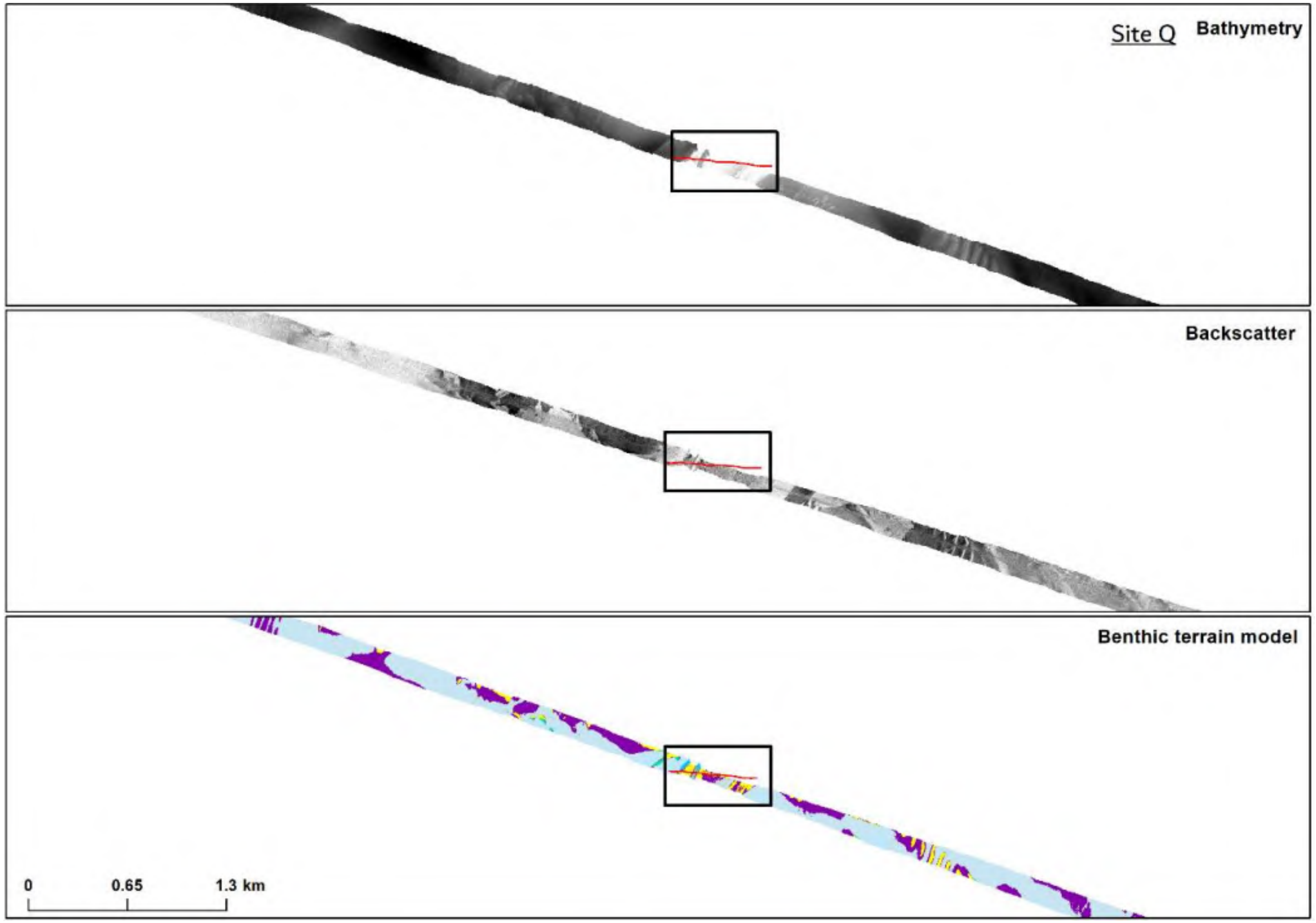

Figure 3-40: Broader extent maps of larger seafloor area mapped (reefs and other unknown features) around site Q (South Trap).

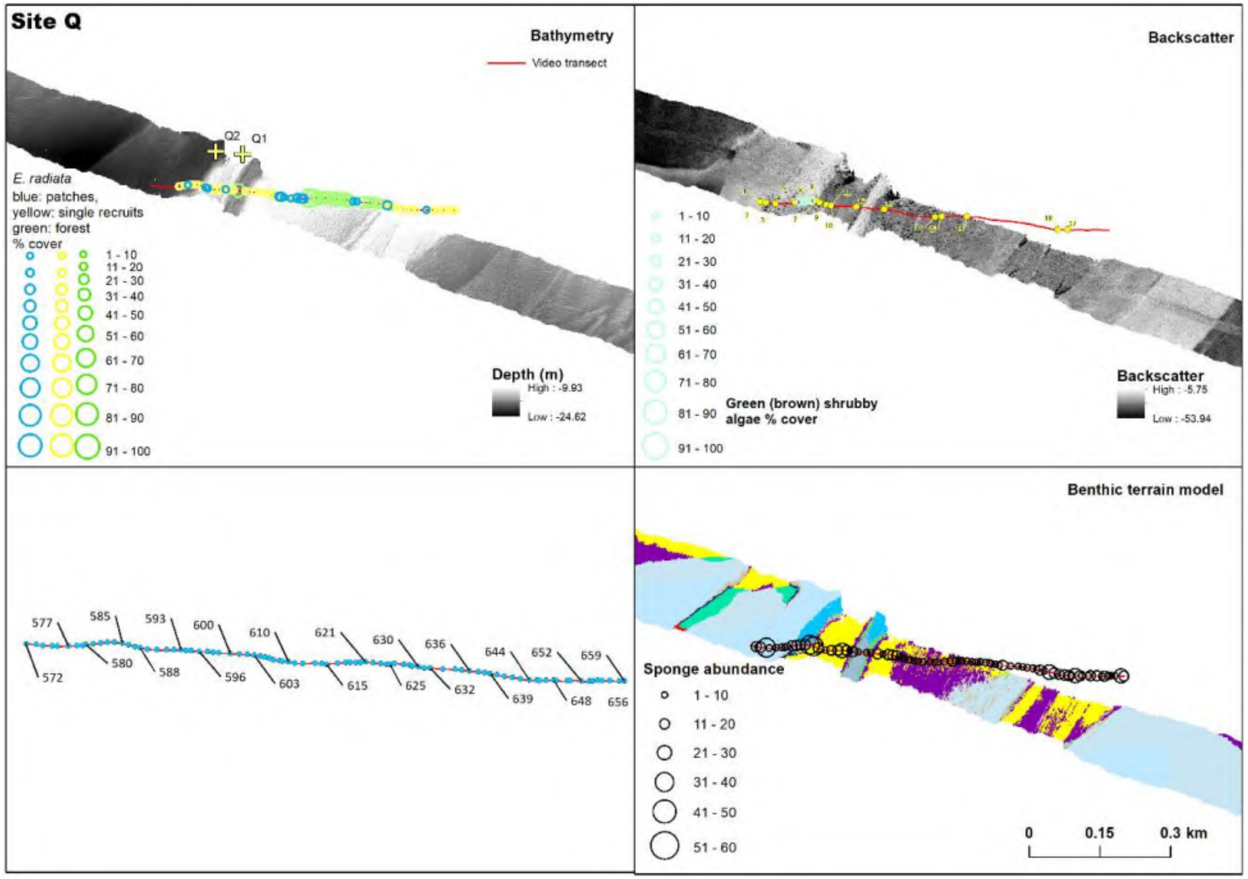

Figure 3-41: Maps of site Q Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment). Two fish traps deployments are also shown (Q1, Q2, see Table 9).

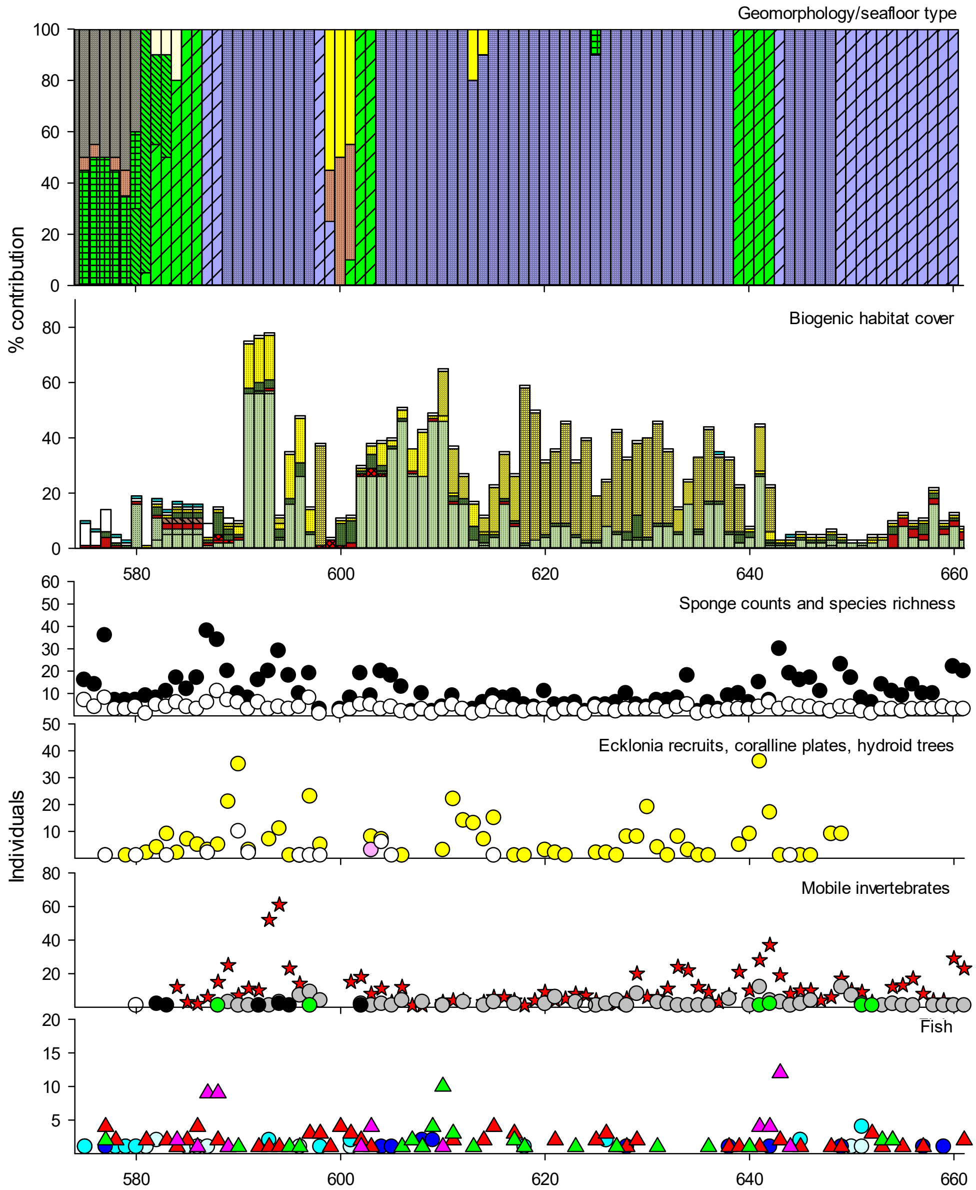

Figure 3-42: Site Q CoastCam data Geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-41.

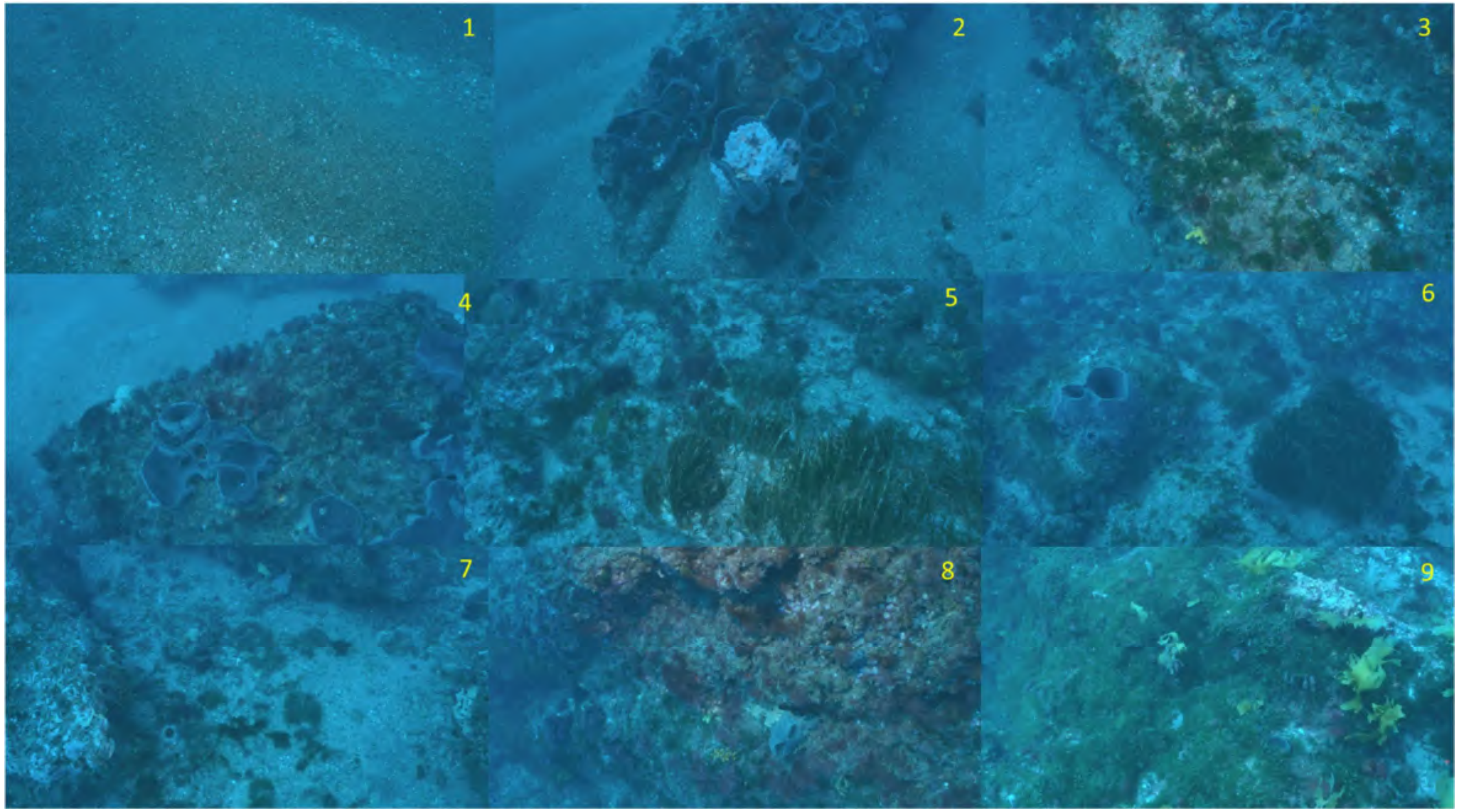

Figure 3-43: Site Q seafloor images image numbers are plotted spatially in Figure 3-41 over multibeam sonar back scatter: 1) soft sediment seafloor; 2–4) oblong reef blocks with grey sponge *E. alata* and white-grey sponge Family Irciniidae species 2; 5) *C. flexilis*; 6) grey cone sponge *S. conulosa*, and *C. flexilis* patch); 7) reef and soft sediment, large anemone (Family Actiniidae); 8–9) low walls, part of the rising reef, with red algae, green lawn algae, and *Ecklonia* individuals appearing prior to the start of *Ecklonia* forest from the ridge top on).

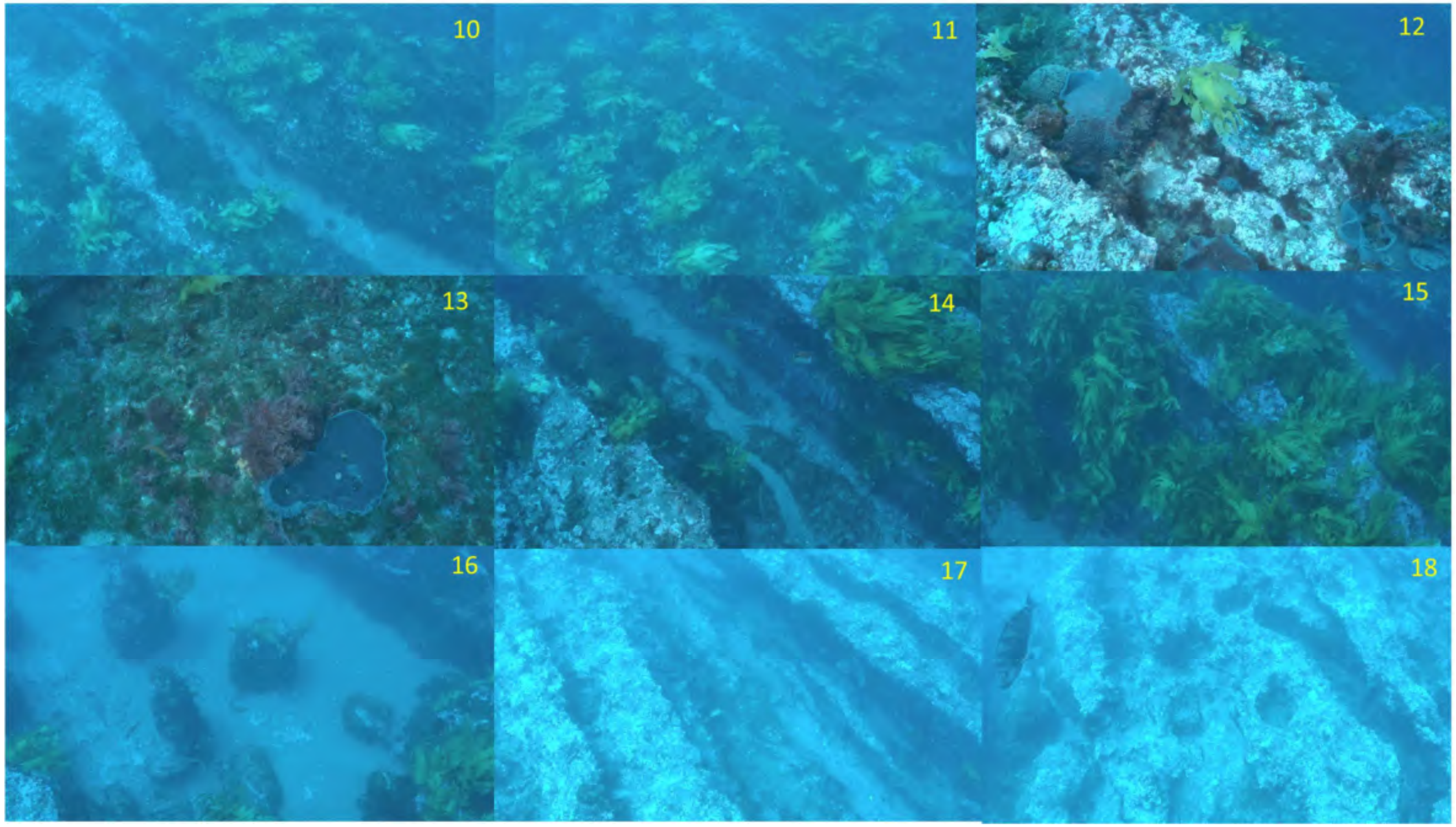

Figure 3-43 Continued 10–11) *Ecklonia* forest and green lawn algae in association with finger-and-gutter reef, (12) a small rock spine with the grey fuzzy football sponge *Polymastia* cf *massalis* (left), grey sponge *S. conulosa* (immediately adjacent), Cook Turban gastropod (far left centre) and grey sponge *E. alata* (right), and 'white coralline paint/crust'; 13) foliose red and green lawn algae; 14–15) finger-and-gutter reef examples; 16) eroded reef stubs; 17) bare finger-and-gutter reef; 18) eroded reef pot-hole form.

3.6.10 Site R

Depth range. 16.6–26.4 metres **Reef size**: 136,726 m^2

Form. A large, multi-faulted reef tilted up on its north side, with putatively 5 fault-line features creating lateral displacement of 60 to 130 metres for several blocks. Four low ridges were present on the north side of the tilted block, along with a large, rounded rock feature on the east side

Part of a larger area of reef features, with a discrete series of ridges and large rock outcrops, which included sites S, T, and U (Figure).

BTM Divisions (cross section along west to east transect): Steep Slopes → Rock Outcrop Highs, Narrow Ridges → Steep Slopes → Rock Outcrop Highs, Narrow Ridges → Steep Slopes → Broad Slopes → Flat Plains → Broad Depression → Depressions → Broad Depression → Broad Slope → Rock Outcrop Highs, Narrow Ridges → Steep Slope → Rock Outcrop Highs, Narrow Ridges → Steep Slopes → Flat Plains → Broad Slopes → Steep Slopes → Rock Outcrop Highs, Narrow Ridges → Steep Slopes (Figure 3-45).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-45 to Figure 3-47)

Geology. Most of the 820 metre long video transect traversed sandstone reef habitat, meandering along two ridge features in the western half, and then cutting obliquely over two further ridge features in the eastern half (Figure 3-45). Poorly sorted coarse sand and shell, and large gravel and stones and shell, contributed to soft sediment habitats on the flat plains either side of the eastern ridges. The ridges proper were composed of low and high broken rock, as well as pillow ridge rock. Some small patches of flat exposed rock tells were present adjacent to the base of the reef, that appeared to be mudstone/Papa rock (18, 20).

Biogenic habitats: Starting on the west side, the transect began a ridge of broken low rock supporting *E. radiata* kelp forest (1–3) with 20–60% cover, followed by broken rock and pillow ridge reef dominated by *C. flexilis* meadows (4–10) (Figure). The transect moved onto a second ridge, with broken low rock and associated *E. radiata* kelp forest (around 40% cover) (11–12). The second half of the transect cut obliquely across a third ridge with a narrow band of *E. radiata* forest on the ridge top, with soft sediments and flat basement and boulder seafloor flanking each side of the ridge supporting a low cover of red filamentous algae and bushy bryozoans (13–19) . On the far eastern side, the transect passed over a large rock feature, with a narrow band of *E. radiata* patches (20% cover) (22) present on the top of the feature, followed by mixed red algae and *C. flexilis* meadow cover (60%) on the eastern downward slope (23–26), grading into C. flexilis meadows on pillow reef (27).

Main invertebrate species: Sponges were the most common sessile invertebrates, with an overall low 0.6% cover contribution across the video transect (Table 6). The dominant taxa were Family Chondropsidae species 2, *S. conulosa*, Family Halichondriidae (genus & sp. unid.), *Stylissa* sp. indet., and *R. topsenti*/*Axinella* sp. indet. (Table 7). Most of the orange fluffy mound sponge *Stylissa* sp. indet. seen across the survey were counted at this site (101 individuals, 67% of all counted in the survey) (with the adjacent S and T sites contributing a further 19%). The reddish-pink/grey ball sponge, *Aaptos rosacea,* was also largely represented by this site (39 individuals, 87% of all counted). Sponge richness and abundance were negatively correlated with *E. radiata* cover on the ridge features. Calcified bryozoans, rare in the survey, were most abundant at this site (*Galeopsis porcellanicus* 48% of individuals, *Adeonellopsis macewindui* 22% of individuals); with the adjacent S and T sites contributing a further 16% and 63% (Table 7). These were associated with the *C. flexilis* meadows on pillow reef.

Mobile invertebrates occurred in low numbers across the reef, dominated by the sea slug *A. luctuosa*, and the gastropods *C. sulcata* and *A. heliotropium*. Only eight kina were counted. One solitary smooth snake-star, *O. maculata,* was also observed, the only individual seen during the survey.

Main fish species: Scarlet wrasse and butterfly perch dominated the fish assemblage, with scarlet wrasse observed across the reef, while butterfly perch occurred as small schools, often associated with abrupt bathymetry changes (Table 8, Figure). No 0+ juvenile blue cod were seen, with most of the sub-adult and adult blue cod clustered along the reef/ soft sediment interface.

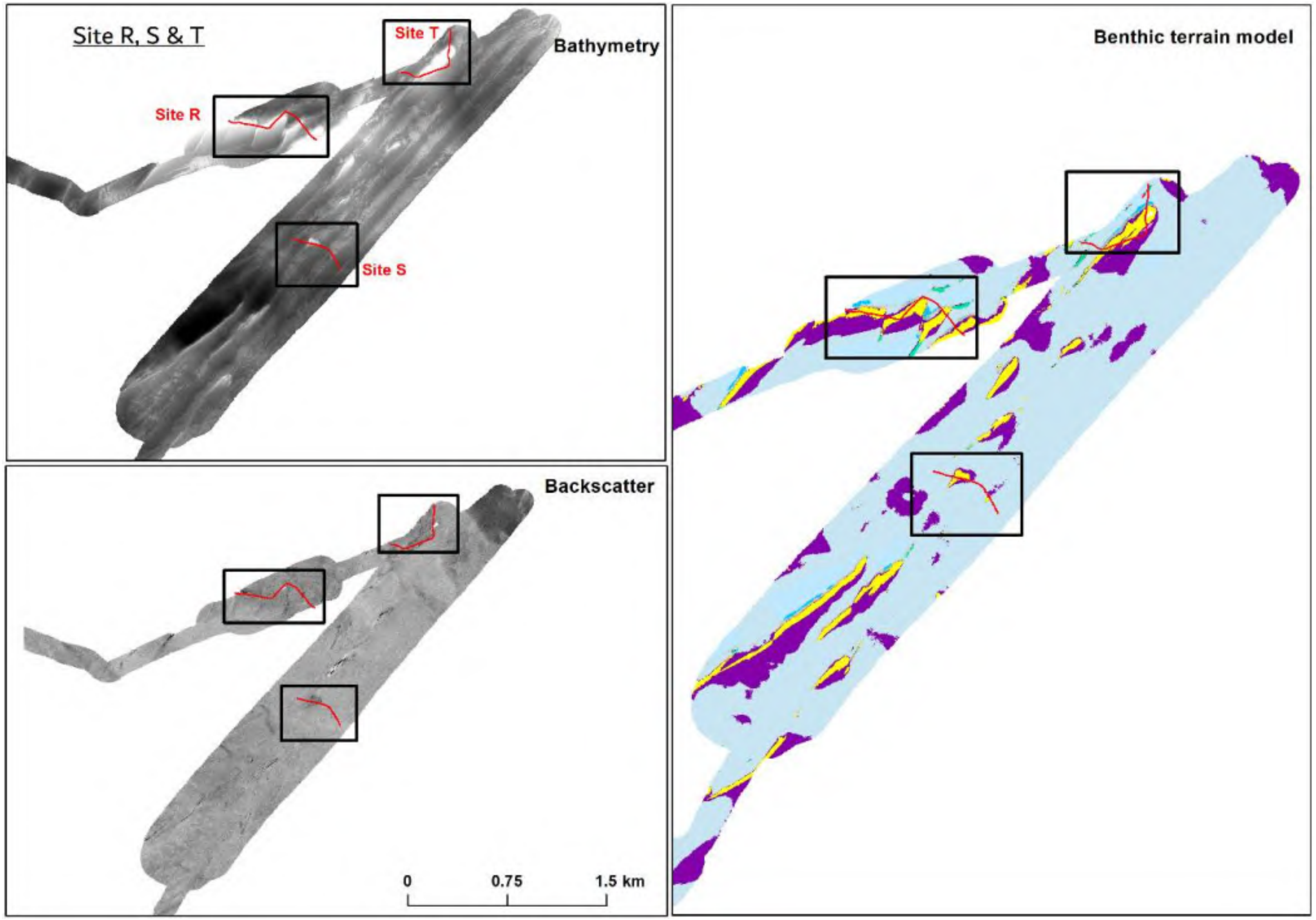

Figure 3-44: Broader extent maps of larger seafloor area mapped (reef and other unknown features) around sites R, S and T.

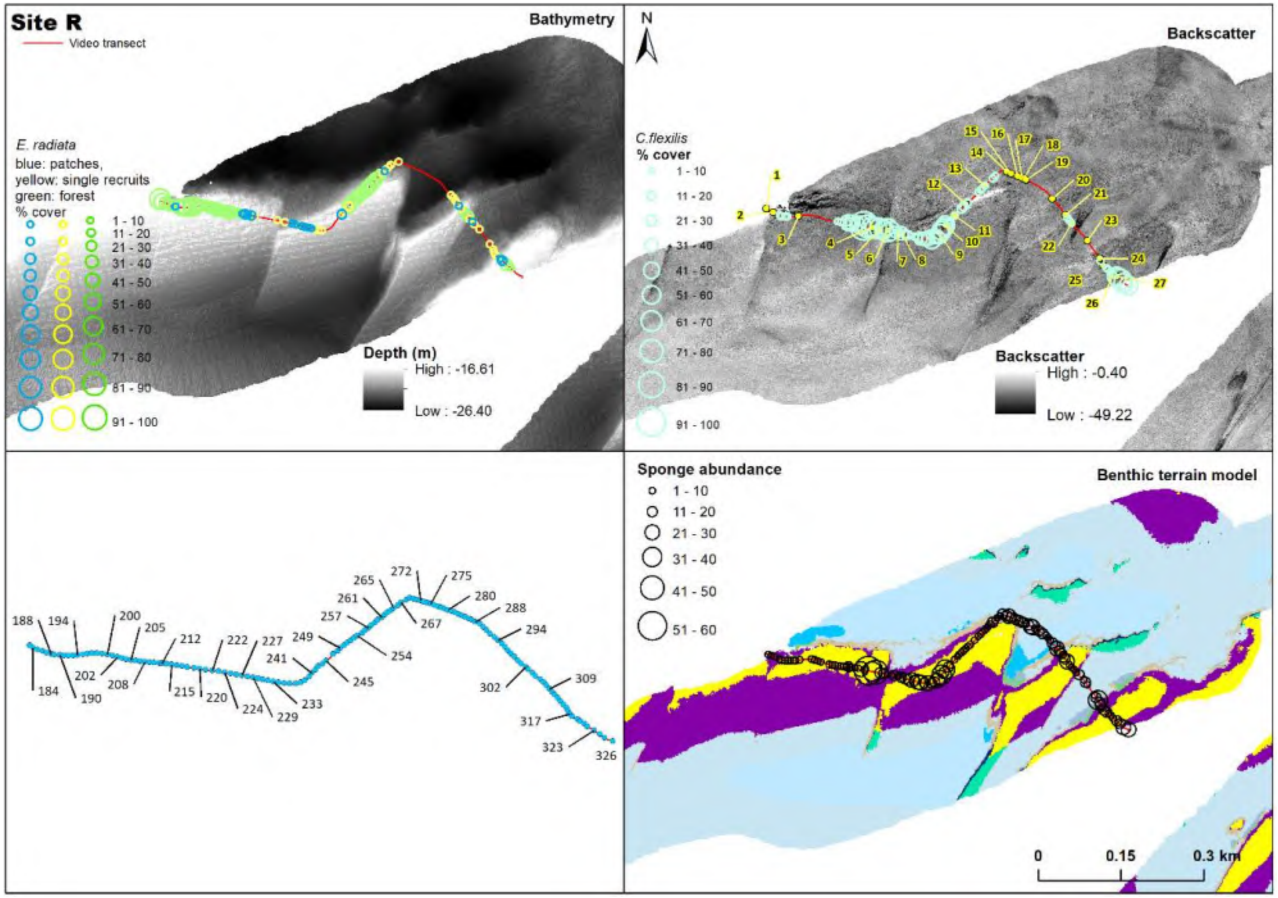

Figure 3-45: Maps of site R Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

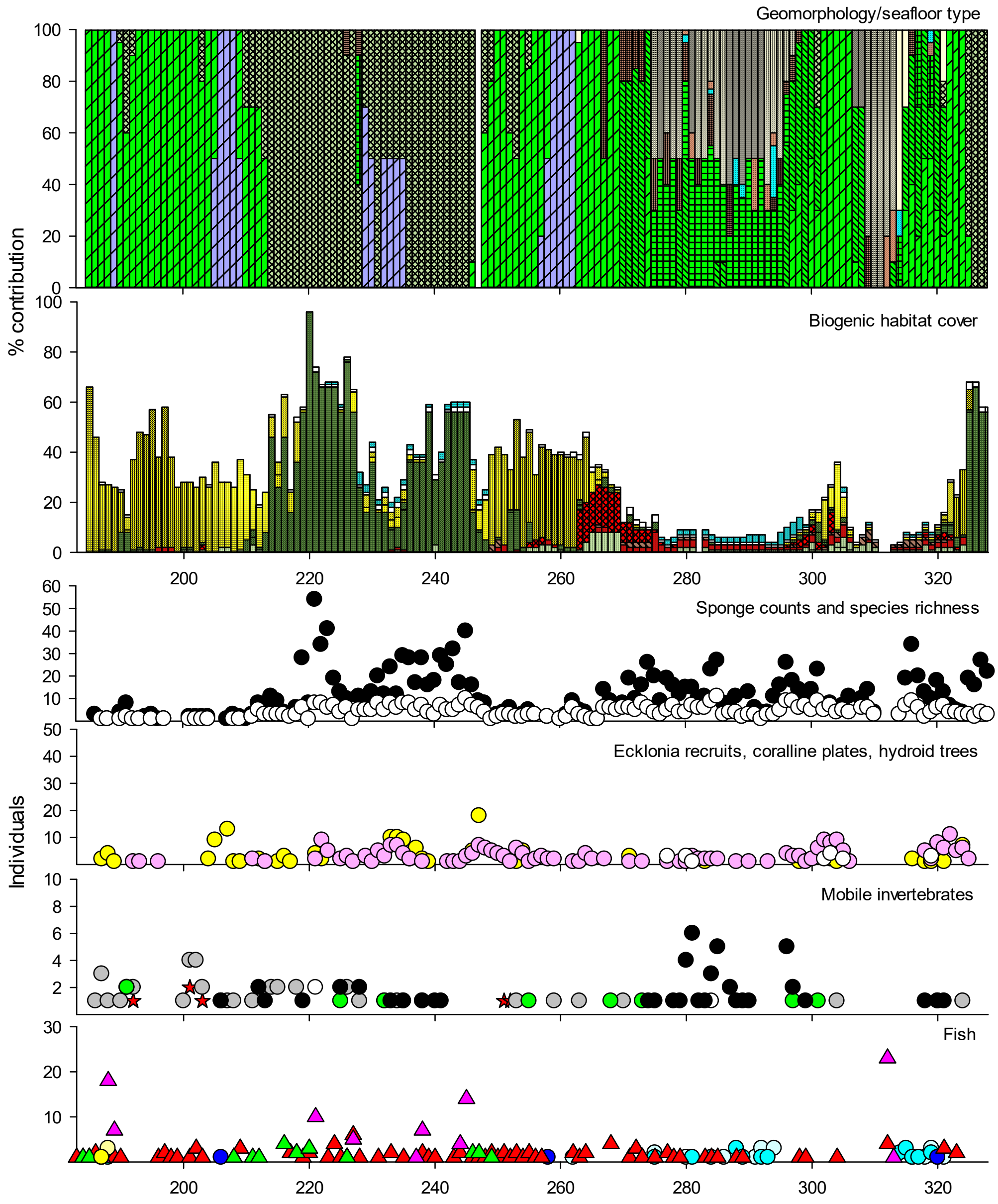

Figure 3-46: Site R CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-45.

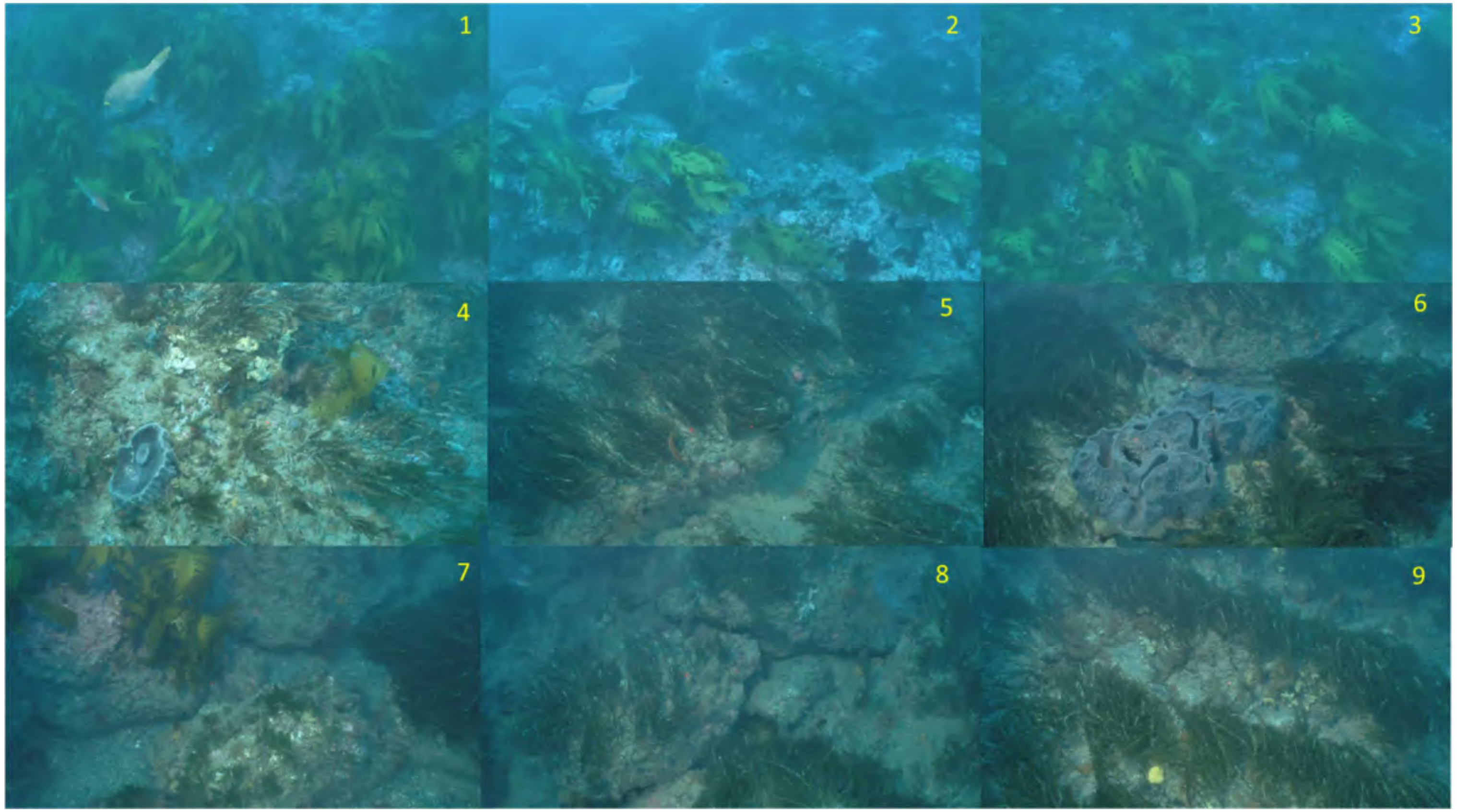

Figure 3-47: Site R seafloor images image numbers are plotted spatially in Figure 3-45 over multibeam sonar back scatter: 1–3) *Ecklonia* forest and patches on the ridge top (scarlet wrasse, leatherjacket and tarakihi present) (lattice reef form seen in 2); 4–9) various forms of 'pillow reef' and/or boulders, dominated by *C. flexis*, and occasional *S. conulosa* and *E. alata* sponges. Image 9 shows the often aligned tows of *C. flexis*, with co-association of small sponges and bryozoans.

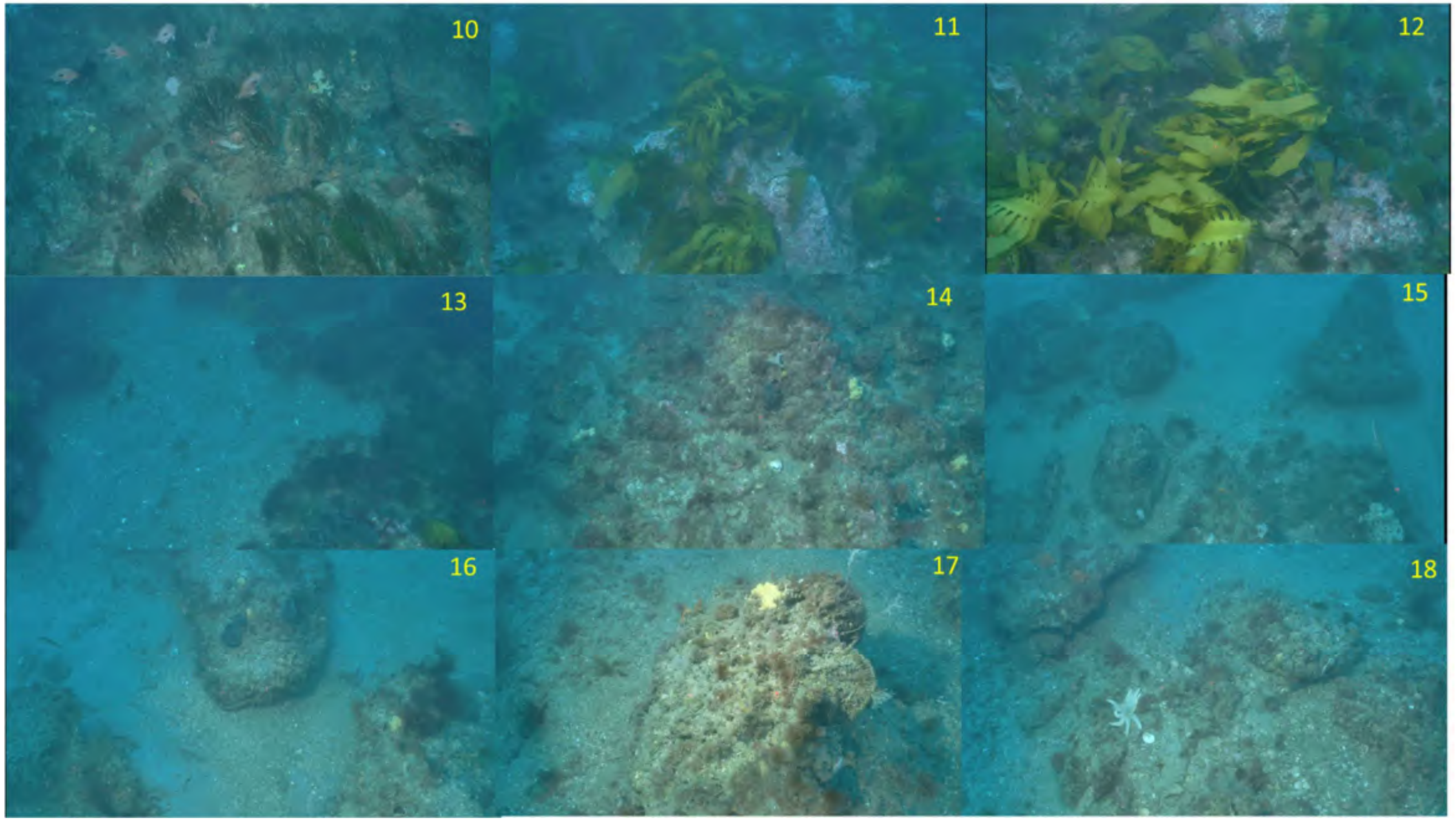

Figure 3-47: Continued 10) *C. flexilis* on pillow reef with small sponge and bryozoans association, with school of juvenile butterfly perch; 11-12) *Ecklonia* patches/forest (lattice reef form in 11); 13–18) flat basement rock and boulders with soft bryozoans and red algae, and the starfish *C. muricata* (18), sitting on small patches of mudstone/Papa rock (smoother flat grey rock).

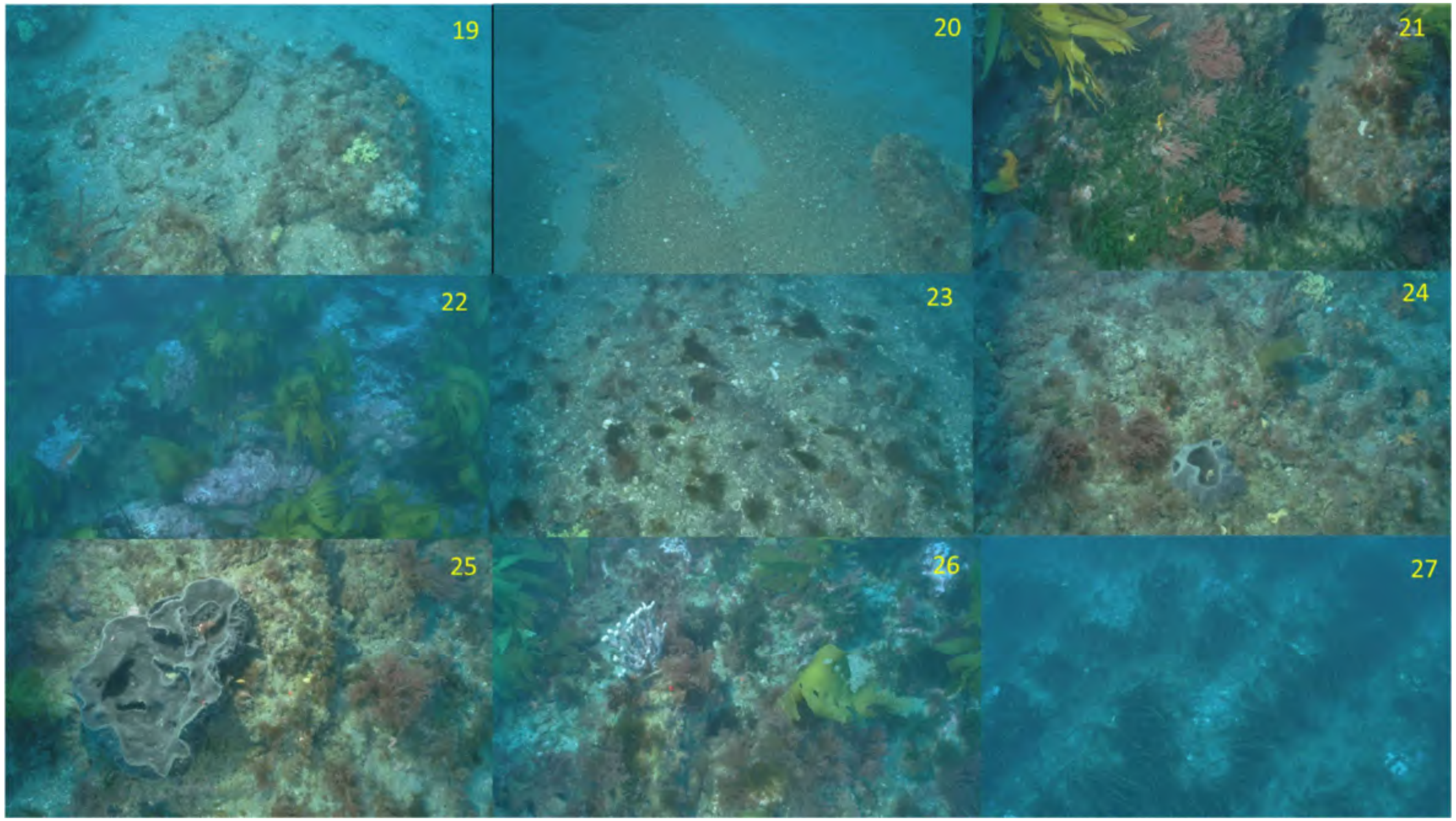

Figure 3-47: Continued 19) flat basement rock and boulders with soft bryozoans and red algae; 20) small patch of mudstone/Papa rock overlain by soft sediment drifts; 21) broken rock with *C. flexilis*, red algae, and *Ecklonia* singles; 22) *Ecklonia* patches (lattice reef form); 23–26) mixed biogenic habitats; 27) *C. flexilis* regular rows on pillow reef.

