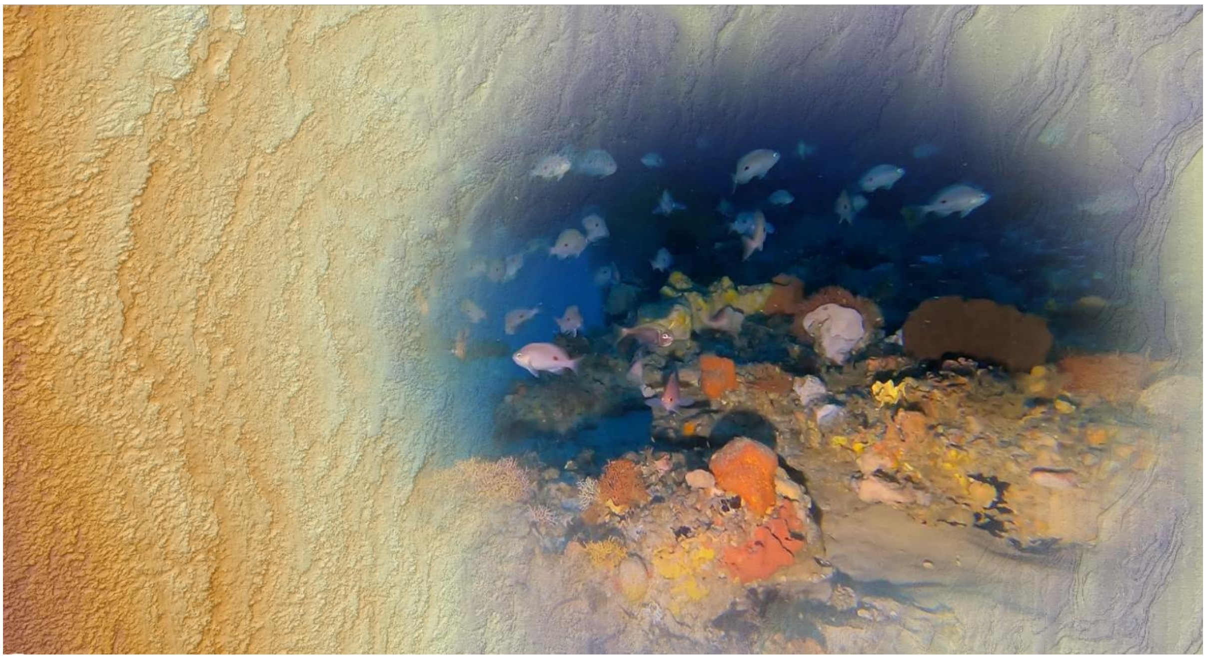
Franklin and Zeehan Marine Park Multibeam mapping and drop-camera validation for Parks Australia



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Important Disclaimer

Table of Contents

List of Tables

List of Figures

Executive Summary

This report provides a comprehensive overview of the fine-scale substrata multibeam bathymetry and habitat mapping efforts conducted in the Franklin and Zeehan Australian Marine Parks (AMPs) located off the west coast of Tasmania, Australia. The primary objective of this mapping exercise was to map the bathymetry of the shelf areas of these AMPs (designated as Multiple Use Zones – MUZ's) for the first time and to understand the distribution of habitats and key sessile invertebrate cover and species within these areas. These habitats support a variety of species including commercially valuable ones such as jackass morwong (*Nemadactylus macropterus*), striped trumpeter (*Latris lineata*) and, potentially, southern rock lobster (*Jasus edwardsii*). Characterisation of the seafloor was undertaken in two phases. An initial stage to comprehensively map these areas by multibeam sonar, followed by extensive ground validation undertaken by a drop-camera system that also recorded the presence of dominant sessile invertebrate fauna as well as benthic/demersal fish species.

Details of the multibeam mapping component of this study are presented in an associated CSIRO data report (Davey et al. 2022) and some additional mapping generated from this data is presented here, including examples of characteristic features of each of the parks surveyed. This survey was undertaken in appropriate weather conditions, with 30% swathe overlap and suitable vessel velocity to ensure all acquired data could be gridded at 2 m x 2 m scale (i.e. as high a resolution as possible for mapping at depths in excess of 100 m) in all shelf waters to enable fine feature detection and allow for optimal subsequent habitat distribution modelling and validation by drop-camera. This provided key insights into the range and extent of seabed features and an initial understanding of the overall bathymetry of shelf waters in both parks. Notable features include the shallow and relatively high profile mesophotic reefs in the northern section of the Franklin MP as well as the extensive low profile pavement reef found in the Zeehan MP, a feature also present in the southern region of the Franklin MP which underpins the shallower complex reef in the north of this park. Closer inspection of this area (in more finely gridded data) revealed clear geomorphological features that suggest the shallower reefs are likely of volcanic origin (likely basalt), reflecting the adjacent coastal and island geology of the region.