3.6.11 Site S

Depth range. 12.7–26.3 metres **Reef size**: 29,393 m^2

Form. A large oblong rock orientated north-east/south-west, approximately 359 metres long by 85 metres wide. The reef rises from around 22–24 metres, to 12.7 m depth, although a small patch of the shallowest northern reef area was not mapped by multibeam. The reef was composed of long terraces/platforms running along its longest axis, that were slightly tilted.

Part of a larger area of reef features, with a discrete series of ridges and large rock outcrops, which included sites S, T, and U (Figure).

BTM Divisions (north to south along video transect): Broad Depression → Local Ridge, Boulders, Pinnacles on Slope → Lateral mid-slope depression → Flat plains → Broad depressions → Depressions → Steep Slopes → Broad slopes → Flat Ridge Tops → Rock Outcrops Highs, Narrow Ridges → Flat Ridge Tops → Crevice, Narrow Gullies over Elevated Terrain → Flat Ridge Tops & Rock Outcrop Highs, Narrow Ridges → Scarp, Cliff → Flat Plains → Local Ridges, Boulders, Pinnacles on Broad Flats (Figure 3-48).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-48 to Figure 3-50)

Geology. Approximately 400 metres of the 670 metre long video transect traversed the block reef habitat proper, with additional boulders and rock tells also present outside of the reef block (transect start in the north (1–4), and some patch reefs to the south-west (32,33,36)). The reef itself was composed of stepped terraces, with broken rock on the reef top/ridge. The terraces were separated by vertical drops of 1 to 2 metres (8,15,18,21,23,24,26,28–30), some of which could be seen as 'creases' on the multibeam sonar bathymetry (Figure 3-48)

Biogenic habitats: The video transect started to the north of the reef block, on a seafloor of poorly sorted coarse sand and shell, with some low, bare, rock (mudstone/Papa rock) showing through the soft sediments. Soft bryozoans were the dominant biogenic habitat cover (2,3,4) (around 20%), with an association of the small yellow and white anemone *Anthothoe albocincta* (Table 6, Figure). The northern edge of the reef block was a field of broken slabs/boulders with many small crevices, with associated biogenic habitat cover of *C. flexis* and red foliose algae (5–7). Flat step terraces followed (8), rising to a reef top of broken rock (12), more flat step terraces on the eastern side (15), followed by irregular broken cobbles with soft bryozoan cover (16–17). These terraces were dominated by *C. flexis* meadow (8–10, 13), with *E. radiata* kelp patches also present (9,12,14). The video transect turned in a wide arc over the off-reef broken cobble field, which supported a low cover of soft bryozoans (17), before passing over the main reef block again going west. Stepped terraces (18,19) rose to the reef top (20) then dropped down the western side as terraces (21–31) to soft sediments and some patch reefs (31–36). *C. flexilis* meadow was the dominant biogenic habitat cover on the terraces (50–100% cover). *E. radiata* was limited to a narrow zone on the reef top, where it occurred as kelp forest (one segment wide) and adjacent patches (20). Sponge cover was low, but a notable feature was the presence of occasional large *E. alata* individuals within the *C. flexilis* meadows (25).

Main invertebrate species: Sponges were the most common sessile invertebrates, with an overall low 0.59% cover contribution across the video transect (Table 6). The dominant sponge taxa were Family Chondropsidae species 2, *S. conulosa*, Family Halichondriidae, genus & sp. unid., *Stylissa* sp. indet. and *R. topsenti/Axinella* sp. indet. (Table 7). Sponge richness and abundance were consistent through-out the first half of the video transect, but noticeably declined on the second half of the transect (Figure 3-49). As with adjacent sites R and T, the calcified bryozoans *G. porcellanicus* and *A. macewindui* were present in association with *C. flexilis* meadow on pillow ridge reef, (*A. macewindui* 82 individuals, 62% of individuals counted in the survey, Table 7). Mobile invertebrates were uncommon, with low numbers of the sea slug *A. luctuosa*, cushion stars (off reef), kina, and the gastropod *C. sulcata* (Table 7, Figure).

Main fish species: Butterfly perch and scarlet wrasse dominated the fish assemblage (Table 8), with scarlet wrasse observed across the reef system, while butterfly perch occurred as adults often associated with abrupt bathymetry changes (15), and as juveniles over the *C. flexilis* meadows (Figure). Blue cod were relatively uncommon and occurred on the reef edges, as well as having an association with *Axinella* sp. and other finger sponges on soft sediments (35).

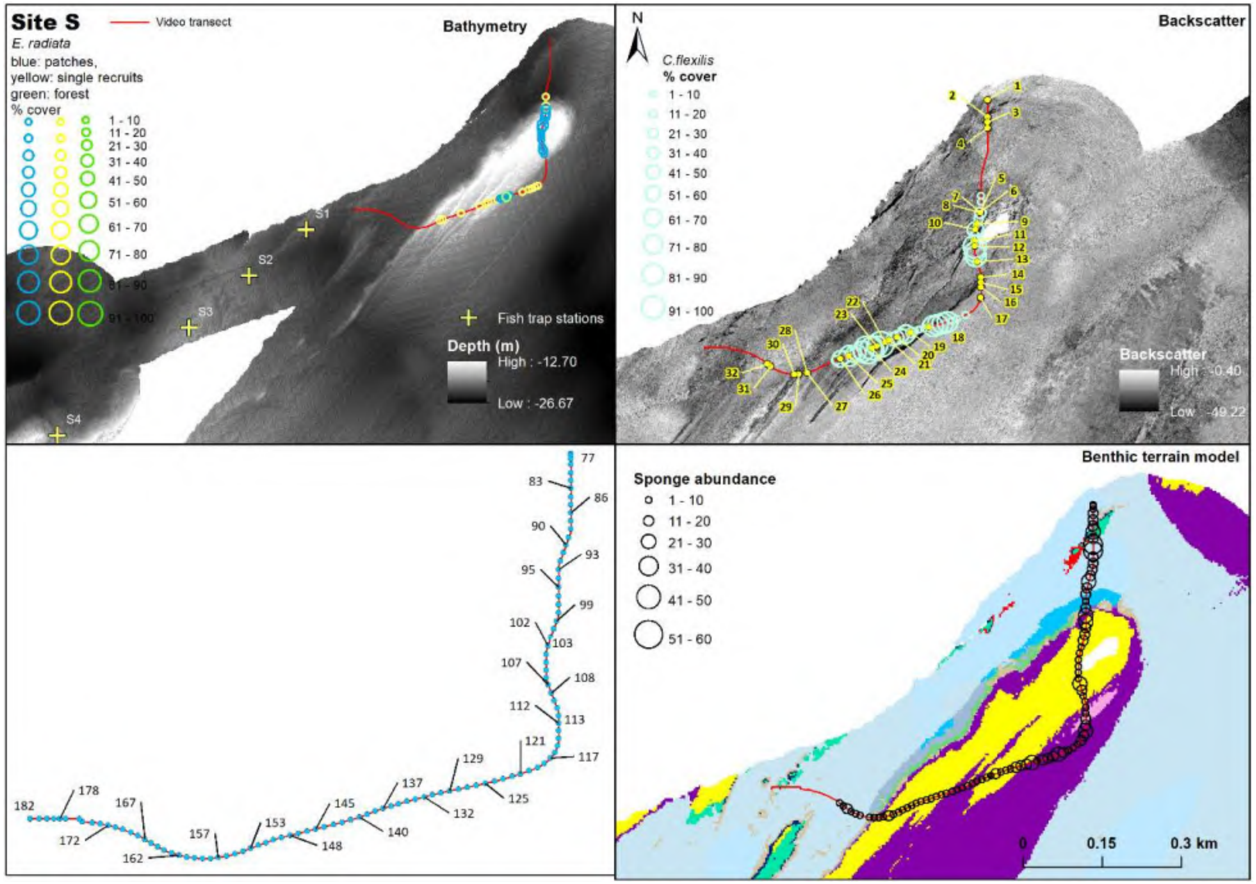

Figure 3-48: Maps of site S Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment). Note that the grey scale colour ramp used to best illustrate the sites depth range 'washes out' some shallower reef complexity.

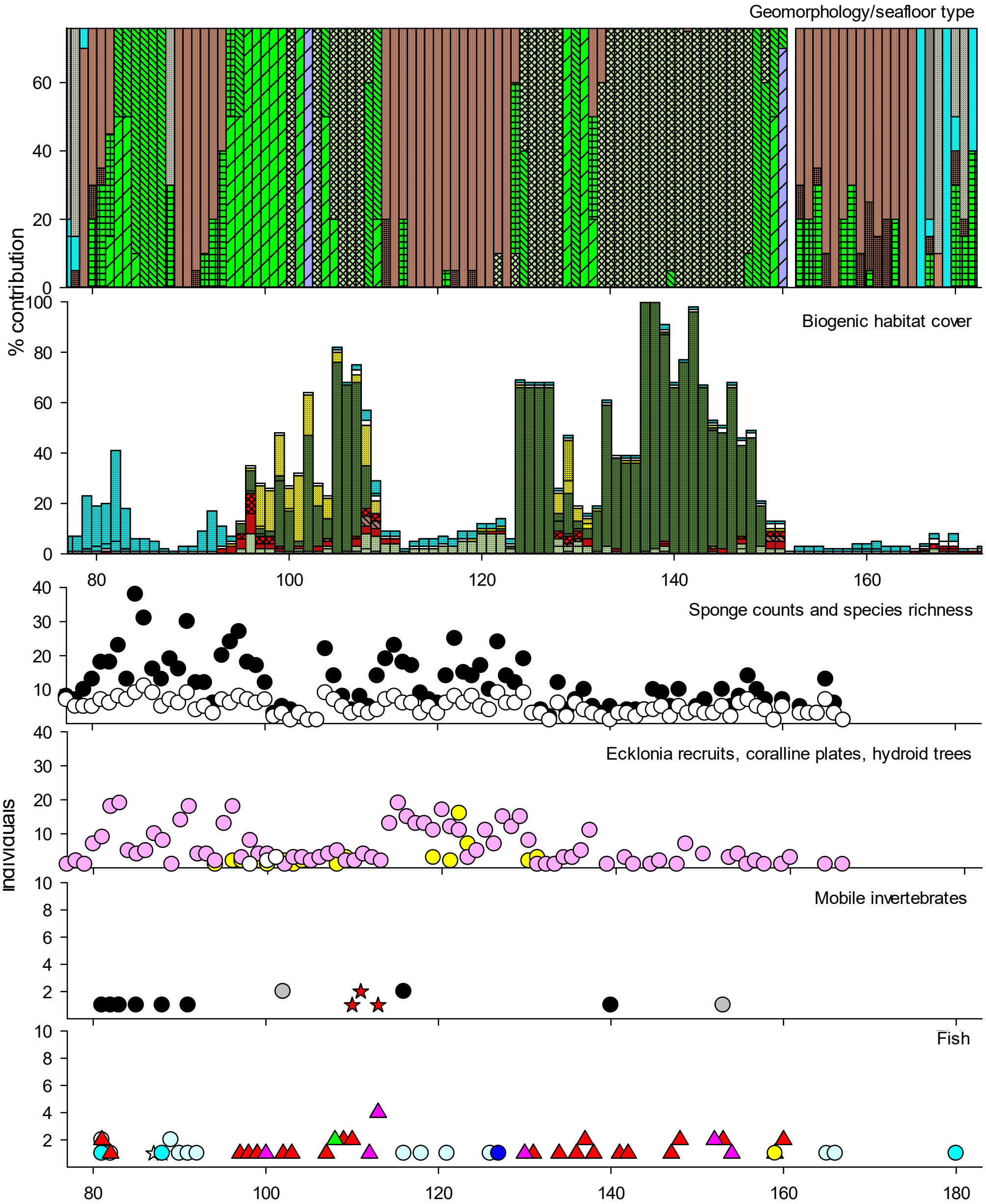

Figure 3-49: Site S CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); invertebrates, and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-48.

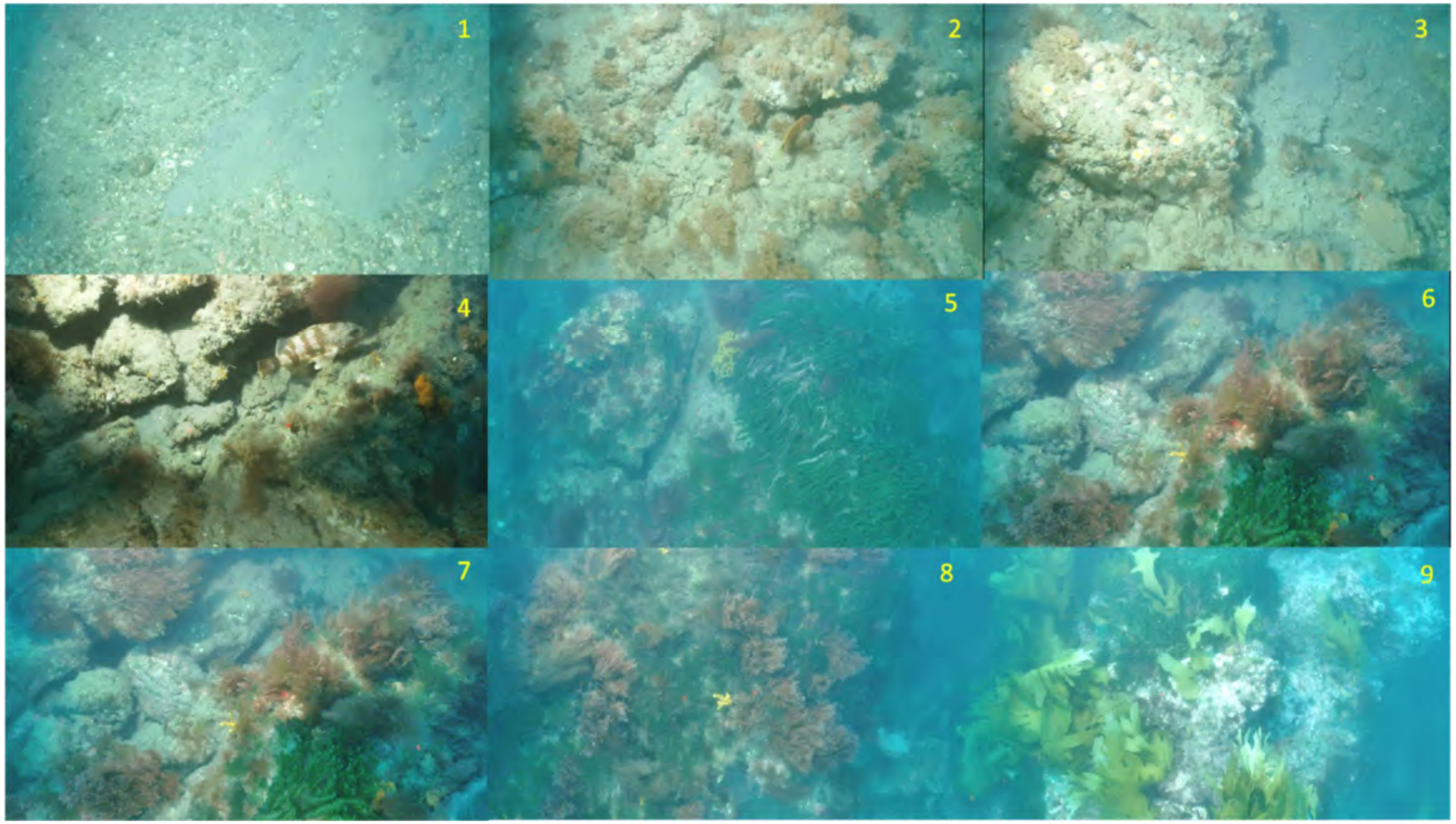

Figure 3-50: Site S seafloor images image numbers are plotted spatially in Figure 3-48 over multibeam sonar back scatter: 1) bare rock tell (mudstone/Papa rock) overlain with soft sediments; 2–4) low reef and boulders (not part of main reef), with soft bryozoans and anemone (*Anthothoe albocincta*) associations and one of two sea perch seen across the survey; 5–7) low broken rock with *C. flexilis* and red algae); 8) step terrace and drop); 9) reef top area with *Ecklonia* forest.

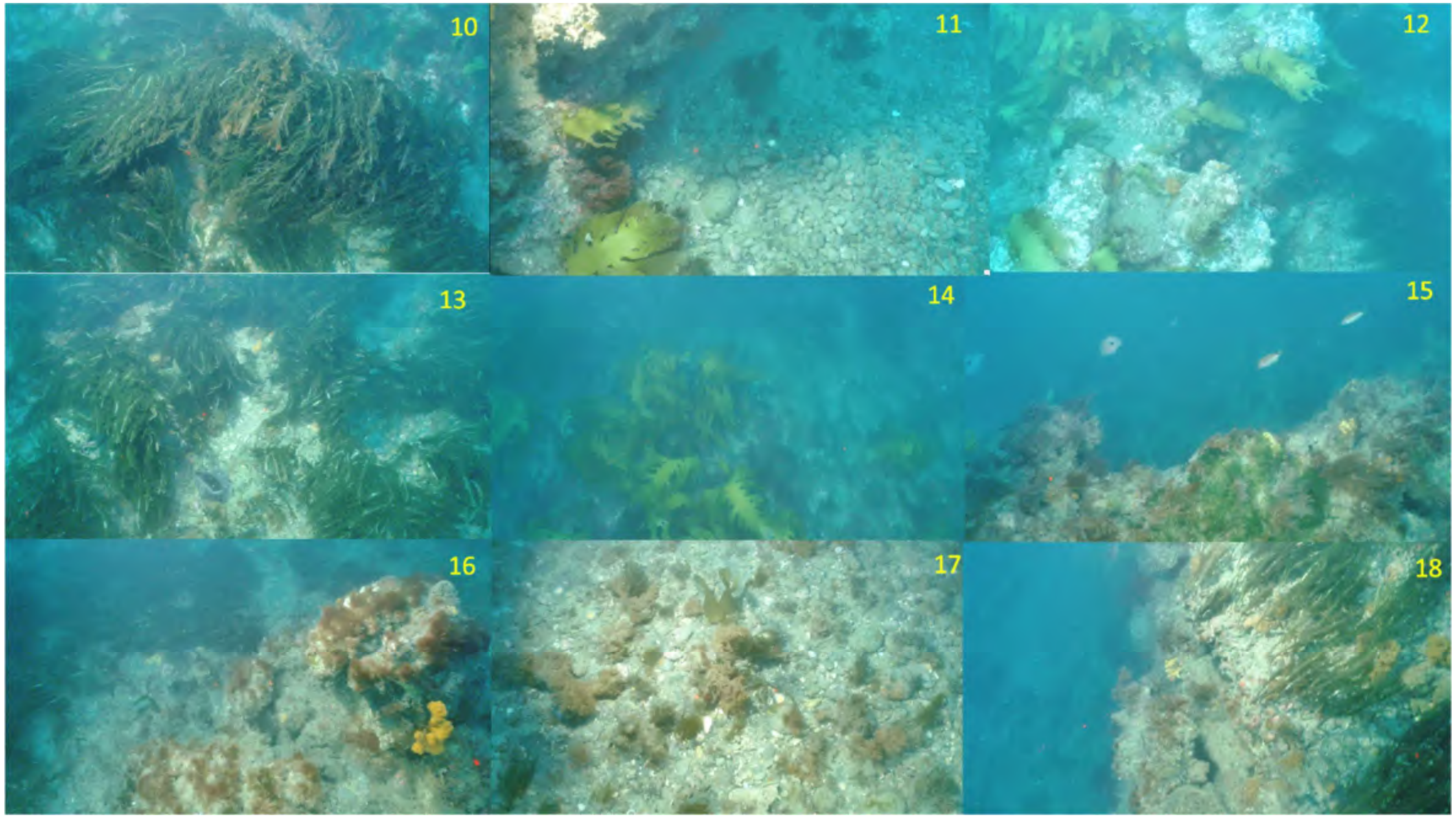

Figure 3-50: Continued. 10–12) reef top area with *C. flexilis* and *Ecklonia*; 13–15) terraces and drops; 16–17) off-reef low rock and irregular cobbles with soft bryozoans (to east of reef); 18) terrace and drop.

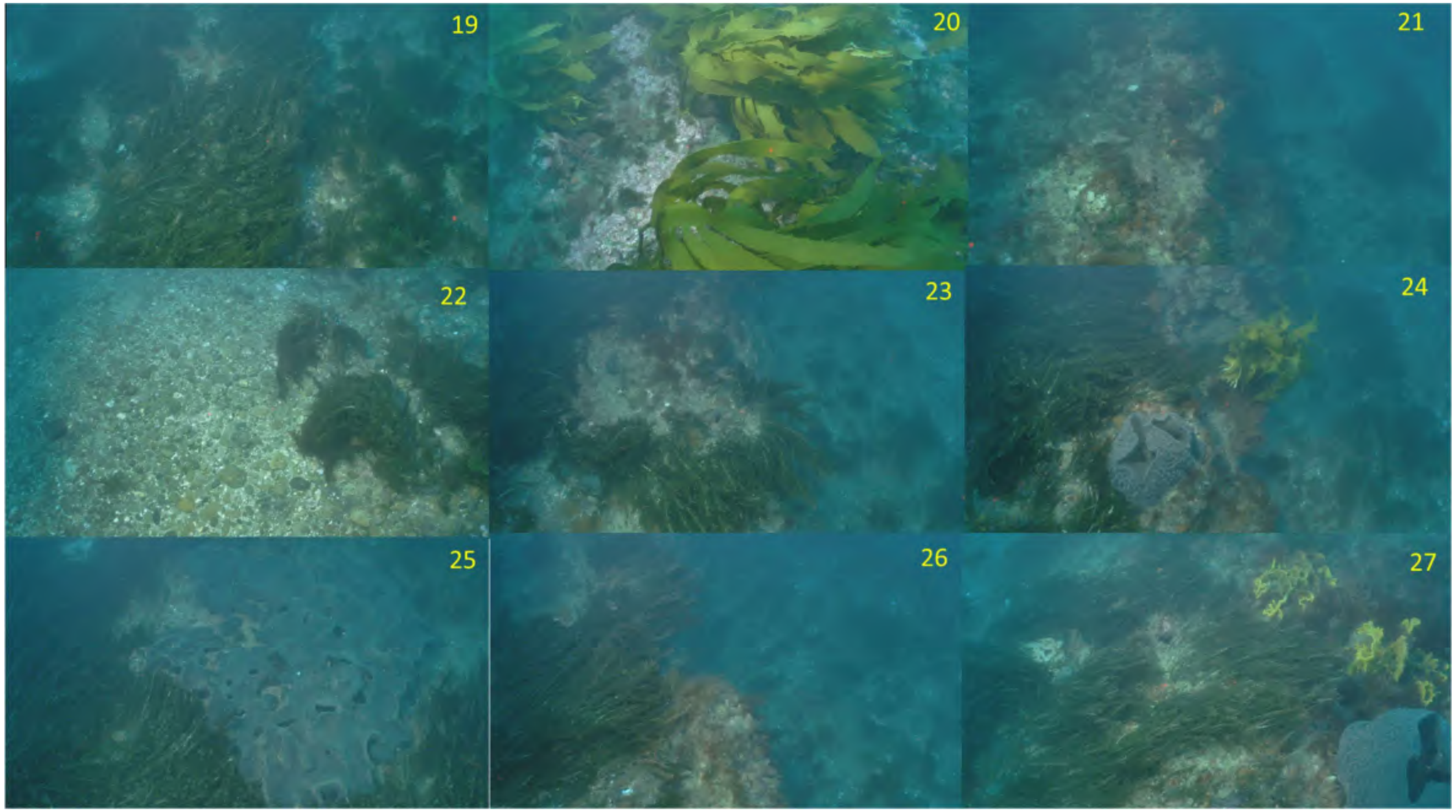

Figure 3-50: Continued 19) terrace with *C. flexilis*; 20) reef top with *Ecklonia*; 21–27) reef terraces and drops, with a large *E. alata* sponge associated with *C. flexilis* meadow (25).

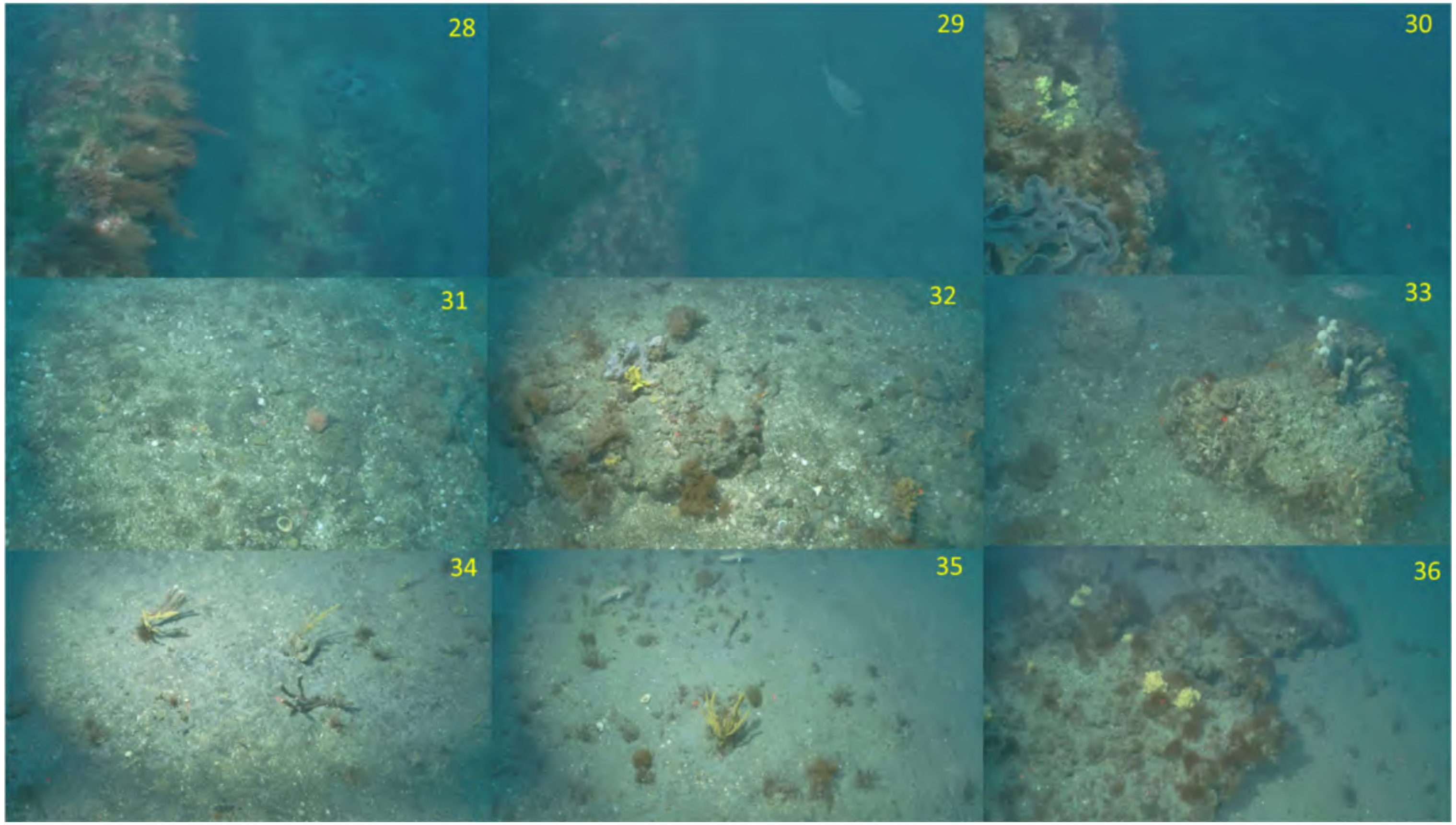

Figure 3-50: Continued 28–30) reef terraces and drops; 31) soft sediments; 32–33) boulders with associated soft bryozoans and sponges; 34–35) soft sediment veneer on flat rock surface, with yellow finger sponges *Axinella* sp. (possibly *Axinella australiensis*), grey sponge *Dactylia varia*, and blue cod; 36) low reef with soft bryozoans and sponges.

3.6.12 Site T

Depth range. 18.7–28.7 metres **Reef size**: 7,101 m^2

Form. A large triangular rock, composed of five terraces with intervening bathymetry drops, orientated west-east. The reef rose from soft sediments at 24–25 metres depth, to the shallowest depth of 18.7 m (6–7 m reef height). Dimensions along the longest two axes were 126 x 95 metres. On the west side, the reef was initially in the form of large, discrete, raised rock slabs surrounded by soft sediments; before becoming continuous reef.

A separate area of low broken rock was present 120 metres to the south-east.

Part of a larger area of reef features, with a discrete series of ridges and large rock outcrops, which included sites S, T, and U (Figure).

BTM Divisions (west to east along video transect): Flat Plains → Local Depressions, Current Scours → Broad Slopes → Flat Ridge Tops → Rock Outcrop Highs, Narrow Ridges → Flat Ridge Tops → Flat Plains → Flat Ridge Tops → Flat Plains (Figure 3-51).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-51 to Figure 3-53)

Geology. The video transect traversed the reef for 95 metres, crossing a series of flat terraces, separated by abrupt bathymetry changes (Figure 3-51). On the western side the reef first appeared as small tells (2), then discrete large, raised rock slabs (3) surrounded by soft sediment, then full continuous reef terraces (4–12), ending on soft sediments on its eastern side (13). A separate area of low broken rock patches were also present to the east (15,17).

Biogenic Habitats: The video transect started to the west of the reef block, on a gravel seafloor (1,2) with no visually-apparent epifauna present (Figure) followed by small rock tells off the main reef, which supported sponge patches (2). Large, raised rock slabs then appeared, with some sponge cover (3), followed by the reef proper. Composed of terraces, the reef had a variable mixed cover of *C. flexilis* and *C. gemmata*, red foliose algae, filamentous green algae, and bushy bryozoans (4–14). *E. radiata* single kelp plants and patches were present (5,7) but relatively uncommon and occurred largely on the upper shallower reef area. Moving east, the reef gave way to gravel seafloor again (14–18), with an area of low patch reef 120 metres to the east supporting a low biogenic habitat cover of filamentous red algae, bushy bryozoans, and sponges (15).

Main invertebrate species: Sponges and bushy bryozoans were the most common sessile invertebrates, with overall low cover of 0.49% and 0.45% respectively (Table 6). The dominant sponge taxa were the Family Chondropsidae species 2, with lesser numbers of *S. conulosa*, the pink ball sponge *Aaptos globosa*, *R. topsenti*/*Axinella* sp. indet., and the low yellow foamy *D. oxeata* (Table 7). Sponge richness and abundance were relatively consistent across the reef feature, with lower values on the low broken rock and gravel patch mosaic to the east (Figure).

Mobile invertebrates were uncommon, with low numbers of the starfish *Coscinasterias muricata* and cushion stars on the soft sediments to the east of the main reef feature, and the sea-slug *A. luctuosa* on the reefs (Table 7, Figure). One saw shell *A. heliotropium* was seen, while no kina were observed.

Main fish species: Butterfly perch, scarlet wrasse, and blue cod dominated the fish assemblage, with leatherjackets being the only other species seen (Table 8). All the butterfly perch occurred as one diffuse school, spread across two contiguous video segments over the main reef (Figure). Scarlet wrasse occurred as individuals spread across the main reef, while blue cod were found on the reef/soft sediment boundary, and in association with the low broken rock/gravel mosaic to the east.

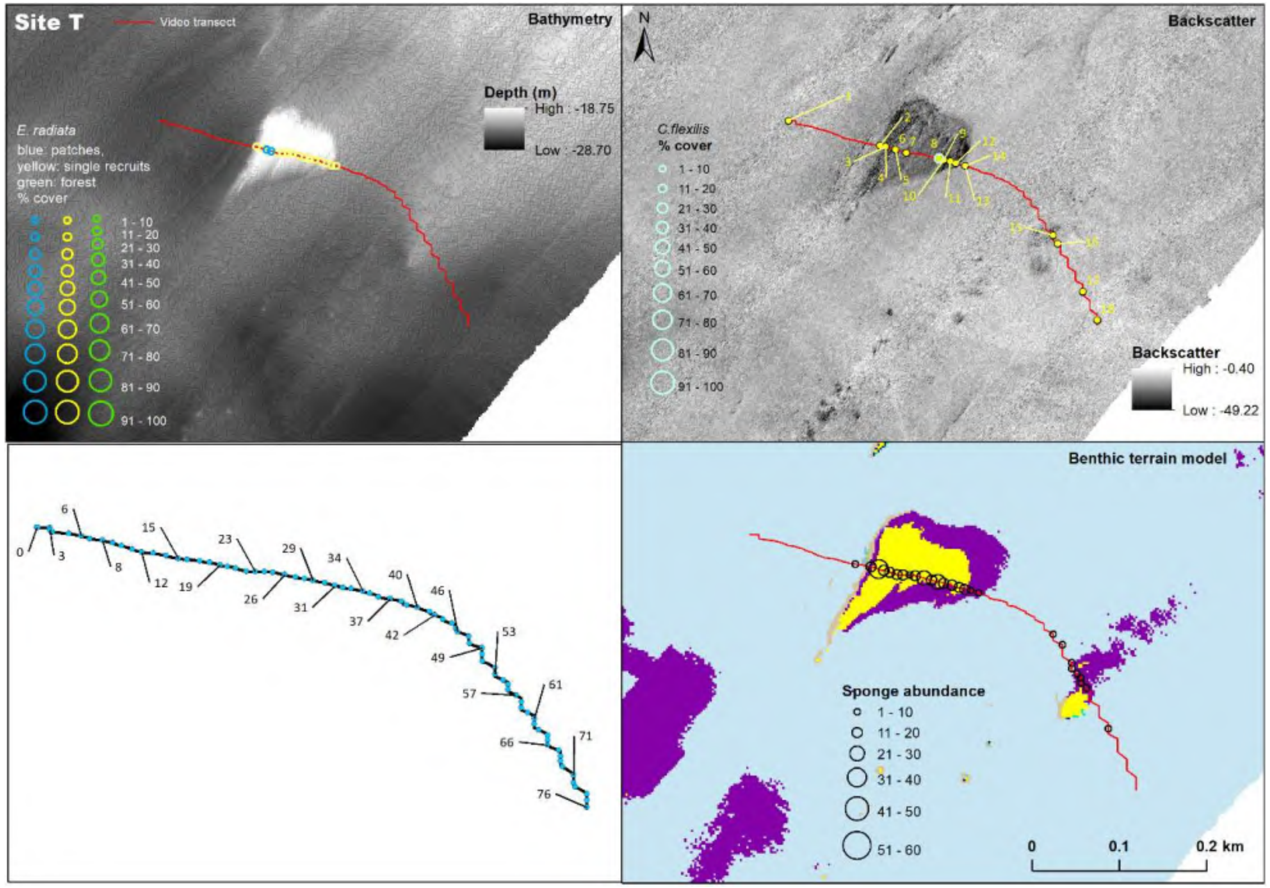

Figure 3-51: Maps of site T Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

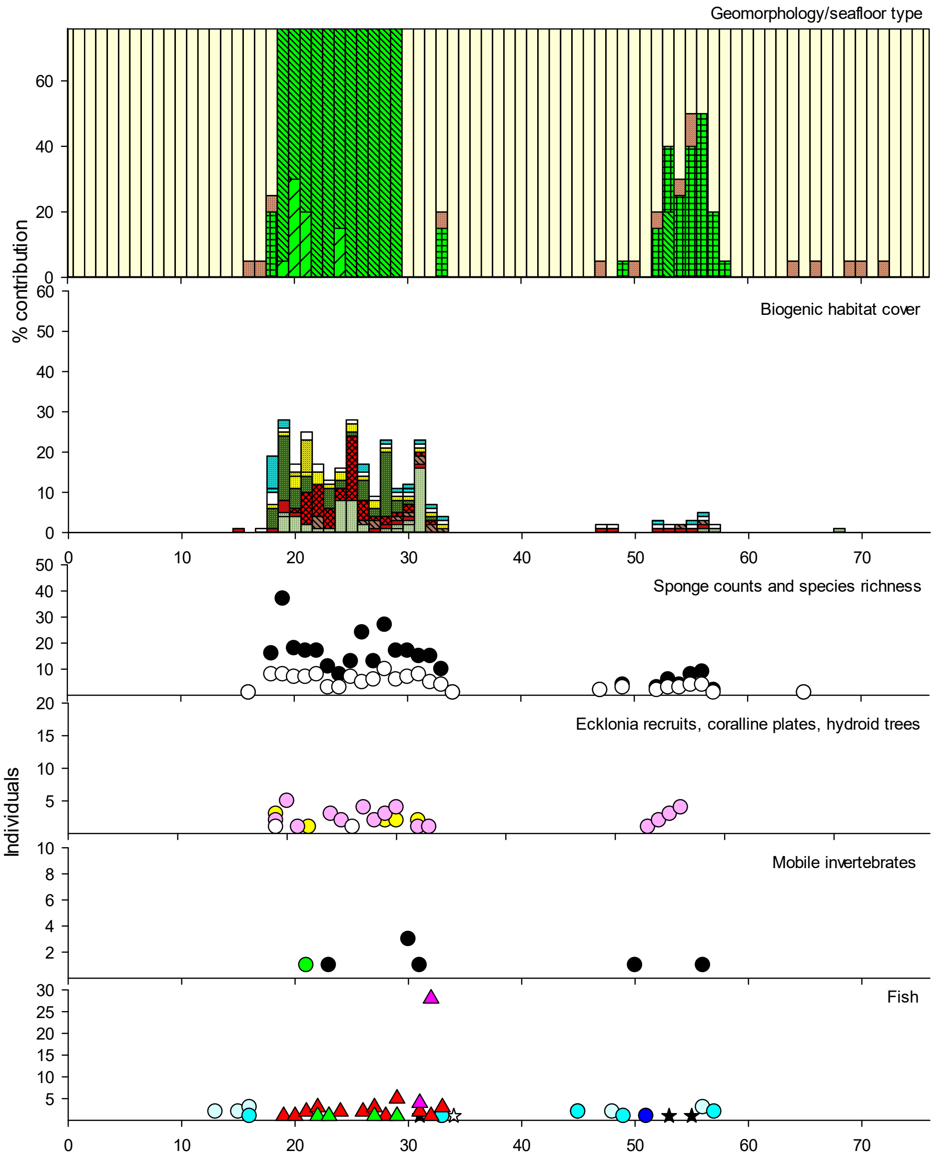

Figure 3-52: Site T CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-51.

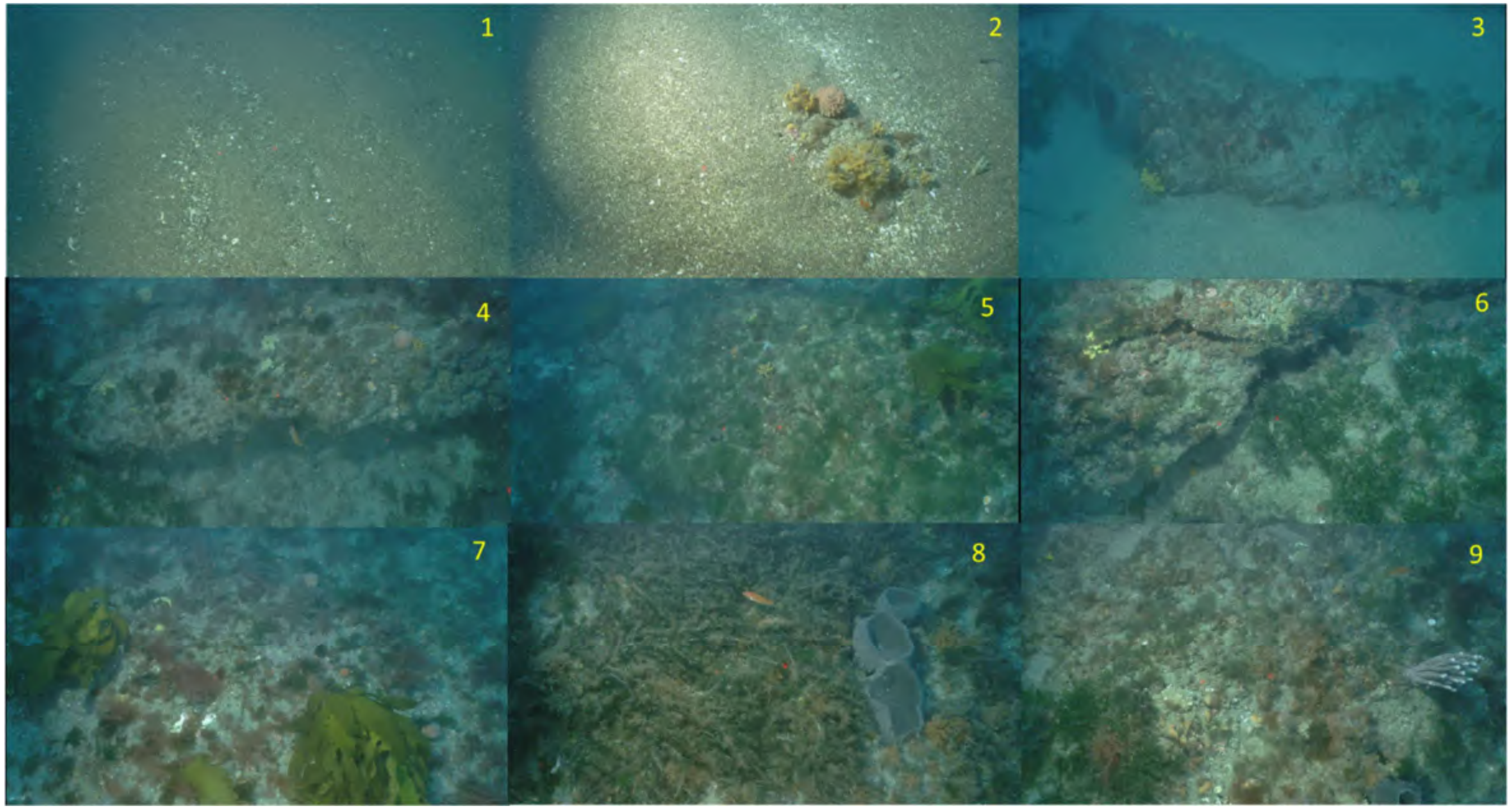

Figure 3-53: Site T seafloor images image numbers are plotted spatially in Figure 3-51 over multibeam sonar back scatter: 1) soft sediments; 2) reef tell with sponge cluster; 3) patch reef with sponges; 4–9) stepped terraces with *C. flexilis*, red algae, *Ecklonia* and sponges

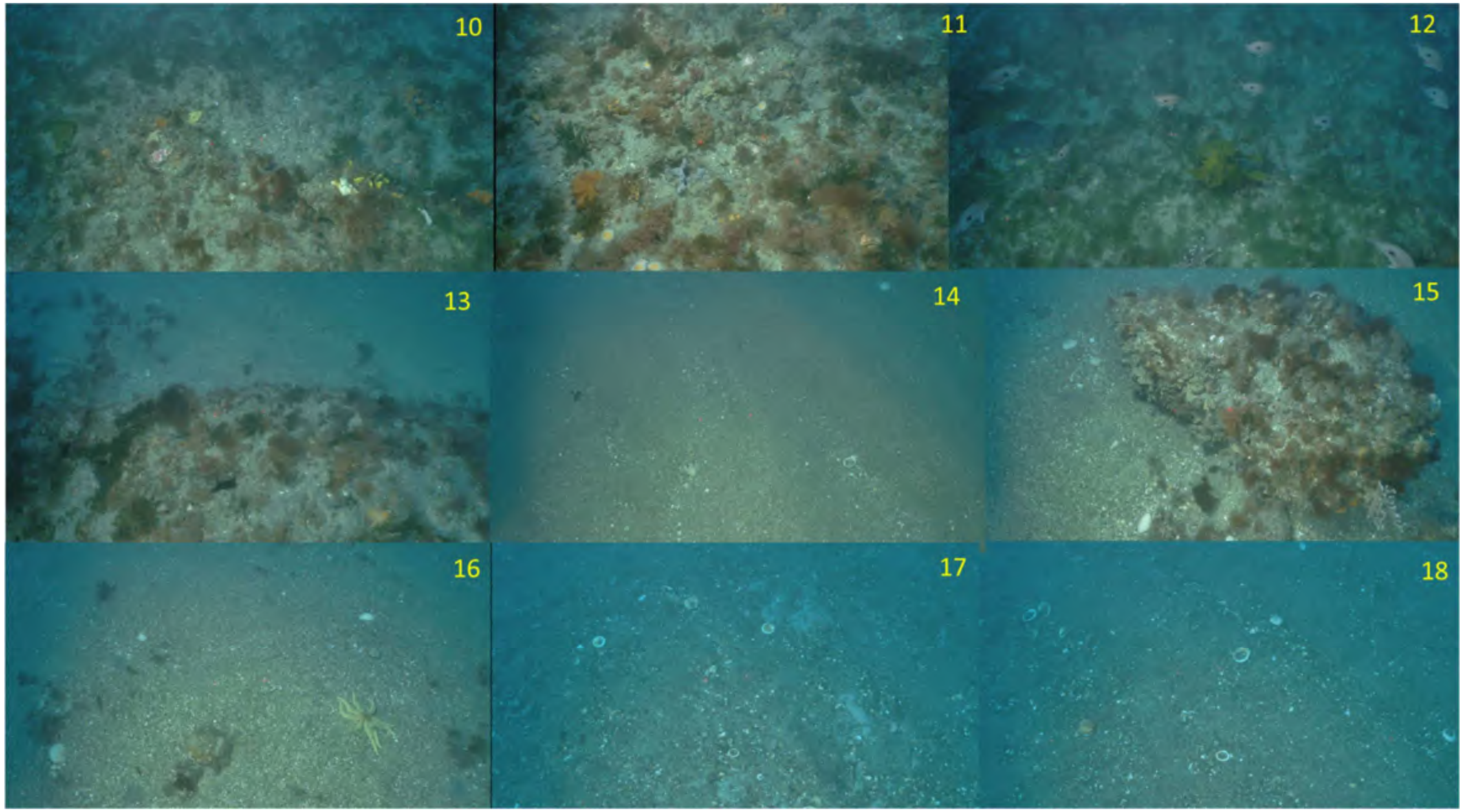

Figure 3-53: Continued 10–13) stepped terraces with *C. flexilis*, red algae, *Ecklonia* and sponges, and part of a school of butterfly perch (12); 14) bare sediment; 15) boulder with soft bryozoans; 16) starfish *C. muricata*; 17-18) tells (probably mudstone/Papa rock but are slightly bumpy), and soft sediments.

3.6.13 Site U

Depth range: 16.9–29.2 metres

Reef size: Reef U#1, 22,695 m^2, Reef U#2 part of a much larger complex (10x longer), difficult to estimate boundaries

Form. The video transect crossed two reefs/reef complexes. These were part of a much larger surrounding series of extensive ridge reef (Figure).

Reef U#1 was a large 580 metre-long elongated rock feature, orientated north-east/south-west. Tapered at its two ends, it spanned 50 metres at its widest point. It rose from around 23 metres depth, up to 16.9 metres (i.e., 6 metres in height).

Reef U#2 was part of a much more extensive reef complex, that ran parallel to Reef U#1, around 70 metres to the west (Figure 3-55). The most northern extent of U#2 started parallel to the most northern extent of Reef U#1 and ran parallel to Reef U#1, but then it continued south-west as a ridge feature for around 4.5 kilometres (Figure). A further reef ridge complex (not video surveyed) started 450 metres south-west of Reef U#1, and then ran parallel to the Reef U#2 ridge complex, for 3.6 kilometres (Figure).

BTM Divisions (east to west along video transect): Flat Plains → Flat Ridge Tops → Crevices, Narrow Gullies over elevated terrain → Rock Outcrops High, Narrow Ridges → Flat Ridge Tops → Narrow Gullies over elevated terrain → Lateral Mid-slope Depression → Local Depression, Current Scours → Flat Plains → Flat Ridge Tops → Rock Outcrop Highs, Narrow Ridges → Lateral Mid-slope Depression → Steep Slopes → Broad Depression → Broad Slopes → Local Ridges, Boulders, Pinnacles on Slopes → Flat Plains → Broad Slopes → Local Ridges, Boulders, Pinnacles on Slopes → Rock Outcrops High, Narrow Ridges (Figure 3-55).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-55 to Figure 3-57)

Geology. Reef U#1 had an initial sharp reef boundary edge (4), followed by upward sloping rock flats that rose to the reef top (5–7), where the reef was fractured by several large crevices/cracks (8,9) (Figure 3-55). The reef then sloped down to the west, as a series of large broken slabs (9,10) before grading into soft sediment flats (11,12).

Reef U#2 began as pebble/cobble seafloor, and then as low flat rock (15,16). This rock then dropped down a slope (17,18), where it merged into coarse sand seafloor (19). The video transect then swung around to the east, and re-crossed Reef U#2, traversing initially small patches of reef surrounded by sand (20), and then continuous low broken reef (21–27).

Biogenic habitats: The soft sediment flats at the start of the transect were composed of poorly sorted coarse and shell (Figure). Unlike most other sites, these soft sediments supported a low but widespread cover of macro-algae, including individual green (brown) shrubby macroalgae, *E. radiata* singles, and some *Carpophyllum maschalocarpum* kelp. Several (five) recessed (alive) scallops were also observed, the only live scallops seen in the survey; although very occasionally, recently dead shells had been seen elsewhere on reef edges (possibly a result of octopus predation), and out on soft sediment plains. Reef U#1 appeared as an abrupt boundary of rising solid reef, with an associated school of large adult butterfly perch (4), and spotties. A narrow band of very healthy (dense, fronds without damage, good colouration) *E. radiata* kelp forest extended from the reef edge up the reef for about 15 metres. This forest gave way to bare rock with turf and occasional sponges, along with kina at sufficient densities (>1–2 m^2) to be called ‘urchin barrens’ (6,7). At the reef crest, several large fractures/cracks were evident (8,9), and a small patch of (putatively) jewel anemones present (8). The reef then sloped down as a series of large rock slabs, with variable patch cover of *E. radiata*, to soft sandy sediments. After a short distance, a pebbly seafloor appeared, which had a variable biogenic habitat cover of green (brown) shrubby macroalgae (10–50% cover), along with lesser contributions of *E. radiata* individuals and *C. flexilis*.

Reef U#2 began as flat rock with *E. radiata* patches and single plants cover (15, 16), followed by the reef sloping down (17,18) to coarse sediment flat (19). These coarse soft sediment flats held numbers of the finger sponge *Callyspongia ramosa*, at the highest densities seen during the survey. The video transect then turned east to return to Reef U#2, where small rock patches were surrounded by soft sediments (20) with *C. maschalocarpum* (singles, some groups of 2–3 plants) kelp plants being a notable occurrence. Full low reef cover then appeared, with an initial relatively high cover of sponges at the edge of the reef (21,22), which was quickly replaced by variable *E. radiata* cover (individuals, patches, forest), as well as green (brown) shrubby macroalgae and *C. flexilis* (23–27). Occasional sponge patches on raised rock were also apparent (27).

Ecklonia forest was the dominant biogenic habitat, with a percent cover of 11.11% (equivalent to sites Q and R, 10.03–10.73%). *Ecklonia* forest covered 7.58% of the rock-based habitats, with Ecklonia patches of 2.93% cover, and singleton plants covering 0.60 of the reef. The kelp distribution on the two reefs differed from the other reef sites. For Reef U#1, *Ecklonia* formed a narrow forest on the east side of the reef, which started flush with the soft sediment boundary, and extended up the reef slope for around 15 metres (#350–352) before being replaced by 'kina barrens'. This forest may extend north and south along the reef side to form a narrow eastern side kelp forest up to 580 metres long (Figure). Beyond the urchin barrens and past the reef ridge, *Ecklonia* forest re-appeared (#371–372) in association with a roughly 45 degree reef slope, forming a second narrow forest band, that also may extend along the reef side to form a second narrow western side kelp forest up to 580 metres long. *Ecklonia* was largely absent from the reef ridge top.

Reef U#2 had no elevated ridge feature, but rather was a narrow rocky reef slope that dropped around three to five metres, separating two soft sediment flats. The video transect first crossed this slope square-on to reveal an associated narrow *Ecklonia* forest, moved onto soft sediments, and then turned back to run along the U#2 reef slope feature, where *Ecklonia* forest continued to be present. This suggests that a long narrow *Ecklonia* forest could be associated with the 4.5 kilometre long Reef U#2 (Figure); and with the 3.5 kilometre long reef feature east of it (not video surveyed).

Main invertebrate species: Sponges were the most common sessile invertebrates, with overall low cover of 0.52% (Table 6). The dominant sponge taxa were Family Chondropsidae sp 2, with lesser numbers of the grey cone *S. conulosa*, yellow-broken ridge *C. incrustans*, and the finger sponge *C. ramosa* (Table 7). Sponge richness and abundance values were relatively consistent across the reef features, with some higher abundance sponge video segments values associated with reef edges.

Kina were restricted to a narrow band of high densities, definable as urchin barrens, on reef U#1 (Figure). Other species present in lower numbers, and more widely distributed across the reefs, included saw shells and Cooks Turban.

Main fish species: Blue cod were relatively abundant, with all size classes well represented, including 0+ juveniles, who contributed 25% of the 256 individuals counted (Table 8). Butterfly perch were also relatively abundant, occurring as small schools associated with the more abrupt bathymetric shifts (Figure). Scarlett wrasse and leatherjackets were also common, along with lesser numbers of goatfish.

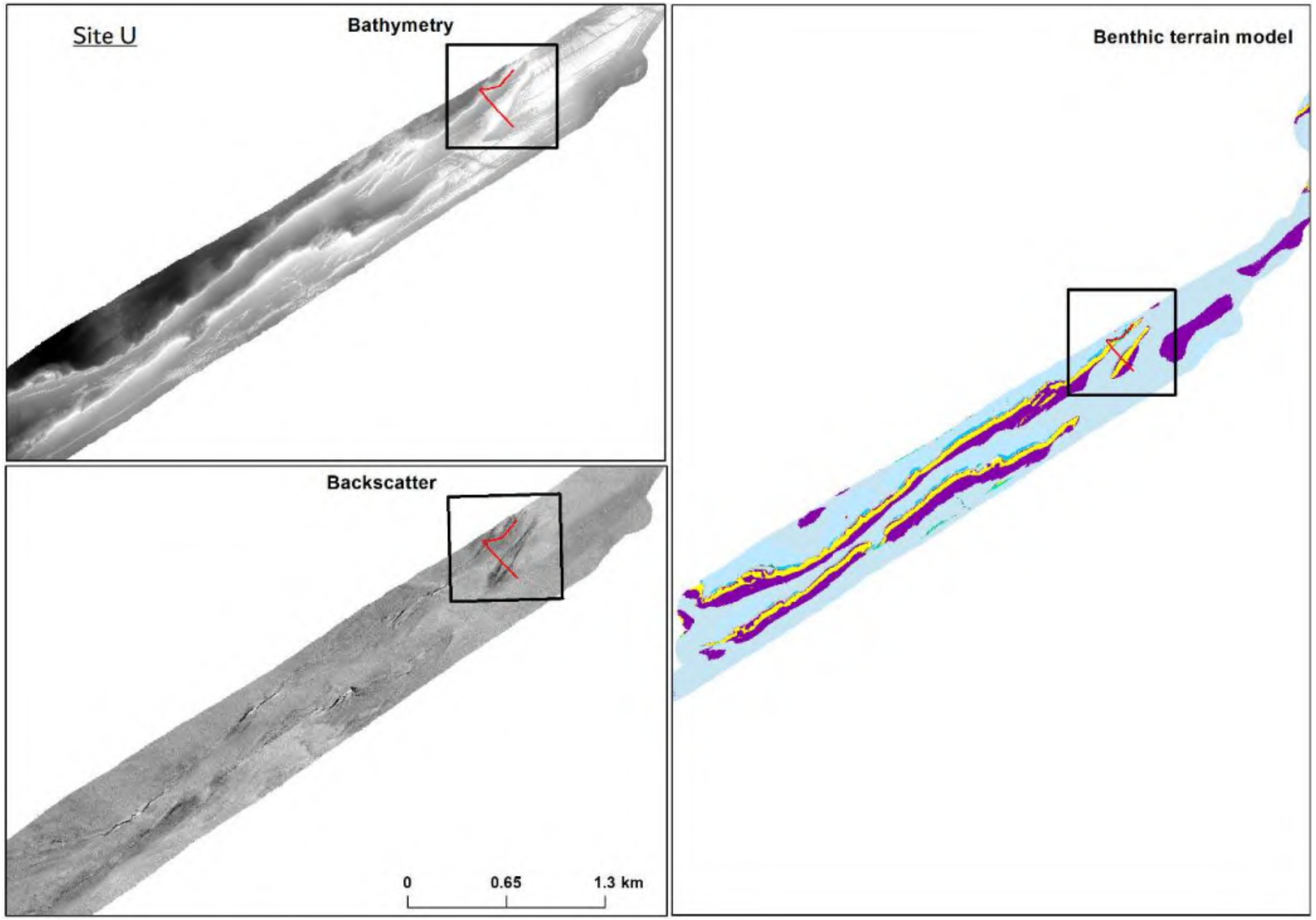

Figure 3-54: Broader extent maps of larger seafloor area mapped (reef and other unknown features) around sites R, S and T.

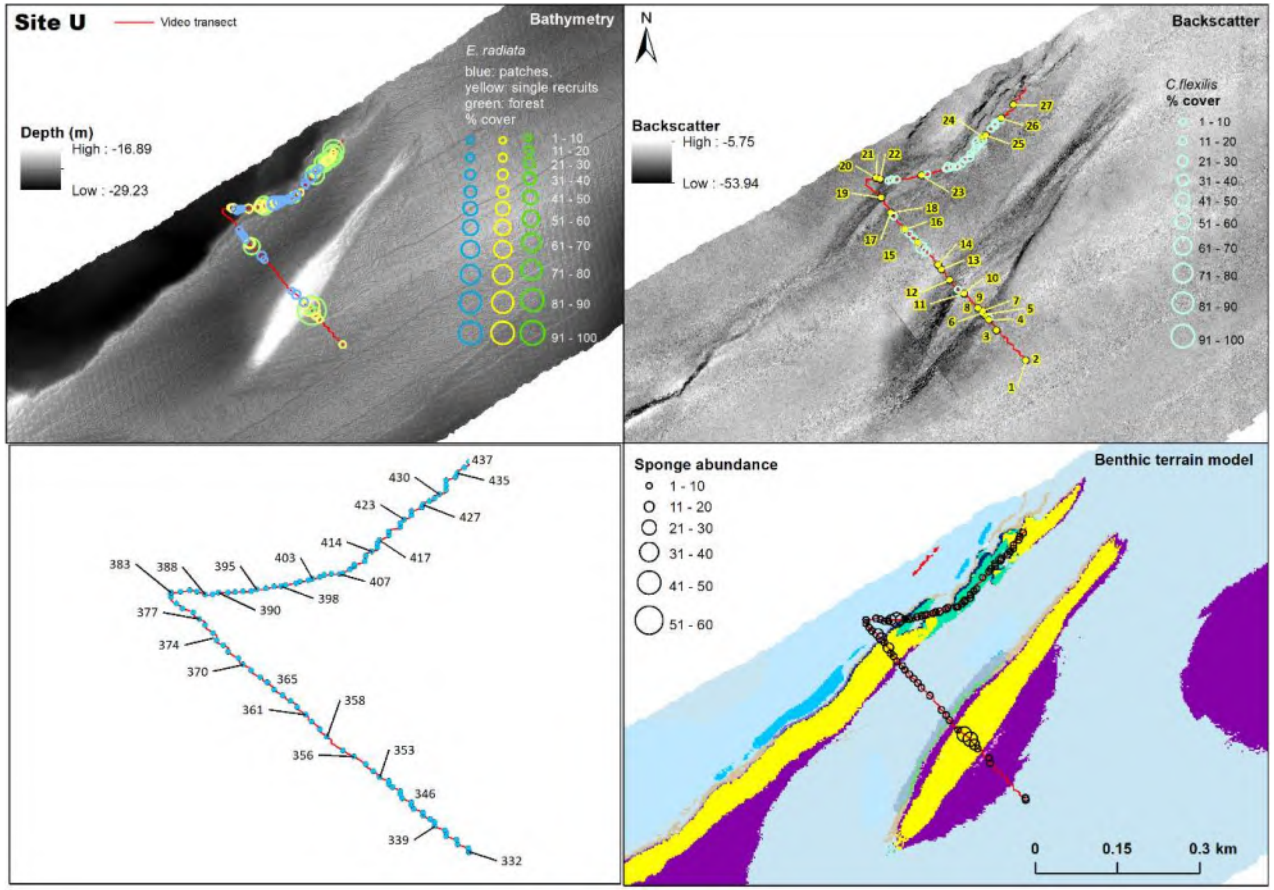

Figure 3-55: Maps of site U Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers; top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

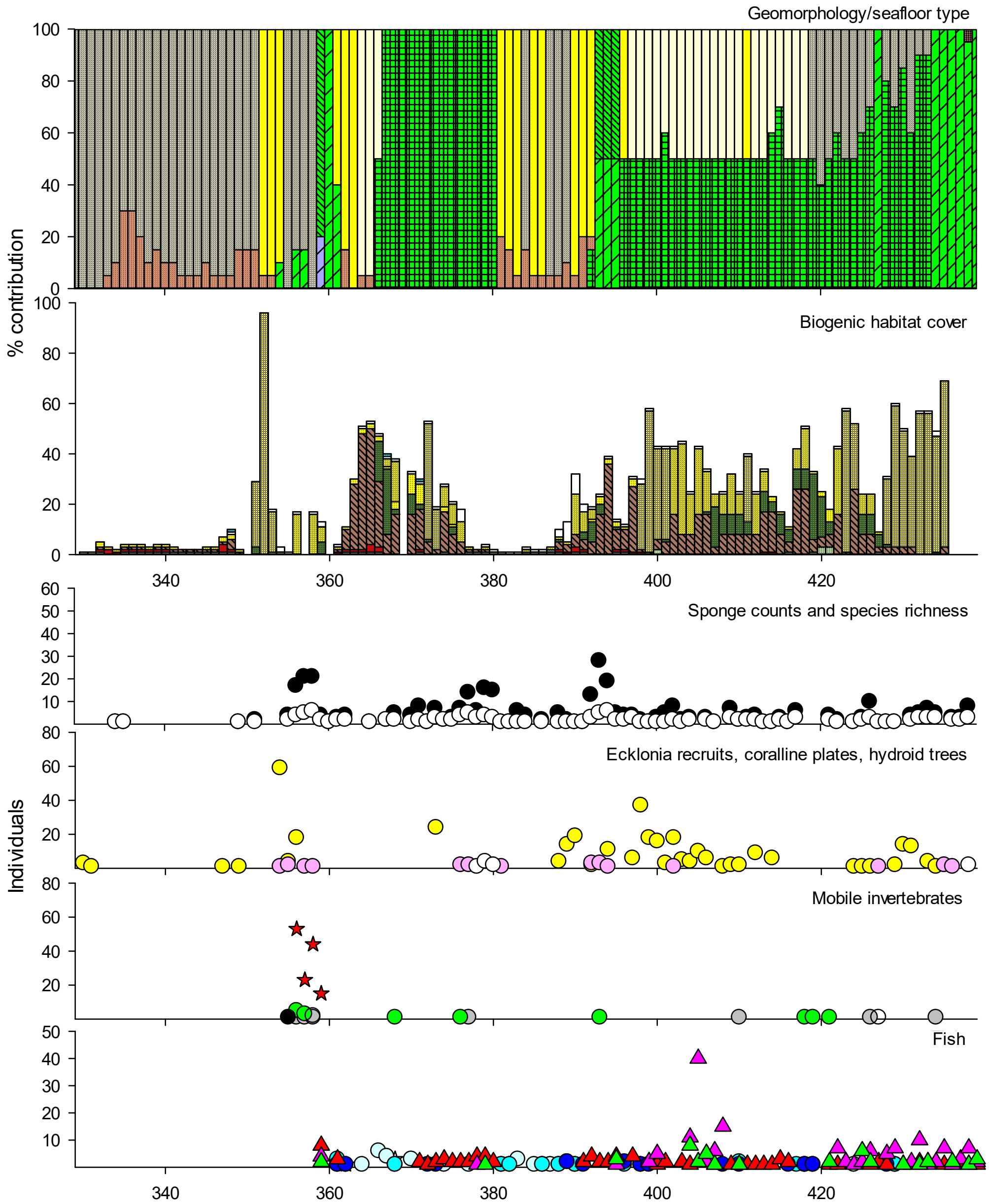

Figure 3-56: Site U CoastCam data geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-55.

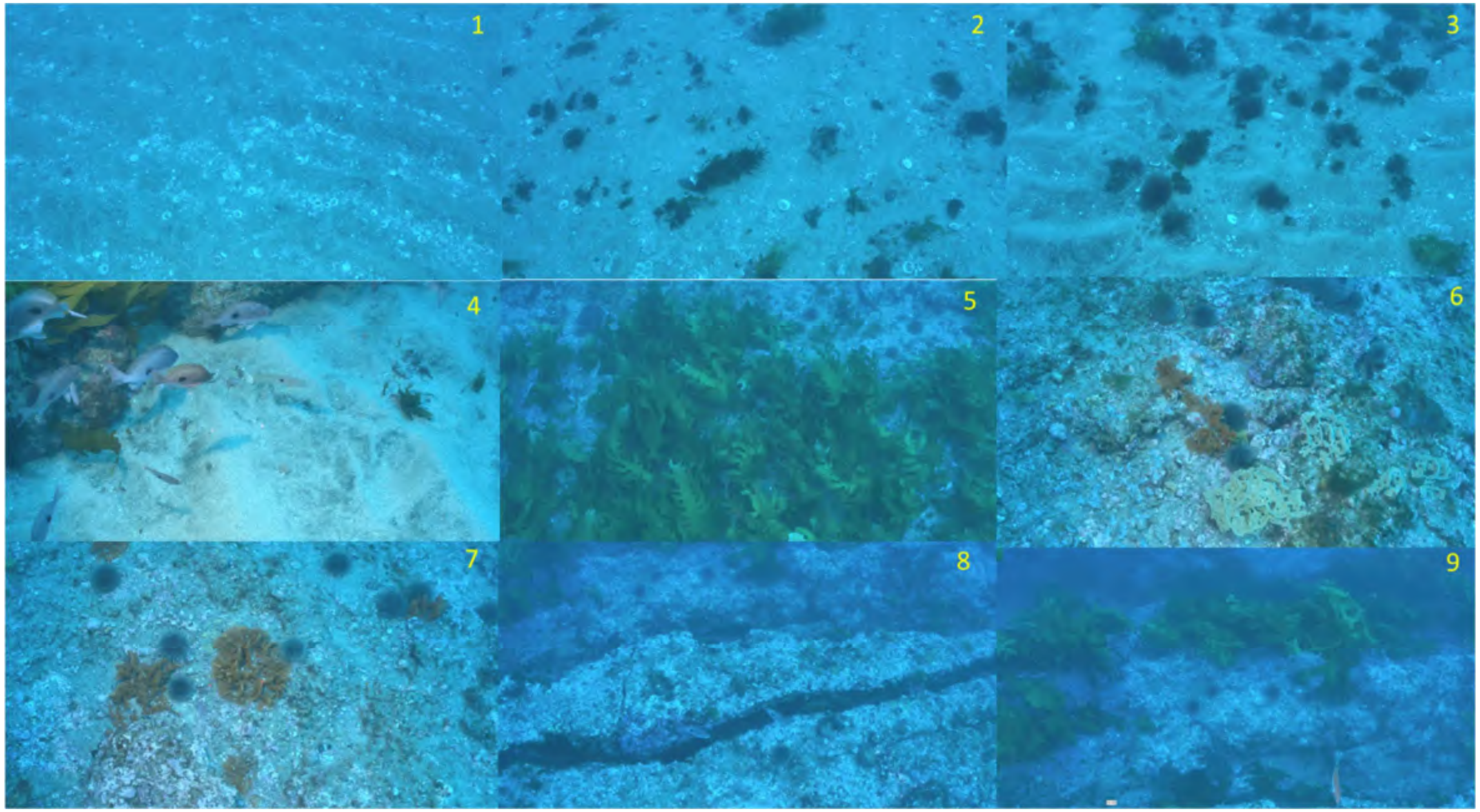

Figure 3-57: Site U seafloor images image numbers are plotted spatially in Figure 3-55 over multibeam sonar back scatter: 1) soft sediments; 2) soft sediments with associated lower density *E. radiata*, *C. maschalocarpum*, small red and brown algae species, and occasional live scallops (not shown, *Pecten novaezelandiae*); 4) reef U#1 edge with butterfly perch and start of *Ecklonia* forest; 5) *Ecklonia* forest edge adjacent to kina barren; 6–7) kina barren; 8) large crevices/fractures on top of reef; 9) reef slope with *Ecklonia*.

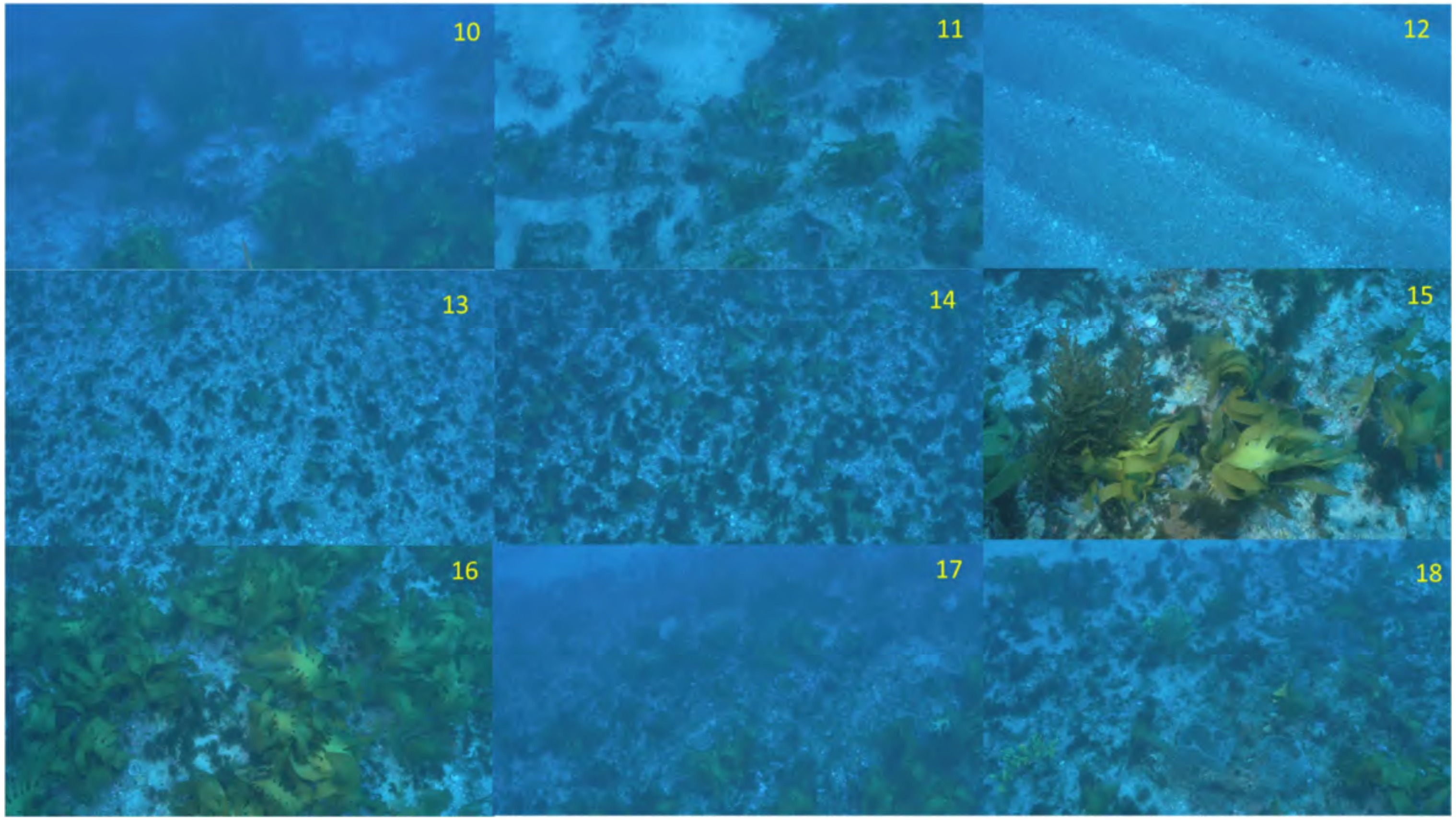

Figure 3-57: Continued 10) reef slope (large blocks) with *Ecklonia*; 11) bottom of reef slope grading into soft sediments; 12) soft sediment; 13–14) pebble/cobble field with attached macroalgae meadow; 15–16) top edge of Reef U#2 with *Ecklonia*; 17) Reef U#2 slope with *Ecklonia*; 18) bottom of Reef U#2 slope grading into soft sediments.

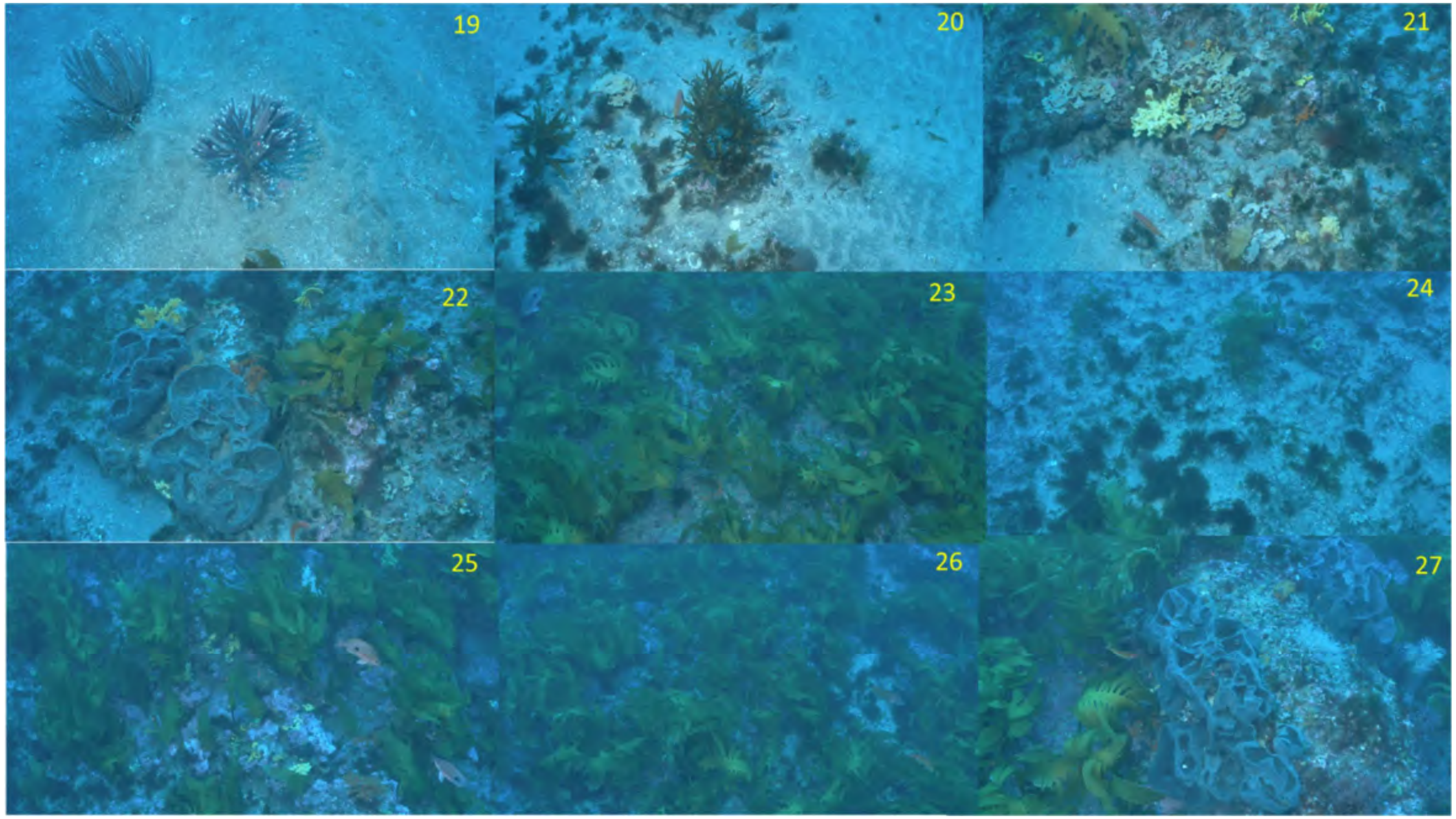

Figure 3-57: Continued 19) sediment flats with *C. ramosa* sponges; 20) patch reef with *C. maschalocarpum* kelp; 21–22) sponge clusters on the edge of Reef U#2; 23) *Ecklonia* forest; 24) green (brown) shrubby algae and *Ecklonia* singles; 25–26) *Ecklonia* forest; 27) *E. alata* sponges on rock outcrop surrounded by *Ecklonia* forest.

3.6.14 Site V

Depth range. 32.7–38.3 metres

Reef size: 14,007 m^2 (two patches, V#1 9,919 m^2, V#2 4, 088 m^2)

Form. Two separate low reef features. The larger southern feature (Reef V#1) formed a low irregular mound, around 124 x 97 metres in cross-section, with a further 115 metre long low extension eastward from its lower western edge (Figure 3-58). The reef was mainly flat sheet rock platforms with low drop-offs (40–50 cm), and an area of raised broken rock in the central area with a maximum height of around 2.5 metres from the surrounding soft-sediments. The rock appeared to be a breccia form. Numerous small reef patches and tells were present on its southern side, where the base rock slightly protruded in spots from sandy sediments.

The smaller northern reef feature (Reef V#2) was rectangular (around 132 x 48 metres) with its longest axis orientated east/west. Located around 170 metres to the north-east of Reef V#1, it was formed of the same flat breccia sheet rock as the southern reef and rose to maximum height of around 1.5 metres. The flat sheet rock was more continuous that at Reef V#1, but with 'seams' filled with soft sediment and several low terrace raises (around 30–60 cm) gaining height from west to east.

The 170 metres of seabed between the two reefs was of coarse sand across the southern half, and dog cockle shell drifts (possibly with live animals present) in the northern half.

BTM Divisions (south to north along video transect):

Flat Plains → Flat Ridge Tops → Flat Plains → Flat Ridge Tops → Rock Outcrop High, Narrow Ridges → Flat Ridge Tops → Flat Plains → Flat Ridge Tops → Rock Outcrop High, Narrow Ridges → Flat Ridge Tops → Flat Plains Flat Ridge Tops → Rock Outcrop High, Narrow Ridges → Flat Ridge Tops → Flat Plains (Figure 3-58).

Physical and biogenic habitat seafloor composition, and taxa abundances (Figure 3-58 to Figure 3-60)

Geology. Reef V#1 was formed of small rock sheet outcrops and tells (centimetres to metre scale) emerging from sand (1–5), sometimes with small overhangs (centimetres scale) (3). These small rock features were present along the southern side of the reef for the first 185 metres of the video transect, before the seafloor changed to purely sand. The video transect then turned to transverse the reef proper, which was formed of flat large rock slabs, raised in height from the surrounding seafloor (6–13), some of which were flat, and some gently sloped. An area of slightly higher reef area was present just north of the transect path (as seen by the attached Go-Pro camera as the towed camera turned, not shown here).

Reef V#2 was very similar in form and structure to Reef V#1. At the approach to the reefs, dog cockle shell drifts dominated (15–19), with some small occasional rock sheet outcrops/tells (17–19) embedded in the shell matrix. The reef proper was formed of low slabbed rock surfaces (21–26), with some low terrace rises (going east) (22, 24). The end of the video transect dropped off the raised reef edge to a sandy seafloor with scattered dog cockle shells (26,27). Dog cockle shell drifts covered 9.4%

of the transect (all rock and non-rock segments included) (Table 4). No mudstone/Papa rock tells were seen.

Biogenic habitats: The small rock outcrops/tells on poorly sorted coarse sand and shell seafloor, present along the south side of Reef V#1, supported a high diversity of sponge species with a patchy distribution (Figure). The species diversity and structure provided by this sponge assemblage, and its spatial extent, qualified this area to be defined as a sponge garden.

On the reef proper, the reef edge rose as a low platform about 50 cm in height and was dominated by a diversity of sponges (6). Heading west, the reef was composed of a series of low height flat and sloping rock slabs, interspersed with soft sediments. These slabs supported a further sponge assemblage, as well as low density large *E. radiata* kelp plants (7–13) and could also be defined as sponge garden. A lost anchor (11,12) that appeared to have been on the seafloor for some time suggested that this small extent reef has been previously discovered.

Adjacent to the second reef (Reef V#2) were dog cockle shell drifts, on both the south-west and east sides (which the towed camera traversed). Little live biogenic habitat was seen to be associated with the shells, but the south-east bed also had small rock outcrops/tells which supported low sponge densities. Reef V#2 supported low sponge densities (25), that did not approach the diversity and abundance/cover seen on Reef V#1. *Ecklonia* was also present, and formed occasional small patches (21,22), which were not present on Reef V#1.

Main invertebrate species: Sponges were the most common sessile invertebrates, with an overall cover of 5.57%, the highest percent cover across all 14 reef sites surveyed (Table 6). The dominant sponge taxa were Chondropsidae species 2, the grey spiral sponge *Cymbastela lamellata*, the slender purple finger sponge *Callyspongia ramosa*, the orange/grey/yellow ball sponge *Tedania* sp. indet., and the yellow foamy sponge *Darwinella oxeata* (Table 7). Most notable was the spiral sponge *Cymbastela lamellata*, absent from all the other 13 reef sites except Site A (one individual observed), with 178 individuals counted. Juvenile blue cod were repeatedly observed perched on the top of *C. lamellata* sponges (1). *C. ramosa* finger sponges were also most abundant at this site, with 125 individuals counted (61% of all individuals surveyed). Mobile invertebrates were not common and were dominated by large gastropod species that were not identifiable to species (23 individuals seen) (Table 7). Two Cooks Turban *C. sulcata*, and one saw shell *A. heliotropium* were counted; along with two *A. luctuosa* sea-slugs.

Main fish species: Blue cod were the dominant fish species, with 391 individuals counted (Table 8). Over half of these (59%, 231 fish) were 0+ juvenile fish which were strongly associated with the sponge garden on rock outcrops, the reef edge with associated sponges, and the dog cockle shell drifts (especially where rock outcrops were also present). These close (biogenic) habitat associations, high density of 0+ juveniles, and relatively large areas of these habitats, can be defined as 0+ blue cod nursery habitats. Larger blue cod juveniles (nominally 1+/2+, 13–20 cm) were also common, contributing a further 23% of blue cod present; with the remaining fish >21 cm in size (18%).

Butterfly perch were the second most abundant fish species, and occurred as large schools over the reef proper, especially reef V#1 (see Figure ; Figure). Tarakihi were common in the same area, occurring as smaller discrete schools that intermingled with the butterfly perch schools. Small groups of goatfish were present over the reef-sand interface. Other species present included leatherjackets, of the transect (all rock and non-rock segments included) (Table 4). No mudstone/Papa rock tells were seen.

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The dense multi-species aggregations seen at Reef V#1 (Figure) of butterfly perch and tarakihi, were highly likely to have been underestimated in their abundance. Footage from the forward facing Go-Pro camera indicated some components of the butterfly perch and tarakihi schools were higher in the water column than the field of view of the main high resolution camera. An educated guess from comparing the two camera fields of view was an underestimation of abundance for these school/s of 20–30%.

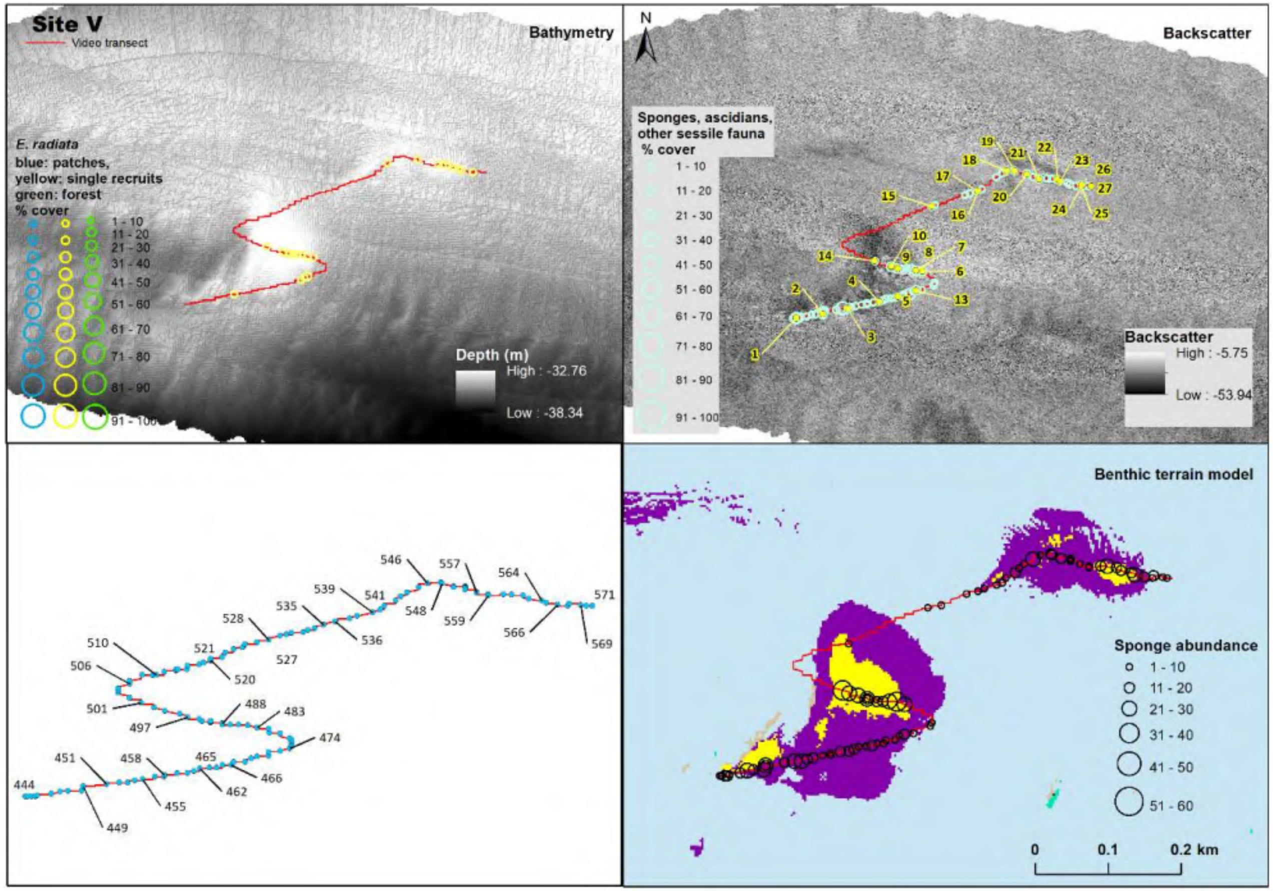


Figure 3-58: Maps of site U Top left) multibeam sonar bathymetry and *E. radiata* kelp %covers;) top right) multibeam beam backscatter and *C. flexilis* green algae %covers; lower left) towed video transect with video segment sequential numbers; lower right) multibeam sonar derived Benthic Terrain Model (BTM) seafloor classes, with sponge abundance (individuals per 20-second video segment).

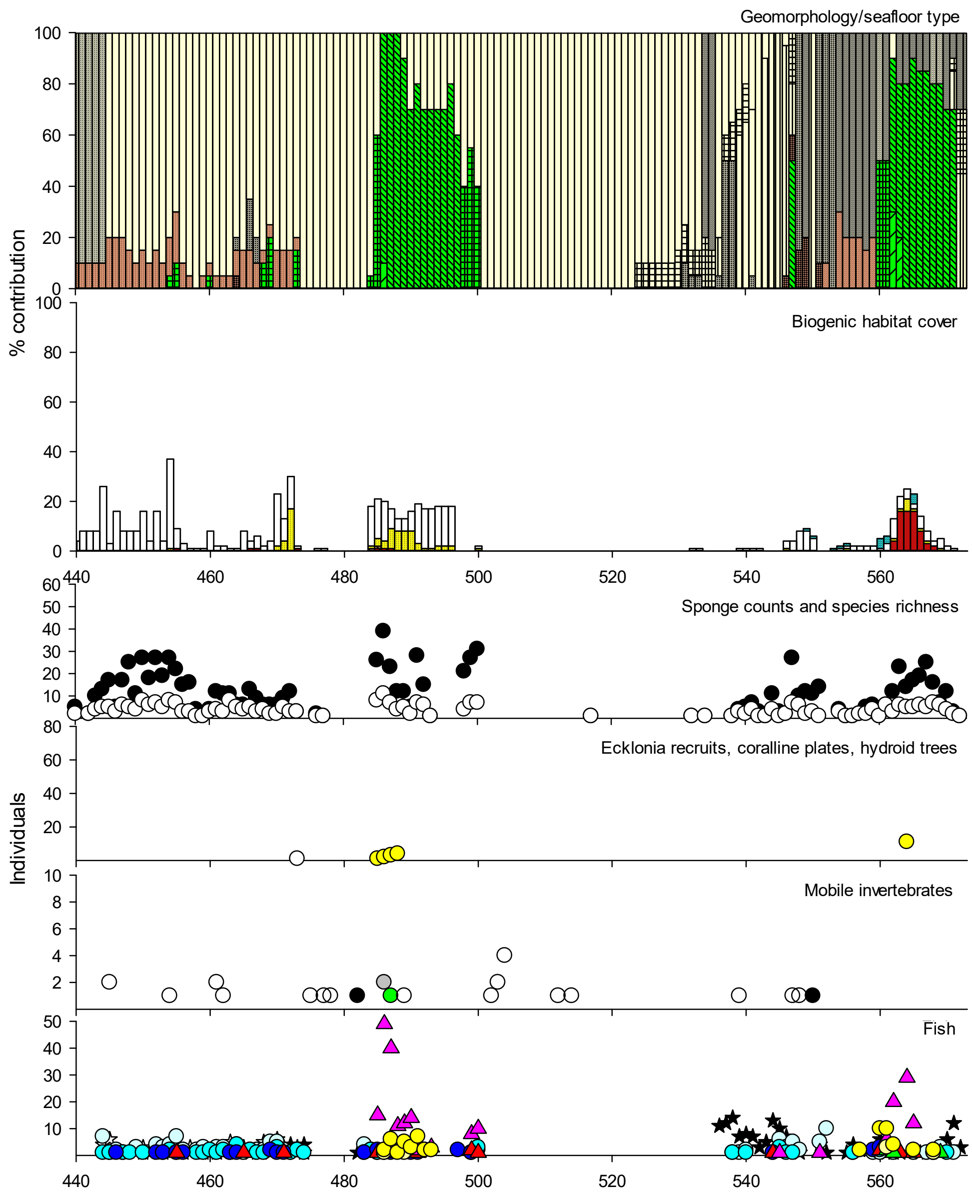


Figure 3-59: Site V CoastCam data: geomorphology/seafloor type, biogenic habitat cover, sponge counts (black) and species richness (white); *Ecklonia* recruits (yellow), coralline plates (pink), and hydroid trees (white); mobile invertebrates; and fish. Class keys are given in Figure 3-11. The x axis plots the sequential spatial position index of the 20-second video segments, which are shown in map form in Figure 3-58.