The location of the 300 camera drops in each park was based on a spatially balanced design (informed by the prior multibeam mapping). A camera system with near 360-degree views was deployed on the seabed for 5 minutes using a standard approach so fish assemblages and sessile invertebrates could also be recorded. The habitat data derived from the imagery was subsequently used in conjunction with the multibeam data to model and classify habitat distribution within the parks, providing the first validated habitat maps of the shelf MUZ's of these parks for use in spatial planning and management. This habitat modelling component, coupled with a comprehensive catalogue of direct imagery of the seabed, revealed key insights about the seabed structure and substrata composition within the Franklin and Zeehan MPs. In the Franklin Marine Park, the dominant substratum types were shelf unvegetated sediments, mixed shelf reefs, and rocky reefs. In the south of the park, lower-profile reef systems (presumably of limestone origin) outcropped in approximately 80 m but were often sand-inundated except at distinct and often linear step-features in the bedrock, whereas, at the northern margin, a more complex high-profile system was present,

extending as shallow as 35 m. Overall, mesophotic rocky reefs and rariphotic shelf reefs represented only a small portion of the mapped area. The soft sediment features that dominate this park were usually observed to be markedly rippled, even at depths below 100 m, showing the significant influence of oceanic swells in this region, that likely regularly impact this substrate preventing any significant colonisation by invertebrate cover. The automated habitat mapping prediction accuracy (assessed by drop-camera validation) for habitat maps generated for the Franklin MP was moderate, with an overall accuracy of 71% and a kappa value of 0.55.

In the Zeehan Marine Park, specifically the continental shelf region of the Multiple Use Zone (MUZ), mapped features exhibited a similar pattern, with shelf unvegetated sediments being the most prevalent substrata type, followed by mixed rariphotic shelf reefs and shelf unvegetated sediments. Typically, the inner third of the shelf region in the park was sand dominated, with increasing flat pavement rariphotic rocky reef in the mid-third, with notable long step-features (often multiple km in length), while in the outer third the pavement (presumed to be limestone, similar to that found in the Franklin MP) became significantly more fractured into distinctively elevated blocks, with more step-features and less sand-inundation. The step-features (ledges) were rarely undercut (based on multiple camera observations), limiting habitat available for crevice-dwelling species like rock lobsters. Much of the shelf area in the park ranged from 100 to 120 m, yet despite this depth, the soft-sediment habitats were often distinctly rippled, showing evidence of significant swell-related disturbance, reflecting the high wave energy of the western King Island region. The automated habitat mapping accuracy for the Zeehan MP based on drop-camera validation of modelled habitat distribution was also moderate, with an overall accuracy of 71% and a kappa value of 0.47.

Accompanying the mapping results, the cover of sessile biota associated with different substrata classes was quantitatively examined. The results describe a diverse range of marine life, from bare rippled sediments to high-profile reefs covered in sponges, gorgonians, hard bryozoans, and tube worms. The diversity of the biota was particularly high on the volcanic reef features mapped at the northern end and mid-eastern margin of the Franklin MP. Additionally, tall *Ecklonia radiata* kelp forests were identified as a prominent feature in the upper mesophotic rocky reefs of the Franklin MP.

The use of drop camera habitat validation also allowed initial quantitative counts of the fish species observed within the Franklin and Zeehan MPs. The Franklin MP exhibited a higher fish species count, with butterfly perch (*Caesioperca lepidoptera*) being the most abundant species, which was typically found in association with the complex mesophotic reef systems. Other species like ocean perch (*Helicolenus percoides*) and jackass morwong (*Nemadactylus macropterus*) were present in the park but in lower numbers. In comparison, the Zeehan MP had a slightly lower fish species count, with butterfly perch and cosmopolitan leatherjackets (*Meuschenia scaber*) being the most abundant species. Similarly, other species such as jackass morwong and red gurnard perch (*Neosebastes scorpaenoides*) were present but in smaller quantities. Striped trumpeter (*Latris lineata*), a highly targeted species, was observed in small numbers in the deeper regions of the mapped area along the shelf break of the Zeehan MP. An initial assessment would indicate that the more fractured nature of the reef systems of the outer shelf area of this park probably provide more suitable habitat for both striped trumpeter and jackass morwong than the inner regions. Notably, no southern rock lobsters *(Jasus edwardsii)* were sighted in the imagery, presumably due to the absence of any suitable crevice-like habitat.

Overall, the use of panoramic drop cameras, when undertaken at high frequency utilising spatially balanced designs, provides a cost-effective and robust tool for initial exploration of MPs at shelf-wide scales, enabling robust validation of multibeam mapped features where such mapping is available. With sufficient replication (as undertaken here) it can also provide accurate substrata mapping (even in the absence of prior multibeam mapping). Importantly, this method of sampling also allows for a robust initial assessment and understanding of habitat relationships of associated demersal fish and dominant sessile invertebrate assemblages in these otherwise unknown regions. Thus, providing valuable information to inform initial management planning and subsequent biological assessments. However, despite the relatively high sampling density utilised here (300 drops per park), this approach only provides pilot-study scale information on the biological assemblages present. Additional sampling effort would be required to gain adequate sample sizes for reliable mapping/monitoring of specific biotic habitat features, as well as the overall distribution of fish assemblages within these parks. Ideally this information would be subsequently obtained by methods more targeted to these tasks.

While only 50% of the Franklin MP was surveyed using multibeam sonar due to bad weather, the subsequent drop camera survey was able to sample multiple sites throughout this unmapped region, suggesting much of this region is likely dominated by soft sediments with the notable exception of a complex mesophotic reef extending into the park midway down the eastern boundary of the MP. It is recommended that completing this multibeam mapping is a priority step to underpin future monitoring, particularly along the eastern margin.

It is also recommended that baited remote underwater video and autonomous underwater vehicle surveys are completed to provide a more comprehensive assessment of the demersal fish assemblages and sessile biota biodiversity of these parks.

In summary, this report, in conjunction with Davey et al. (2022), describes bathymetric features and distribution of substrata habitats within the Franklin and Zeehan MPs as well as some associated biota. It provides a first and sound understanding of the habitats of the region and how these may drive the distribution of key species such as lobsters, along with associated anthropogenic pressures. The detailed bathymetry and seabed habitat maps have refined the identification of priority areas for future biodiversity survey and monitoring. These include the complex mesophotic reef, hosting sponge gardens and kelp beds in the north of the Franklin MP (one of two MPs in the South-east Network to contain kelp), and deeper reefs in the south-east of the Franklin MP supporting invertebrate assembles consisting of hard bryozoans, a diversity of sponge morphologies and delicate gorgonian fans. While in the Zeehan MP, it appears that most structured and least sand-inundated reef (and associated sessile biota) is in deeper regions towards the shelf break, and based on the observed fish assemblages, is the area most likely to provide habitat for a range of key commercially targeted species. Despite this, a notable and distinct community of fan worms and hard bryozoans appear to be interspersed throughout the sand inundated reefs along the mid-shelf region of the study location, demonstrating a clear cross-shelf zonation of marine fauna and shelf-wide gradients in the overall habitat diversity and biodiversity represented by the park.

Key Summary Points:

- Fine resolution multibeam mapping of the shelf areas of Franklin and Zeehan MPs completed.
- Extensive drop-camera survey of shelf regions of Franklin and Zeehan MPs completed.
- Fine-scale substrata maps generated for shelf region of Franklin and Zeehan MPs.
- Complex mesophotic and rariphotic reefs found in the Franklin MP along with areas of deeper pavement reef, although generally a sand-dominated region.
- Extensive pavement reef found in the Zeehan MP, grading in extent and complexity across the shelf from inner to outer.
- Habitat surveys also enabled initial pilot understanding of fish and sessile invertebrate assemblages in the region.
- Combined mapping and biological information suggest Zeehan MP is likely low-quality lobster habitat but does support striped trumpeter on the outer shelf. potentially informing the extent of potential benthic fishing pressures on the shelf
- Follow-up quantitative surveys of fish, lobster and sessile biota surveys recommended.
- Completion of mapping of Franklin MP required.

Introduction

The Franklin and Zeehan Australian Marine Parks (AMPs) are two marine protected areas in the South-east MP (SE MP) Network located off the west coast of Tasmania, Australia. They provide protection for shelf habitat that supports a range of species, including commercially valuable species such as jackass morwong and potentially, southern rock lobster. Yet despite a range of recent data collation projects to help inform understanding and management within the South-east MP network (Lucieer et al. 2016, Hayes et al. 2021, Dunstan et al. 2023), very little was known about the shelf waters of these parks prior to this study, either in the way of existing bathymetry, habitat distribution or even the key species present. The notable exception was a historical survey of the slope and very outer edge of the Zeehan MP during early planning stages of the SE MP network by CSIRO in 2004 that involved mapping by a deep-water multibeam system, and some spatially limited video-tow descriptions of habitat features observed in the video (Williams et al. 2007).