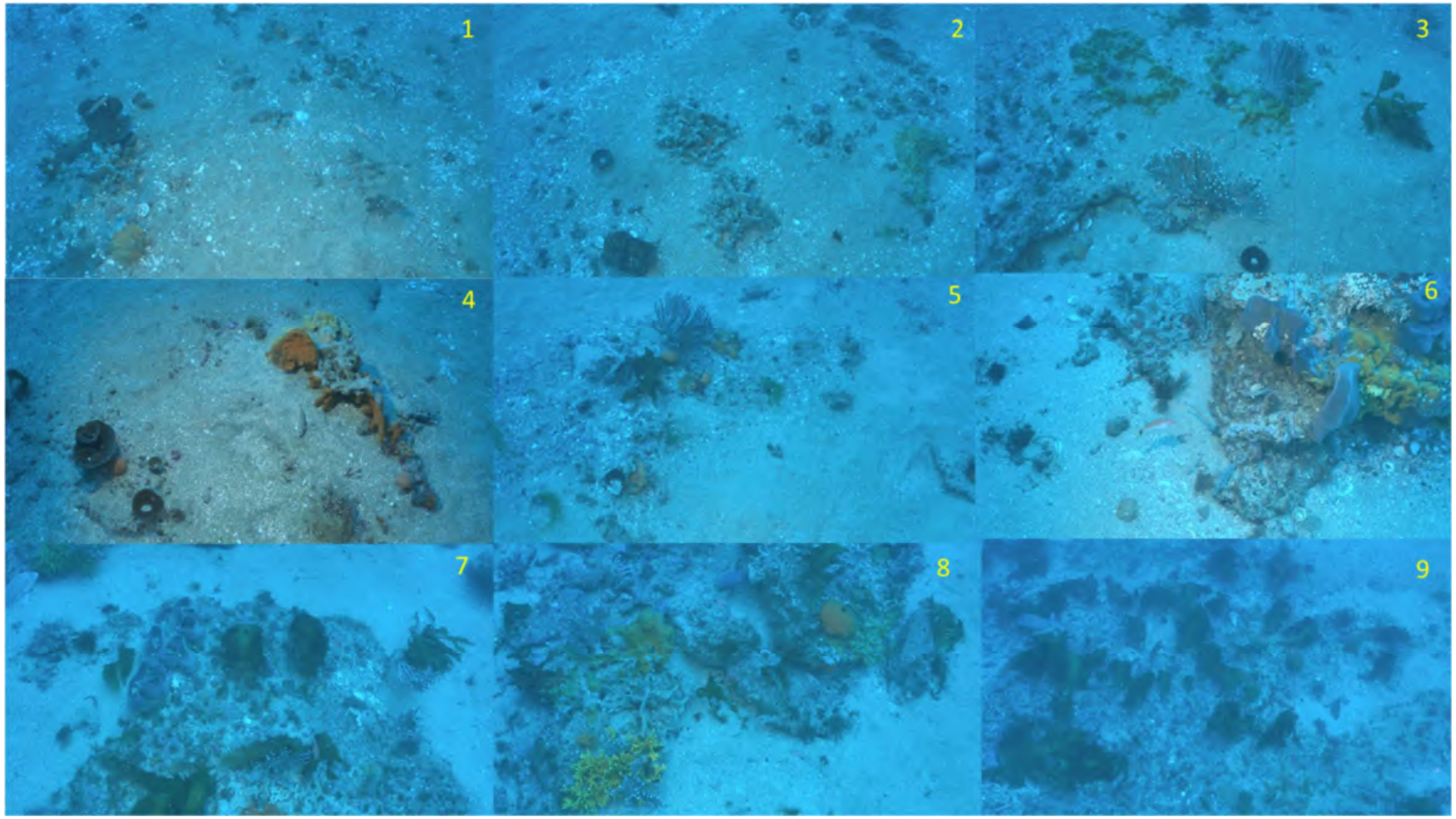


Figure 3-60: Site V seafloor images image numbers are plotted spatially in Figure 3-58 over multibeam sonar back scatter: 1–5) rock outcrops/tells with high sponge diversity and abundance, and associated 0+ and older juvenile blue cod (difficult to see at this image page scale); 6) reef edge with 0+ juvenile cod (see Figure 6 for the same image at larger size, with fish marked up); 7–9) flat slab reefs of Reef V#1 with sponges and large *Ecklonia* singles.

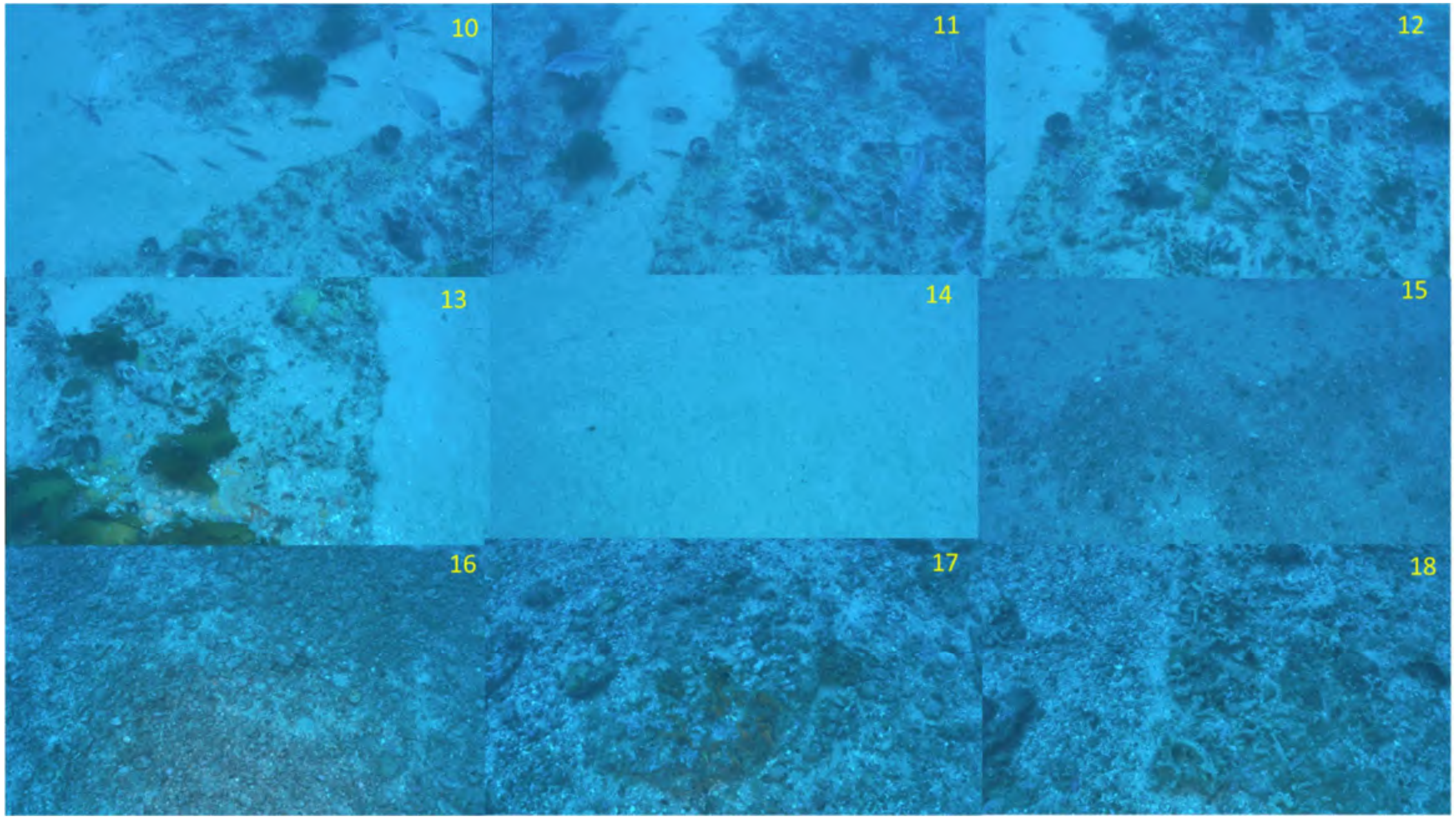


Figure 3-60: Continued 10–12) flat slab reef at Reef V#1 with blue cod, goatfish, tarakihi, butterfly perch and blue moki shown, and a lost anchor in images 11 and 12 – middle right; 13) resting carpet shark; 14) soft sediments; 15–17) dog cockle shell drifts and rock outcrop tells; 18) flat basement reef.

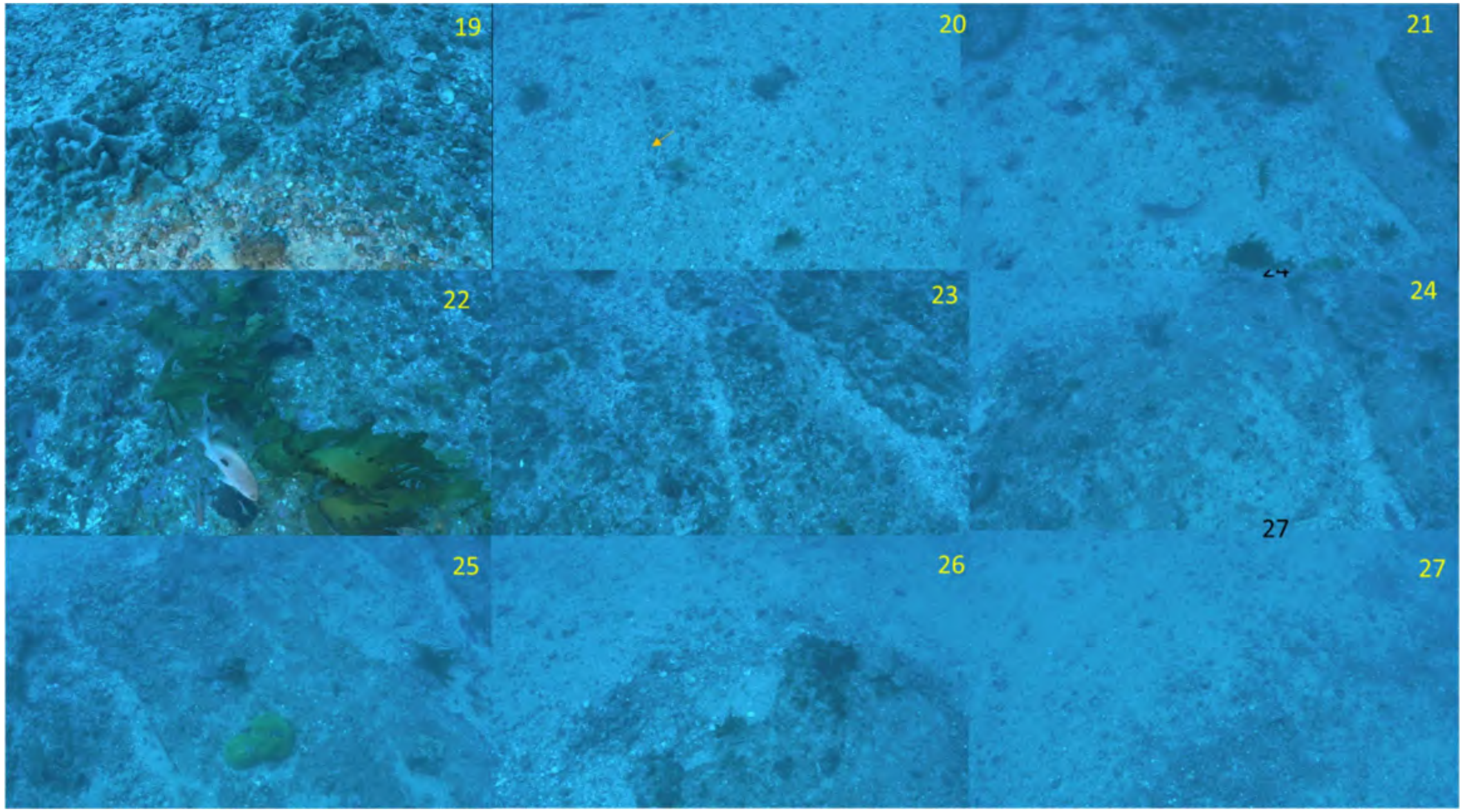


Figure 3-60: Continued 19) dog cockle shell drifts and rock outcrop with sponges; 20–21) start of Reef V#2; 22–26) Reef V#2 low slab reef with 'seams' and low terraces, sponges and *Ecklonia* singles; 26) eastern end of Reef V#2, with adjacent dog cockle shell drifts; 27) off-reef dog cockle drifts.

4 Summary across the 14 reefs

The 14 reefs surveyed have greatly increased our knowledge of the reef structures and their biological assemblages within the South Taranaki Bight. However, this was not a comprehensive survey and the reefs surveyed are just a sample of the overall reef number and complexity on Pātea Bank. Figure summarises the current science knowledge of where reefs are present/may be present on Pātea Bank. The next obvious step will be formal statistical analyses, which will include a formal assessment of what biogenic habitat landscape elements/features are present, where, and in what spatial configurations. In this report, we have presented biogenic habitats largely as percent cover estimates of individual species (e.g., *E. radiata*, *C. flexilis*) or species groups (e.g., macroalgae, and sponge and other sessile invertebrates) at the 20-second video segment scale. Terms such as forest, field, meadow have also been used informally in this report to describe patterns at scales larger than that of the 20-second video segments. These terms describe biogenic habitat features, i.e., how biogenic habitats are described at the large scale of habitat landscapes.

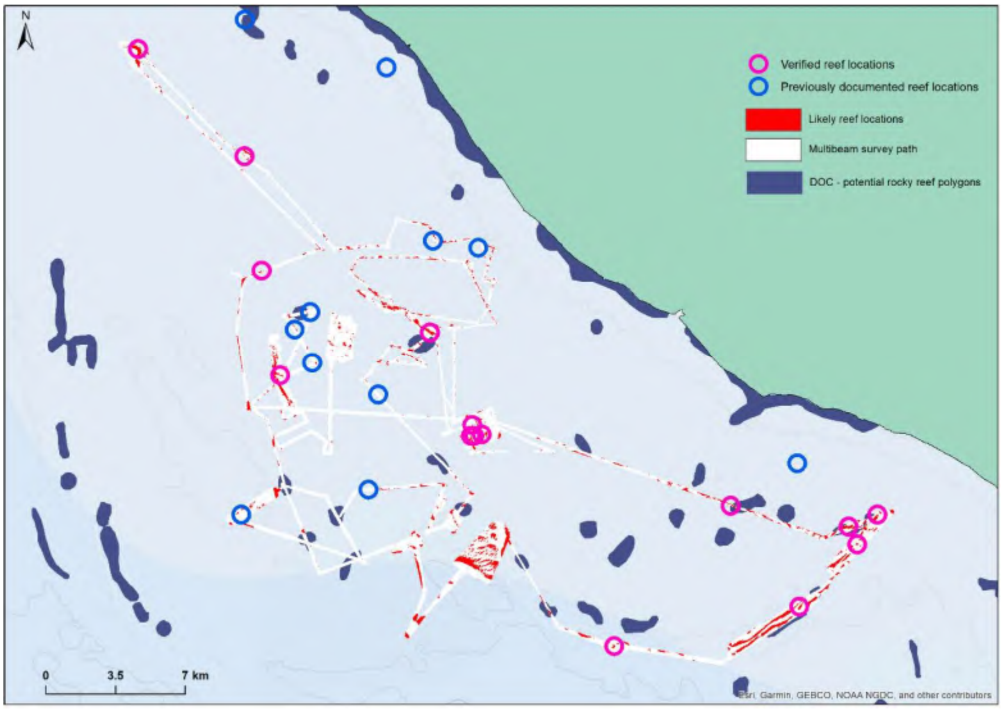


Figure 4-1: Known and likely reefs (by science survey) of Pātea Bank circles denote reefs verified with cameras, red polygons are other likely reefs encountered during multibeam sonar mapping, and the blue polygons putative reefs from DOC assessment of abrupt bathymetric changes on old fairing sheets.

In this report we have used such land-scape terms to describe areas where we have seen selected species occur at sufficient abundance and spatial extent to be considered landscape elements (e.g., *E. radiata* kelp forests, versus *E. radiata* patches and singles). While semi-quantitative only, Table 14 provides an informal summary of those assessments, across the 14 reef sites surveyed, to provide a first broad-brush view of what South Taranaki subtidal reef complexes hold. There are two scales of observations in Table 14: that derived from the multibeam sonar across the full reef; and that derived from the towed video transect, which is a much smaller area of the full reef. It is important to remember that while data from the video transect can give a good proxy of the overall habitat cover of a reef, the numbers derived from it (e.g., spatial extents, percent biogenic over, and species richness) have not yet been scaled to the full reef by depth band, rugosity etc using the multibeam sonar data for scaling.

The data presented in Table 14 are ordered by increasing water depth. There was no obvious depth-related trends in Species Richness (number of species observed) for the three taxon groups listed, but this was unsurprisingly as the overall average depth range across all sites was only 14 m (and individual sites varied in their internal depth ranges from 1.8 to 14.7 m). The two mudstone sites (Papa, D) had the lowest sponge richness values, and some of the lowest mobile invertebrate values; but site D fared better for fish richness (site Papa scored lowest, tied with site O). An important caveat to note is that species richness is a function of the area sampled (the greater the area, the more species are likely to be encountered); these values have not been standardised to area sampled, so direct comparisons should be made with caution.

The semi-quantitative application of biogenic habitat feature designations across the 14 sites revealed seven obvious biogenic habitat features: *Ecklonia* forest (6 sites, one or more per site), *Caulerpa* meadow (3 sites) Macroalgae garden (4 sites), Bryozoan (uncalcified species) field (3 sites), Sponge garden (1 site), Urchin barren (2 sites), and Bivalve bed (1 site). Each biogenic habitat feature will have a preferred/obligate depth range, which may vary spatially with environmental conditions (e.g., light climate at the seafloor for macroalgae). The narrow depth range of this survey will not have encompassed those ranges, with perhaps the exceptions being the lower depth boundary for *Caulerpa* meadows and sea urchin barrens (in the context of Pātea Bank).

In terms of ecological function, four sites provided a habitat function for juvenile blue cod (sites D, K, U, and V), although the small spatial extent of Site K limits its possible contribution to local blue cod populations. Biogenic habitat features that supported these nursery functions were sponge gardens, dog cockle shell drifts/beds, some reef edges, and some cobble and shell zones adjacent to reef edges. Other ecological functions are not included here (e.g., primary production, oxygen production, nutrient recycling, provision of prey for larger predators), but may also be significant.

Table 14: Summary of the 14 sites surveyed Sites are ordered by increasing median water depth (the midpoint of the range occupied by rock-based habitats at site). Depths from the multibeam sonar data for rock-based habitat at each site are given in metres (Med, median; Min, Minimum; Max, Maximum). *, reef extent only partially mapped. The transect area calculated only includes video segments where rock was present. %biogenic cover was the sum of all biogenic habitat classes present. Biogenic habitat features are marked as 'Yes' if present at a site. Blue cod nursery function, ^, denotes sufficient abundance but reef extent too limited. Species richness (Sp. R) is the proportion of the overall species pool (survey level) present at a site, for sponges (39 species), mobile invertebrates (14 species), and fish (24 species). A colour ramp visualises differences (bright yellow (low values) through to dark green (high values). Mudstone/Papa rock reefs are grey high-lighted.

		Multibeam						Video									Sp. R		
Site	Description	Depth (m) Med	Min	Max	Range	Transect Area (m^2)	Reef area (m^2)	% biogenic	*Ecklonia* forest	*Caulerpa* meadow	Macroalgae meadow	Bryozoan field	Sponge garden	Urchin barren	Bivalve bed	Blue cod nursery	%present Sponges	Inverts.	Fish
Q	Raised reef with terraced slopes and finger-gutter reef morphology	17.3	9.9	24.6	14.7	85,794	1,452	22.1	Yes					Yes			54%	14%	38%
A	Large reef composed of bedrock and cobbles, arranged as long escarpment	19.4	13.9	24.8	10.9	425,000	3,486	23.4	Yes	Yes							64%	71%	33%
S	Large oblong rock with stepped terraces	19.5	12.7	26.3	13.6	29,393	1,478	11.4		Yes		Yes					74%	57%	38%
J	Low ridge of broken rock and irregular mixed cobbles	21.3	18.4	24.1	5.7	*38,990	453	6.7			Yes						38%	21%	21%
K	Low reef composed of low terrace rock, and irregular mixed cobbles	21.3	19.9	22.6	2.7	2,933	1,993	11.4								Yes^	59%	7%	33%
R	Large, multi-faulted tilted rock block with slopes and ridges.	21.5	16.6	26.4	9.8	136,726	1,813	28.5	Yes	Yes		Yes					67%	43%	29%
O	Long ridge >1.61 km, composed of low rock and irregular cobbles	22.5	19.6	25.4	5.8	176,692	955	18.0	Yes		Yes						54%	36%	13%

Site	Description	Multibeam						Video									Sp. R		
		Depth (m)				Transect Area (m²)	Reef area (m²)	% biogenic	*Ecklonia* forest	*Caulerpa* meadow	Macroalgae meadow	Bryozoan field	Sponge garden	Urchin barren	Bivalve bed	Blue cod nursery	%present		
		Med	Min	Max	Range												Sponges	Inverts.	Fish
Papa	Sparse mudstone patches of broken slabs/boulder piles, low basement	22.6	21.7	23.5	1.8	-	296	0.0									21%	21%	13%
L	Long 1.17 km ridge feature, composed of low rock and irregular cobbles	23.0	20.05	25.9	5.8	301,673	689	15.2	Yes								51%	36%	21%
U	1. Large elongated rocky reef. 2. Sloping large boulder/rock slab field	23.1	16.9	29.2	12.3	226,950	1,379	20.4	Yes		Yes			Yes		Yes	36%	29%	29%
B	Extensive low mixed reef, cobble, and coarse sediment field with knolls	23.6	21.2	25.9	4.7	*211,957	1,715	37.2			Yes						62%	21%	33%
T	Large triangular rock, with five terraces and drops	23.7	18.7	28.7	10	7,101	443	6.7				Yes					56%	50%	17%
D	Largely continuous north-south reef terrace drop (scarp), 3.45 km long	25.2	22.3	28	5.7	399,750	1,241	2.2								Yes	33%	14%	38%
V	Two low reef composed of large flat rock slabs, composed of breccia	35.5	32.7	38.3	5.6	14,007	943	7.9					Yes		Yes	Yes	59%	43%	54%

5 Regional context

To put this survey in a wider context, this section provides a summary of wider regional subtidal reef focussed work (including North Taranaki), and relevant comparisons with the findings of this 14 site Pātea Bank survey. Figure shows the North Taranaki reef sites covered in this section, as well as a mudstone reef site off Whanganui. The site names are as used in the various contributing reports and thesis; Sugarloaf Islands encompass several discrete subtidal rocky reefs areas.

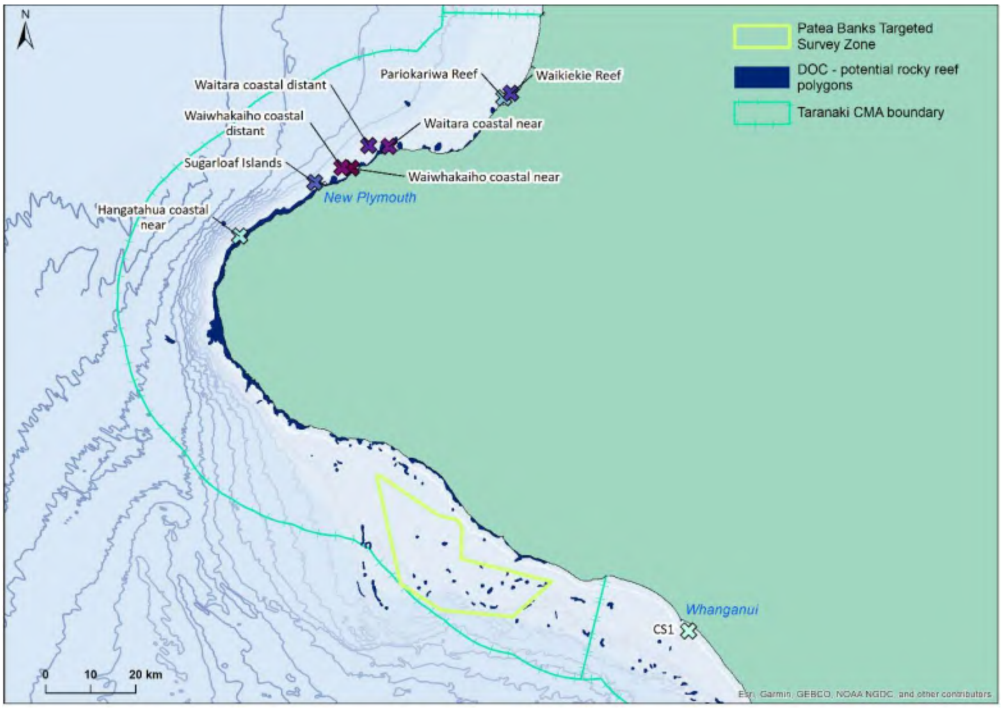


Figure 5-1: Broader subtidal rocky reef research sites in the Taranaki coastal marine area DOC potential reef polygons are shown. In North Taranaki, the Waitara, Waiwhakaiho, and Hangatahua sites are all volcanic boulder-based reefs with no bedrock (Cormack 2021), the Sugarloaf Islands are a range of volcanic bedrock and boulder reefs, and the Pariokariwa/Waikiekie reefs formed of mudstones. For South Taranaki, the work area of this report is shown as a light green polygon, along with a mudstone reef site located further south, off Whanganui.

5.1 South Taranaki reefs

5.1.1 South Taranaki-Wanganui marine area review 2006

A DOC project called "*Netting coastal knowledge: a report into what is known about the South Taranaki-Whanganui marine area*", used a literature review, interviews, workshops, and a questionnaire to learn more about the region. A range of useful information was included in the associated report (DOC 2006).

Fishers most common catches were dominated by blue cod and snapper; with kahawai and gurnard also common but to a lesser degree. Other species caught included tarakihi, barracouta, john dory, and trevally. Rarer caught species included groper and kingfish, while spiky dogfish was the most caught shark. Divers visiting the North and South Traps reported regularly seeing terakihi, red moki, blue cod, snapper, rock lobster, Spanish lobsters and packhorse crayfish, kingfish, blue moki, big eye, leather jacket, conger eels, banded wrasse, parrotfish (presumably scarlet wrasse and spotties), and triplefins on the reefs (Figure).

Figure 5-2: Diver photos of species at the Traps reefs (Source: J. O'Leary, in DOC 2006).

Divers mentioned diving off Pātea, Waverley and Waitotara. They described rock 'mounds' sitting on the sand which were papa rocks with shell layers, about knee high, in 8–10 m water depths. They also described "*papa rock structures running out from the coast like fault lines or a papa uplift*", and that "*Off Waverley and north of Waitotara there are papa rock ledges and gutters running about 0.5 km long on a 45 degree angle to the sea floor, perpendicular to the coast. Rock lobster hide there (clinging under the roof of the rock formation). It's in water from 8m – 20m deep*.". Other divers described further areas off Pātea and further along the coast "*…papa ridges – scattered – long ridges of reef with bits broken off and cracks once off ring plain area*.". Graham Bank was also mentioned "*On the edge of the Graham Bank there's a steep drop off with a ridge of papa. Good visibility*.", but also "*Graham Bank is pure sand. There is nothing on it*.". Note that Site V described in this report was located on the south-east side of Graham Bank (Figure 3-1).

DOC (2006) described a south to north transition, from mudstone and sandstone dominated coastline, to volcanic lahar and breccia materials, near the Kapuni Stream and Waingongoro River mouths. This volcanic geology extended around the Taranaki Peninsula, as part of the 'ring plain' (built by multiple volcanic eruptions). Coastal reefs are composed of large boulder-platform reefs, extending up to several kilometres offshore at a gentle gradient. DOC (2006) described a 2005 survey for a pipeline by Origin Energy, using video cameras to view the seafloor, from the shoreline to 2.65 km offshore. At 1,200 m offshore, the seafloor was dominated by the eroded remnants of a volcanic debris avalanche deposit. Volcanic rock formed of rock material was once bound together with ash and mud; however, the soft materials had been washed away, leaving boulders, cobbles, and gravel. Those had been then eroded to more rounded forms. Patches of sand were also present in the video. The next 300 metres heading offshore were occupied by "*hard reef of intact volcanic rock comprised of angular cobbles and gravels, with some pockets of sand. No large boulders were observed on the hard reef*.", which was assessed as the "*margin of the* [volcanic] *debris avalanche*". Beyond this margin, the seafloor changed to "*mudstone, typically covered by a thin veneer of sand, and occasional cobbles and boulders*.".

DOC (2006) also noted the presence of ancient river channels ('paleo-channels') off the Taranaki coastline, carved rivers in the last Ice Age (20 000 years B.P.), when sea level was lower and the coastline 100 km further south. This might explain the presence of the smooth grey cobbles of site A, which bear a very strong resemblance to stones from stony rivers.

Knowledge of the South Taranaki seafloor and its biological species and assemblages was viewed by DOC (2006) as being very limited. Kelp's were reported as present, but never dominant. *C. maschalocarpum* was the main species to around 5 m water depth, where *E. radiata* replaced it, extending out to depths of at least 20 m. High water turbidity was suggested as a limiting factor. In the present study. C. *maschalocarpum* occurred as occasional plants at site U, at 20–23 m metres, while *E. radiata* was present as healthy plants at 32 m depth at site V (the deepest reef surveyed). While water clarity was not measured during the present survey, it appeared that inshore reefs (e.g., site A) had reduced water clarity relative to those further offshore (e.g., sites D, U, and V) – a gradient that is readily seen across the camera imagery in this report.

It was stated that along the "*mudstone and sandstone dominated coast, good fishing grounds exist around reefs, which provide abundant food species for fish. Sizeable reefs out from Pātea have been described as being responsible for some of the best fishing in Taranaki. These 'rubble-strewn platforms'* [our emphasis] *have been described as containing abundant food species for fish such as corals, bryozoans, sponges, crustacea, mollusca and polychaetes. These organisms are an intricate part of the marine ecosystem and draw the demersal fish such as snapper, tarakihi, blue cod and gurnard near to shore*" (DOC 2006).

5.1.2 South and North Traps drop camera survey 2005

In 2005, a drop camera survey was undertaken on the North and South Trap reefs (see Figure 3-1 for locations), with up to 2 minutes of video footage collected for each drop, with 145 and 124 sites surveyed respectively across fixed grids (ASR Ltd, no report available). These were classified into six habitat classes: sand, sand-covered reef, kina barrens, *Ecklonia*, mixed algae, and diverse reef. Bombosch (2008) re-analysed these 269 clips in more detail, looking to improve the information outputs for macro-algae and invertebrates, and to "*develop an easily extendable benthic habitat classification scheme that can be used for future mapping projects of the shallow subtidal zones of New Zealand*". It was noted that limitations of the video footage included a lack of a visual scale (e.g., paired lasers) and inconsistent video quality (Bombosch 2008). The lack of a visual scale means that the field of view could not be calculated (the width of the video imagery). No apparent record was made by ASR Ltd of the distance the survey vessel drifted during each up to 2-minutes video drop (likely to vary with tide times, wider currents, and wind), meaning that video swept area (m^2) could also not be calculated.

Bombosch (2008) defined nine physical habitat classes for the Traps (Table 15), very similar to the classes used in this report. Figure (images 1–5) shows representative seafloor imagery as given by Bombosch; equivalent present survey imagery is shown in Figure 3-43. While the older imagery is of lower resolution (older technology) and the original video could not be located, features such as the gutters/finger-and-gutter reef type are clearly the same. There is some variation in how Bombosch (2008) and this report defined these seafloors. For example, Bombosch (2008) defined three levels/mixes of reef complexity (high, mixed, low), all of which appear to be composed of broken gutter morphology (Table 15). In contrast, we separated broken gutters as a separate rock class (‘finger-and-gutter’ reef) in its own right; separate from high relief (= ‘broken rock high’) and low relief reef (= ‘broken rock low’) rock classes. This report also used the class ‘flat basement’ to describe flat reef with little to no local relief variation. All four of these classes were encountered by the towed camera transect.

Table 15: North and South Trap geomorphology classes of Bombosch (2008), and present survey equivalents. Bombosch (2008) term definitions: rubble, mixture of pebble and cobble as video resolution too poor to distinguish; sparse, not touching. An * shows which classes were absent at South Trap/site Q , relative to the present study. Soft sediment ripple/wave (and other) features were present but not scored. (Source, table 1 of Bombosch 2008).

Bombosch (2008) classes	Present study geomorphology classes
High relief reef, broken gutters	Broken rock high. Broken gutters split off as a separate class (finger-and-gutter reef)
Mixed relief reef, broken gutters	Not specifically classified, is an emergent variable/class from using a segmented video transect. Broken gutters split off as a separate class (finger-and-gutter reef)
Low relief reef, broken gutters	Broken rock low. Broken gutters split off as a separate class (finger-and-gutter reef)
(no equivalent)	Flat basement, low pillow reef*, low patch reef, fallen slabs*, boulder, smooth grey cobbles*, bare raw rock*, tell*
Reef-sand transition	Not specifically classified, is an emergent variable/class from using a segmented video transect
Rubble field	Mixed irregular cobbles (sparse/field cobble density estimated at 20-second video scales as % cover)
Sand, ripples	Sand
Sand, ripples, sparse rubble	Sand
Sand, waves	Sand
Sand, waves, sparse rubble	Sand

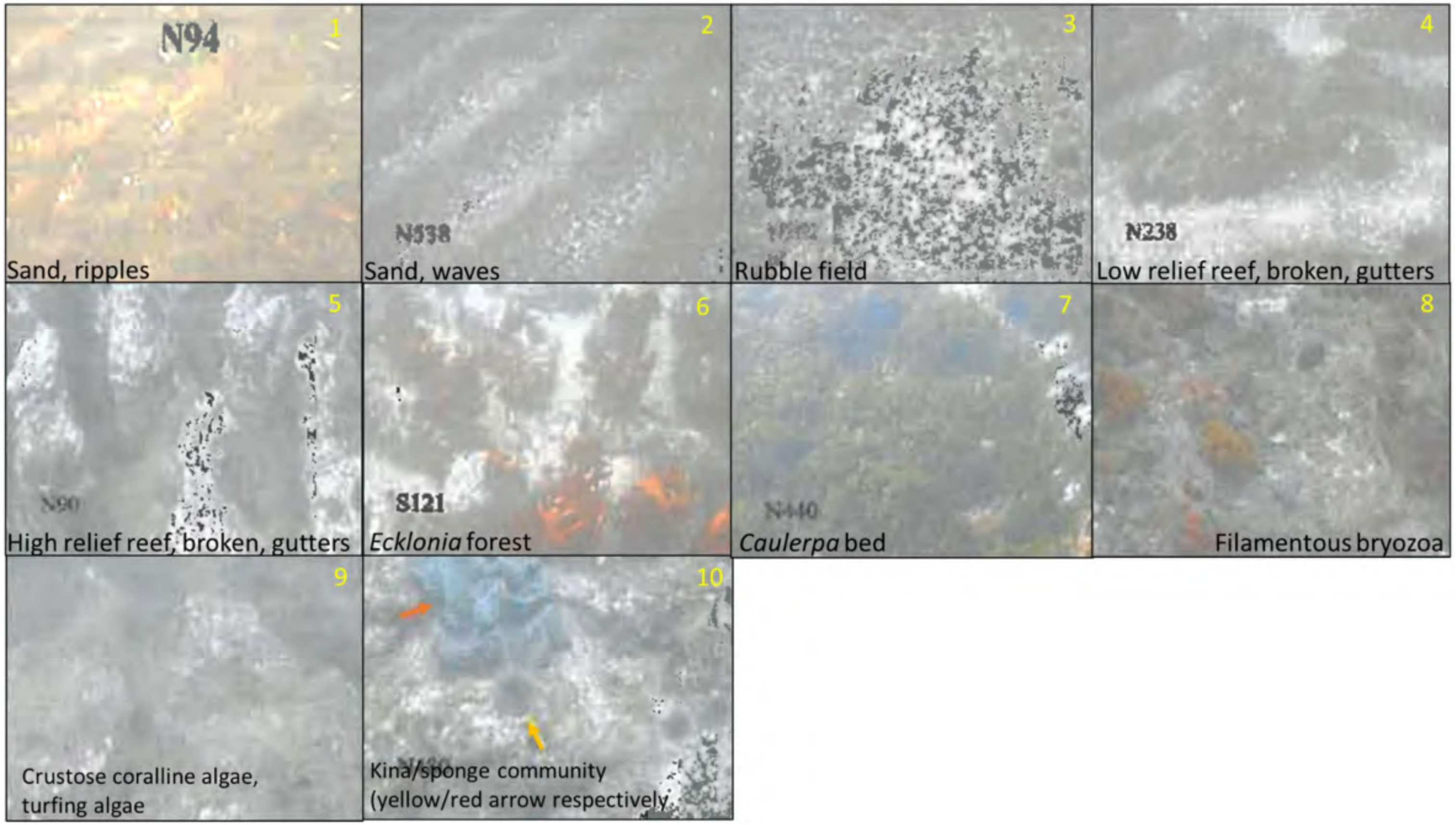


Figure 5-3: Representative seafloor images given by Bombosch (2008) 1–5) geomorphology classes; 6–10) biological habitat classes (Source: figures 2, 3, Bombosch 2008).

Bombosch (2008) assigned each of the 269 video drops to one of these nine geomorphological classes (Table 16, Figure). For the South Trap, 51.6 of the video drops were classed as reef gutter geomorphology (Table 16). In the present study (noting the different percent cover estimation approach, continuous versus point sampling, and much smaller spatial area sampled), the site Q gutter reef estimate was very similar (55.7%, Table 4). For the North Trap, 64.5% of the video drops were classed as reef gutter geomorphology (note: none of these three contribution estimates removed non-reef site (sand) contributions).

Table 16: Classification of the 269 video drops into nine classes, by Trap %cover was estimated at the Trap survey scale, as the proportion of stations assigned to each of the nine classes (Bombosch 2008).

Physical habitat	North Trap		South Trap	
	Drops	%cover	Drops	%cover
High relief, broken, gutters	5	3.4	10	8.1
Low relief reef, broken, gutters	26	17.9	22	17.7
Mixed relief reef, broken, gutters	44	30.3	48	38.7
Reef-sand transition	7	4.8	7	5.6
Rubble	17	11.7	3	2.4
Sand, ripples	18	12.4	10	8.1
Sand, ripples, sparse rubble	9	6.2	1	0.8
Sand, waves	13	9.0	22	17.7
Sand, waves, sparse rubble	6	4.1	1	0.8

With respect to biological assemblages, Bombosch (2008) was able to identify the following 15 taxa from the 2005 video footage: 4 macroalgae (*E. radiata*, *Caulerpa brownii**, *C. flexilis*, *Caulerpa gracialaris**); 7 sessile invertebrates (sea anemone *Ulactis* sp., jewel anemone *Corynactis* sp., soft coral (Order Alcyonacea*), the sponges *Tethya* sp. (ball sponge) and *Ancorina* sp. (now *Ecionemia*, massive sponge), ascidian *Cnemidocarpa* sp*.; and 4 mobile invertebrates (biscuit sea star *Pentagonaster pulchellus**, kina, Cooks Turban, the large slit limpet *Scutus breviculus**, and reef octopus *Pinnoctopus cordiformis** [*, seven species not seen in the present survey).

All other species were only able to be assessed at higher levels as four group morphologies – filamentous/foliose macroalgae, turfing algae, bryozoans (soft uncalcified Catenicellid spp.), and sponges (with 5 sub-groups – branching, encrusting, globular, massive, papillate (with bumps). The terms ‘turfing algae’ and ‘foliose/filamentous macro-algae’ were defined essentially by height:

> *“Turfing algae – used as a general descriptor of small algae having a lower height than bryozoans or kina. All major algal taxa, e.g., Rhodophyceae, Phaeophyceae, and Chlorophyceae could be represented. It has to be noted that turfing algae described all algae species being smaller than bryozoans or kina. Thus, some of the Phaeophyceae and Chlorophyceae could include Caulerpa sp. and Ecklonia radiata that were assumed to be grazed or re-growing, as fully grown individuals were found in the vicinity. Even though they are not turfing algae as defined in the literature, it was not chosen to count those as Caulerpa sp. and Ecklonia radiata as clip quality did not allow for a reliable identification.” (Bombosch 2008).*

“*Foliose/filamentous macro-algae – this term was used to identify algae of all three taxa, which were higher than turfing algae, but smaller than Caulerpa sp., and the canopy species Ecklonia radiata.*” (Bombosch 2008).

Based on the dominance of the species/groups present in the two minute video drops, eight 'dominant biological community' classes were defined (Table 17). Figure (images 6–10) provides visual examples of some classes.

Table 17: North and South Trap's nine dominant biological habitat classes and a list of associated sub-dominant species/groups (Source: table 4 of Bombosch 2008).

Dominant biological community	Associated biological communities
Ecklonia forest	Turfing algae
	Crustose coralline algae
	Bryozoa
	Sponges
	Small *Caulerpa* patches
	Kina in varying densities
Filamentous bryozoa	Turfing algae
	Occasional filamentous/foliose brown/red algae
	Kina in varying densities
Filamentous bryozoan with sparse *Ecklonia*	Sparse *Ecklonia*
	Turfing algae
	Occasional filamentous/foliose brown/red algae
	Kina in varying densities
Caulerpa beds	Bryozoa
Ecklonia/Caulerpa mixed	Turfing algae
	Bryozoa
	Kina in varying densities
Coralline crustose algae, turfing algae	No macrofauna
	Occasional sparse bryozoan
Kina/sponge community	Turfing algae
	Bryozoa
	Juvenile *Caulerpa*
Kina/sponge community with *Caulerpa* patches	Turfing algae
	Bryozoa
	Caulerpa patches

Bombosch (2008) assigned each of the 269 video drops to one of these eight dominant biological communities (Table 18, Figure). The percent cover of these nine classes was similar between the North and South Trap; with the North Trap having higher kina/sponge community (urchin barren) (20.7 vs. 12.1%) and turfing algae (18.6% vs. 4.8%) cover. The South Trap had higher crustose coralline algae/turfing algae (16.1 vs. 4.1%) and filamentous bryozoa (26.6 vs. 15.9%) cover. *Caulerpa* bed (2.8%, 5%) *Ecklonia* forest (5.5%, 5%) and *Ecklonia/Caulerpa* mixed (4.1%, 7%) cover was very similar.

The present survey covered only a small area of the South Trap (Figure). Seven ASR Ltd video drop sites fell to each side of the site Q transect, which were all classified by Bombosch (2008) as kina/sponge community (urchin barrens). In contrast, the present study found the same sub-area to be around 50% *Ecklonia* forest (western half), and 50% urchin barrens (eastern half). These two estimates, 16 years apart, suggest that these habitat classes (as probable alternative states) may vary in their extent (percent cover) over time. Here the kelp forest (2021) replaced urchin barren habitat (2005), but with only 2 time points, nothing can be inferred regarding the temporal dynamics of kelp forests vs. urchin barrens.

As a general note, Bombosch (2008) noted that in many of the video clip the reefs were white (North Trap 25.5%, South Trap 20%), whereas in other clips "*the visibility seemed to be highly reduced and the reef appeared to be covered by sediment*" (North Trap 20%, South Trap 39.5%). These estimates were not used in the percent cover estimates, with their cause/s unknown, and were suggested to need direct investigation by divers (Bombosch 2008). This white coloration was seen in the 2021 video footage also (Figure , images 12,14–18), and is white-coloured non-geniculate coralline algae.

Table 18: Classification of the 269 video drops into nine classes, by Trap %cover was estimated at the Trap survey scale, as the proportion of stations assigned to each of the nine classes (source: appendix 4 of Bombosch 2008).