Mapping the seabed features in shelf waters of the Franklin and Zeehan MPs is an important first task for understanding the distribution of habitats that support resident species within the park, one necessary to inform the next stages of biological inventory to underpin ongoing adaptive management under Parks Australia's new Monitoring, Evaluation, Reporting and Improvement (MERI) framework. By creating detailed seabed habitat maps of the MPs, researchers and managers can identify areas of high biodiversity, target and stratify sampling designs, prioritise conservation efforts, assess the impacts of human activities on the marine environment and assess effectiveness of current management strategies.

Here we report on the results of a two-part survey to map the shelf areas of the Zeehan and Franklin MPs. The first stage involved seabed bathymetric mapping in fine detail by multibeam sonar during the second stage a drop-camera system to visually validate the habitat distribution inferred by the multibeam sonar data was used. This also provided an initial indication of the key sessile invertebrate communities and benthic/demersal fish present. The primary aim of this report is to summarise and give examples of the bathymetric maps generated (in addition to those reported in the initial data report; see Davey et al. 2022) as well as provide an initial validated fine-scale habitat map for the Franklin MP and the continental shelf region of the Zeehan MP, based on an automated, model-based classification process. A secondary aim is to provide a brief overview of the MPs features and the sessile organisms and fishes that characterise these habitats.

Methods

Study sites

The Franklin MP is located offshore of the north-west corner of Tasmania (Figure 1), while the Zeehan MP is located directly west of King Island (Figure 2). The Franklin MP is located mid-shelf, is zoned multiple use and ranges in depth from 35 to 121 m, with most of the park ranging from 70 to 100 m depth. While the Zeehan MP contains special purpose and multiple use zones and spans depths of 90 to 3000 m. Mapping in this study was limited to the continental shelf region of the Multiple Use Zone that ranges from the inner to outer shelf, ranging in depth from 94 to 260 m, with most of the shelf area in the park ranging between 97 and 130 m.

Multibeam sonar and covariates

The multibeam echosounder (MBES) derived bathymetry (Figure 1; Figure 2) and backscatter (Figure 3; Figure 4) data sets were acquired by CSIRO and IMAS from the University of Tasmania vessel Bluefin in February/March 2022, utilising CSIRO's Kongsberg EM2040c sonar system and Geoscience Australia's Applanix motion reference unit. This resulted in mapping of the entire shelf area of the Zeehan MP out to the shelf break where it overlapped prior mapping of the upper slope and shelf crest by CSIRO. Approximately 50% of the Franklin MP was mapped before a severe weather system prevented completion of the survey. The sampled bathymetry data was processed by CSIRO at a 2-metre cell resolution for subsequent analysis. Further details of the methods used in this component of the study are given in the associated data report for the multibeam sonar survey (see Davey et al. 2022).

To develop habitat maps from the acquired multibeam data, an initial model-based automated substrata classification was undertaken using a range of variables derived from both the MBES bathymetry and backscatter datasets (Table 1). The choice of variables was informed by previous studies which also intended to delineate substratum type (Huang et al. 2018, Ji et al. 2020, Xu et al. 2021). Variables were calculated in the ArcGIS platform using the 'Spatial Analysist tool' and 'Benthic Terrain Modeller' packages and in R using the 'WhiteBoxTools' package. All attributes were calculated using an analysis window of 3 x 3 cells unless otherwise stated.

Table 1. The derivative products from multibeam echosounder data used in substrata classification.

Variable	Description	Software	Retained in final model
Backscatter	Provides information on the hardness and softness of the seafloor which depends on the intensity of the signal received (LeGonidec et al. 2005) .		x
Bathymetry	Depth (negative elevation) of the seafloor.	Spatial Analyst tool – ArcGIS 10.5	x
Aspect (eastness/northness)	Depicts the direction of the slope of each cell compared to its neighbouring cells. Eastness was calculated based on sin(aspect*pi/180). Northness was calculated based on cos(aspect* pi/180).	Spatial Analyst tool - ArcGIS 10.5	eastness
Fine Bathymetric Position Index (5 cells)	Compares the mean elevation of the surrounding cells with an analysis extent of 5 cells. A positive value indicates a location higher than the surrounding cells and a negative value indicates a location lower. Flat areas will have values closer to 0 (Weiss 2001).	Benthic Terrain Modeller 3.0 - ArcGIS 10.5	
Broad Bathymetric Position Index (10 cells)	Compares the mean elevation of the surrounding cells with an analysis extent of 10 cells. A positive value indicates a location higher than the surrounding cells and a negative value indicates a location lower. Flat areas will have values closer to 0 (Weiss 2001).	Benthic Terrain Modeller 3.0 - ArcGIS 10.5.1	
Minimal Curvature	The lowest value of curvature within the analysis extent (Florinsky 2017).	WhiteBoxTools - R	x
Maximal Curvature	The highest value of curvature within the analysis extent (Florinsky 2017).	WhiteBoxTools - R	x
Terrain Rugosity Index	A quantification of the topographic relief (Riley et al. 1999). Flat areas will have a rugosity value near to 1 and high relief areas will have higher values of rugosity.	WhiteBoxTools - R	x
Slope	Change in depth of each cell compared to neighbouring cells.	Benthic Terrain Modeller 3.0 - ArcGIS 10.5	x

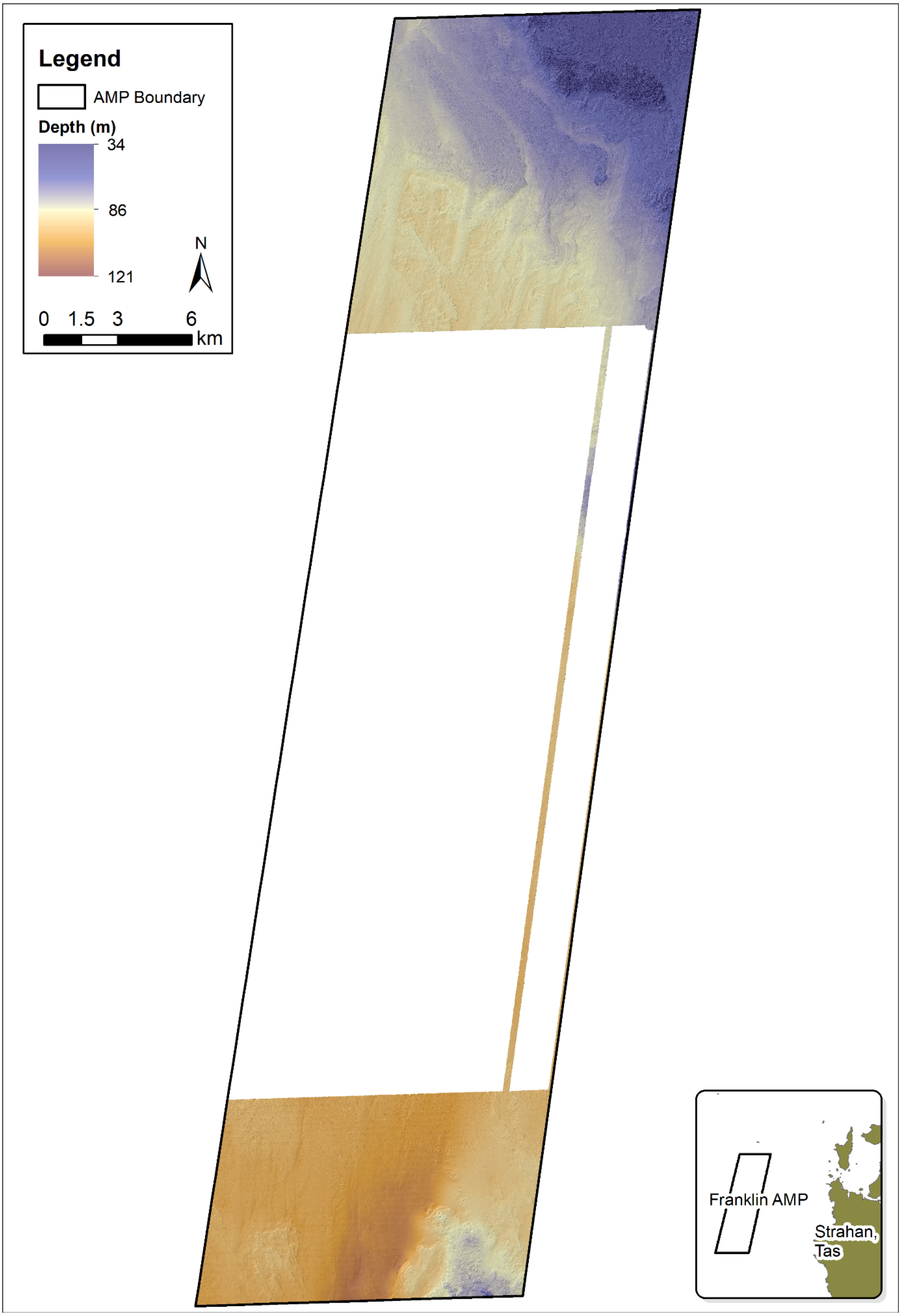

Figure 1. Depth range of the Franklin MP captured using multibeam sonar.