	North Trap		South Trap	
	Drops	%cover	Drops	%cover
Absent	33	22.8	29	23.4
Caulerpa bed	4	2.8	5	4
Crustose coralline algae, turfing algae	6	4.1	20	16.1
Ecklonia forest	8	5.5	5	4
Ecklonia/*Caulerpa* mixed	6	4.1	7	5.6
Filamentous bryozoa	23	15.9	33	26.6
Filamentous bryozoa with sparse *Ecklonia*	5	3.4	3	2.4
Kina/sponge community	30	20.7	15	12.1
Kina/sponge community with *Caulerpa* patches	3	2.1	1	0.8
Turfing algae	27	18.6	6	4.8

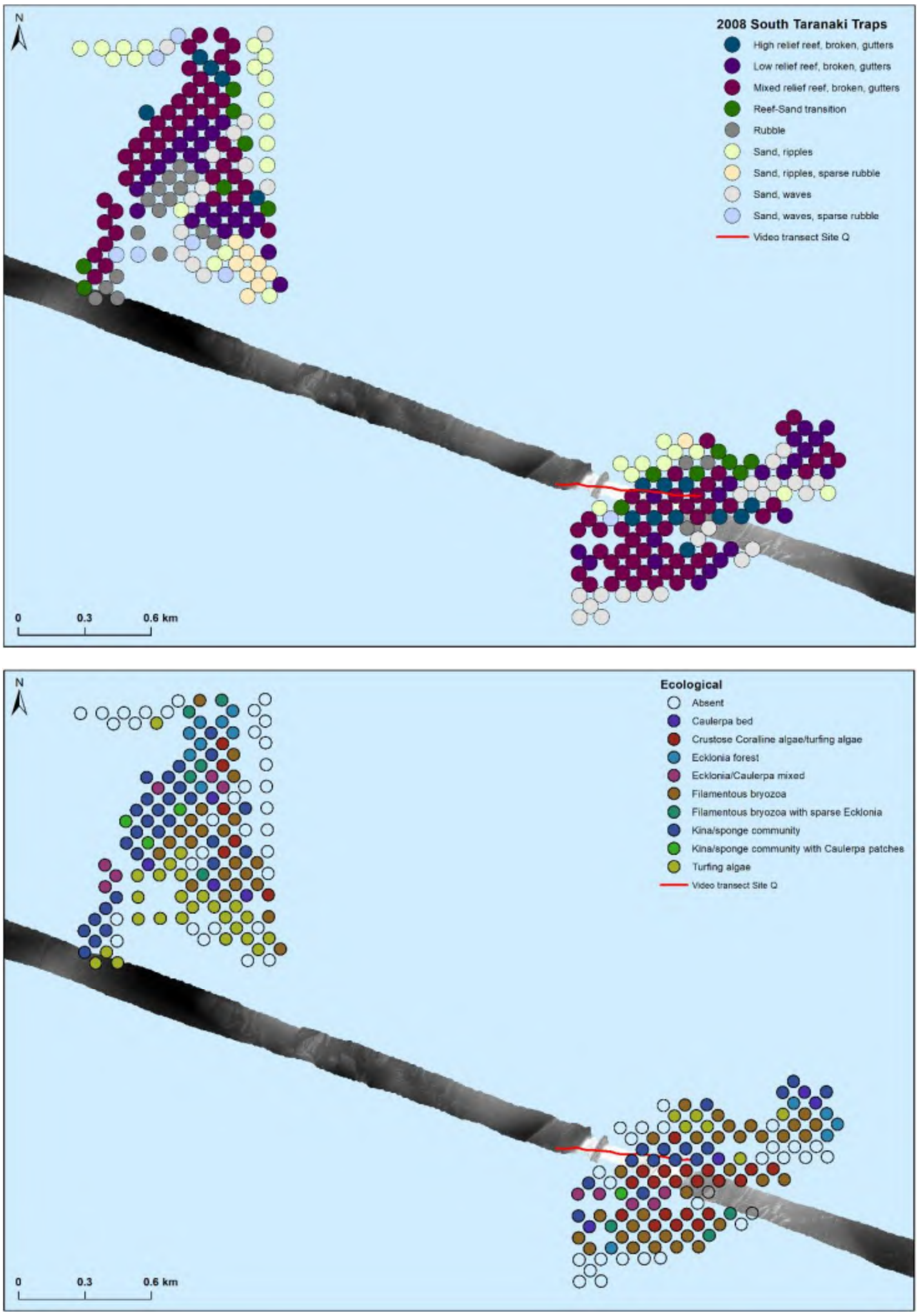


Figure 5-4: North and South Trap video drop grid Also shown are the multi-sonar transect (bathymetry plotted over South Trap in the 2021 survey (site Q transect shown as red line), and the North Trap's southern boundary (Source: figures 4, 5, appendix 3 of Bombosch 2008).

5.1.3 Broad scale benthic surveys of Pātea Bank and adjacent areas 2011–13

Two benthic surveys were conducted for Trans Tasman Resources Ltd. as part of a proposed iron-sand mining project off Pātea Bank. A large survey in 2013 sampled at 145 sites with a range of methods (144 towed videos each 300 m long, 116 epifaunal dredges, and 331 sediment cores from 103 sites) (Beaumont et al. 2015). Each station was assigned a benthic habitat identity, of which seven included rock/reef contributions (Figure). The seven rock 'point sites' were used to inform the survey design of the 2020 multibeam sonar mapping transit route (see Figure 3-1), All seven rock-sites fell inside the 12 nautical mile limit (Figure). A second smaller 2013 survey using 100 m-long camera transects (12 photo-quadrats taken within each and analysed for seafloor percent cover), and some dredging, sampled a further 36 sites closer inshore, including 10 sites off Whanganui, with five found to hold rock habitats (12.8–22.3 m water depth) (CS1 – see Figure) (Anderson et al. 2015).

Table 19 gives short descriptions of the rock habitats recorded in these surveys; while Figure 67 shows the relevant seafloor images from the two reports. The seven sites of Beaumont et al. (2015) fell within the range of rock geomorphologies and benthic assemblages quantified in the present report, but probably at the lower end of complexity and species assemblage abundance (based on data in Table 19). The 2020 multibeam sonar survey did not pick up significant seafloor structure at any of these seven sites (except for the large multibeam sonar block which site #20 fell within (Figure 3-1). The five sites of Anderson et al. (2015) revealed reefs to be present in shallower water (Figure 3-1). Three of these were of harder rock, with associations of sponges, *Ecklonia*, red algae, and bryozoans depending on site. The other two were composed of mudstone / Papa rock, with low to no associated biodiversity (Figure , images 7–8; one off Whanganui, see Figure).

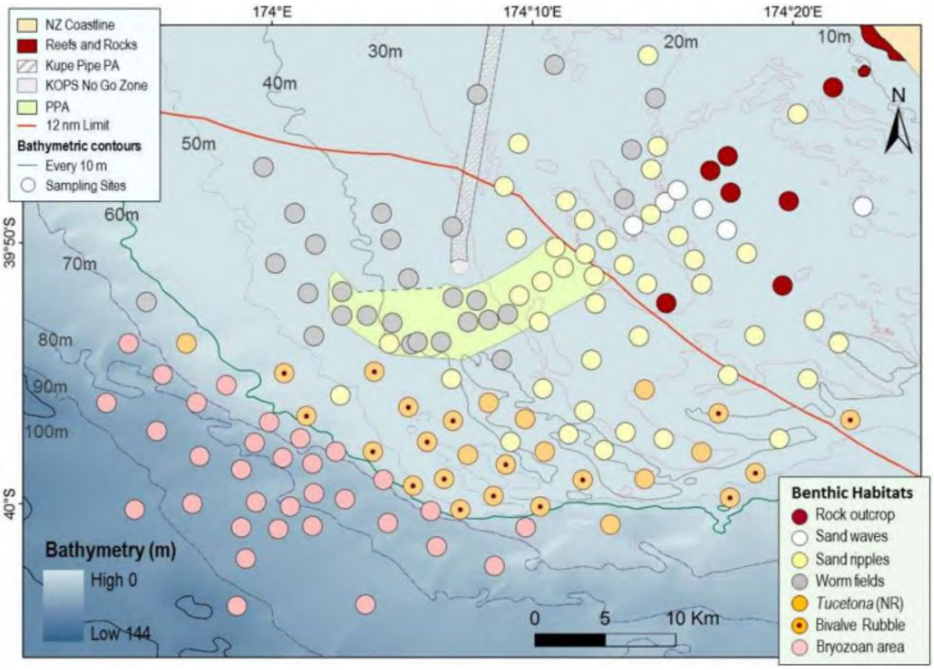


Figure 5-5: Sites and associated habitat types for the 145 stations sampled as part of iron-sand mining proposal investigations Seven sites where rock was observed are shaded as dark red circles (stations also shown on Figure 1). *Tucetona* (NR) are sites where live dog cockles (*Tucetona laticostata*) were present but with little to no associated dead shell (referred to here as 'rubble') (Source: figure 7 of Beaumont et al. 2015).

Table 19: Brief descriptions of the seven rock associated sites sampled by Beaumont et al. (2015), and five rock sites by Anderson et. al (2015). (Source: appendix B, Beaumont et al. 2015; appendix A, Anderson et al 2015). A prefix of "#" indicates offshore sites (Beaumont et al 2015), a prefix of "+" indicates inshore sites (Anderson et al 2015).

Site	Depth (m)	Geomorphology	Seafloor assemblage notes	Fish
#5		Low relief outcrop with rippled sands	Bryozoans and macroalgae	
#7	26	Low relief bedrock, boulders, cobbles, and pebbles partially covered by iron-sand/shell hash	Filamentous and turfing red algae, sponges (encrusting, massive, ball), sponges, fan worms sp1, star fish x1	Blue cod x10, spotties x1, cardinalfish x1
#20	–	Low relief outcrop partially buried by rippled sand, shell debris and gravel/pebbles in troughs, mudstone cobble		Opalfish x5, small fish x1.
#42	26	Low bedrock and cobbles, partially covered in coarse sand and shell hash; adjacent to linear-rippled sand with shell-hash and gravel/pebbles in troughs	Bedrock with sponges (encrusting, massive, ball), coralline algae, ascidian, star fish (*Coscinasterias*), filamentous red algae	
#46	–	Coarse sands with gravels, pebbles, cobbles and shell hash, shell hash. Possible shallow buried reef as sponges caught in dredge	3 sponges in dredge sample	
#50	–	Buried bedrock outcrop, boulders, cobbles		
#53	–	Buried rock/Rippled sands. Shell-debris flats. Adjacent to iron-rich rippled sands with heavy shell-debris and gravel/pebbles in troughs.	Small tufts of filamentous red algae growing on underlying bedrock. Large shell debris encrusted with coralline paint	
+5	21.7–22.3	Rocky outcrop (low-relief mix of boulders, cobbles, sand), mixed algae, and blue cod	Mixed algae, bryozoans, anemones	Blue cod
+6	21–20.3	Rocky outcrop (moderate/low relief, bedrock, boulders, cobbles, and sands with shell gravel);	Bryozoans, mixed algae, yellow sponges (*Halichondria*).	
+7	12.8–13.0	Rocky outcrop (contiguous moderate relief bedrock with boulders, adjacent to coarse sediments);	*Ecklonia*, red algae, bryozoans, and sponges	
+14	13.8–14.2	Mudstone outcrop (Low-lying partially covered in coarse sands), mean rock cover 10.35% ± 5.35%	No visible biota	
+CS1	13.5–13.7	Mudstone outcrop (moderate relief mudstone adjacent to rippled sediments);	Benthic diatoms, red algae, and a few small sponges.	

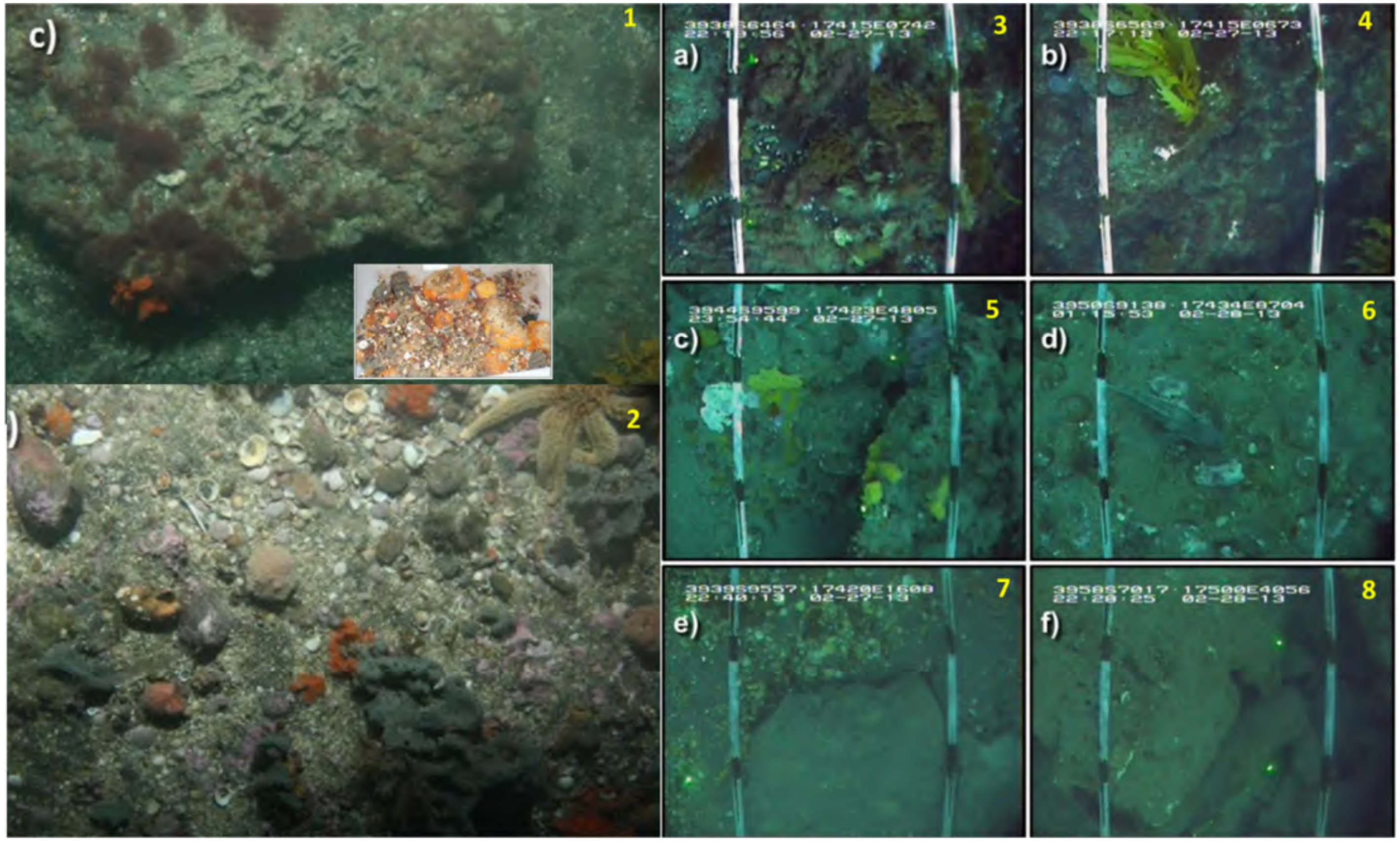


Figure 5-6: Seafloor images of other South Taranaki rock/reef sites Beaumont et al. (2015) 1) site #7 (26 m), low-lying rock outcrop (7.35% transect cover) (insert; dredge sample at site). Species visible are grey sponge Family Chondropsidae species 2, orange and yellow sponges (and either filamentous red algae or bryozoans); 2) site #42 (26 m), low-lying rock outcrop (<1% transect cover). Anderson et al. (2015). 3–4) site +7 (13 m), rock with bryozoans, *E. radiata* kelp and grey sponge *E. alata*; 5) site +6 (20 m), yellow *Halichondria* sp. sponges; 6) site +5 (22 m), encrusting sponges and blue cod; 7) pale grey mudstone with no visible biota (top half of image is soft sediment); 8) site +CS1 (13 m) offshore of Whanganui, mudstone outcrop with patches of benthic diatoms and red filamentous algae.

Three of the five inshore rock sites of Anderson et al. (2015) were physically sampled with a dredge, and taxa identified to species where possible. The mudstone site (+14, Table 19) displayed heavily eroded surfaces, and notably had records of the rock-boring bivalve, *Barnea similis*.This species in part might be responsible for the rock boring seen at sites Papa and D.

On the three rock sites the following were recorded: 3 brown algae species (including *E. radiata*), 2 green algae (*C. flexilis*, *C. brownii*), 10 red algae species, 27 bryozoan species, 6 sponge species (*A. globosum*, *C. ramosa*, *Haliclona* (*Adocia) ventistina*, *Hymedesmia* cf *microstrongyla**, *Leucettusa lancifera**, *Halichondria* sp., *Iophon proximum*) (*, not observed in present survey), 2 amphipod taxa, 2 crab species, 1 shrimp, 2 ophioroids (not *O. maculata*), 1 starfish (cushion star *Patiriealla mortensoni*), 1 bivalve (*B. similis*), and 3 gastropods (small-bodied species). Blue cod were also caught (size/s not given).

Site +6 was located in the most inshore area covered by the 2020 multibeam sonar mapping transects (Figure 3-1), which revealed many reef patches and potentially large reefs in this area (Figure , Appendix A). This area was initially included within the plan for the 2021 CoastCam survey but these sites were not completed due to time constraints.

Site +7 traversed the north-west side of a large rock outcrop (around 3.8 x 0.8 km, 2.45 km^2, based on the DOC putative reef polygon, see Figure 3-1), which based on the site +5 video footage (noting that only covered a 100 metre distance) was thought to be extensive consolidated reef (Anderson et al. 2015).

Collectively, these limited site observations suggest that extensive rock/reef habitat exists inshore of the extent of the surveys reported on here (2020 multibeam and 2021 CoastCam). Note, however, that the 2020 multibeam sonar survey revealed numerous reef targets north and east of site J (Figure 3-1).

The large and extensive 145 site survey of Beaumont et al (2015) sampled numerous species over soft sediment habitats, and revealed extensive offshore dog cockle beds, associated shell drifts (‘rubble’), and calcified bryozoan species fields (Figure). Soft sediment habitats are not the focus of this report, but some of the species seen on the 14 reefs sampled in the current study also occurred on soft sediments. A few interesting contrasts included:

- The saw shell *A. heliotropium* was the most numerically dominant mollusc species sampled (579 individuals, 27 sites), with the highest numbers on deeper water dog cockle rubble. The present survey counted 43 individuals on rock/reef.
- The snake star *O. maculata* was the numerically dominant ophiuroid sampled (260 individuals, 18 sites) also associated with dog cockle rubble (42–74 m water depth). The present survey counted one individual, despite it being common on reefs elsewhere.
- The sea cucumber (holothurian) *Australostichopus mollis* (49 individuals, 12 sites) was also strongly associated with dog cockle rubble (28–80 m). The present survey saw none, despite it being common on reefs elsewhere.

5.2 North Taranaki reefs

The Taranaki Catchment Commission (1980) sampled the 'Waitara Reefs', in 14 to 18 metres water depth, with ten quadrats, and reported a low cover of organisms, with species richness ranging up to eight per metre square (species not known, cited in Cole & McComb 2001). They provided a species list of fish observed in the area, with blue cod and scarlet wrasse being the most common of the 28 species reported.

Willan (1980) provided detailed investigations from Tataraimaka and Oaonui, both south of New Plymouth (cited in Cole & McComb 2001), looking at shallow water boulder-reef habitat (depths not given, but appear <10 m). The sponges *Ecionemia alata* and *Iophon minor* were the most common, along with the mussel *Modiolus areolatus*. *E. radiata* was described as rare, small (<25 cm) height), and only occurring in more than 5 metres water depth. *Carpophyllum* was restricted to depths of less than five metres. Kina were present in low densities (maximum 0.08 m^2), with the more common gastropods being *Trochus viridis*, *Cantharidus purpureus*, *Cellana stellifera* (a limpet) and *Cookia sulcata*. A discrete large rock (four metres tall, in seven metres water depth) was described as having its upper reaches covered by *C. maschalocarpum* and *E. radiata*), with a small red and brown algae understorey. Large, green-lipped mussel's *Perna canaliculus* was abundant (160 per $1m^2$), along with lower densities of their predator, the starfish *Stichaster australis* (~ 3 per $1m^2$).

The Taranaki Catchment Commission (1982) surveyed a shallow area (to 9 metres water depth) northeast of the Waiwhakaiho River mouth, along around 600 m of shoreline (cited in Cole & McComb 2001). Using quadrats along five transects extending offshore, animal and plant cover generally reduced with increasing water depth; while species richness increased with distance from the river mouth. *C. maschalocarpum* was most abundant in shallow water, with deeper areas being dominated by the coralline turf *Corallina officinalis*. *E. radiata* was also more common in deeper water, with the highest abundances being observed 800–1200 m offshore. Encrusting species were generally low in their percent cover, with only six of 61 occurrences exceeding 10% cover, and 21 of 61 occurrences contributing less than 1 % average cover (species identities were not given). The authors suggested that sediment from the Waiwhakaiho River mouth was negatively affecting sponge diversity, with grazers (gastropods) possibly controlling the distribution of small individuals. Fish noted as present included spotty, banded wrasse, marblefish, red moki, blue moki, blue cod, and kahawai.

5.2.1 Sugarloaf Islands subtidal reefs

North Taranaki reefs, in particular the Sugar Loaf Islands (Ngä Motu) and associated reefs off New Plymouth, have received significantly more science attention (e.g., Miller et al 2003a,b, Green et al (DOC)., unpubl data), than South Taranaki reefs. Now protected by the Tapuae Marine Reserve (since 2008), and more broadly the Sugar Loaf Islands Marine Protected Area (SLIMPA), these reefs continue to be a focus of marine research in the region. The area was fully multibeam sonar habitat mapped for Port Taranaki and DOC in 2021 (Figure), as well as a wider area (not shown) (DML 2021).

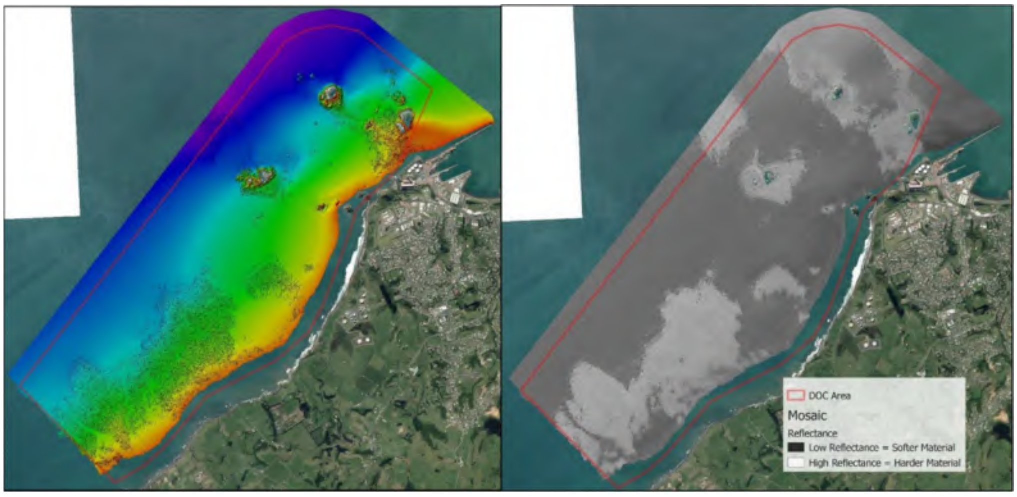


Figure 5-7: Multibeam sonar bathymetry and backscatter maps for the reef systems off New Plymouth, North Taranaki (Source: DML 2021) The mapped area extends out to 40 metres water depth and covers 20.28 km². The southern half holds extensive boulder fields. Left: bathymetry (red is shallow, blue/purple is deep; Right: backscatter plot showing areas of hard (light grey) and soft sediment (dark grey).

An earlier seafloor map created with sidescan sonar delineated the subtidal reefs, with 16 of those individually named and provided with a brief text description and photograph (Figure , Figure , Table 20; DOC/UoW undated). The reefs were of volcanic origin with many characterised as having cliffs, caves, drop-offs, overhangs, and guts (Figure , image 3), while others were composed of large boulders (Figure , image 1). Vertical faces were a common element. This volcanic rock geology and often sharp topographies differs from that of the South Taranaki reef sites, which had lower relief, were composed of mudstone/sandstone/limestone, and had fewer pronounced walls and drops; with most of those in the form of step terraces with between-terrace drops of 1–2 metres.

Ecklonia was mentioned as being present at 10 of the 16 sites, but data on percent cover (singles, patches, forest) and feature associations (e.g., depth, what rock topologies) was not available (DOC/UoW undated). *Carpophyllum* (presumed to be *C. maschalocarpum*) was present at 9 sites and appeared common (unlike the current report's South Taranaki sites). However, many of the Sugarloaf Islands reefs extended into shallower water and had some degree of storm protection (preferred conditions for *Carpophyllum* spp.); so, the comparison is probably confounded by depth and shelter differences. DOC (2006) noted *Carpophyllum* to be common on reefs in less than five metres water depth on the South Taranaki coast.

Zoanthids (Order: Zoanthidea), visually striking and colourful yellow anemones which can form dense clumps, were present at four Sugarloaf sites. Although these species can occur down to more than 50 metres depth; none were seen in the South Taranaki surveys. Urchin barrens (e.g., Figure , image 4) were also present at four Sugarloaf sites. These were recorded from two reef sites within the South Taranaki survey (note that urchin barrens tend to occur on shallower reefs and the Sugarloaf Islands have more extensive shallow reefs relative to the 14 South Taranaki sites).

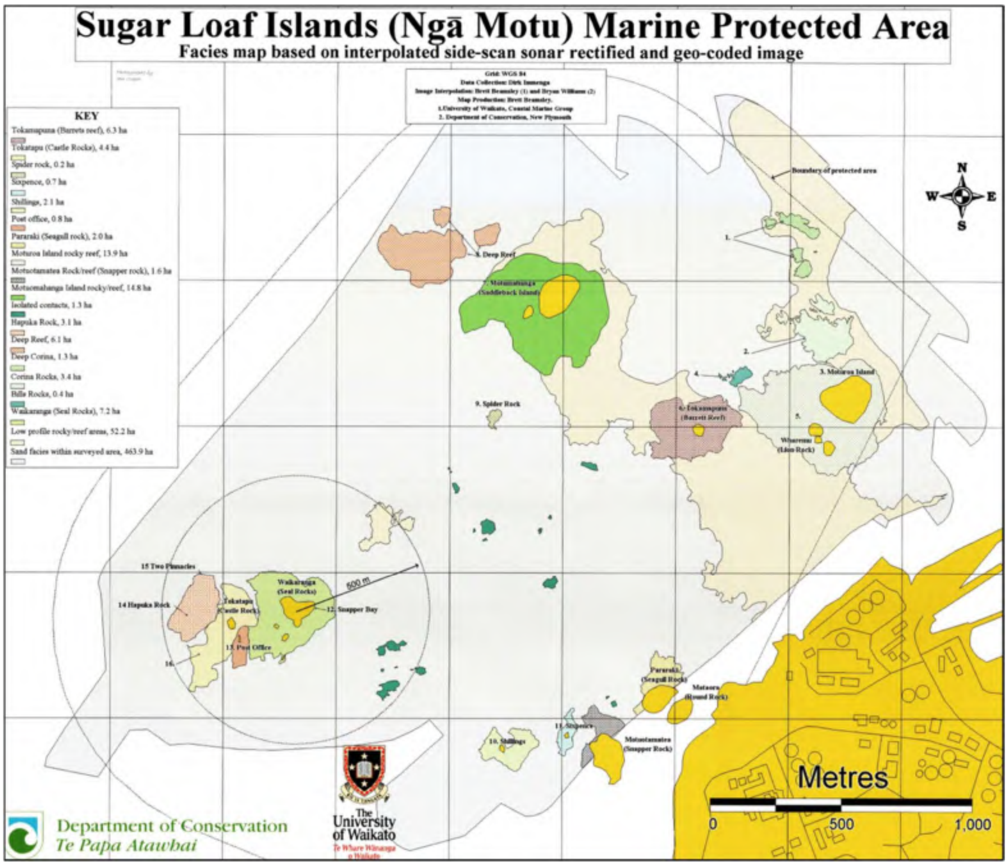


Figure 5-8: Sidescan sonar derived map of the Sugar Loaf Islands area See Table 20, Figure 5.9 for reef descriptions.

Table 20: Sixteen named reefs brief descriptions from DOC/UoW (undated) numbers match labelled and spatially delineated reefs of Figure 69. The sponge *Ecionemia* was previously known as *Ancorina*.

Site #	Name	Physical description	Biological assemblage
1	Deep Corina	Three deep volcanic reefs, rocks, structures, 27 m at base. Caves, drop-offs, overhangs, guts, silt deposits.	Finger sponges, yellow-orange encrusting, *Ecionemia*, green algae, hydroids
2	Corina	Extends out from Moturoa Island. Long volcanic reef with several small rock-reef areas separate from the main reef. 25 m at base, 8 m at top, silt deposits.	Finger sponges, green algae, *Ecklonia*, bryozoa, urchin, green-lipped mussels (*P. canalicus*), paua (few), *Ecionemia.*
3	Moturoa Island	Extends out from Moturoa Island. Long volcanic reef with several small rock-reef areas separate from the main reef. 25 m at base, 8 m at top, silt deposits.	Generally shallow around island. Lava outcrops, patchy *Ecklonia*, *Carpophyllum*, golf ball and finger sponges. Encrusting brown and yellow sponges. Polymastid sponges, bryozoan, paua, and mussels

Site #	Name	Physical description	Biological assemblage
4	Bills Rock	Volcanic reef surrounded by mud/sand. 20 m to 8 m depth at top of reef, gut overhangs, large cave on eastern face. Face 12 m high. Silt deposits.	*Ecklonia* forest on western slope, finger sponges, anemones, zooanthids, bryozoa, yellow and orange encrusting sponges, algae and *Ecionemia*
5	Area south of Wharemu (Lion Rock).	Conglomerate rock, volcanic rock, some guts running se/nw, silt deposits. Out to Barrett's reef lave rock, large boulders.	Patches of *Ecklonia*, encrusting sponges (red/yellow), brown coral, finger sponges, *Ecionemia*
6	Tokamapuna Reef	Large volcanic reef. Caves, overhangs, and archway (seaside)	*Ecklonia* and *Carpophyllum*, anemones, encrusting sponges (green).
7	Motumahanga Reef	Shallow on e/se corner, 8 to 20 m, rock slabs close to island, guts, and large boulder banks. Deep on north side (30 m), with boulder bank. Exposed to weather	Urchin barren, *Ecklonia* forest, encrusting sponges (yellow/red and orange). *Carpophyllum*.
8	Deep Reef	Isolated reef surrounded by sand and mud. Extends to 35 m, volcanic reef, rock structures. Caves, drop-offs, guts, some silt (3 separate reefs)	Anemone, hydroids
9	Spider Rock	Deep reef extending to 20-26 m. Some cuts, small face with overhang. Silt deposits.	Finger sponges, algae, anemones, *Ecionemia*.
10	Koruanga (Shilling Reef) outer	Volcanic habitat with some caves and guts.	Largely urchin barren with some *Ecklonia* and *Carpophyllum*
11	Sixpence (inner reef)	Volcanic rock with a hole.	Urchin barren with some *Ecklonia*, encrusting orange anemones (very colourful) and *Carpophyllum*
12	Snapper Bay	Boulder bank on se corner of Waikaranga. Large boulders.	Large *Ecklonia* forest. *Ancorina*, anemones, hydroids, *Carpophyllum*. Urchin barrens
13	Post Office	Volcanic reef in 8-20 m. Large crevasse and the boulder bank to the se are often full of rock lobster. *Ecklonia* forest out to 20 m, zooanthids, anemones, encrusting sponges, urchin, paua, chitons, *Carpophyllum*. Urchin barren at back of reef.	*Ecklonia* forest out to 20 m, zooanthids, anemones, encrusting sponges, urchin, paua, chitons, *Carpophyllum*. Urchin barren at back of reef.
14	Hapuka Rock	Large cave extending from 16 to 30 m, Some guts, overhangs, and rock faces. Top of reed in 6 m water depth.	Anemones, sponges, zooanthids, encrusting sponges, *Carpophyllum* (very colourful). Large number of rock lobster.
15	Two Pinnacles	Off northern corner of Hapuka rock. Rises 27 m.	Anemones, sponges, zooanthids, encrusting sponges, *Carpophyllum* (very colourful).
16	Area southeast of Hapuka Rock	Caves, rock faces, large boulders, some sand and mud.	Finger sponges, anemones, sponges, encrusting sponges.

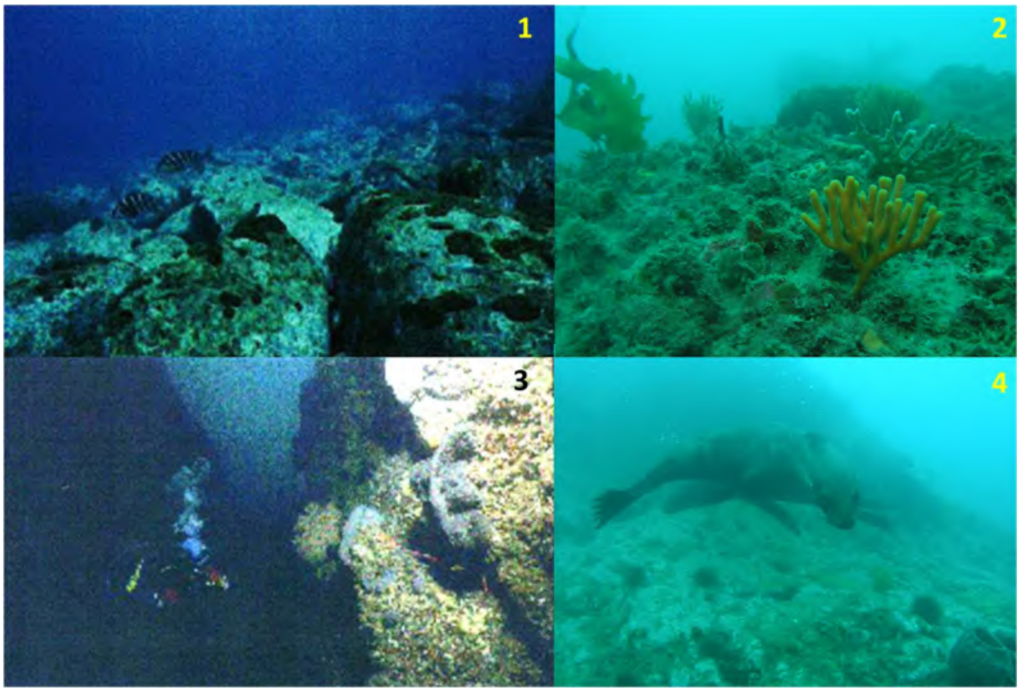


Figure 5-9: Seafloor images from the Sugar Loaf Islands reefs 1) Boulder field with red moki, site 7 of Figure , Table 18; 2) sponge assemblage on reef (source C. Lilly, DOC); 3) Reef cliffs with sponges and zooanthids, site 1 of Figure , Table 18); 4) Sloping reef with New Zealand fur seal (source C. Lilly, DOC).

Sugarloaf Islands monitoring surveys from 2001–2003 examined seafloor (Miller et al. 2005) and fish assemblages (Miller et al. 2013), with sites both in and outside the SLIMPA (Tapuae Marine Reserve not established until 2008). Six sites were assessed, with two assigned to each of three levels of protection (full, partial, none). Focal species were rock lobster, kina urchins and three gastropods (*C. sulcata*, *Trochus viridis* (see Figure) and *Calliostoma punctulatum*), as drivers of subtidal reef habitat structure within SLIMPA. Non-focal species were estimated at the group levels of sessile invertebrates, coralline algae, and Chlorophyta and Rhodophyta species.

One-metre square quadrats were randomly placed on the seafloor, and substrate type, depth, grazing invertebrates counts, percentage cover of algae and encrusting invertebrates, and kelp density recorded for each quadrat. Lobsters were counted using a search time method, with the same diver consistently searching all known rock lobster shelters at each site. The overall finding across the three years was that the "*densities of many of the benthic species surveyed significantly differed between survey sites and years, but in many cases a significant site-by-year interaction resulted in observed patterns being inconsistent. There were significant associations between kina and species such as coralline algae, suggesting that kina were associated with 'barrens' habitat*" (Miller et al. 2005). Lobster CPUE and sizes were higher inside the 'Conservation Area'.

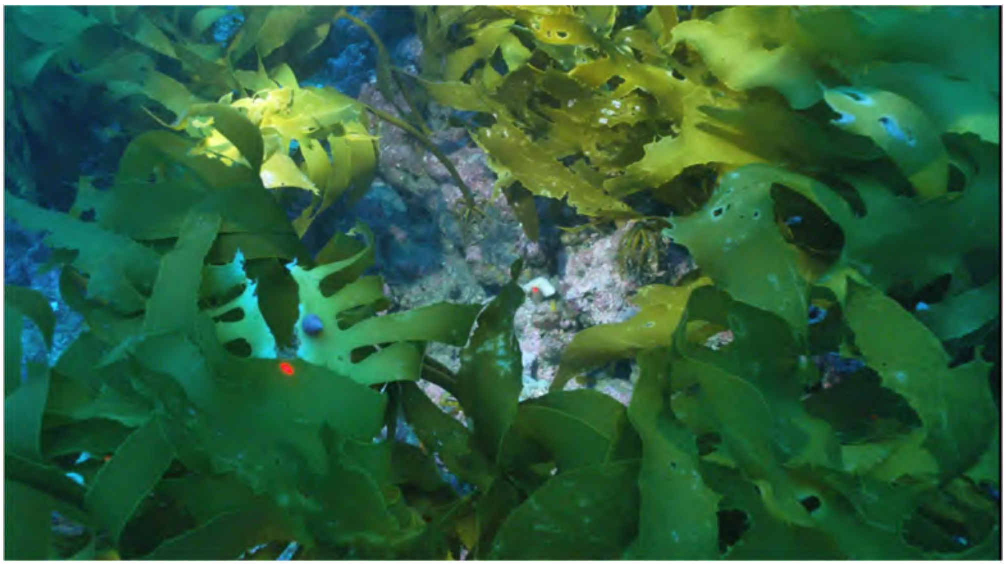


Figure 5-10: Likely *Trochus viridis* (now *Coelotrochus viridis*) seen on *Ecklonia* frond at site U, South Taranaki. The red circle mark is one of the scaling lasers, the second laser end can be seen in the central image area.

Fish assemblages were assessed across the same six sites using diver censused 25 x 5 metre transects, with around 20 transects per site (Miller et al. 2013). Eighteen species were observed, with the summed count of individuals given in Table 21. These numbers can only broadly be compared to those of 14 South Taranaki reef sites in the present study; due to the different census methods, shallower depths, different overall swept/sampled extents, and the Sugarloaf Island sites being fixed multi-year sites (sampled repeatedly), versus the much larger scale, one-year South Taranaki survey (sampled once).

The most striking fish species difference between the two survey regions was the dominance of jack mackerel (*Trachurus* spp.) at the Sugarloaf Islands, which were completely absent from the South Taranaki sites. Jack mackerel are very common on north-eastern New Zealand coastal reefs as juveniles, often as large schools over *Ecklonia* forests. However, they were present in only two of the three years sampled by Miller et al. (2013), with no jack mackerel recorded in 2001 for unknown reasons; they may have similarly been temporally missing from the 2021 South Taranaki survey. They have been seen at Project Reef (e.g., see https://www.youtube.com/watch?v=QX_eAeyZgTE)

Only repeated temporal sampling will address whether this absence is constant or varies over time with unknown factors. The other notable difference was the presence of two-spot demoiselles (*Chromis dispilus*) on the Sugarloaf reefs; none were seen in South Taranaki. This species is endemic to warm-temperate waters of New Zealand, and its range is considered to be the north-eastern New Zealand coastline and the Kermadec Islands. The New Plymouth presence may represent its most southern distribution; it was seen in numbers across all three survey years. Of note, silver drummer (*Kyphosus sydneyanus*) were also mentioned as present; this shallow reef herbivorous species is also a warm temperate species.

Sweep (*Scorpis lineolata*) are a planktivorous fish species often seen in small schools around reef outcrops and over *Ecklonia* forest, in shallow waters. Large numbers were counted at the Sugarloaf Islands (2,079 individuals, Table 17), compared with only 23 individuals counted across the 14 South Taranaki reefs (sites A and Q/South Trap, Table 10) (and a further Nmax of 7 sweep from a site Q trap video, Table 11, Figure 8). These two South Taranaki reef sites (A, Q) were the shallowest reef areas sampled in the present report (up to 9 metres water depth). The preference for shallower water reef by sweep may explain much of this large abundance difference, given the shallower focus of the Sugar Loaf Islands reef sites. Site A (Four-Mile Reef) is reported by locals to large schools of sweep (Karen Pratt, pers. comm.).

Large similar differences for other species might also be a depth effect e.g., red moki (393 vs. 11), banded wrasse (123 vs. 3), spotty (117 vs. 11), and marblefish (76 vs. 2), through water temperature differences might also influence the distribution of some species.

The other large contrast between the Sugarloaf and STB data was for blue cod (Sugarloaf 191 fish, seventh most abundant, vs. 2,200, highest abundance, South Taranaki). One potentially major driver of this difference was that fish diver surveys set up to assess habitat type, and/or marine protection effects, try to select sites that are as internally consistent as possible (i.e., are not mosaics, and do not have major habitat transitions such as reef/soft sediment boundaries running their centre). Blue cod are known to have a strong association with such mosaics and edges, and to be relatively uncommon up on reefs proper, and around *Ecklonia* forests (patterns clearly present in the CoastCam transect plots of reef geomorphologies, biogenic habitats, and fish occurrences). Hence, towed camera transect across the full seafloor habitat landscape, especially when specifically placed to cross over as much seafloor variation as possible, favour species such as blue cod. These method/habitat effects can be assessed by segmenting the video transects by habitat, depth, and other variables such as slope, rugosity etc in formal statistical analyses – one of the future use plans for the South Taranaki 14-site survey data. Of note, scarlet wrasse, a species that inhabits the reef proper (unlike blue cod) had high abundances in both studies (Sugarloaf 2782 fish, 2nd most abundant, vs. 744, 3rd most abundant, South Taranaki).

Table 21: Fish counts from diver census, at six reef sites, over three years The rock cod is *Lotella rhacinus*. Other species noted as present were kingfish, magpie morwong, silver drummer (*Kyphosus sydneyanus*)*, slender roughy, and scorpion fish (*, species not seen in other studies) (Source; table 7 of Miller et al. 2013).

Species	Total Count
Jack mackerel	5,075
Scarlett wrasse	2,782
Sweep	2,079
Butterfly perch	454
Red moki	393
Demoiselle	269
Blue cod	191
Banded wrasse	123
Spotty	117
Marblefish	76
Snapper	52
Leatherjacket	50
Tarakihi	26
Eagle ray	18
Blue moki	10
Rock cod	6
Goatfish	2
Kahawai	1

5.2.2 Pariokariwa Reef

This large coastal reef was surveyed with multibeam sonar in 2014, along with the smaller nearby Waikiekie Reef (Figure) (Sturgess 2015). Pariokariwa Reef is around 4.8 km long, by 1.5 km wide, and is orientated north-east. It ranges from 4 to 20 metres in depth, with its shallower areas containing more complex features including ridges, overhangs, and saw-tooth reef forms. Sturgess (2015) identified three distinct benthic habitats; bedrock with complex topography, sediment inundated reef, and mud and siltstone. Four fault lines run through the reef, seen in Figure as NE/SW line features. The faulting has pushed some reef areas up, while others have remained in their original position, and others worn away (if composed of siltstone or other softer rock). The saw-tooth structures, prominent across the reef, are known as a flysch sequence (Sturgess 2015). Alternating stacked layers of harder and softer (here siltstone and mudstone) rock are differentially eroded by the sea, creating undercuts as the softer material is removed; creating the saw-tooth structures, which are also warped through tectonic faulting. A nearby smaller reef (Waikiekie Reef) has undergone the same processes, but has a simpler morphology with single ridge top and a deep overhang running the length of the reef on the landward side (Figure) (Sturgess 2015)

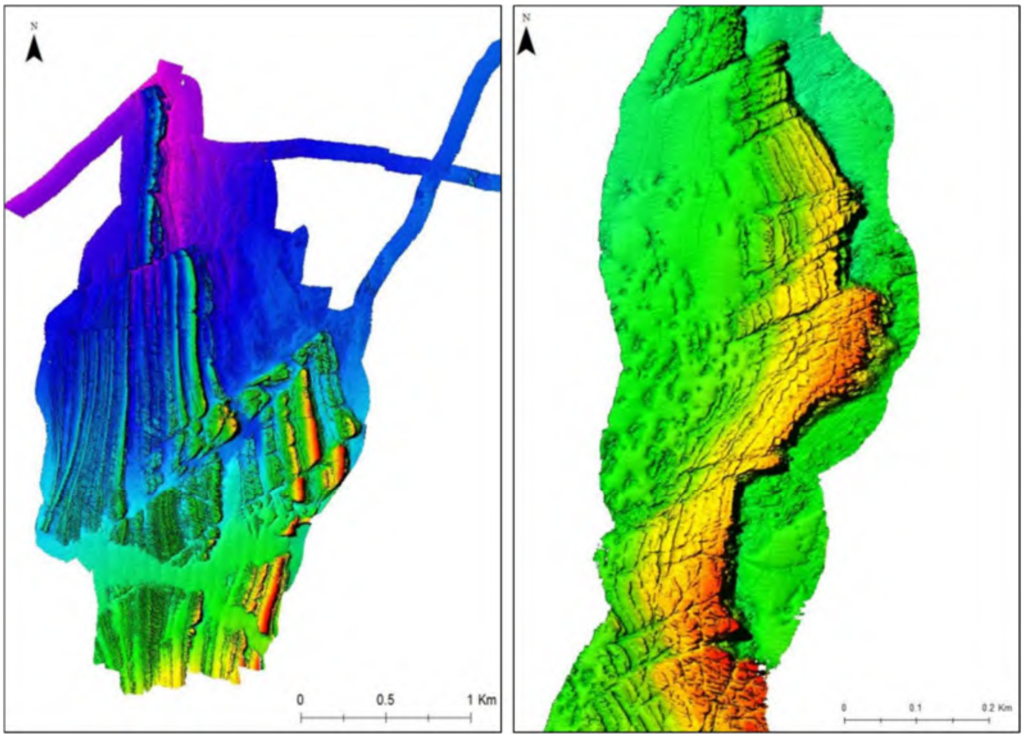


Figure 5-11: Multibeam sonar bathymetry maps of Pariokariwa Reef (depth range 4–20 m) and Waikiekie Reef Note that the two reefs are shown at different scales (a factor of 5x, Waikiekie Reef is only around 20% the length of Pariokariwa Reef). (Source: figures 2.4, 2.7 of Sturgess 2015).