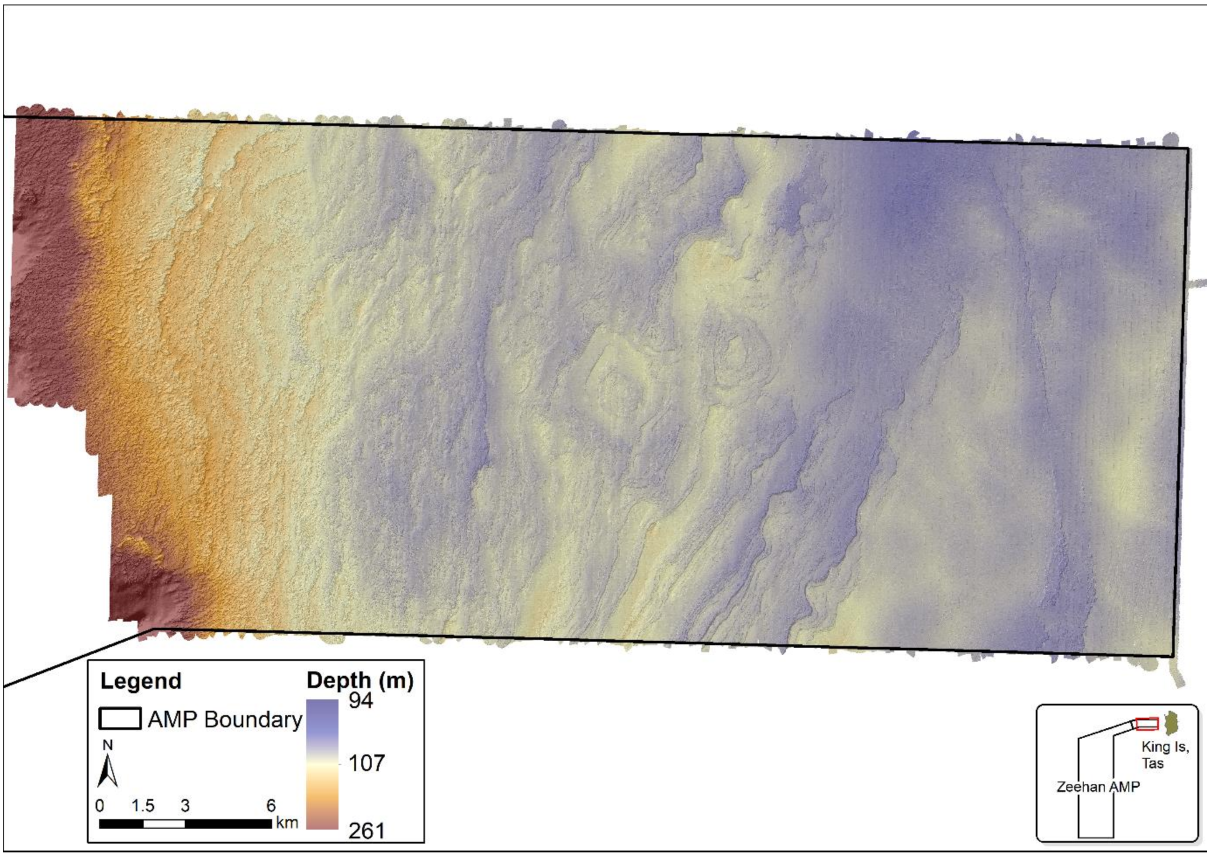

Figure 2. Depth range of continental shelf portion of the Zeehan MP captured using multibeam sonar.