The first ecological survey of Pariokariwa Reef was completed in 1995, with a one-day diving survey focussed on sponge assemblages (Battershill & Page 1996). Five dives (5–20 metres depth) were made across the reef, with observations made of the seafloor and species, and photographs and specimens collected. Three key geomorphological reef types were identified (Table 22). The first two were rocky outcrop and boulder reef areas at 5–10 m, and 10–15 m water depth, each with a different biogenic habitat assemblage. The first reef type supported a bryozoan and filamentous algae assemblage; and the second, had sponge gardens dominated by the sponge *Polymastia crassa* with a percent cover of 70% or more (Figure , images 1–2). The third geomorphological reef types, deep broken rock at 10–25 m, supported three distinct biogenic habitat assemblages; a) low density *Ecklonia* forest intermixed with finger sponges; b) Axinellid sponge gardens; and c) underhang communities of extremely dense encrusting sponges and some ascidians (Table 22, Figure).

Table 22: Pariokariwa Reef geomorphology and biogenic habitat classes (Battershill et al. 1996).

Geomorphology	Depth	Description		Ecological assemblages
Rock outcrop and boulder reef	5–10 m	Sand sweeps around boulders and rock outcrops, abrading the sides.		Base rock is barren. The rock outcrop and boulder tops are 100% covered with a relatively small variety of hardy bryozoan (*Bugula* spp.) and filamentous algae (*Polysiphonia* spp.) species
Rock outcrop and boulder reef	10–15 m	Sediments are not as deep or as mobile between rock outcrops		**Sponge garden**. Community characterised by bright orange sponge *Polymastia crassa*, densities of 70% cover or more on the top surfaces of boulders. Interspersed are other sponge species (*Polymastia* (n. sp. 2, or former *granulosa*), *Tethya aurantium*, *Aaptos aaptos*.
Deep broken rock	10–25 m	Rocky reef outcrops, platforms, and boulders. Several sub-habitats present	A	**Ecklonia forest**. Patches of *Ecklonia* forest occur, but canopy cover <30%. Often 1 per m^2 plant density. Densely encrusting subcanopy of turfing bryozoans and hydroids, many finger sponges. Finger sponge density appears inversely related to macroalgal density; two sub habitats separated on this basis, together with aspects of reef topography (finger sponges more prevalent in more dissected reef areas).
			B	**Axinellid sponge gardens**. In slightly deeper water (10-20 m), where extensive and dense sponge community, characterised by finger sponges (*Raspailia topsenti*, *Raspailia* n. sp., *Axinella* spp.) and massive sponges (*Ecionemia alata*) Often finger sponges densities >10 per m^2 of finger sponges). High sponge biomass. No bare rock present. Smaller sponges, turfing bryozoans, and hydroids present. Patches of large numbers of hydroid trees *Solanderia* (possibly two new species).
			C	**Underhang Communities.** Many under hangs, tunnels and shaded canyons supported extremely dense community of encrusting sponges and some ascidians. Characterising species were sponges *Clathrina* spp., *Ircinia* spp., *Leucosolenia* spp., and *Cliona celata*.

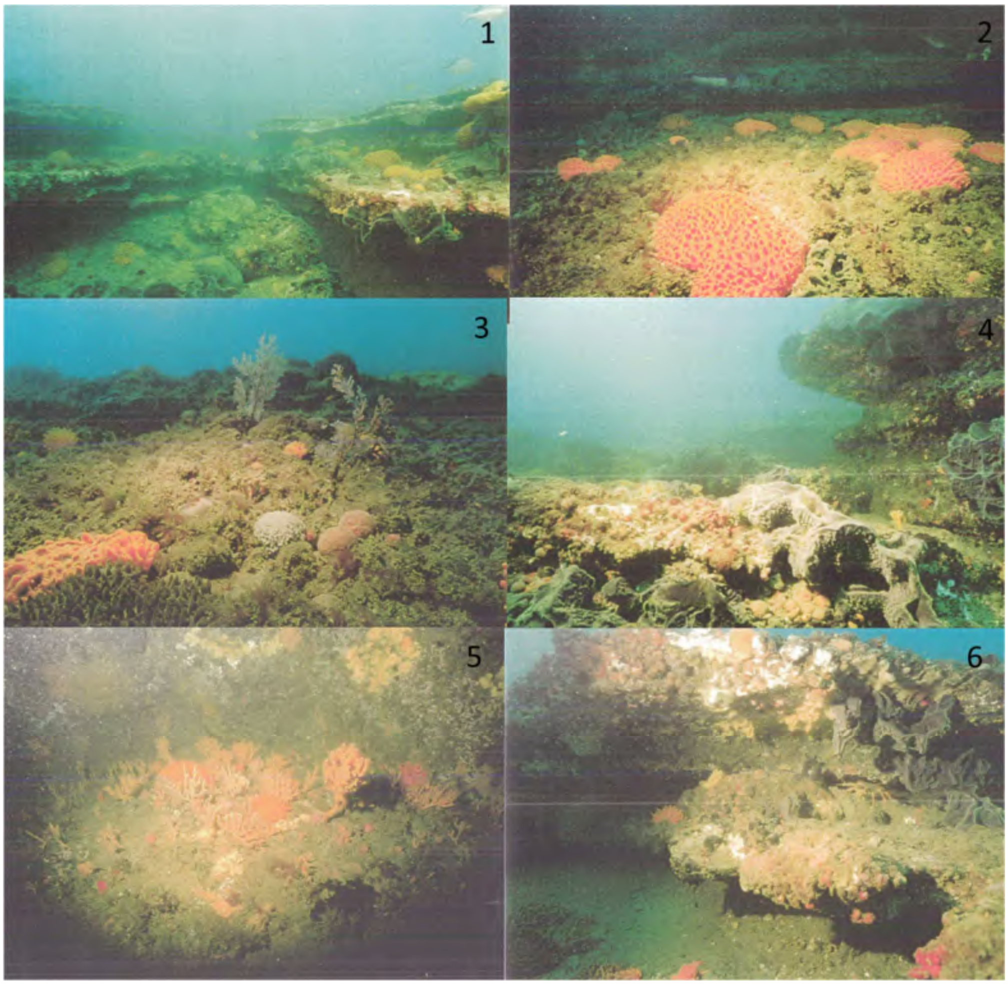


Figure 5-12: Pariokariwa Reef seafloor images 1–2) shallow reef habitat characterised by the orange sponge *Polymastia crassa*; 3–4) Slightly deeper reef with *Polymastia crassa* community giving way to *Ecionemia alata* and other sponge assemblages; 5–6) Deep-reef community characterised by finger sponges and massive sponges. (Source; plates 1–3, Battershill et al 1996).

Kina were uncommon, with densities never exceeding one urchin per 5 m^2. Large numbers of crayfish were present (red *J. edwardsii*, and packhorse *J. verreauxi*), and "*a number of extremely large crayfish were observed in deeper water*" (Battershill et al 1996). The fish assemblage was noted to have large populations of kingfish, but small populations of juvenile blue cod and other reef associated species. Thirty one other reef fish were also listed as being present, most of which were the same as those from other North and South Taranaki reefs. Notable 'new' species to this report were ruby-fish (*Plagiogeneion rubiginosum* – a commercial species usually caught in 50–600 m water depth), grouper (*Polyprion oxygeneios* – usually confined to deeper waters due to fishing out of shallow water populations), and blue maomao (*Scorpus violaceus* – a warm-temperate species usually constricted to north-eastern New Zealand; also mentioned as seen at the Traps by divers, DOC 2006). Three soft sediment fish species were also seen, as well as a further 20 smaller reef or pelagic species (e.g., triplefins, blennies, pipefish, seahorses, piper, yellow-eyed mullet etc).

The most obvious difference between Pariokariwa Reef and the 14 South Taranaki reefs was the prominent absence of dense macro-algae habitats. While *Ecklonia* forest was present, it was described as patchy, with low canopy cover and plant densities. *Caulerpa flexilis* was absent from the species presence list (*Caulerpa articulata* and *Caulerpa brownii* listed). The overall species list included 14 red algae, 8 brown algae (including *C. maschalocarpum* and *Zonaria* sp.), and 5 green algae. The location is known to experience prolonged periods of very low water visibility, which is likely to influence the local abundance and distribution of macroalgae due to limited light attenuation. Other species groups listed included 13 species of cnidarian (anemones, corals, hydroids including two hydroid tree *Solanderia* species), and molluscs (25 species including saw-shells, Cooks Turban, green-lipped mussels, octopus (*Octopus maorum*), and the sea-slugs *A. luctuosa* and *Jason mirabilis*. *J. mirabilis* is a bright purple and white animal that associates in clusters with hydroid trees and are visually obvious; none were seen at the South Taranaki sites. Other groups were bryozoans (18 species), brachiopods (1 species), crustaceans (7 including the two lobster species), echinoderms (9 species), and ascidians (13 species).

Fifty-nine species of sponge were observed by Battershill & Page (1996). The first of two sponge garden types present at Pariokariwa Reef, the strong 'sponge *Polymastia crassa* – Rock *outcrop and boulder reef (10–15 m)'* association (Table 22) was not present at any of the 14 South Taranaki sites. In fact, no *P. crassa* sponges were observed at all (Table 9).

The second sponge garden type present at Pariokariwa Reef was that of 'Axinellid sponge gardens on broken reef in 10–20 m depth, with an extensive and dense sponge community characterised by finger sponges (*Raspailia topsenti*, *Raspailia* n. sp., *Axinella* spp.) and massive sponges (*Ecionemia alata*), often finger sponge densities >10 per m^2 of finger sponges)'. These species were common on the South Taranaki reefs but did not form the dense concentrations (and inferred larger spatial patch areas) described for Pariokariwa Reef by Battershill & Page (1996), sufficient to be considered sponge gardens.

Underhang communities cannot be compared between the two studies as these are inaccessible to towed cameras; through the occurrence of 'under-hangs, tunnels and shaded canyons' habitats seemed quite limited for the South Taranaki reefs (though underhangs were present).

Only one type of sponge garden was recorded in South Taranaki (30–33 m, site V), with a different sponge species composition to that observed by Battershill et al 1996 (see Table 9). The STB sponge garden included Family Chondropsidae species 2 and *Cymbastela lamellata* (species only recently identified/described), *Ciocalypta polymastia*, and *Dactylia varia*. The site V sponge garden was in waters 11–21 metres deeper than those of Pariokariwa Reef, and much further offshore, with clear waters and coarse bottom sediments suggesting low terrestrial run-off inputs. The high juvenile blue cod nursery value was also in contrast to Battershill & Pages observation of "*small populations of juvenile blue cod*" for Pariokariwa Reef.

Sturgess (2015) also sampled the Pariokariwa Reef seafloor assemblages using one-metre square photo-quadrats. At four sites images were taken of the reef, across the reefs four 'faces/planes' – bottom, vertical, overhang and top – with 10 random photo-quadrats per plane, per site. Of these images, 137 proved suitable for point-intercept analysis, and were scored for percentage cover of individual organisms (e.g., sponges, jewel anemones), mixed turf, biogenic reef, and silt deposit.

The images were dominated overall by sponges and anemones. Overhang communities were also dominated by sponges (e.g., *Ecionemia alata*) and anemones (e.g., jewel anemones *C. australis*). Bryozoans only a small percent cover and were mainly found on vertical faces. Mixed turf (Phaeophyta/Chlorophyta) and *Polysiphonia* beds (Rhodophyta) were largely associated with reef tops, where mixed turf could occupy up to 80–100% cover.

The sponges *Ecionemia alata*, *Haliclona heterofibrosa*, *Polymastia* pepo and *Tethya burtoni* were strongly associated with overhangs and vertical reef faces. The sponges *Aaptos globosum*, *Clathria macrotoxa*, *Callyspongia* sp., *Pararhaphoxya pulchra* and *Stelletta conulosa* were commonly found on the top surfaces of the reef, while the sponge species *Callyspongia conica*, *Callyspongia ramosa*, *Ciocalypta polymastia*, *Mycale* spp., *Polymastia croceus*, and *Raspailia topsenti* were commonly associated with both the top and bottom of the reef.

5.2.3 New Plymouth region *E. radiata* kelp distribution

Cole & McComb (2001) sampled an area of subtidal reef and sand (4 to 14 metres depth) (Kawaroa Reef) just east of New Plymouth port (Figure). Using a drop video, they sampled 217 sites across a 150 m spacing grid and assigned each site to one of four possible habitat types. For those sites that fell on rock/reef habitat (167 sites), the estimated percentage contribution of habitats was *Ecklonia* forest (7%), mixed algae (*E. radiata*, *C. maschalocarpum*) (10%) and coralline pavement (83%). All soft sediment sites held sand. The kelp forests were concentrated in the 5–10 metre depth zone. More intensive sampling by divers (not included here) found these kelp habitats to hold higher abundances of smaller animals (gastropods, starfish, sea cucumbers, kina, and the sponges *Tethya ingalli* and *Tethya aurantium*); while the deeper water areas (>10 m) had high covers of turfing red seaweeds, and low grazing gastropod abundances. Fishes were "*not conspicuous*".

Wider limited drop video sampling to the west (11 sites towards Oakura), and east (14 sites toward Waitara found the reefs to be dominated by coralline pavement habitat, with only three sites holding *E. radiata* forest (Figure). The fish fauna was noted to be like the main survey area.

Figure 5-13: Kelp forest around New Plymouth Left) drop camera survey of Kawaroa Reef (water depth 4–14 metres), showing 5-m depth contours (blue shadings), reef (un-speckled), and sand (speckled). Right) broader regional sampling with video drop camera, with *E. radiata* kelp forest sites labelled in green (sites 1, 9, 17). (Source: figures 9 & 10 of Cole & McComb 2001).

Crofskey (2007) used the same drop camera approach as Cole & McComb (2001) to assess seafloor type, complexity, and *E. radiata* kelp cover around the Taranaki Peninsula. Video drops were made along a 60 km gradient starting from in the southern, with 804 sites located along 46 onshore-offshore transects. Each site was assigned a substate (9 classes), a topographic complexity (13 classes), and a kelp density (7 classes) identity (Figure).

Most of the coast held large reef areas, with smaller contributions of sand. These reef areas dominated along the coast, from 800 m beyond MHWS through to around 3 km offshore. The exception was the area around New Plymouth, which in contrast was dominated by sand. The highest kelp densities occurred in the southern 10 km, with the average density of kelp steadily decreased northwards from Oakura towards Motunui, aside from a few patches. Transects devoid of kelp were more often encountered in the most northern area (Waitara through to Motunui).

An assessment of potential explanatory factors found the greatest negative spatial correlation between kelp density and annual mean water turbidity (inferred from satellite-derived measures of the downward attenuation of 490 nm irradiation). These gradients of decreasing kelp cover and increasing water turbidity ran from south to north. In contrast, measures of the near bed wave kinematic energy regime found much larger ambient and storm wave velocities to be experienced in by the Cape Egmont region (the south), compared with the Motunui zone to the north. Crofskey (2007) concluded that "*that water turbidity is the primary factor that defines the Ecklonia distribution in Taranaki, although the wave energy and habitat complexity of the reef are likely to be influential as well. Wave action has the potential to limit the size and abundance of E. radiata in shallow waters, while water turbidity reduces the depth range that the kelp can occupy. The direct effects of fine terrigenous fluvial sediments was hypothesised to be the main limiting factor for kelp colonisation on the north-eastern reefs, particularly near the Waitara River*".

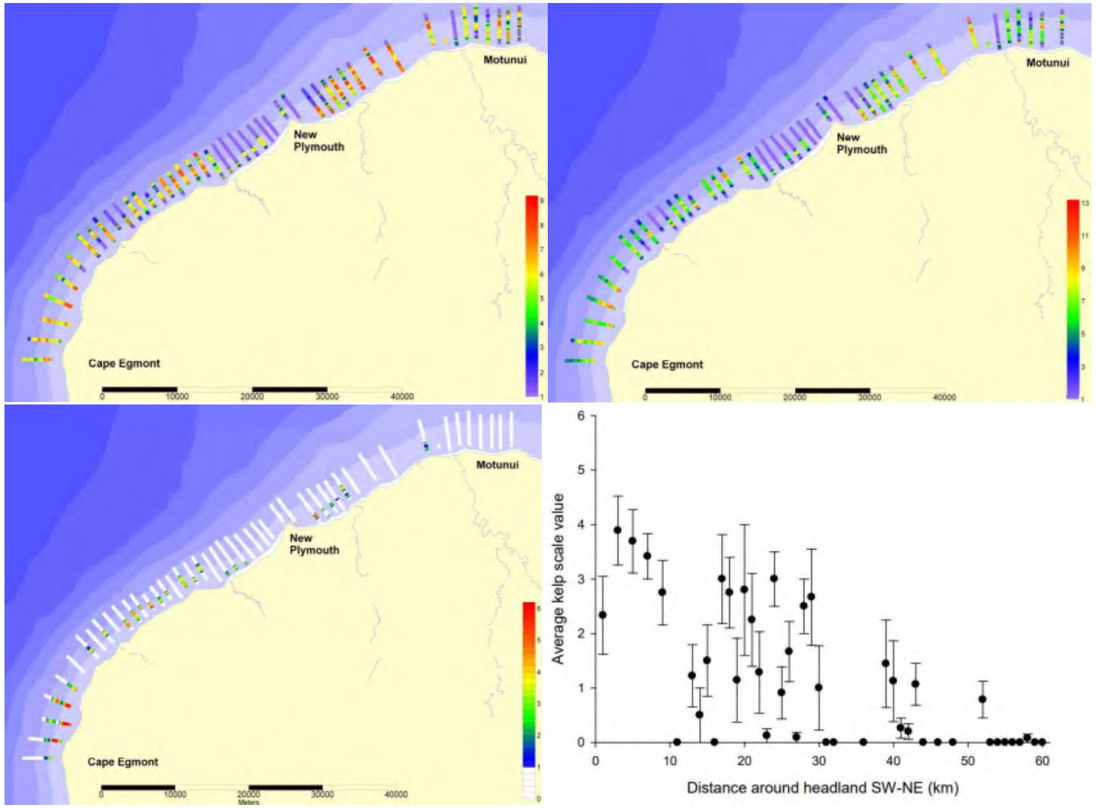


Figure 5-14: North Taranaki survey of Crofskey (2007), with transects starting in the south Upper left) substrate distributions; upper right) habitat complexity distribution; lower left) *E. radiata* kelp density; lower right) average kelp density estimate (± SE) (all sand sites excluded). Kelp densities are expressed as percentage cover classes; 0, 0%; 1, 1–5%; 2, 5–9%; 3, 10–19%; 4, 20–39%; 5, 40–79%; 6, >80%. Substrate and habitat complexity categories are given in Appendix C; increasing values indicate increasing rock proportion/increasing rock object size contributions, and rugosity/topographic variation, respectively.

5.2.4 Large scale sponge distributions, Taranaki region

A PhD thesis described the geographic distribution of sponges in the Taranaki region (Cormack 2021). To investigate the potential effects of terrestrial inputs to the sea on sponge assemblages, reef/s offshore from three North Taranaki rivers (discharging from three discrete catchments varying in their 'pristineness') were sampled for sponges. These were the Waitara reefs (near and distant to shore), the Waiwhakaiho reefs (near and distant) and Hangatahua Reef (one site only) (Figure). Sponges were collected by divers, with the goal to collect as many sponge species as practical by hand. Due to low (<4 m) visibility, sites were searched using a ten metre circle sweep. In addition, five 0.25 m^2 quadrats were haphazardly placed, and percent cover of the various phyla present visually estimated. Volumes (height × width × length) were also estimated for each individual sponge, and some algae and other invertebrate taxa. Number of taxa within each phyla, number of sponge species, and number of sponge individuals were also recorded. Identification was to species level where practical.

As well as these 5 field collection sites, three additional reefs (Pariokariwa Reef, Pātea Project Reef (site K), and Kapiti Island reefs, west Wellington coast) were added as desktop data additions, using all available literature and other information sources to assemble species lists. An overall species/taxa pool of 242 sponges was calculated. An obvious important caveat here is that sampling effort will have varied across the three locations not sampled directly by Cormack (2021), the sponge species list used for the Project Reef was also an older version that missed several sponge species confirmed as present on the reef.

Thirty-five sponge species were found to only be present at the geographic end sites (Pariokariwa Reef to the north, Kapiti Island to the south). For the Taranaki sites (Kapiti Island excluded), it was estimated that average sponge species richness (number of species) was around 9.6 per 1 m^2 of rocky reef. *Ecionemia alata* was the most widely distributed species, and the only taxa recorded at all six locations. For the Taranaki sites, Pariokariwa Reef had the largest number of unique species (44), followed by Waitara sites (36), Pātea (12), Hangatahua (9), and Waiwhakaiho (6). The Waitara reef result was considered a surprise, as the reefs were adjacent to the largest river (Waitara River) and catchment in the Taranaki region, with the catchment also being the most human-modified with high sediment discharges. The author suggested that the sponge species present at Waitara represented a sediment tolerant specialist group of sponges. It was noted that sponges collected at the site had not been identified even to a generic level and had not been recorded elsewhere in New Zealand (Cormack 2021).

Sponge diversity and abundance was higher at sites in closer proximity to river mouths. It was suggested that terrestrially derived organic matter from rivers might be driving these patterns. Sponge volumes were greater at reef sites positioned next to rivers with a relatively large coverage of indigenous terrestrial forests, versus those adjacent to modified and urbanized catchments.

Cormack (2021) also provided a brief description of the five 'new' reef sites sampled off North Taranaki. All the reefs were composed of boulders of varying sizes; bedrock was absent (Table 23).

Table 23: Descriptions of the five reef sites of Cormack (2021) All were composed of boulders, with no bed rock present. Sp%, the relative contribution of sponges to overall organism seafloor cover (as measured in 0.25 m2 quadrats. Three *E. radiata* plants were counted at the Hangatahua coastal near site (17 m depth).

Site	Depth (m)	Sp. %	Seafloor description	%Boulders		
				Large >30 cm	Medium 10-30 cm	Small <10 cm
Waitara coastal near	12	85	Predominantly large boulders (flat not regular), and sand. Small to medium boulders less common. Large quantity of suspended sediments.	36	21	21
Waitara coastal distant	19	81	Predominantly large/medium boulders, some smaller boulders. Approximately 5% gravelly shell-hash.	40	37	14
Waiwhakaiho coastal near	18	79	Boulders up to one metre wide, creating tiny caves/overhangs (caves 40 cm × 30 cm × 20 cm). Large proportion of medium and small boulders packed together. Limited sand among boulders, white to cream yellow, many tiny broken shells. Large area of rippled sand adjacent to reef. Most three-dimensional reef site.	34	37	19
Waiwhakaiho coastal distant	18	29	Large boulders dominate slightly. Sand, gravel, and broken shell also present. Large and small size boulders mixed.	35	25	27
Hangatahua coastal near	17	64	Large 1–1.5 metre boulders on sand covered seafloor. Sand was white and black colouration. Reef surrounded by sand.	84	10	1

A recent study by Harris et al. (2021) used ROV/divers to sample reefs at the Poor Knights Islands, in the Fiordland Marine Area, around the Project Reef, and at Parininihi Reef. Water depths extended from 5 to 120 metres depending on region (restricted to 15–30 metres at the Project Reef area, and 10–25 metres at Parininihi Reef). Images were extracted from the video and scored for percent cover of taxa groups. Most of the sampling effort was focussed on the Poor Knights and Fiordland. Sponges were found to dominate most of the benthic communities sampled, with their abundance varying significantly with depth at 3 out of 4 location; and their morphological composition (complexities of form) changing with depth at all locations. Of relevance here, "*sponge cover at Patea (25 m)* [water depth] *was particularly high (30% ± 3 SE)* [relative to all other locations] *and higher than macroalgae and CCA cover (3.1 ± 1.9 to 3.9% ± 0.8 SE, respectively)*"(CCA, calcified coralline algae; SE, standard error]; "*while Parininihi had lower sponge cover (19.6% ± 2.3 SE) but with high corresponding macroalgae cover (37.4% ± 3.6 SE)*" (macroalgae were only given at the Phylum level). Additionally, a measure of 'sponge assembly complexity' (how much 3D sponge complexity was present) found that "*Patea showed the highest sponge assemblage complexity score of all locations at 25 m"* [water depth]. Parininihi had a lower overall sponge complexity than Patea, but "*showed the highest overall cover of high complexity forms (2.9% ± 0.6 SE) of all locations at 25 m*", with "*the largest proportion of high complexity forms of any assemblage at 25 m across all locations*". Put another way, comparing sponge assemblages across all the areas at 25 metres water depth, Patea held the highest value for overall sponge 3D-complexity, while Parininihi Reef held the highest values for the most complex 3D-sponge contributions.

6 Recommendations

The multibeam sonar survey, and subsequent ground-truthing and examination of 14 rock/reef sites using the CoastCam towed video array, has clearly shown that rocky reef habitat is much more common and widespread on Pātea Banks than documented in the scientific literature.

The video camera data was presented here in semi-quantitative narrative form. Data were processed as 20-second video segments; the next step will be to analyse these data in relation to the area surveyed (e.g., inds./m^2 of reef), which combined with the underpinning multibeam sonar data, will enable a range of powerful formal statistical analyses to be advanced. The multibeam sonar data also provides additional landscape variables not covered in this report, such as seafloor slope, aspect, and rugosity (roughness), at fine scales (tens of metres) that can be matched to the video segments rich data sets. Combined, these ecological and geophysical data-sets should be analysed to answer a range of fundamental questions about South Taranaki's subtidal reefs (see below for examples). Predictive models can then be used to estimate likely species densities, species assemblages, and habitat types over larger reef areas (e.g., as determined by multibeam sonar mapping). Questions include:

Are important biogenic habitat forming species (e.g., *Ecklonia*, *C. flexilis*) showing recurring associations with different reef types, morphologies, depths, and other factors, e.g., *Ecklonia* forest with reef ridges, *Caulerpa* meadows with stepped terrace reefs? The reef tell sponge clusters seen for *C. ramosa* at site U? The Axinellid sponge clusters on buried rock seen at site S?

Are there recurring groups of species/taxa that collectively can be defined as discrete repeating ecological assemblages? E.g., for the sponge garden seen at site V? Or for the smaller scale sponge clusters seen on some reef edges? The *Caulerpa* 'pillow ridge reef' meadows that often have an apparent small sponge and bryozoan species association?

Are the low 'pillow reef' forms seen a result of biological carbonate production and build-up (e.g., by bryozoans)? Why does *C. flexilis* show such a strong association (100% of all ridges are occupied by this species) with these ridges, and why are they formed as such multiple linear rows? Some of these questions will require direct diver-based observations and collections.

Can we define and identify juvenile fish – nursery habitats quantitatively, e.g., the very strong 0+/larger juvenile blue cod associations with the sponge garden of site V? Scarlett wrasse and leatherjacket juveniles (although not formally separated from adults in the counts) also showed clear habitat preferences at sites where they were common (e.g., juvenile scarlet wrasse with some *Caulerpa* meadows, sponge clusters and gardens; juvenile leatherjacket with *Ecklonia* forest)., One of the objectives of the science outreach from the NIWA Juvenile fish habitat bottlenecks programme to the South Taranaki coast, was to see if 0+ blue cod habitats/nurseries could be found, what they were, and compare and contrast then to other regions such as the Marlborough Sounds. Data from the 14 sites (absences as much as presences) will help answer these questions, with the strong nursery values of the sponge garden and low reef habitat of site V being a particularly valuable discovery.

For all these questions, there is a fundamental habitat/landscape focus. If strong predictive relationships can be found and validated between these species/species assemblages/functions, and the reef and other habitat geomorphologies (which are able to be mapped by multibeam sonar) then it will become possible to use statistical models to predict where these assemblages may occur.

Knowing what is where, and how much, is a fundamental requirement for effective resource management (however 'resource' is defined).

This study surveyed 14 of an original target of 20 sites, selected using the multibeam sonar maps to maximise their geographic and depth spread. It is unlikely that all the reef types and species/species assemblages present in the survey areas were 'captured' from three days of field work. Significant new discoveries are likely yet to be made. Any new CoastCam towed camera survey work across the existing multibeam sonar mapped reefs would fundamentally strengthen the findings of this report, both through the likely discovery of new reef types and assemblages; and potential site replication of habitat types currently represented by only one site (e.g., the deeper water sponge garden and associated 0+ blue cod nursery function of site V). Systematically sampling rock seafloors/reefs across a gradient of water depths including the inshore/shallow environment would be particularly useful, there are known to be large reef extents shoreward of site J (the shallowest of the 14 sites) not yet investigated. A community inclusive approach would be to work with Citizen Scientists to deploy drop-cameras from small boats to cover a wide range of sites quickly and cost-effectively, to assign them seafloor/habitat identities. The local diver community might also be engaged with to gain underwater footage of some reefs, e.g., with head mounted Go-Pro cameras, which are left to record as the diver goes about their dive. Such approaches are very amenable to citizen science approaches. More formal technical science deployments could then subsequently be made as appropriate, targeting a subset of sites of particular interest selected from the wider reef visits.

In an ideal world, the entire Pātea Bank (and beyond) would be fully multibeam sonar mapped. That is unlikely in the short term but remains the ideal. Of note, bycatch records from MPI research trawl surveys (50–100 m water depths) suggest deeper offshore sponge garden habitats with different species assemblages may exist to the south/south-east of Pātea, although these largely fall beyond the 12 mile nautical limit in which Regional Councils have CMA responsibilities (Morrison et al., in editorial), Emma Jones, NIWA Scientist, pers. comm.).

A fundamental immediate need is to gain a better understanding of the geology of the different reefs. In this report the terms mudstone/Papa rock, and sandstone, have been used to define the different reefs. However, the Project Reef (site K) is at least in part formed of hard fossil-rich rock, and site Q (South Trap) at least partially formed of limestone (with parts of other reef sites showing very similar-looking rock and erosion forms, e.g., 'lattices' on the top of some reefs). Other rock forms are the flat grey rock surfaces, flush with soft sediments, seen adjacent to some reef boundaries. These may be newly uncovered Papa rock flats that have not yet been exposed to weathering and bioerosion but they appear different to the two mudstone reef sites (Papa, D). There is also a suggestion that there are components of harder rock small boulders at some of the more northern sites, perhaps transported south from the volcanic rock region around Taranaki Maunga. The smooth grey cobbles of site A are also an anomaly. Site V reefs appear to be formed of a breccia rock, different from all the other reefs surveyed.

Direct diver-based visits to some reefs, both to collect geological samples and to undertake targeted species collections, would fundamentally advance knowledge of these reefs. Higher priority biological targets would be the species compositions of macroalgal meadows, and the likely bio-eroding infaunal communities of sites D and Papa. Why carnivorous fish assemblages (e.g., snapper, blue cod) are associated with such fauna depleted reefs in relatively high abundances (e.g., site D) is also unclear, but could be addressed by sampling those fish to see what they are eating.

Finally, there were also a range of unusual seafloor bedforms in some areas, that may be soft-sediment based, that were partially mapped with multibeam. Camera ground-truthing of these sites is likely to produce novel new habitat types, with new species associations; some of which may (or may not) be structured in part by the presence of rock/reef components.

7 Acknowledgements

We are grateful to the fishers and divers of Taranaki that shared some of their hard won knowledge with us; having that spatial knowledge to help direct the survey route was invaluable in avoiding the issue of searching for needles in a haystack. We thank skipper Lindsay Copland and crew of the R.V. Kaharoa for their work travelling the 24/7 multibeam sonar mapping route in 2020 in the face of up to 30 knot gusts, and Craig Robinson and Richard (Dick) Leppard for their good company and able handling of the R.V. Ikatere in 2021 for the three days of CoastCam operations. Aaron Dalbeth skilfully operated the CoastCam system, in the face of at times trying sea conditions that took their toll. Nick Eton provided appreciated CoastCam set-up overview, and post-field video file handling advice. We thank Sadie Mills, NIWAs National Invertebrate Collection (NIC) manager for coordinating species identifications from images (and identifying some species), with the following taxonomists (also thanked): Dennis Gordon (bryozoans), Wendy Nelson (algae), Michelle Kelly (sponges), Kate Neil/Diana Macpherson (hydroids, anemones, starfish), Jill Burnett (gastropods and bivalves). Clinton Duffy (DOC) provided appreciated advice on several fish images to confirm species identities, while Callum Lily and Monique Ladds (both DOC) are thanked for sharing some hard to find documents, and seafloor images. Jennifer Beaumont provided much appreciated refereeing of the draft report, while Jess Moffat ably formatted the report.

8 References

Anderson, T.J., MacDiarmid, A., Stewart, R. (2015) Benthic habitats, macrobenthos and surficial sediments of the nearshore South Taranaki Bight. *Unpublished NIWA Client Report* NEL2013-012 prepared for Trans-Tasman Resources Ltd. 46 p.

Battershill, C.N., Page M.K. (1996) Preliminary survey of Pariokariwa Reef North Taranaki. Report prepared for Department of Conservation, Whanganui. 15 p. + Appendices.

Beaumont, J., Anderson, T.J., MacDiarmid, A.B. (2015) Benthic flora and fauna of the Pātea Shoals region, South Taranaki Bight. *Unpublished NIWA Client Report* WLG2012-55 prepared for Trans-Tasman Resources Ltd. 200 p.

Bombosch, A. (2008) Developing a benthic habitat classification scheme. Analysis of subtidal drop camera data from the southern Taranaki coast. Unpublished report prepared in partial fulfilment of the Masters in Marine Conservation for the Department of Conservation. 45 p.

Coffey, B., Williams (1992) Coastal and marine habitats of North Taranaki. Unpublished report for the Department of Conservation by Brian. T. Coffey and Associates Ltd. 11 p.

Cole, R.C., McComb, P.J. (2001) Port Taranaki maintenance dredging consent renewal studies report 4 - Biological description and assessment. NIWA Client Report prepared for Westgate Transport Ltd.

Crofskey, E. (2007) The distribution of *Ecklonia radiata* around the North Taranaki Headland and its relationship with key physical characteristics. Unpubl. MSc Thesis, University of Auckland. 118 p.

DML (2021) Tapuae Marine Reserve and Ngā Motu / Sugar Loaf Marine protected area bathymetry survey. Report of survey for the Department of Conservation. Discovery Marine Ltd.

DOC (1998) Further Information on Parininihi Marine Reserve Application. Unpublished report prepared by the Department of Conservation, Wanganui Conservancy for the Minister of Conservation 1998.

DOC (2006) Netting coastal knowledge. A report into what is known about the South Taranaki-Whanganui marine area. Department of Conservation, Whanganui Conservancy. 224 p.

DOC/UoW (undated) Sugar Loaf Islands (Nga Motu) Marine Protected Area. Facies map based on interpolated side-scan sonar rectified and geo-coded image. Unpublished map.

Francis, M.P. (1996) Geographic distribution of marine reef fishes in the New Zealand region. *New Zealand Journal of Marine and Freshwater Research* 30(1): 35–55.

Harris, B., Davy, S.K., Bell, J.J. (2021) Benthic community composition of temperate mesophotic ecosystems (TMEs) in New Zealand: sponge domination and contribution to habitat complexity. *Marine Ecology Progress Series 671*: 21–43.

Jones, E.G., Morrison, M.A., Davey, N., Hartill, B.W., Sutton, C. (2016) Biogenic habitats on New Zealand's continental shelf. Part I: Local Ecological Knowledge. New Zealand Aquatic Environment and Biodiversity Report No. 174. 95 p.

Mc Cormack, S.P. (2021) The biogeography and trophic roles of coastal marine sponges (Porifera) from the west coast of the North Island, New Zealand: Influences of catchments. Unpublished PhD thesis, University of Waikato. 202 p.

MetOcean Solutions (2007) Parininihi Marine Reserve reef fish survey. Unpublished report prepared for Department of Conservation.

Miller, R., Williams, B., Duffy, C. (2005) Reef fish of the Sugar Loaf Islands (Ngä Motu) Marine Protected Area, New Zealand. DOC Research and Development Series 226. 26 p.

Miller, S., McDonald, S., Williams, B. (2013) Benthic invertebrate monitoring at the Ngā Motu / Sugar Loaf Islands Marine Protected Area, 2001–2003. DOC Research and Development Series 335. 63 p.

Morrison, M, Woolley, J.-M., Mills, S., Yeoman, J., Bian, R., Kelly, M., Tracey, D., Anderson, O., Nelson, W., Gordon, D., Read, G., Marshall, B., Jones, E. (in editorial) Deep rocky and biogenic reefs (50–300 metres) around New Zealand. Science for Conservation.

Pinkerton, M. (2014) Predicting the effects of iron sand mining on optical properties of the South Taranaki Bight. Expert evidence for Taranaki iron sand mining application, Environment Court. https://www.epa.govt.nz/assets/FileAPI/proposal/EEZ000004/Evidence/c8fd9eb306/EEZ000004-Matt-Pinkerton-Optical-properties-18-March.pdf

Shears, N.T., Babcock, R.C. (2007) Quantitative description of mainland New Zealand's shallow subtidal reef communities. Science for Conservation 280.

Shears, N.T., Babcock, R.C., Duffy, C.A.J., Walker, J.W. (2004) Validation of qualitative habitat descriptors commonly used to classify subtidal reef assemblages in north-eastern New Zealand. *New Zealand Journal of Marine and Freshwater Research 38*: 743–752

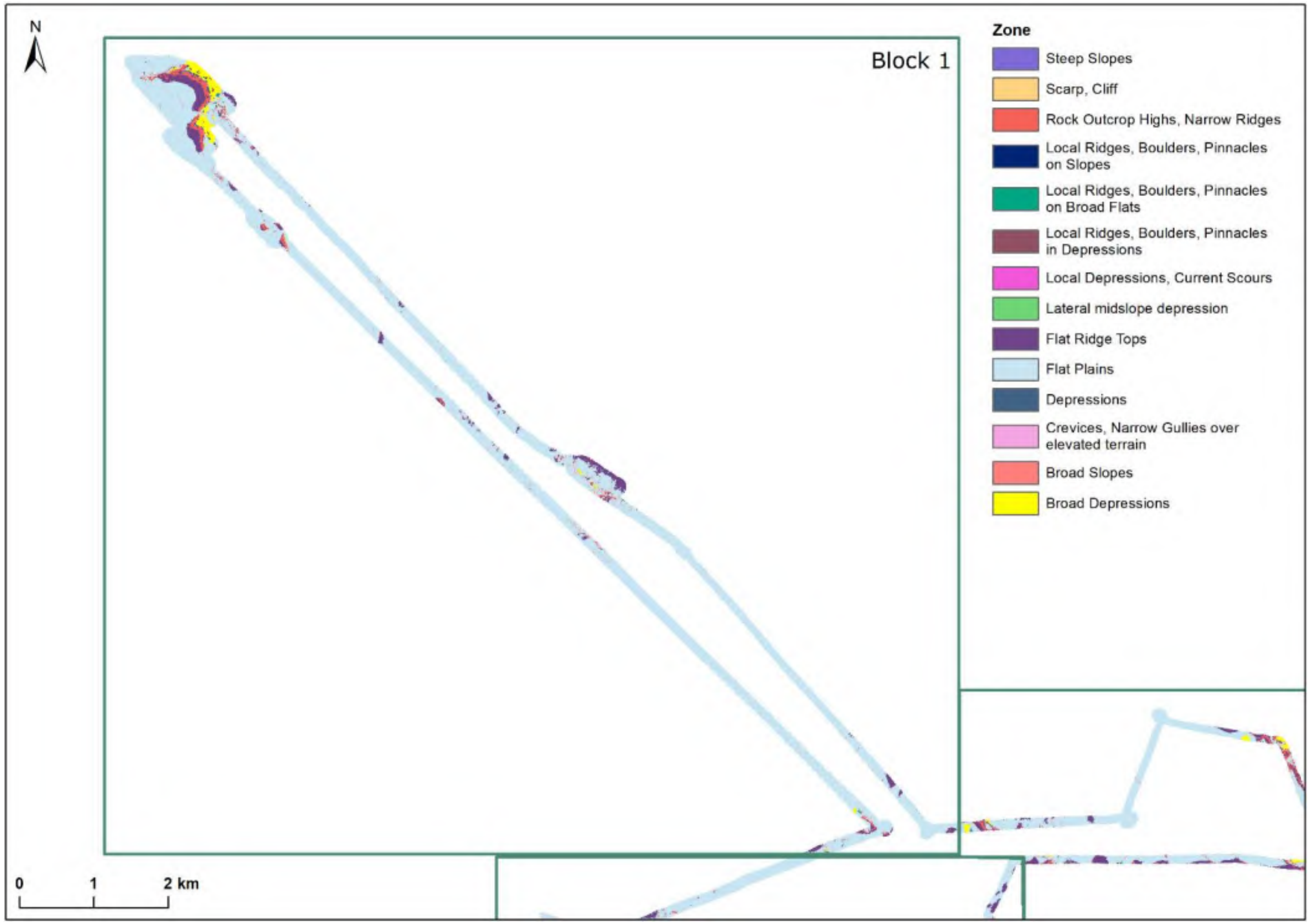
Sturgess, N. (2015) Mapping the ecological and biophysical character of seabed habitats of the Paraninihi Marine Reserve, Taranaki, New Zealand. MSc Thesis, University of Waikato.

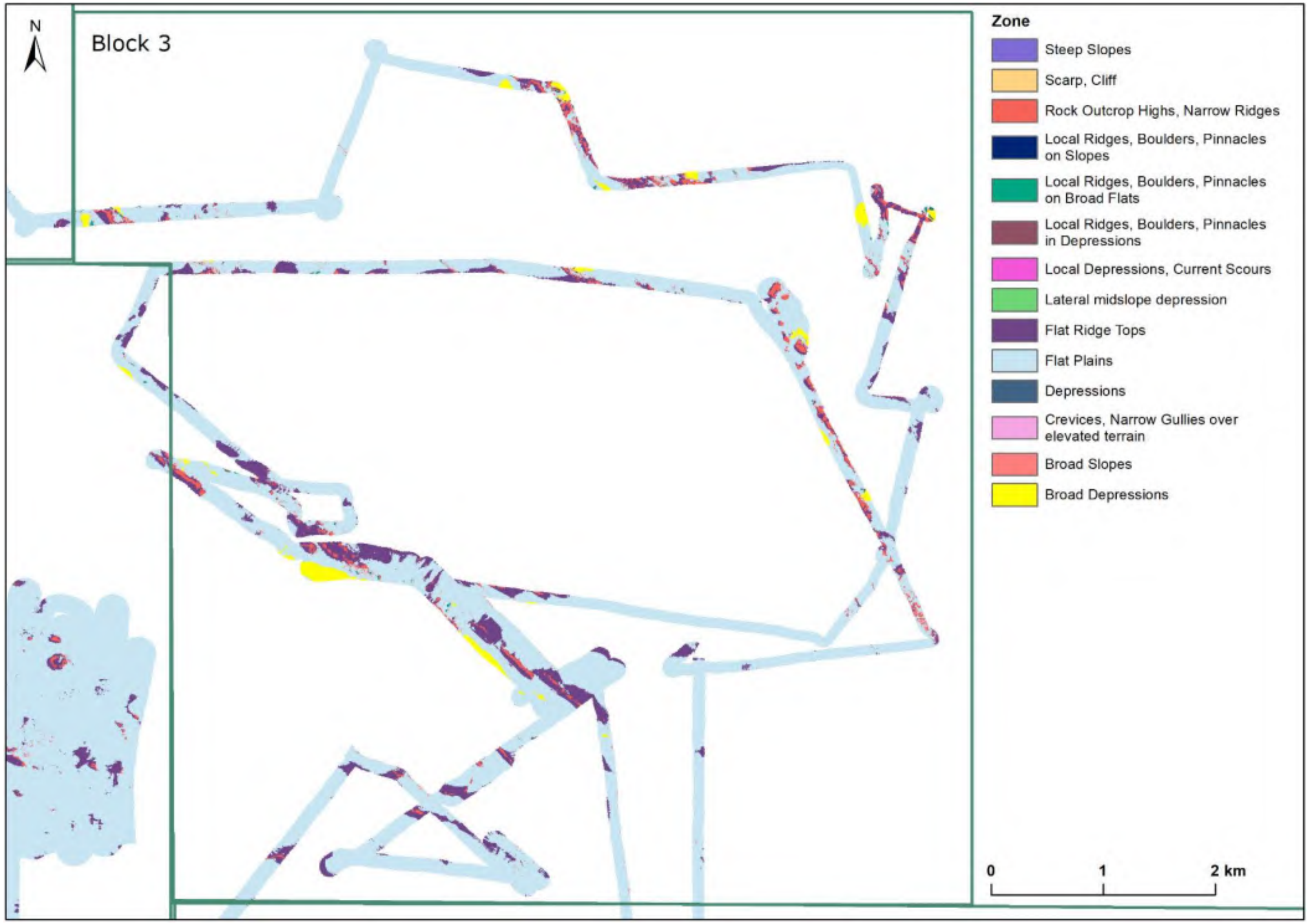
Taranaki Catchment Commission (1980) Marine ecology. Water resource investigations - Petrochemical development - Tikorangi. Taranaki Catchment Commission, Stratford. 72 p.