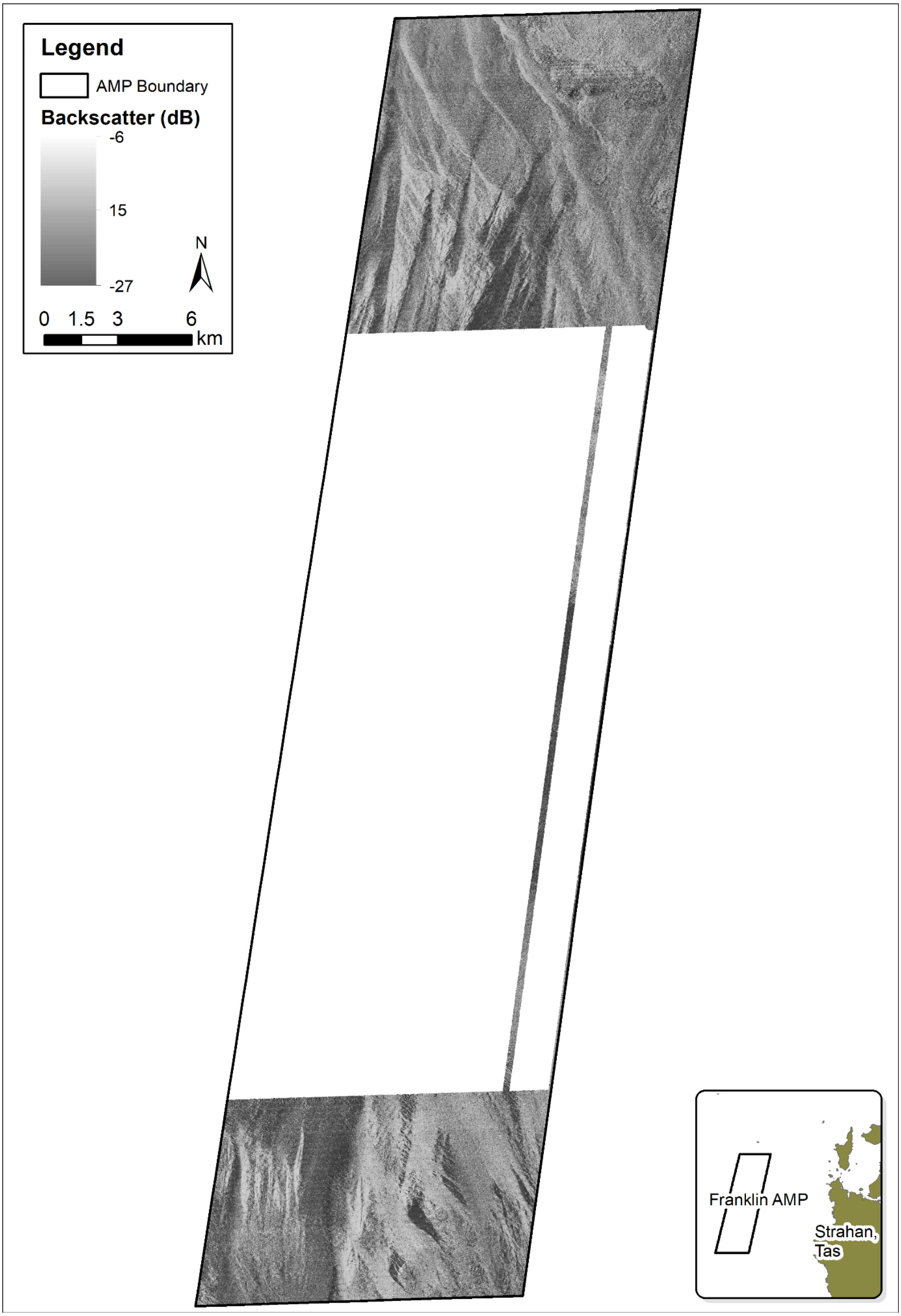

Figure 3. Backscatter representing hardness (high values) and softness (low values) of seafloor of the Franklin MP captured using multibeam sonar.