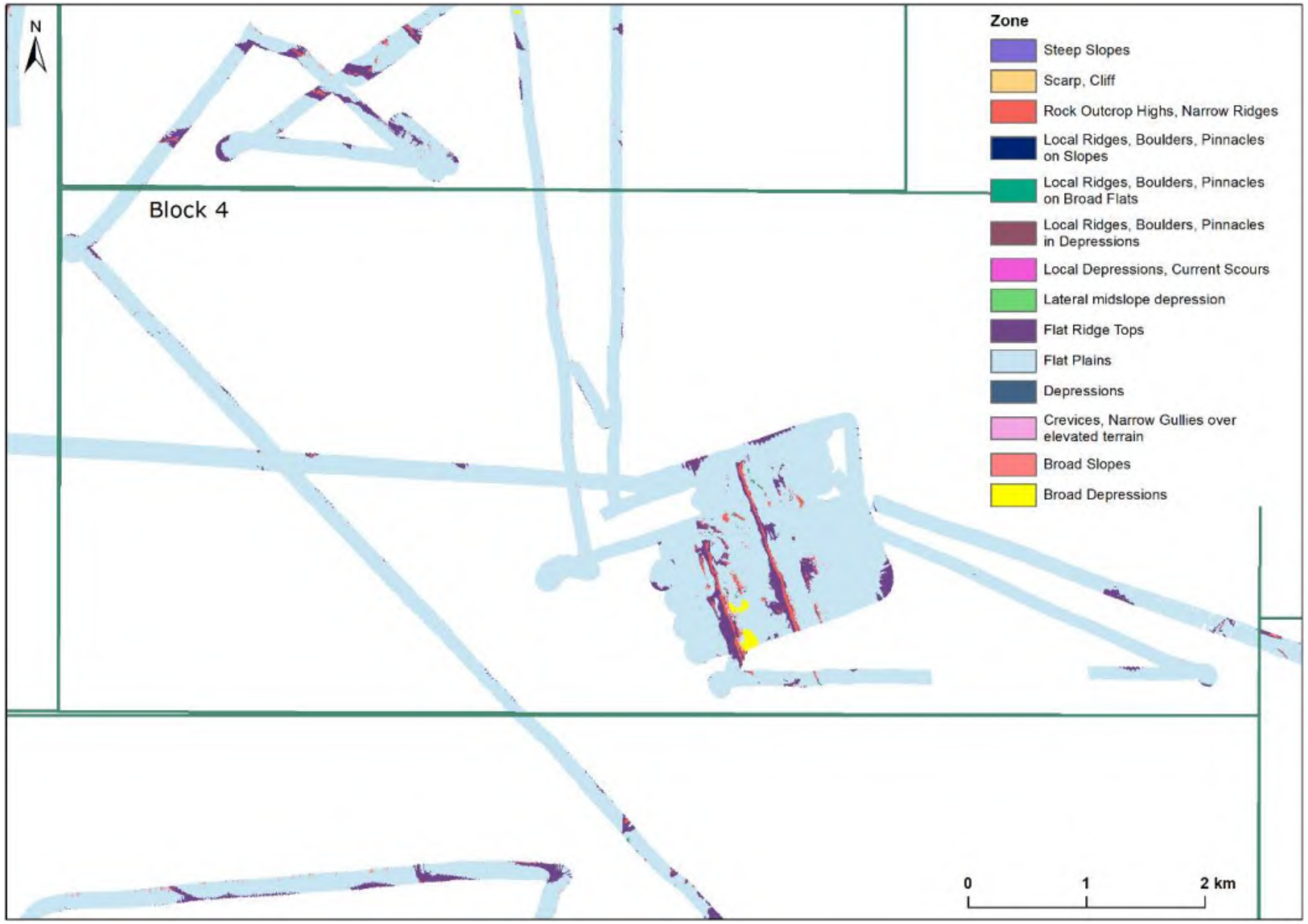
Taranaki Catchment Commission (1982) Ecological survey of the Waiwhakaiho marine and estuarine environments. Taranaki Catchment Commission, Stratford. 76 p.

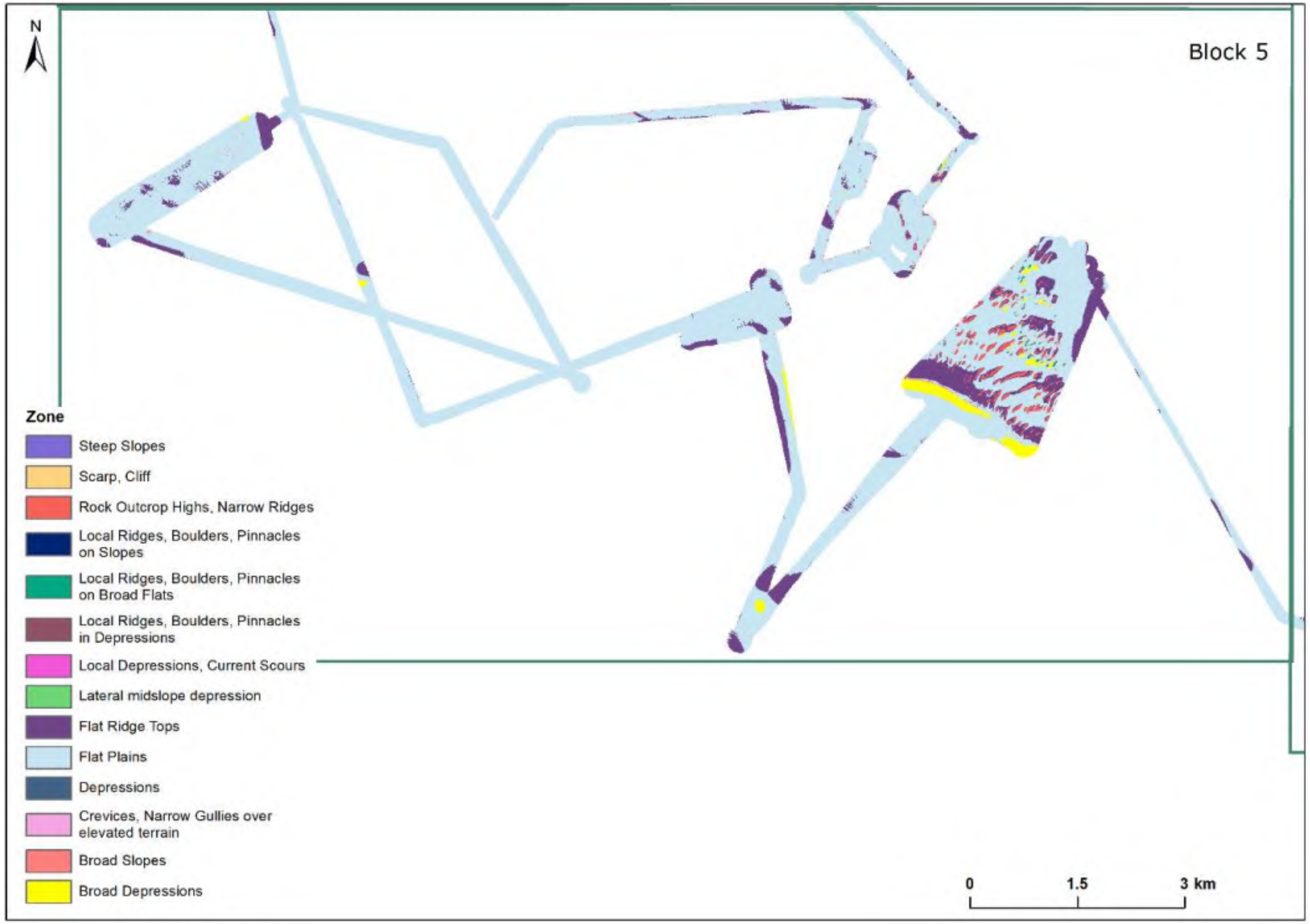
Willan, R.C. (1980) Report on the subtidal marine biological surveys in inshore waters of the Taranaki coast. Maui development environmental study Phase II. Subtidal monitoring study. Report 79–18.

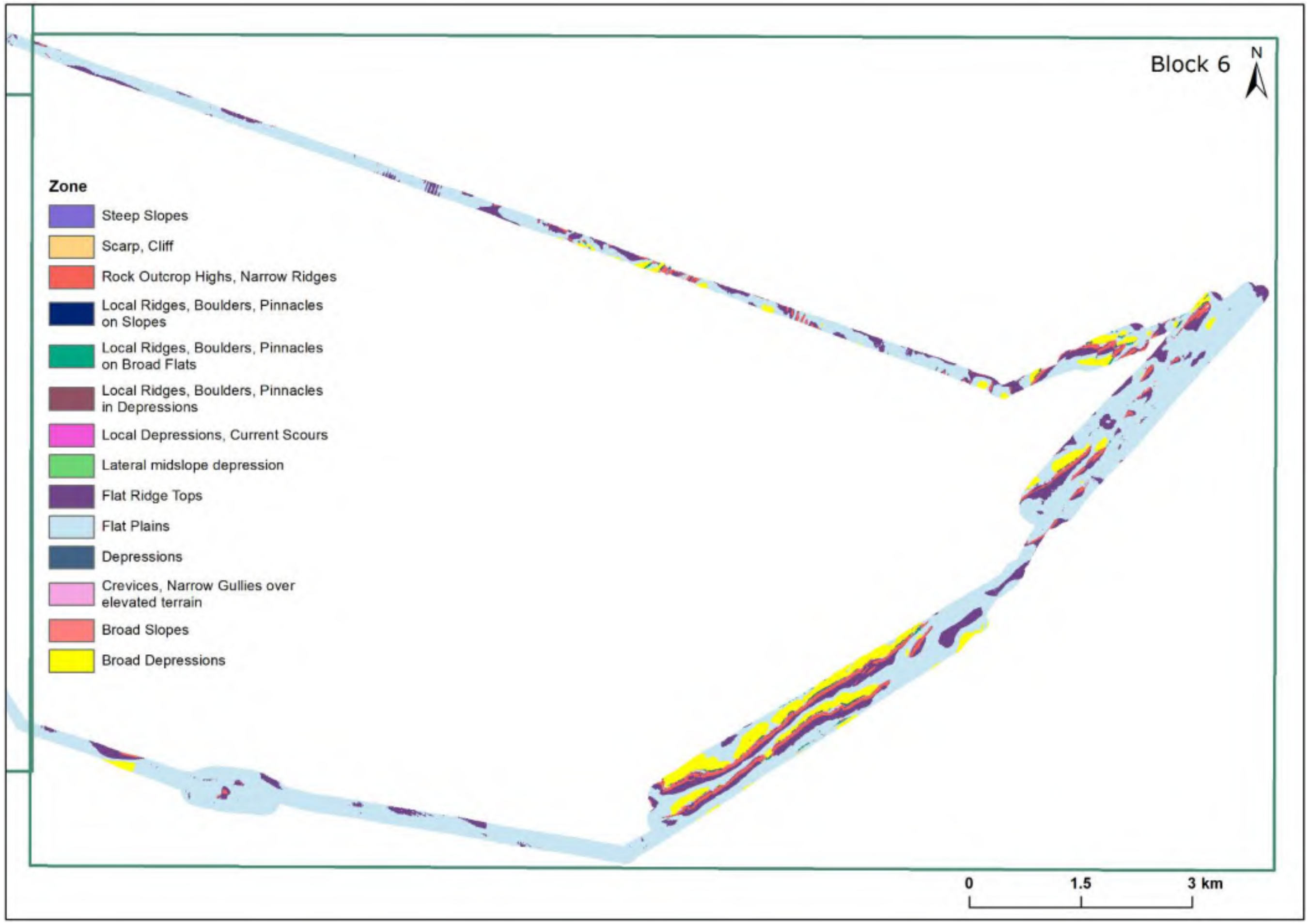
Appendix A BTM maps of Blocks 1 to 6, at closer resolution




N
Block 3
Zone
Steep Slopes
Scarp, Cliff
Rock Outcrop Highs, Narrow Ridges
Local Ridges, Boulders, Pinnacles on Slopes
Local Ridges, Boulders, Pinnacles on Broad Flats
Local Ridges, Boulders, Pinnacles in Depressions
Local Depressions, Current Scours
Lateral midslope depression
Flat Ridge Tops
Flat Plains
Depressions
Crevices, Narrow Gullies over elevated terrain
Broad Slopes
Broad Depressions
0
1
2 km


N
Block 4
Zone
Steep Slopes
Scarp, Cliff
Rock Outcrop Highs, Narrow Ridges
Local Ridges, Boulders, Pinnacles on Slopes
Local Ridges, Boulders, Pinnacles on Broad Flats
Local Ridges, Boulders, Pinnacles in Depressions
Local Depressions, Current Scours
Lateral midslope depression
Flat Ridge Tops
Flat Plains
Depressions
Crevices, Narrow Gullies over elevated terrain
Broad Slopes
Broad Depressions
0
1
2 km


N
Block 5
Zone
Steep Slopes
Scarp, Cliff
Rock Outcrop Highs, Narrow Ridges
Local Ridges, Boulders, Pinnacles on Slopes
Local Ridges, Boulders, Pinnacles on Broad Flats
Local Ridges, Boulders, Pinnacles in Depressions
Local Depressions, Current Scours
Lateral midslope depression
Flat Ridge Tops
Flat Plains
Depressions
Crevices, Narrow Gullies over elevated terrain
Broad Slopes
Broad Depressions
0
1.5
3 km


Block 6
N
Zone
Steep Slopes
Scarp, Cliff
Rock Outcrop Highs, Narrow Ridges
Local Ridges, Boulders, Pinnacles on Slopes
Local Ridges, Boulders, Pinnacles on Broad Flats
Local Ridges, Boulders, Pinnacles in Depressions
Local Depressions, Current Scours
Lateral midslope depression
Flat Ridge Tops
Flat Plains
Depressions
Crevices, Narrow Gullies over elevated terrain
Broad Slopes
Broad Depressions
0
1.5
3 km

Appendix B Figure 1 pink boxes (Z series) – not CoastCam video sampled

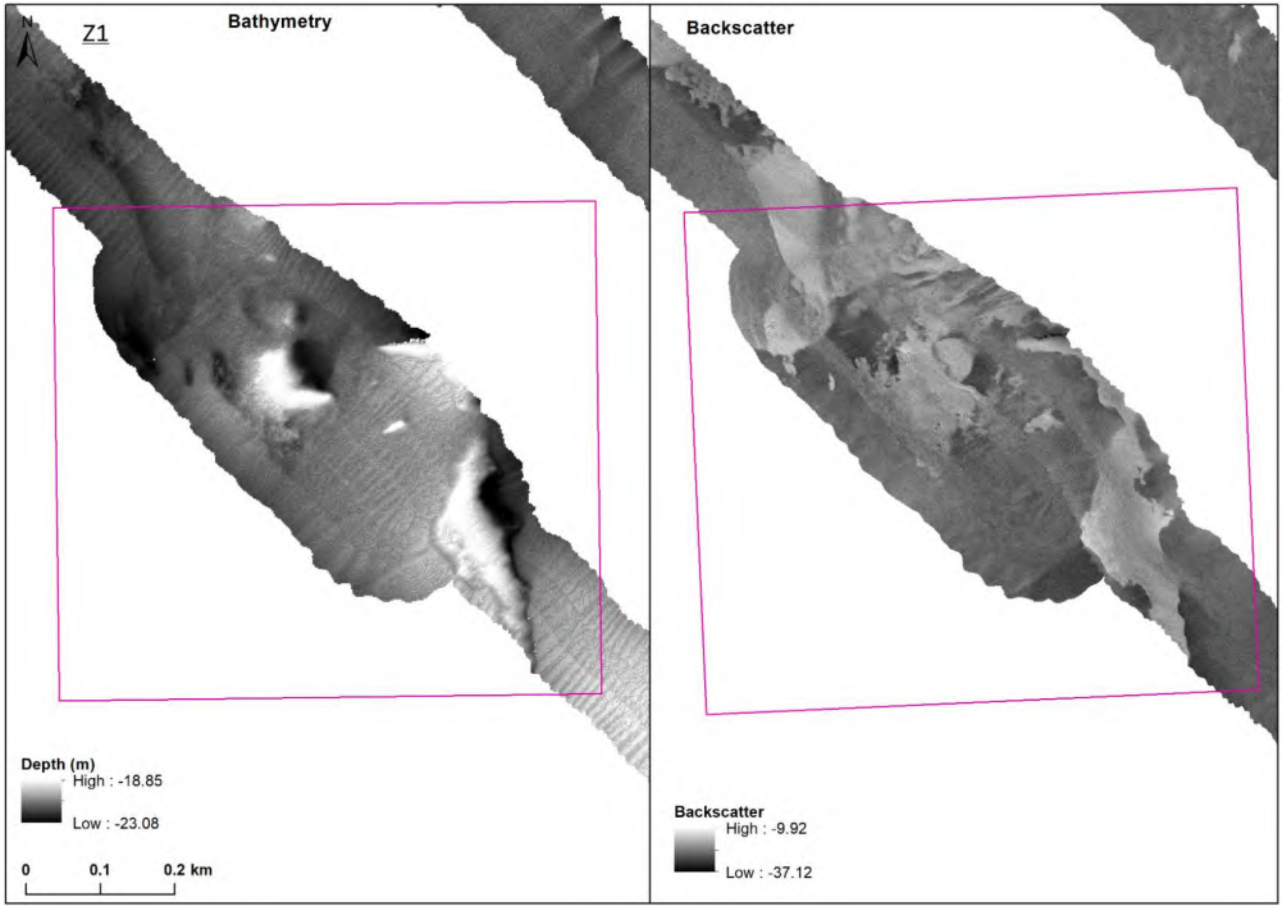


Figure B-1: Z1 – Likely raised sandstone reefs with ridges. (like site A but smaller), with backscatter suggesting central/north/south reef fields (like site B).

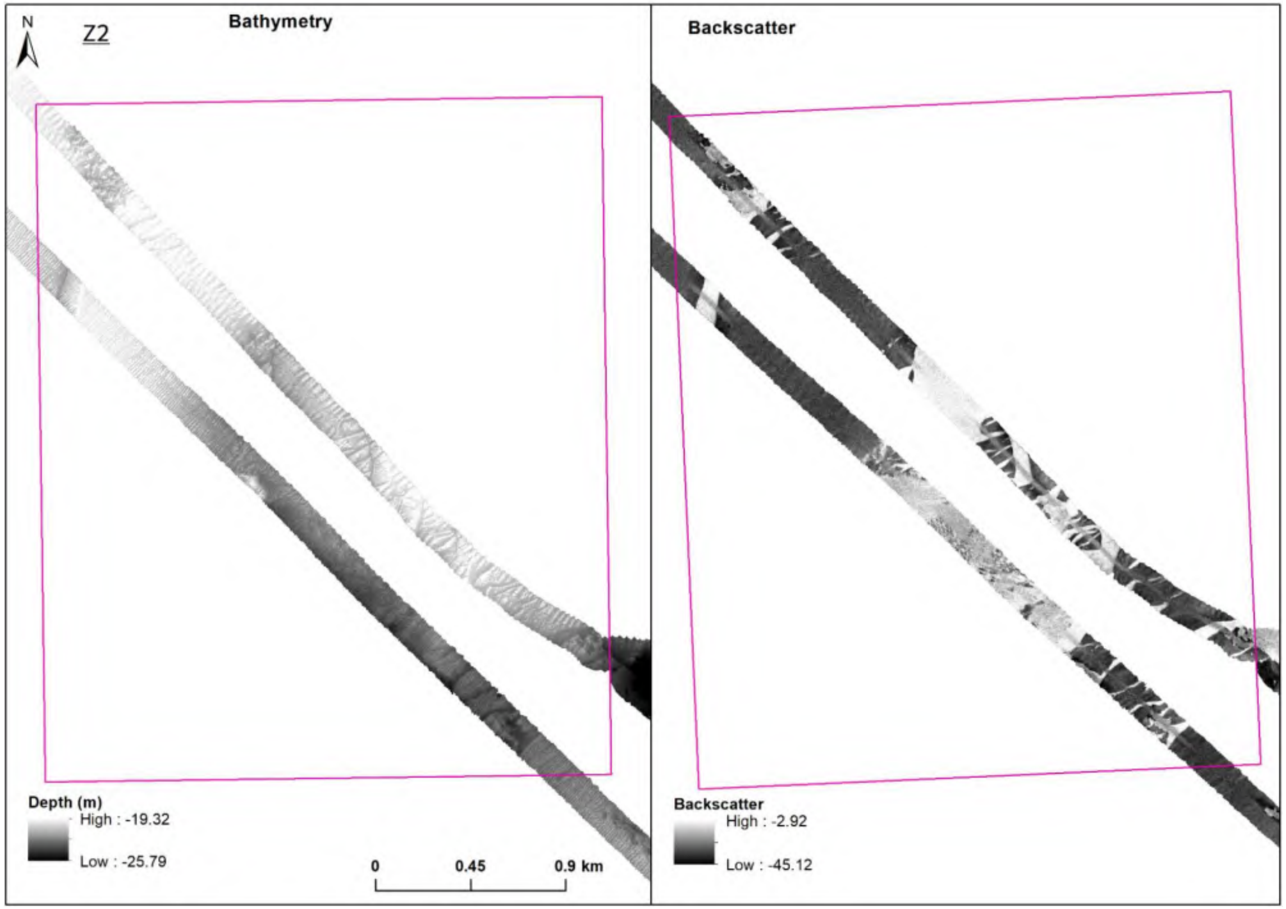


Figure B-2: Z2 – Likely to be extensive low rock/reef fields, interspersed with sand flats. (like adjacent site B, but at larger scale). Interesting channel feature in north.

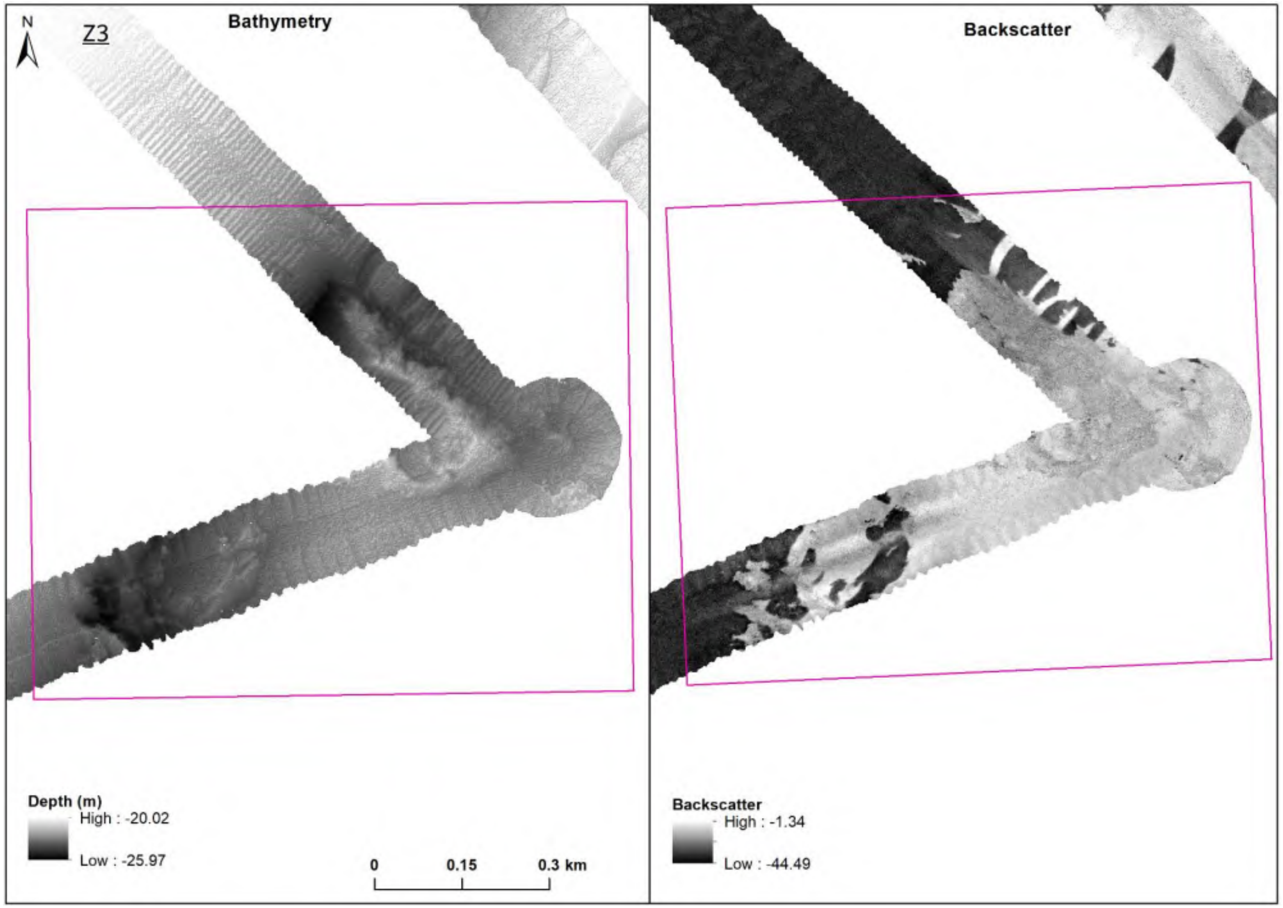


Figure B-3: Z3 – Likely to be a sandstone reef ridge feature. (centre) with low rock/reef field to the east, and lower reefs to the west (possibly mudstone).

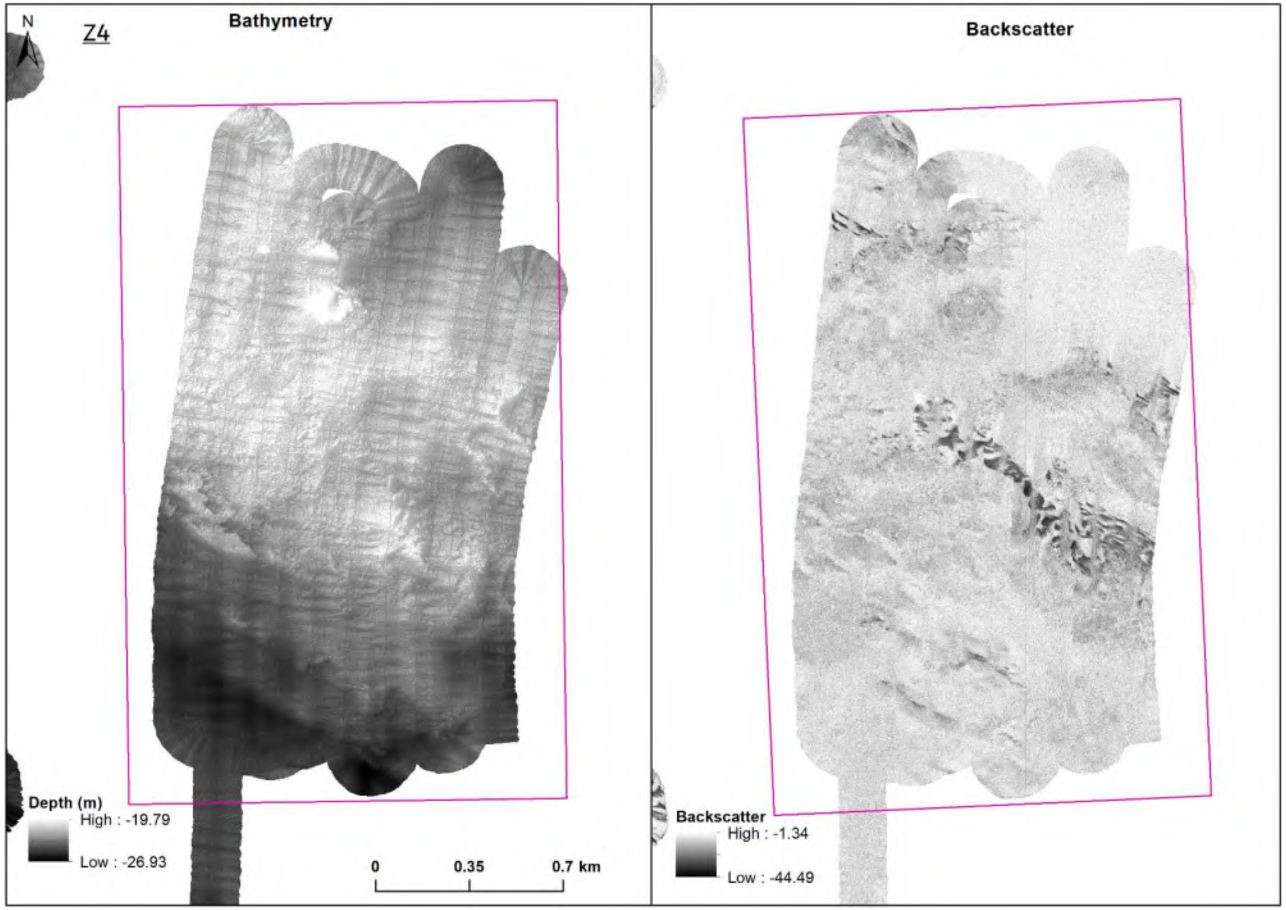


Figure B-4: Z4 – Likely be a mixed reef outcrop and cobbles complex, with knolls.

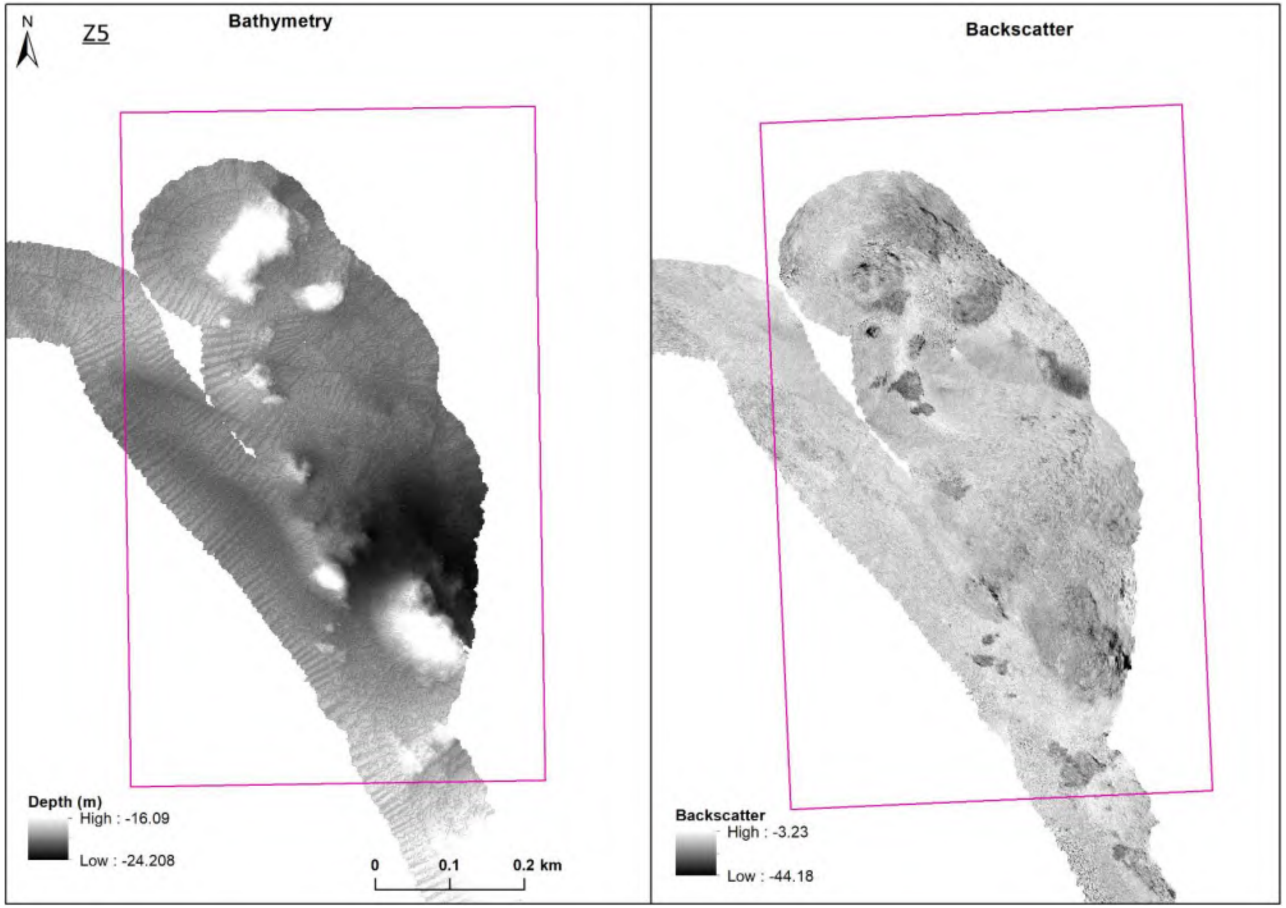


Figure B-5: Z5 – Likely to be discrete raised reefs. (note that there are extensive areas of reef to the west and south of this sub-area).

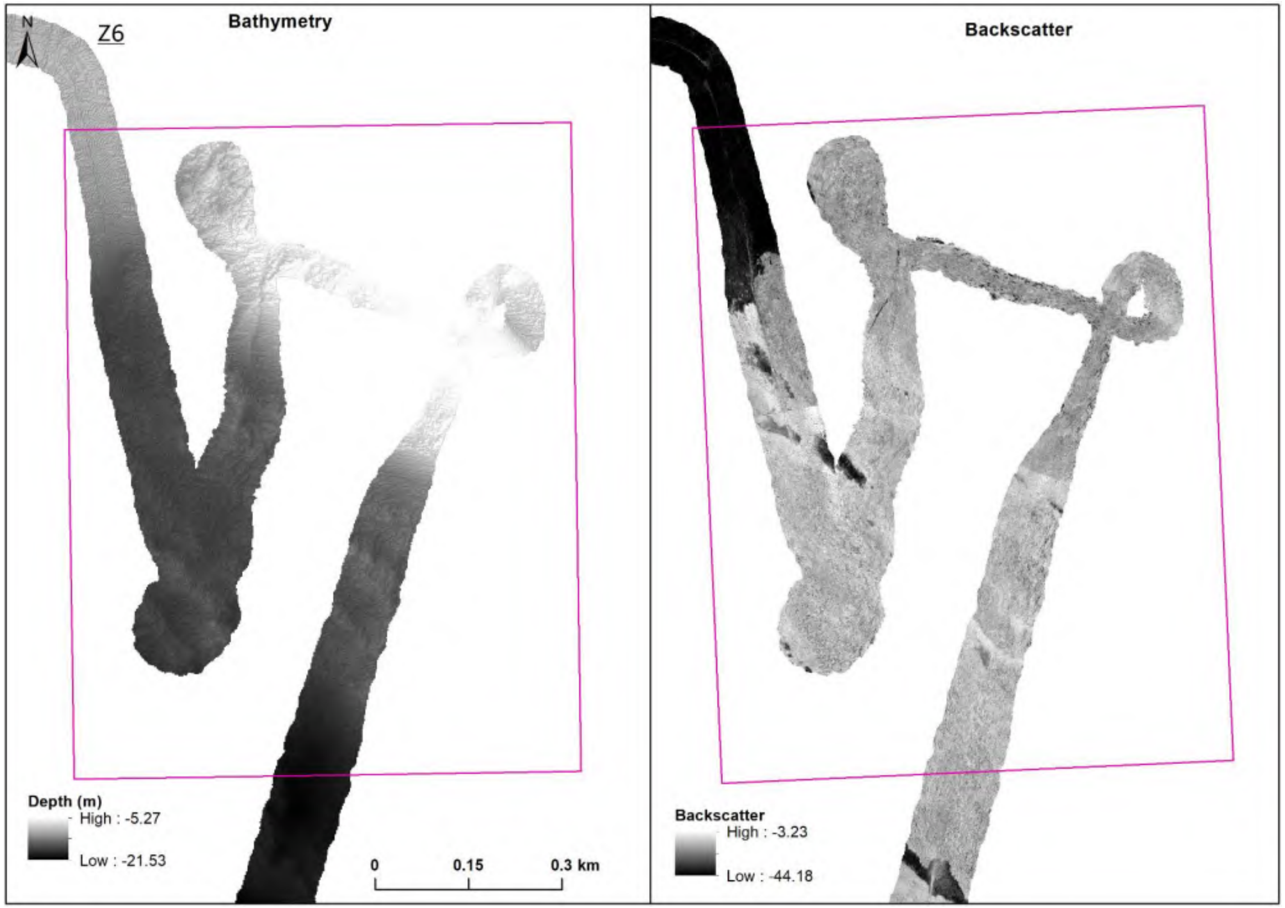


Figure B-6: Z6 – Shallowest reef mapped. (note the very narrow swathe width = shallow water). Extensive shallow rock, seen as a rising north slope.

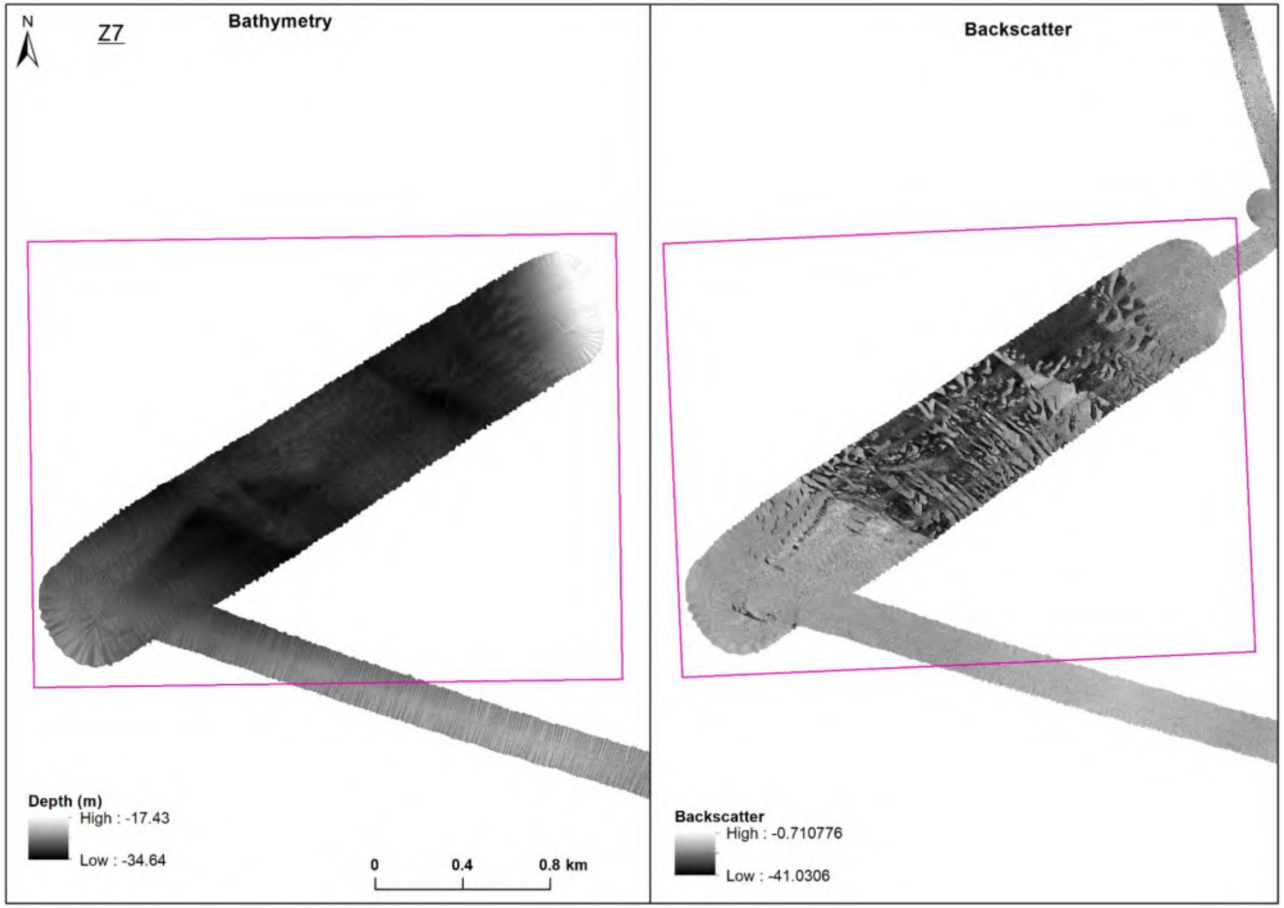


Figure B-7: Z7 – Area of large seafloor bedforms, down a bank from east to west. Possibly rock present as part of depth drop seen in western half.

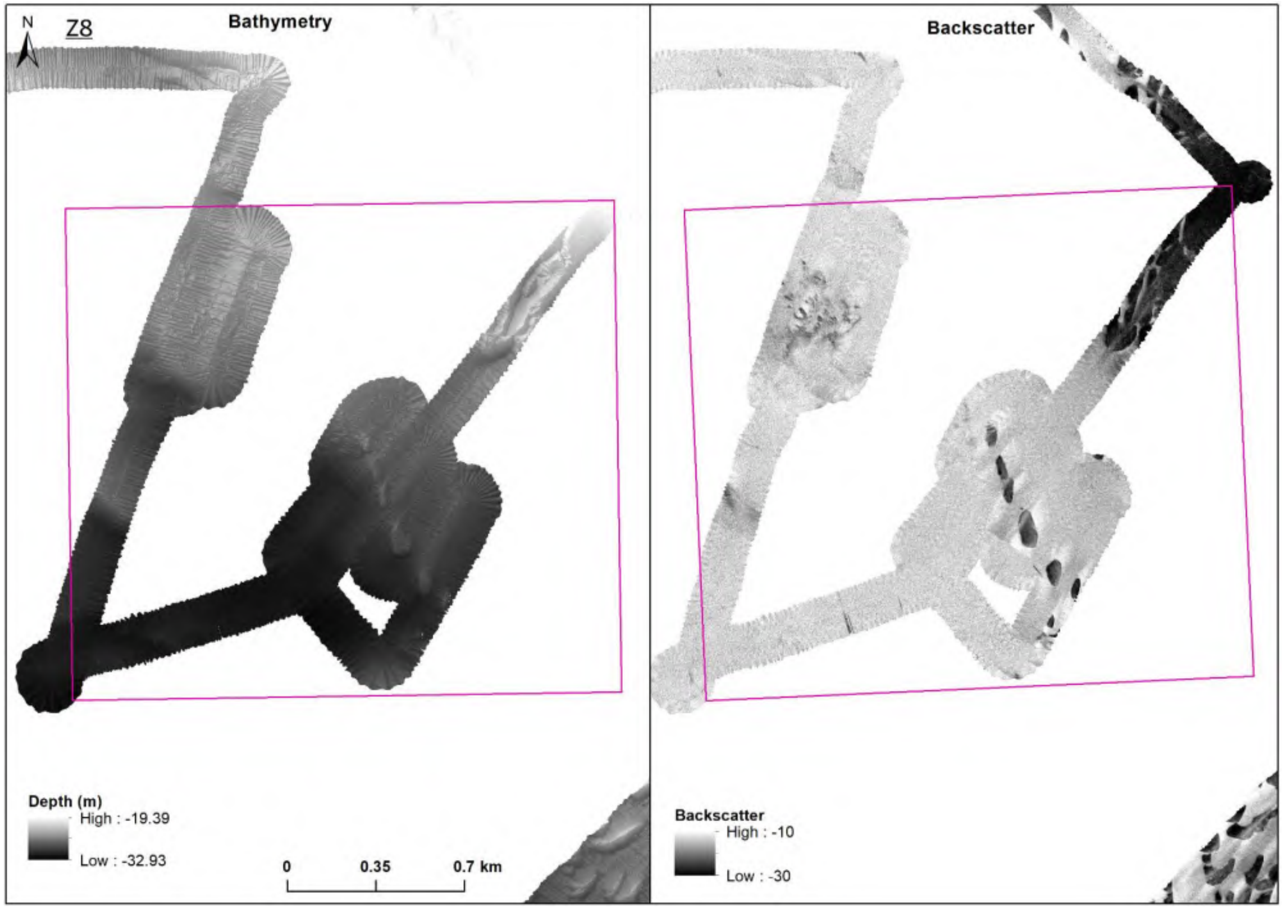


Figure B-8: Z8 – Raised seafloor bedforms. in the western block almost certainly reef, less clear for the two features in the east block and adjacent north transect.

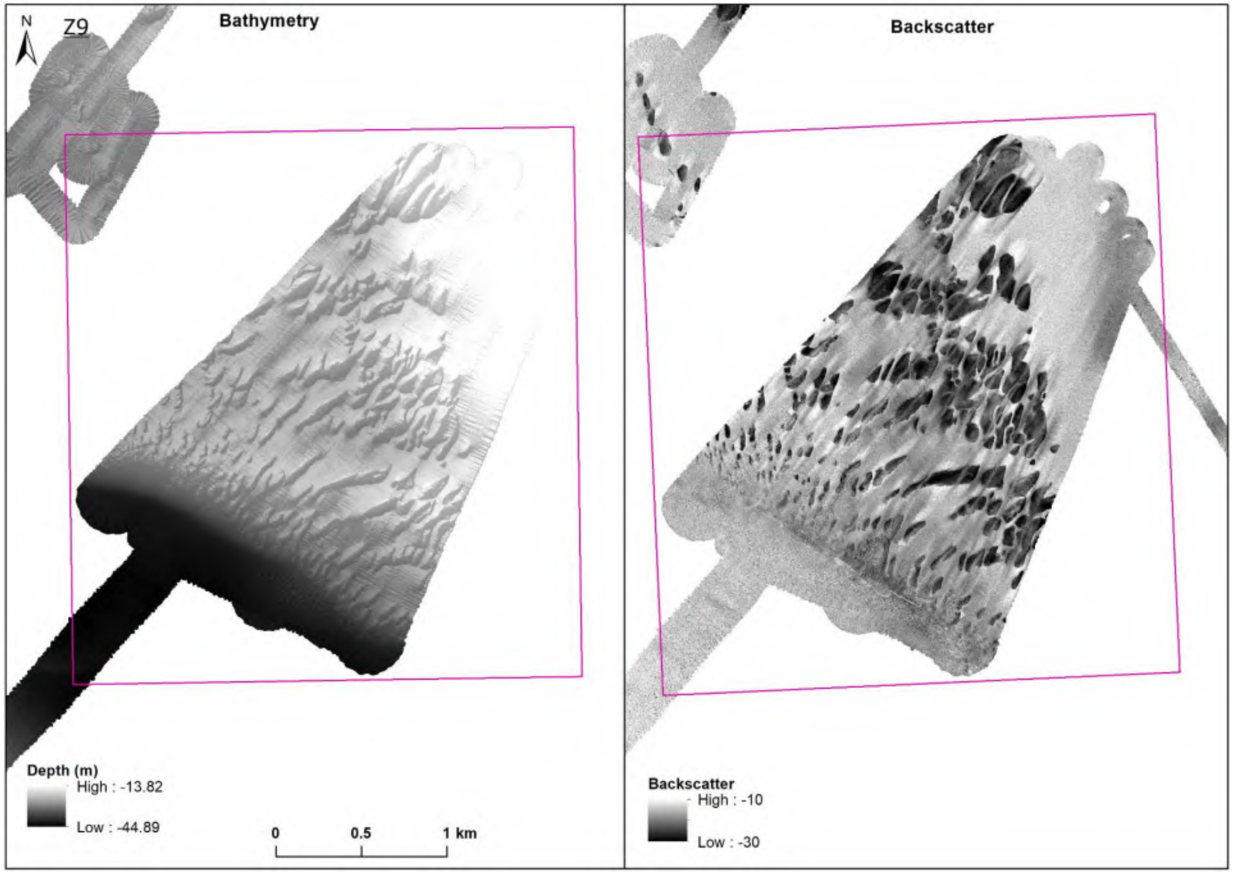


Figure B-9: Z9 – Large field of raised bedforms extending down a slope, identity unknown. Likely to join with Z8, present to the north-west.

Appendix C Crofskey (2007) classifications

Table 3.2 Habitat substrate and sea-bed topography index, adapted from Willan *et al.*, (1979) and Wentworth (1922).

Class	*Substrate type*	*Substrate sub-class*
1	Sand. Ranging from mud to gravel (maximum particle diameter *c.* 16 mm); rocks absent	Sand
2	Sediment covered rock flats. Again flat in character, with quite extensive sand patches which may merge into each other, or a sand mantle. There should, however, be a continuous rock basement	Mobile reef
3	Mixed rock and sand. Flat. Rock basement interspersed with equal areas of surface sand in discrete patches; requires a continuous rock floor	Mobile reef
4	Pebbles. Rocks with diameter of 16 – 64 mm. All rocks are mobile and interspersed with sand.	Mobile reef
5	Cobbles. Rocks up to c. 256 mm in diameter interspersed with a sand matrix. All rocks must be mobile	Mobile reef
6	Small boulders (256 – 512 mm). Rocks less then 512 mm high, fixed or mobile; shape irregular, no undercutting. Requires a more or less continuous sand basement	Rock reef
7	Large boulders > 512 mm. Rocks more than 512 mm high, fixed, with abundant crevices and undercutting. Sand and small boulders usually present also.	Rock reef
8	Rock flats, bedrock. Flat or gently shelving rock, devoid of sediment or with a very light covering in small depressions	Rock reef
9	Rock reefs. Massive submarine reefs with no sand; rocks highly dissected and irregular, with abundant fissures and undercutting	Rock reef

Table 3.3 Topographic habitat complexity scale and predominant habitat types used to classify the bottom topography (adapted from Mead and McComb, 2002).

Complexity scale	*Habitat type*	*Corresponding scores from previous table (1-4)*	*Complexity*
1	Sand (100%)	1	Low
2	Mainly sand (>95%) with visible cobbles or rocks	1.25	Low
3	Mainly sand (50% - 95%) with areas of rock	1.5	Low
4	Rocks and cobbles inundated with sand (<50%)	1.75	Low
5	Cobble and pebble reef	2	Low
6	Mainly cobble reef	2.25	Medium
7	Cobble and rock reef	2.5	Medium
8	Rock and small boulder reef	2.75	Medium
9	Small boulder reef	3	Medium
10	Small and large boulder reef	3.25	High
11	Large boulder reef	3.5	High
12	Large boulder reef, large rock outcrops	3.75	High
13	Complex boulders, large wall, rocky overhangs	4	High

Figure C-1: Crofskey (2007) dropped video classifications

Taranaki Regional Council

AGENDA
Policy & Planning

Date	7 February 2023
Subject:	**Submission on Natural and Built Environment Bill and Spatial Planning Bill**
Approved by:	A D McLay, Director - Resource Management
	S J Ruru, Chief Executive
Document:	3141294

Purpose

1. The purpose of this memorandum is to seek approval of the Council submission on the Spatial Planning Bill (SP Bill) and Natural and Built Environment Bill (NBE Bill).

Executive summary

2. The government signalled its intention to reform the resource management regime in 2019, with the appointment of the Randerson review panel. The panel's report was released in 2020 and has informed the policy decisions made leading up to the development of these two Bills, which will replace the Resource Management Act 1991 (RMA).
3. Officers have reviewed the two Bills and have drafted, given the limited timeframes available, a Council submission that focusses on the larger scale issues that are likely to be of interest to this region.
4. Officers expressed a general support for the need for reform, as well as for the move to implement a spatial planning model, the proposed monitoring and compliance regime and give effect to the principles of Te Tiriti o Waitangi.
5. Concerns were expressed about the pace and focus on change (especially the lack of consideration of local government structure), the function and nature of Regional Planning Committees (RPCs) and the lack of consideration required to be given to existing resource management policies and plans.

Recommendations

That the Taranaki Regional Council:

a) receives this memorandum *Submission on Natural and Built Environment Bill and Spatial Planning Bill*

b) approves the Submission on Natural and Built Environment Bill and Spatial Planning Bill

c) determines that this decision be recognised as not significant in terms of section 76 of the *Local Government Act 2002*

d) determines that it has complied with the decision-making provisions of the *Local Government Act 2002* to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Background

6. The Government announced an intention to reform the RMA in February 2021. That announcement followed the extensive review conducted into the current Act and the surrounding regime in 2019-2020 (the Randerson Review).
7. Central to the reform proposal is splitting the RMA into two separate acts:
    7.1. The Spatial Planning Act ("SPA" or "SP Bill") - covering overarching, regionally focused spatial planning processes that would identify and guide things like development corridors, infrastructure needs and areas of regional significance.
    7.2. The Natural and Built Environments Act ("NBA" or "NBE Bill") - "the primary replacement for the RMA", which will incorporate the functions of current regional and district plans into single, regionally focused natural and built environment plans.
8. Government also propose a third piece of legislation in this overall resource management structure; the Climate Adaptation Act, which will focus on climate change response and adaptation.
9. An "exposure draft" of the NBE Bill was released for public consultation in mid-2021. That draft was intended as a signal of intended policy direction. Feedback on the exposure draft was considered by the Environment Committee, with some of the Committee's recommended changes being incorporated into the first draft of the full Bill
10. The NBE Bill and SP Bill were tabled in Parliament in December 2022, some 12 months later than the government's originally planned timeline. The submission period was initially a month from tabling, although that was subsequently extended to 5 February 2023.

Discussion

11. The NBE Bill and SP Bill together account for approximately 900 clauses and over 1000 pages of legislation. Given the complexity of the legislation and the limited timeframe within which it has had to be considered officers have focused on the more significant items that are likely to be of concern to this region. They have not had the opportunity to consider the detailed provisions in depth.
12. Against that background, officers found the following factors as positive elements of the proposed Bills:
    12.1. The commitment to giving effect to the principles of Te Tiriti o Waitangi and providing greater recognition of Te ao Māori, including matauranga Māori.
    12.2. The move to implement spatial planning. TRC sees the move to require the development of spatial plans as providing a strong platform for creating a more

integrated resource management and service planning system for local communities.

12.3. The provisions in relation to monitoring and compliance. The approach that is proposed in the NBE Bill is one that aligns with TRC's experience in how the RMA has been implemented in Taranaki.

13. While Officers reiterated their general support for the need for reform, they also raised concerns with the following matters:

13.1. Concerns that the approach taken, especially in not also focusing on local government reform, and the pace at which the changes are being pursued will lead to compromises in the 'quality' of the resulting resource management regime and legislation. The situation is exacerbated by the significant resource demands placed on local government and iwi to engage on other government change initiatives.

13.2. Concern at the structure and functions of RPCs. The current proposal, creating them as a committee of the local authorities within a region, risks creating tensions between RPCs and their 'parent' authorities. TRC submitted an alternative structure, establishing a 'special purpose' local authority, to be called a Regional Planning Authority (RPA), under the Local Government Act 2002. Officers believe that this approach would remove the potential tensions and maintain or strengthen existing local governance.

13.3. Concern that currently, under both Bills, the requirements on RPCs to consider existing Regional Policy Statements and RMA plans are superficial and do not respect the importance of these documents. The existing RMA plans are the result of extensive community consultation in accordance with RMA Schedule 1 processes, which in a number of cases will also include consideration via the judicial system. As a result, Officers believe that there should be a positive obligation on RPCs to take account of them, unless they can provide good cause not to.

14. As the closing date for submissions on the Bills was before the date of this meeting, officers presented the submission, with a reservation of the right to make any amendments to it, if directed by the Committee.

Financial considerations—LTP/Annual Plan

15. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

16. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Iwi considerations

17. There has not been the opportunity to formally engage with Iwi about the provisions included in the two Bills or what might be included in the Council submission. There was, however, a general discussion about the nature of some of the issues to be canvassed held with one of the Iwi chief executives.

18. Officers understand that a number of the Iwi authorities are looking to lodge submissions on the two Bills.

Community considerations

19. This memorandum and the associated recommendations have considered the likely views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

20. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

Document 3140751 - Submission on Natural and Built Environment Bill and Spatial Planning Bill

Taranaki Regional Council

24 January 2023
Document: 3140751

Environment Committee
Parliament Buildings
Wellington

Attention: Committee Staff

Dear Sir/Madam

Submission on Natural and Built Environment Bill and Spatial Planning Bill

1. The Taranaki Regional Council (TRC) thanks the Environment Committee (the Committee) for the opportunity to make this submission on the Natural and Built Environment Bill (NBE Bill) and the Spatial Planning Bill (SP Bill).
2. The following comments reflect our considered review of both Bills and our observations and experience with implementing the Resource Management Act (RMA) over the last 30 or so years. They are offered in a spirit of collaboration and as our suggestions on ways that the current legislative proposal can be improved to ensure that it delivers on the step change improvements in resource management that all parties are seeking.

EXECUTIVE SUMMARY

3. TRC supports both the need for reform of the RMA and a number of the specific proposals included in the NBE and SP Bills. This includes the move to implement a Spatial Planning model and give effect to the principles of Te Tiriti o Waitangi.
4. In reforming the RMA it is appropriate that a holistic 'systems based' approach be used to the design and implementation of the new policy and legislative frameworks. Such an approach means that we should not be afraid to implement change to all parts of the system, including administrative structures, where change is needed.
5. TRC believes that the two Bills as currently drafted contain a number of compromises that will deliver less than optimal outcomes, as a result of what appears to be an unwillingness to address some of the more challenging issues. This includes the need for reform of local government and the need to take the time needed to ensure that the changes being made across different areas of the system are consistent and implemented in a coordinated way.

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6. TRC believes that continuing to drive for the passing of new legislation within artificial time constraints, when there is already significant pressure on the system as a whole, will lead to less than optimal outcomes. TRC encourages Government to 'slow down' and stage the implementation of change across the system as a whole and in a way that delivers the best possible outcome for the environment and local communities.
7. To drive the changes needed across local government TRC submits that the Environment Committee should recommend the establishment of a Royal Commission of Inquiry to consider and lead implementation of a new model of local government having regard to the final report from the Future for Local Government Panel.
8. TRC believes that the current proposal to establish Regional Planning Committees (RPC) as a committee of the local authorities within a region is problematic and will create unnecessary tension within the new system including between the committee and their 'parent' authorities. To address these issues TRC submits that RPCs should be established as a 'special purpose' local authority, to be called Regional Planning Authorities (RPAs), under the Local Government Act 2002. This approach would see RPAs being directly accountable to local communities in the same way as any other local authority and would remove a number of the practical issues associated with the RPC model as currently designed.
9. TRC is concerned that the current requirements for RPCs to take account of existing resource management documents during development of the new planning instruments are too weak and need to be strengthened. The only reference to these documents as a consideration for RPCs is a discretion to consider these documents in cl 2 of Schedule 1 of the SP Bill and an implicit inclusion of these documents in cl 24 of the SP Bill. Even then the effect of cl 24 is diminished by the provisions in Schedule 1 of the SP Bill.
10. The existing RMA plans are the result of extensive community engagement and rigorous development processes as provided for under schedule 1 of the RMA. Many of those documents are viewed positively by large sections of those communities where they apply and provide a considerable degree of certainty to resource users, communities and other stakeholder groups while new plans and RSS' are developed.
11. TRC submits that both Bills should be amended to include a requirement for RPCs to review and, unless good reason exists to the contrary, to adopt existing RMA planning documents as a starting point for the new plans. This approach will also ensure that work, such as the development of new Freshwater plans required by the end of 2024, currently underway will continue to have value under the new framework.

GENERAL COMMENTS

Aspects of reforms that are supported

12. Subject to the specific comments on both Bills, below, TRC supports both the general need for reform of the RMA and supports a number of specific elements in each Bill. Those elements include:

- The commitment to giving effect to the principles of Te Tiriti o Waitangi and providing greater recognition of Te ao Māori, including matauranga Māori. There is a need for further work to be done with Maori to ensure that the mechanisms proposed for their input are practical.
- The move to implement spatial planning. TRC sees the move to require the development of spatial plans as providing a strong platform for creating a more integrated resource management and service planning system for local communities. It creates a mechanism via which local communities can develop a vision for their long term development which can be used by a wide range of agencies to drive their long term strategic planning.
- The provisions in relation to monitoring and compliance. The approach that is being recommended in the NBE Bill is one that aligns with TRC's experience in how the RMA has been implemented in Taranaki. In our view, and (anecdotally) the view of a large proportion of the Taranaki community, this approach is positive. Government should be commended for employing it.

Need for and nature of reform

13. TRC supports the need for reform of the current resource management system and the broader framework within which we make decisions about how resources are used and the effects that these decisions have on the environment.

14. Much has changed in the last thirty years and it is timely that we collectively look at adopting a new more holistic and sustainable 'systems based' approach to the way in which we seek to understand the state of our environment, manage the effects of allocating and using resources and then seek to implement strategies aimed at improving environmental outcomes.

15. The effective functioning of the resource management system needs its many parts to work well. TRC therefore believes that resource management system review needs to start at the national level and then work its 'way down' through the system. That means having a close look at the regional and local structures that are in place to support local decision-making and implementation of those decisions. In this regard TRC supports the view expressed by the Randerson Panel[1] when it said:

> *It has become clear to us that the resource management system would be much more effective if local government were to be reformed. The existence of 78 local authorities in a nation of just five million people is difficult to justify. Much could be achieved by rationalisation along regional lines, particularly in improving efficiencies, pooling resources, and promoting the coordination of activities and processes. Reform of local government is an issue warranting early attention.*

16. It is the TRC view that some of the structures and processes proposed in this legislation, including the arrangements proposed for Regional Planning Committees, are less than optimal because of the decisions made to date that reform of the resource management system should not be a driver of local government reform.[2]

[1] Report of the Resource Management Panel Review, June 2020, p 6.
[2] Review into the Future for Local Government, Terms of Reference, p 3.

17. The risk of proceeding with implementation of a 'less than optimal' approach is that outcomes end up being compromised and that many of the issues which the reform process seeks to address are not resolved.
18. While there is a need for change to the regional and local decision-making structures in place in the local government part of the system it is also fundamental that there should continue to be a high level of local 'place based' decision-making and input to these processes. The effects of strong and timely engagement with iwi and local communities more broadly are key to the level of operability and success of the functioning of the resource management system. Taking away the capacity for a high level of local input runs a significant risk of weakening the system and exacerbating the concerns that have led to the calls for reform in the first place.
19. There have been many examples of policy that has been developed at the national level that has proven to be difficult, if not impossible, to operationalise 'in the field'. In this regard there have been challenges in the national freshwater policy space because it was unworkable and could not be operationalised. The net result left local councils and the community confused and frustrated.

Ensuring that the reform is a considered yet timely process

20. The government is pursuing a legislative agenda for the two Bills where it wants to see them both enacted this parliamentary term. Even allowing for the time taken with and the baseline outputs from the Randerson Review, this timeline is tight, particularly given the significance of this legislation, the importance of 'getting it right' and the range of other reform processes, particularly those affecting local government, that also need to be considered if changes to the resource management system are to be successful.
21. The timeframes being pursued are significantly shorter than the time taken to develop and enact the RMA in the first instance. That legislation also enjoyed a unique position of bipartisan support in the house – for the legislative intent, if not necessarily the precise drafting. Even with that considered approach and that level of support, as is well known, the RMA has met challenge, criticism and had significant amendment over its life.
22. Comparing the approaches, the current approach appears to lack the consideration and attempts at developing more universal support that characterised the RMA process. Instead, speed and the need to implement a new approach quickly and within what some would see as an 'artificial deadline' seem to be the main characteristics of the NBE and SP Bill approach.
23. The speed with which the current regime is being implemented also fails to recognise the pressure that the system, as a whole, is under with delivery of business as usual, other existing 'improvement and reform' initiatives, such as Essential Freshwater and 3 Waters, and the tight labour market within which everyone is operating. There is a finite pool of skilled resource available that is being significantly stretched at present, which only serves to escalate risk.
24. TRC is concerned that the current approach could very easily result in a situation where the legislation and resulting regime, despite best intentions, ends up creating a less than

optimal outcome that is never fully implemented and/or is likely to be subject to much ongoing amendment and litigation.

25. TRC submits that consideration should be given to a more staged process, which would start with implementation of the new spatial planning regime, with the NBE Bill being progressed following implementation of a new model of local government.

Impacts on local governance and the functions of local authorities

26. TRC is concerned that the regime that is being proposed by the combined effect of the NBE Bill and SP Bill has the effect of breaking the existing resource management system's link to local governance and input.

27. The extensive shift to centralisation and the discretionary nature of many of the elements for RPC consideration means that links to local knowledge are in danger of being significantly weakened, if not removed from local resource management policy development. At the same time, the significance of local environmental issues are in danger of being sub-ordinated to a form of national 'averaging' that is inherent in the centralisation of elements such as the NPF. Examples of the factors that give TRC concern include the results of the unclear relationship between RSS, SCEO and NBE plans (as discussed in paragraph 53 below), as well as the comments on treatment of existing Regional Policy Statements in the transitional process (see paragraphs 82 to 84).

28. The creation of the RPC, under the currently proposed 'committee' framework, breaks the link between resource management and public accountability under what are well known and tested processes, such as the LTP and annual planning/reporting cycle, provided for under the Local Government Act 2002.

29. While regional councils will continue to have functions related to identifying and managing significant resource management issues within their respective jurisdictions, by narrowing the scope of that jurisdiction, the proposed regime breaks the link between those functions and the broader environmental policy functions, which will become the preserve of RPCs.

30. In doing so, there is a fundamental risk that councils become 'administrative bodies', focusing on implementing those elements that are within their areas of responsibility.

31. The net result of these factors is that the proposed NBE Bill and SP Bill undermine the broader purpose of local government, as contained in s 10 of the LGA, of promoting community, cultural, environmental and economic well-being of the communities that they serve. There is already waning support for resource management processes due to the sorts of centralisation and removal of local voice that the new regime could be seen to accelerate.

32. As such, the proposals in these Bills are likely to exacerbate, rather than alleviate, the concerns that are currently being expressed about the RMA. They should be carefully reconsidered and reviewed, via a less pressured and more inclusive process that provides for a greater local voice.

33. TRC would strongly urge consideration of the matters raised in the discussion of the structure and nature of the RPC (paragraphs 34 to 40), as well as the more general comments on structure in paragraphs 13 to 16 as matters to be considered in parallel to relaxing the timelines.

Submission Points

It is submitted that:

a) The Environment Select Committee note that TRC supports the need for reform of RMA

b) Consideration be given to a more staged implementation process, which would start with implementation of the new spatial planning regime with implementation of the NBE Bill being progressed following implementation of a new model of local government.

c) The Environment Select Committee should make a finding that it supports the need for the reform of current local government and local governance structures as being integral to enabling the successful implementation of the Strategic Planning Bill and Natural and Built Environment Bill

d) The Environment Select Committee recommend the establishment of a Royal Commission of Inquiry to consider and lead implementation of a new model of local government having regard to the final report from the Future for Local Government Panel

NATURAL AND BUILT ENVIRONMENT BILL

Regional Planning Committees

TRC's Concerns with Current Proposal

34. Regional Planning Committees (RPCs) will have a key role in the new resource management and planning regime, given that they will have the primary responsibility for leading development of both the Regional Spatial Strategy (RSS) and Natural and Built Environment Plan for each region.

35. If they are to be successful in this role, they will need to have the courage to make the difficult decisions that will ultimately need to be made and also be prepared to be accountable for those decisions. This approach requires the creation of an appropriate structure and system design that reflects the important role that the committee has to play. It also requires that the Committee have members with an appropriate range of skills to make the decisions needed. TRC does not believe that the currently proposed 'committee' model meets the required standard.

36. The decision to shift the responsibility for plan making to the RPC creates a 'disconnect' with the on-going role of regional councils to identify and manage the significant resource issues of the region (or of a district or local community within a region). Despite this responsibility the regional councils will not have the ability to manage the policy aspects of the way in which natural resources – air, land, freshwater and the coastal marine area - are managed given that these will now sit with the RPC. TRC considers that this is a significant design weakness and would support the view expressed by the PCE that:

> *As for the proposed new quasi-democratic regional planning committees, they seem in part to be an unspoken work around for avoiding the word that shall not be uttered – amalgamation.*

As already noted TRC submits that avoiding the need for reform of local government in reforming the resource management system is a recipe for a less than optimal outcome.

37. On the one hand the RPC is a committee of the constituent councils, they are required to fund its work and implement its decisions - and yet constituent councils have very limited ability to influence, let along control, its work. Indeed the Bill goes so far as to place a statutory obligation on the RPC to act independently of its constituent local authorities (cl 100). If local councils are expected to fund a particular activity they will have an expectation that they should also be able to influence the work that is delivered with that funding.

38. Under the Bill as proposed, the only formal opportunities that constituent councils have to influence the work of the RPC are:
    - Indirectly through the decisions that they make about who should be appointed to the committee
    - Through the statement of community outcomes and/or statement of regional environmental outcomes that the councils are entitled to produce under the Spatial Planning Bill. (See submission points on this issue in paragraphs 48 - 50, below.)

39. Alongside of the limited ability that local authorities will have to influence the work of the RPC there are also very limited public accountability processes in place via which the RPC can be held accountable for its decisions and overall performance.

40. While the RPC is required to produce a Statement of Intent and Annual report there is no formal 'public accountability' regime that allows, for example, for members of the public and external stakeholders to be able to hold the RPC accountable for the decisions that it makes and the impact that these might have on local communities. Given the strategic significance of the both the RSS and NBE Planning documents TRC considers the lack of a more formalised accountability regime to be unsatisfactory.

Proposed Alternative Structure for RPCs

41. TRC submits that each RPC should be established under the Local Government Act 2002 as a 'special purpose' local authority to be known as the Regional Planning Authority. Regional Planning Authorities would have a similar status to regional councils under the LGA but with a more clearly defined and limited range of functions.

42. Key features of the Regional Planning Authority proposal would include:
    - That as with any other local authority it would be established as a body corporate with a power of general competence and a responsibility to promote the social, economic, environmental and cultural well-being of the communities it serves
    - It would have a similar status to regional councils in that it could not undertake significant new activities without following the process provided for in sections 16 and 17 of the Local Government Act 2002
    - It would be subject to the normal public accountability processes such as the development of an LTP/Annual Plan and Annual Report as apply under the LGA
    - It could set its own rates, which would be collected via the same mechanism as the current regional council rates in each region, and therefore be publicly accountable for the public funding it requires to undertake its activities

- It would be able to borrow in its own right which would give it more flexibility to spread the costs associated with development of its main planning documents over the life of those plans
- Its membership could continue to be appointed by the local authorities, Iwi and hapu committee in each region and the Crown as agreed under a Composition Agreement.
- It would be required to give effect to the principles of te Tiriti o Waitangi and give effect to existing treaty settlement legislation applying in each region.

43. Even with the proposal to establish a Regional Planning Authority it will, in a number of cases, still be appropriate for the RPA to have a host local authority, which would be similar to the role played by the Waikato Regional Council with the Waihou, Piako and Coromandel Catchment Authority proposed under the Pare Hauraki Redress Bill. The work that is required to be completed by the RPA will, in a number of cases, not be of a scale that would justify the formation of a completely stand-alone local authority with its own completely independent administrative structures.
44. TRC considers that the creation of the RPA as a special purpose local authority would also create a model for the NBE regime that could, with agreement of the local authorities within each region be used to support and/or undertake a number of other resource management and/or regulatory activities that the constituent councils see as being appropriate to be undertaken via a collaborative 'shared service' model. These could include, for example, environmental monitoring and compliance or consent processing work.

Submission Points

It is submitted that:

e) That Regional Planning Committees be established as a 'special purpose' local authority, to be called a Regional Planning Authority, under the Local Government Act 2002.

f) That Regional Planning Authorities be able to initiate a formal relationship with a host council should they so choose.

g) Schedule 8 Clause 38 of the NBE Bill should be amended to require the RPC to go through a community consultation process prior to formal adoption of its Statement of Intent.

Regional Planning Committee Secretariat

RPC Director

45. Clause 33(1) requires the RPC to appoint a director of the secretariat to provide support for the committee in carrying out its functions.
46. In some of the smaller Unitary authorities and/or regions it may be appropriate for the RPC Director to be an employee of the host local authority. While there appears to be nothing in the two Bills that would prevent this from occurring it is seen as appropriate that it be proactively allowed.

Submission Point

It is submitted that:

h) Schedule 8 Clause 33(1) of the NBE Bill be amended to explicitly authorise the appointment of a host council employee as the director of the secretariat for an RPC.

Clause 33 Committee secretariats

47. Clause 33 (4) provides that the host local authority remains the legal employer of secretariat employees albeit that it must delegate these responsibilities in relation to the director.
48. Clause 33(5) then places an obligation on the host local authority to ensure that the director meets its obligations as an employer but has no authority to direct or exercise a level of control over the actions and performance of the director.
49. The drafting of these provisions appear to place the host local authority in the invidious position of having to meet its responsibilities as an employer of RPC secretariat staff but having no authority to require the director, as manager of the secretariat staff, to take appropriate action to meet those responsibilities.

Submission Point

It is submitted that:

i) Schedule 8 Clause 33(1) of the NBE Bill be amended to give the chief executive of the host council authority to be able to direct and otherwise manage any employment matters relating to the director as it would with any other council employee. The exercising of this authority could be subject to a requirement being placed on the host authority Chief Executive to consult with the Chair of the RPC.

Regional Planning Committee Membership

Committee Required Skillset

50. In setting out the provisions relating to RPC membership, Schedule 8 is very focused on the procedural elements of making appointments to the committee.
51. TRC believes that, while those rules are important, the significant role that RPC’s will play means that equal attention needs to be given to achieving a broad coverage of key skills amongst RPC members. The sort of skills that are required in an RPC will include “technical resource management skills” (including an understanding of both mātauranga māori and science approaches), general governance and strategic development and an understanding of regulatory systems (including operationalising those regimes, monitoring and compliance).
52. This approach would require development of a skills matrix and the use of a coordinated recruitment and selection process amongst the appointing bodies to ensure that, collectively, members of the RPC have all of the skills needed to effectively perform their governance role.

53. In developing the skills matrix, TRC would strongly encourage giving regard to the view expressed by the Parliamentary Commissioner for the Environment[3] (PCE) when he said:

> *If anything is to be learnt from our experience of the Resource Management Act, it is that placing aspirational words on the face of a statute is no guarantee of their ambition being realised.*
>
> …
>
> *The RMA did not fail to achieve environmental outcomes because it failed to provide the legal authority to pursue them.* ***Rather, decision makers were unwilling to impose solutions (emphasis added)****. In a sense nothing has changed. A requirement for environmental limits that bite will not make them any less controversial because a statue has made their prescription mandatory.*

54. TRC supports the messages implicit in the PCE's comments that decision makers, at all levels of the system, need to have the skills and courage to make the decisions that need to be made. The skills matrix and coordinated appointment process required for each RPC could be developed, as part of the process of agreeing the composition agreement required under Schedule 8, cl 3 of the NBE Bill. There would be merit in a draft skills matrix being developed at a national level to provide a level of guidance for regions in developing their own local matrix.

55. TRC has been involved in a similar approach recently with the proposal to establish the Waitara River Committee. In this instance the Council and Iwi have specified what they see as the skills necessary and agreed a staged appointment process that they believe will set that Committee up for success. TRC would commend the use of a similar approach here.

Submission Points

It is submitted that:

j) That the NBE Bill be amended by inserting a clause requiring that, as part of the composition agreement process required under Schedule 8, cl 3 of the NBE Bill each region is to develop a skills matrix and agree a coordinated appointment process, detailing the skills that will be collectively needed across members of the RPC.

Matters for Consideration in Preparing NBE Plans

56. Under the current drafting of the NBE Bill, RPC's only need to "have regard" to Statements of Regional Environmental Outcomes and Statements of Community Outcomes. However, these two documents are the principal means, under the currently proposed regimes, for providing a community voice on the issues and opportunities that are important to them (especially given the expected prescriptive nature of the NPF).

[3] What I will be looking for in resource management reform, Simon Upton, Parliamentary Commissioner for the Environment, 23 September 2022

57. Recognising and providing for these documents will be crucial for bringing discussions on significant resource management issues within a region to the forefront in NBE Plan development. Not recognising and providing for them will see an undue shift in influence towards the necessarily more generalised NPF standards. As such, key environmental limits within regions may not be managed as effectively as they should be. Follow on implications could also result for the range of operational projects and measures that regional councils and territorial authorities are charged with implementing under this and other legislation.
58. TRC submits that a 'higher level' test/requirement should be inserted into the Bill. The Pare Hauraki Redress Bill provides a model that the TRC would encourage the Select Committee to consider. Under cl 116 of that Bill, the Waikato Regional Council is given the discretion to consider including all or part of the Waihou, Piako and Coromandel Catchment Plan into its operative RPS. This section also specifies factors that the Council must consider in making that decision. Should it decide not to do this then it is required, under cl 121, to "recognise and provide for the vision, objectives and desired outcomes in the plan". TRC strongly urges that similar direction and guidance is included in the equivalent NBE Bill and SPA Bill provisions.

Submission Point
It is submitted that:
k) Cl 14 of Schedule 7 of the NBE Bill be amended to require RPC's to "recognise and provide for the vision, objectives and desired outcomes of any applicable Statement of Regional Environmental Outcomes and/or Statement of Community Outcomes".

SPATIAL PLANNING BILL

General support for SP Bill's intent, but question the separation from NBE Bill

59. TRC supports the intention and content of the SP Bill. We see the move to explicitly recognise and provide for the larger infrastructure and land use allocation issues within a region across a 30 year horizon as very positive.
60. TRC is, however, concerned at the fact that these matters, in being provided for by the SP Bill, are separate from the NBE Bill. Given their over-arching importance and role in setting regional direction (as stated in cl 3 and cl 4(1)(a) of the SP Bill, for example), it seems strange to not include these requirements in that primary legislation.
61. Separating the contents of the SP Bill from the NBE Bill has the potential to add confusion and complexity to the implementation of environmental management regimes in New Zealand. Particular, concerns that TRC has include:
    a. The inevitability of amendments to each piece of legislation over their lives means that extra care has to be taken to ensure that the two pieces of legislation remain consistent. There is every possibility that, despite 'the best will in the world', they will get out of step – resulting in potential confusion for resource users, general public and local authorities (all things that the current reform is seeking to reverse).
    b. Already there is a lack of clarity about the relationship between key instruments under the SP Bill and NBE Bill. In particular, the relationships between RSS', existing RPS', SCEO's and NBE Plans (including the NPF) are not clear.

For example, an RSS must be amended if there is a significant change in a NBE Plan, but NBE Plans are required to be consistent with the applicable RSS. The result of this drafting is that the RSS is simultaneously superior to and subordinate to the NBE Plan.
Similar concerns exist with the status of Implementation Plans under the SP Bill. While required and while RPC's are required to report on them, there are no specific measures on how they will be implemented. One could also reasonably assume that a major means of implementation will be through developing and implementing NBE Plans, yet there is no apparent link between the documents.

c. The potential for a clever (or vexatious) party to use the separate nature of the two Bills to identify and exploit differences between them to pursue litigation that has the primary intention of tying up councils or slowing processes. Experience with the RMA was that seemingly benign provisions were used in this manner for a number of years until a body of case law was established (eg., the reason behind the exclusion of trade considerations in the NBE Bill), so TRC believes that the potential for similar behaviour here is at least as strong.

Submission Point
It is submitted that:

l) The SP Bill provisions (incorporating all changes resulting from this consultation process) should be incorporated within the NBE Bill, creating a single piece of resource management legislation.
m) Amend the resulting single piece of legislation to clearly define the relationship between the core planning and implementation instruments that are currently defined in the two Bills.

Scope of regional spatial strategies – clause 15 and 16 of SPA

62. There should be a requirement built into these sections for the RSS to also support promotion of the four well-beings. This is consistent with the view that a regional spatial plan needs to look at all four well-beings to be able to develop a view on regional development issues and also outline a vision and objectives for regional development. It will also help avoid any conflict between the SPA and the purpose of local government under the LGA.

63. The Bill lacks clarity around the 'level' of management direction hat is expected to accompany the spatial components of the RSS. As drafted, the SP Bill would enable an RSS to be anything from effectively an RPS with maps to a document that operates at a level higher providing spatial direction but with limited management. Further clarity is particularly sought on the following:

    a. The intended meaning/details expectation of "provides strategic direction"
    b. Whether an RSS should only include objectives and vision, or should also include details of priority actions?

Submission Point

It is submitted that:

n) Amend cl 3 of both Bills to explicitly recognise the promotion of the four well-beings under s 10 of the Local Government Act 2002 as being a part of the Purpose of each Bill.

IWI ENGAGEMENT

Enabling Full and Effective Iwi Engagement

64. TRC is concerned that the current proposed structure and timeline for NBE Bill implementation will prevent the full, effective and productive engagement that is needed with iwi.

65. This concern is based in part on our current experience with the level of demand on iwi resources from on-going consultation. Feedback to TRC from iwi of Taranaki is that the constant stream of initiatives out of government that require iwi engagement has stretched resources too thinly – meaning that they are often forced to choose between engaging on 'BAU items' with TRC (eg., input to resource consent applications) or responding to central government demands.

66. Additionally, the proposal under Schedule 2 of the NBE Bill to re-open existing treaty settlements is liable to place an even greater demand on iwi resources. Those iwi who have existing settlements will, quite understandably and prudently, be wanting to focus first and foremost on ensuring that their interests under those settlements are maintained or enhanced. It may well be a stretch to expect them to also be willing and, in some cases, able to fully engage on such issues as RPC membership, RSS development and transitional provisions around planning.

67. TRC believes that these issues will be a significant impediment to both the timeline of the implementation of the new resource management regime, as well as the quality of that implementation. The solution is to review the proposed timelines and tasks in light of available resources and to adjust the former two elements accordingly. In Taranaki at least, the solution is not simply a matter of throwing more money at the parties – as the necessary resources simply do not exist.

Submission Points

It is submitted that:

o) Government review the impacts of the proposed implementation timeline with those parties who are expected to be actively engaged in the process, with a view to ensuring that the timelines are operable and achievable without placing undue stress on the parties' resources and without compromising the quality of overall outputs from the process.

Decision Making Principles – Iwi and Hapu

68. TRC submits that the decision making principles in cl 6(3) of the NBE Bill should have some form of threshold requirement or status that still enables effective and purposeful iwi and hapu engagement, but that addresses a potential "floodgates" risk as currently drafted.

69. TRC makes this submission having had experience of a similar situation during consultation on an earlier version of the Taranaki Coastal Plan. Many years ago, a small group claimed mana whenua status as an iwi authority over a part of the coast that was already included within the rohe of recognised iwi of Taranaki. The group in question called for recognition as tangata whenua and sought recognition of their view on certain issues.

70. A similar situation exists in Taranaki at present, with the Poutama Kaitiaki Charitable Trust group who claimed mana whenua over the land that comprises the proposed route for the Mt Messenger/SH 3 Bypass. Although that group was ultimately unsuccessful in its claim of mana whenua, that determination only came about after they were taken to the Environment Court over a series of hearings.

71. As these two situations illustrate, similar assertions of mana whenua are a very real possibility over the lifetime of the NBE Bill. If that did happen, as the legislation is currently drafted the RPC would be required to take account of any plans or other documents that groups like these two may put forward. The only way for the RPC to safely determine that it does not need to consider a document, such as that, is to go to the Environment Court – with all of the inherent costs, delays and uncertainties for the RPC, local authorities and communities.

72. TRC submits that including some form of threshold standard could enable RPC's to weigh and, if necessary, decide on the merits of this type of claim. Alternatively, RPC's could work with local authorities and iwi (especially with PSE's) to determine who are the tangata whenua parties to speak on issues within the area. Such an approach would still enable recognition of iwi-hapu relations, while avoiding the need for extensive legal processes.

Submission Point

It is submitted that:

p) A standard is included in the legislation that must be met by any organisation seeking to put forward a management plan, policy statement or other document for consideration by an RPC or local authority in line with the appropriate decision making principles in cl 6(3) of the NBE Bill; or

q) Include a requirement in the establishment of RPC's that they are to work with local authorities and iwi authorities within the region to identify those tangata whenua groups with whom they should engage during planning processes.

Treatment of Existing Treaty Settlements

73. TRC submits that in creating a new 'special purpose' local authority the Select Committee should also give it a number of features that recognise the responsibilities that the Crown has under Te Tiriti o Waitangi including those provided for under existing treaty settlement legislation.

74. In relation to the Taranaki region, for example, it is noted that Nga Iwi o Taranaki, have the right to appoint 3 Iwi representatives to the TRC Policy and Planning Committee. Amongst other functions this committee is responsible for providing governance oversight of TRC resource management planning and policy development processes. TRC submits that, as this right to representation is additional to any rights in the NBE Bill, it should be incorporated into the statutory provisions relating to the formation of a RPC for the Taranaki region.

75. In a similar vein the rights that Maniapoto have under the Maniapoto Claims Settlement Act 2022 and the iwi of Taranaki have been granted under other legislation, such as the New Plymouth District Council (Waitara Lands) Act 2018 and Ngati Maru (Taranaki) Claims Settlement 2022 should also be transferred over to the new legislation and/or the arrangements applying under the SP Bill and/or NBE Bill.

76. Currently, the only such agreements recognised are those relating to the Waikato River. However, TRC is in the latter stages of implementing the agreements noted in paragraph 47, above. Any review of those agreements (subject to Schedule 2 of the NBE Bill or otherwise) has the potential to significantly impact the work done by TRC and iwi to date to express and prepare to implement their intentions.

77. Accordingly, TRC submits that the Bills should be amended to include TRC, as a party to those treaty settlement related agreements, to be a part of any discussions on how they are provided for under the NBE Bill. Similar amendments should be made for any other similar agreements that exist in other parts of the country.

Submission Points

It is submitted that:

r) The Crown should consult with Nga Iwi o Taranaki to develop an understanding of how treaty settlement legislation obligations might best be reflected in the Spatial Planning Bill and Natural and Built Environment Bill

s) Subject to consultation with Nga Iwi o Taranaki and TRC consider whether it is appropriate to amend schedule 8 of the NBE Bill be amended to make explicit provision for Iwi o Taranaki to have the right to appoint at least three members to the RPC in accordance with the provisions of the Te Atiawa Claims Settlement Act 2016.

t) The Crown should consult with Ngati Maru and Maniapoto about how any provisions that might be included in a Joint Management Agreement or Relationship Agreement with TRC under their relevant treaty settlement legislation might be best reflected in the arrangements that will apply under the Strategic Planning Bill and/or Natural and Built Environment Bill.

u) Expand the scope of the discussions on how to provide for treaty settlements under the NBE Bill regime to include TRC as a party to the discussions pertaining to the Taranaki region. Include a similar amendment for other similar agreements that may exist in other parts of New Zealand.

TRANSITIONAL PROCESS AND PROVISIONS

Achievability of the Proposed Timelines

78. Extending from our comments on the pace of reforms (paragraphs 9 to 22) and on the impact of resource demands on our ability to engage effectively with Taranaki iwi and hapu (paragraphs 54 to 57 and 63 to 67), TRC has a broader concern about the achievability of the proposed timelines – and, as a consequence, of the quality of the outputs and processes that will result.

79. Similar issues and concerns as are found in the referenced paragraphs are applicable to this submission point.

80. An example of the basis for the concern is the development of RSS. The Bill requires a lot of steps to be undertaken at a regional level before councils can even start developing the RSS, viz;

    a. Setting up engagement agreements

    b. Engagement policy

    c. Identification of major regional policy issues – which must then be publicly notified

    d. Compounded by the resourcing constraints.

81. On top of this, there are the requirements to get the Local Government Commission review of the various instruments, all while meeting the seven year time limit for the first run of plans. When councils already have a full plate with policy processes under the RMA obligations over the next few years, most will only have limited resourcing available to help support the set up of the new systems as well.

Submission Points

It is submitted that:

v) Government review the proposed implementation timeline with all parties who are expected to engage in the process, with a view to ensuring that the timelines are operable and achievable without compromising the quality of overall outputs from the process.

Transitional Treatment for RPS and Existing Plans

82. TRC believes that the requirements for RPCs to take account of existing resource management documents in their deliberations and preparations of instruments under both the SP Bill and NBE Bill are too weak.

83. The Bills are explicit in their requirements for RPCs to consider various iwi management plans and Mana Whakahono a Rohe agreements. Yet the policy statements and plans that currently guide resource management implementation are largely ignored. The only reference to these documents as a consideration for RPCs is a discretion to consider these documents in cl 2 of Schedule 1 of the SP Bill and an implicit inclusion of these documents in cl 24 of the SP Bill. Even then the effect of cl 24 is diminished by the provisions in Schedule 1 of the same Bill. TRC considers that the current differential treatment accorded to iwi management plans and Mana Whakahono a Rohe agreements as compared with existing RMA plans is simply not justified.

84. The existing RPS and other RMA plans are the result of extensive community engagement and rigorous development processes. Many of those documents are viewed positively by large sections of those communities where they apply. Ensuring that they are considered also provides a considerable degree of certainty to resource users, communities and other stakeholder groups while new plans and RSS' are developed.
85. Case in point is the fact that every Regional Council is currently embarking on a huge work programme to have updated Freshwater plans notified by the end of 2024, as required to implement the NPS-FM. If stronger consideration of this work is not included in the NBE Bill then it may jeopardise the value placed on the current processes.
86. Delaying the freshwater work is not an option, as the associated environmental issues simply cannot wait for the NBE and SP Bills to be enacted and implemented. However, as currently drafted, there is a very high risk that, if the work programme results don't align perfectly with the Bill's intentions, the work to date could be disregarded. Such a possibility creates a high risk of unnecessary cost for ratepayers and their associated local authorities.
87. Similarly, it is clear in the NBE Bill that the NPF doesn't apply to current RMA plan making processes. However, what is less clear is what happens if there is something new and/or different in the NPF and councils are still in the process of preparing plans under the RMA or an applicable NPS. Allowing consideration of the NPF or making updates to the NPS under the RMA to reflect any proposed significant changes would assist in the transition period. Doing so would allow RMA plans under prep now will begin to address directions ahead of NBE plans being developed.
88. Any concern about possibly prolonging elements of the existing RMA regime that are considered no longer appropriate is easily managed by specifying that inconsistency with Part 1 of the NBE Bill is a "strong reason" (with appropriate guidance given, consistent with the comments in paragraph 48, above) for not adopting a part of any existing document. This provision could be seen as an extension to the provisions currently contained in cl 2 of Schedule 1 of the SP Bill.

Submission Points

It is submitted that:

w) Both Bills should be amended to include an explicit requirement for RPC's to review and, unless there are strong reasons to the contrary (with guidance given as to what constitutes those reasons), to adopt existing policy statements and plans prepared in accordance with the RMA.

Conclusion

Resource management reform is very much due in New Zealand. The RMA came about in part because the preceding legislation was 24 years old and had grown exponentially (with an accompanying increase in complexity) since its initial passing. Now the RMA finds itself in a similar place after 32 years, a doubling of size – and a significant growth in the sorts of issues it must address.

To add to that complexity, given the paramount role of local government in resource management implementation in New Zealand, any change in the legislation has significant implications for the responsibilities and functioning of regional councils and territorial authorities. Any changes to the legislative regime must be cognisant of that fact and ensure that changes needed to the current model of local government are made in parallel.

Against this background, TRC wishes to commend the government for commencing this review. However, in saying that, we wish to express concerns that the pace of the reform is preventing the level of consideration and engagement that is warranted for such a crucial piece of legislation. Of particular concern is the fact that groups who are intended to be key engagement and implementation partners – tangata whenua and local government in particular – will struggle to devote the resources needed to the project under the current timeframes.

When these demands are combined with the apparent erosion of local governance (via measures such as the NPF and the establishment of RPC's), TRC would caution against the potential for the revised regime to be a step backwards from the current position under the RMA.

Against that background, TRC again thanks the Committee for the opportunity to make this submission and welcomes the opportunity to work with Government on attempting to make the new Bills legislation that will support environmental, community, economic and cultural well-being for the communities that we serve.

Yours faithfully

S J Ruru
Chief Executive

Taranaki Regional Council

AGENDA
Policy & Planning

Whakataka te hau

Karakia to open and close meetings

Whakataka te hau ki te uru	Cease the winds from the west
Whakataka te hau ki tonga	Cease the winds from the south
Kia mākinakina ki uta	Let the breeze blow over the land
Kia mātaratara ki tai	Let the breeze blow over the ocean
Kia hī ake ana te atakura	Let the red-tipped dawn come with a sharpened air
He tio, he huka, he hauhu	A touch of frost, a promise of glorious day
Tūturu o whiti whakamaua kia tina.	Let there be certainty
Tina!	Secure it!
Hui ē! Tāiki ē!	Draw together! Affirm!

Nau mai e ngā hua

Karakia for kai

Nau mai e ngā hua	Welcome the gifts of food
o te wao	from the sacred forests
o te ngakina	from the cultivated gardens
o te wai tai	from the sea
o te wai Māori	from the fresh waters
Nā Tāne	The food of Tāne
Nā Rongo	of Rongo
Nā Tangaroa	of Tangaroa
Nā Maru	of Maru
Ko Ranginui e tū iho nei	I acknowledge Ranginui above and
Ko Papatūānuku e takoto ake nei	Papatūānuku below
Tūturu o whiti whakamaua kia	Let there be certainty
tina	Secure it!
Tina! Hui e! Taiki e!	Draw together! Affirm!

AGENDA AUTHORISATION

Agenda for the Policy and Planning Committee meeting held on 07 February 2023.

Confirmed:

30 Jan, 2023 9:09:35 AM GMT+13

A D McLay

Director Resource Management

Approved:

30 Jan, 2023 10:54:51 AM GMT+13

S J Ruru

Chief Executive