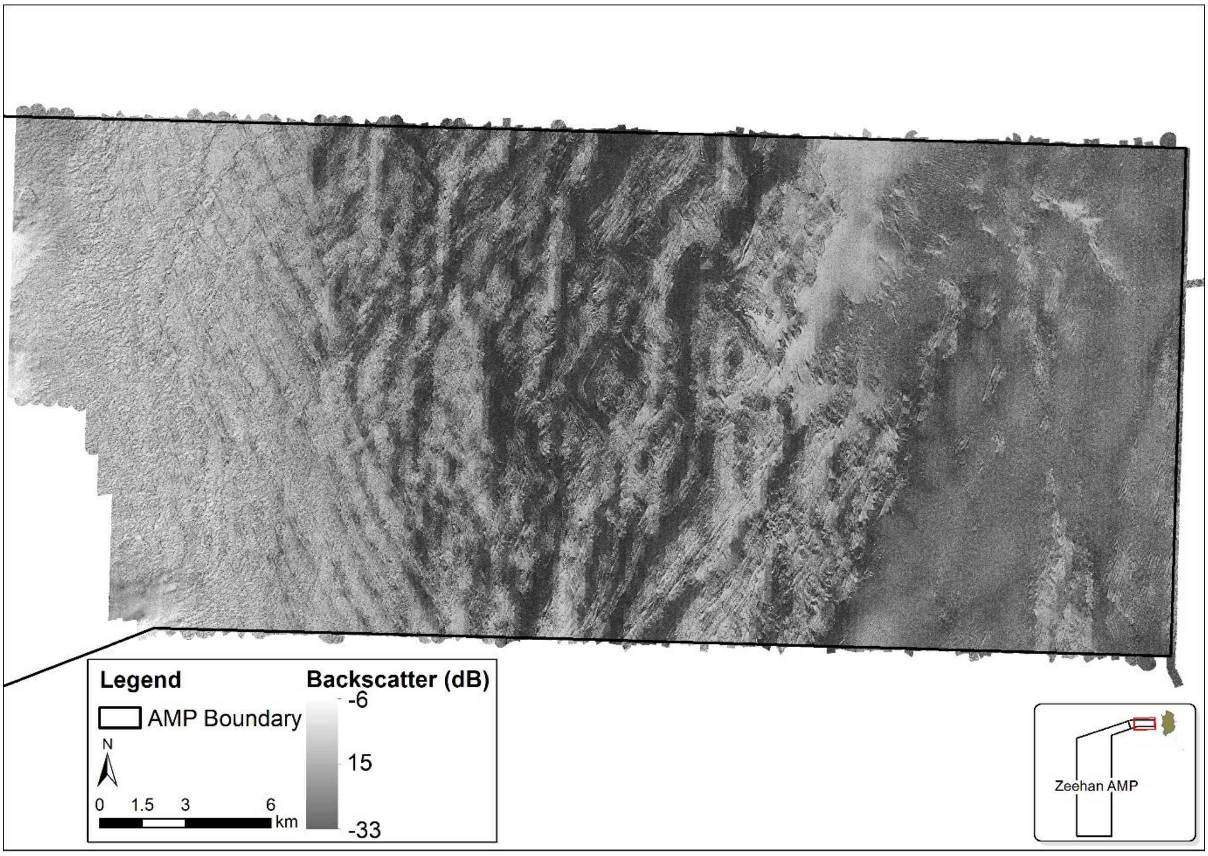

Figure 4. Backscatter representing hardness (high values) and softness (low values) of seafloor for the continental shelf portion of the Zeehan MP captured using multibeam sonar.

Panoramic drop camera habitat validation

For habitat validation, visual habitat inspection and initial description of seabed biota, the seabed of the shelf waters of each park was surveyed using a panoramic drop camera (Figure 5) which consisted of four outward views of the seafloor (at 90 degrees to each other) as well as one downward view (Figure 6). These were recorded on GoPro Hero 9 Cameras fitted in SeaGIS underwater housings. This camera system is notionally called a Benthic Ocean Observing System (BOSS), with the concept initially developed by the Fisheries and Conservation Biology Lab (FCBL) in the USA for deep water research (https://mlml.sjsu.edu/fisheries/benthic-observation-survey-system-boss/). Around 300 individual camera drops were undertaken in each park (Figures 7&8), based on a spatially balanced survey design whereby an increased inclusion probability was set for higher relief regions within each MP (see Foster et al. 2020). This included spatially balanced sampling of the un-mapped portion of the Franklin MP to allow initial habitat delineation in that region as well. Camera drops were set for a 5-minute duration to allow habitat-associated benthic/demersal fish to be recorded, following recently developed protocols for this method developed by FCBL (https://mlml.sjsu.edu/fisheries/wp-content/uploads/sites/24/2018/05/WGC_Fields-BOS-Poster_180207.pdf) and trialled in a NESP Hub survey in the SW Corner Marine Park (Langlois et al. 2022). This method replicates the rapid visual count method utilised by divers in some shallow water fish census studies to quantify fish abundances (Jones and Thompson 1978), hence providing a standards-based methodology for subsequent use in other MP or shelf-based studies, including inventory and monitoring.

Each camera drop was geolocated so it could be subsequently used for training and validation of the habitat-prediction models (see below for details of the Random-Forests model used) based on multibeam bathymetry and backscatter data (Figure 7; Figure 8). Each GoPro Hero 9 camera view on the panoramic drop camera was given a cardinal direction (North, East, South, West), however it is important to note that each POV does not necessarily face the orientation labelled (Figure 6). A still image was taken from each video sample and annotated for habitat and associated sessile invertebrate or macroalgal cover using 20 overlaid dots in the bottom 50% of each camera view (Figure 9). Each dot was classified according to the Collaborative and Automated Tools for Analysis of Marine Imagery (CATAMI) classification scheme (Althaus et al. 2015). The substratum was later grouped into three SeaMap Australia substratum types, 1) hard corresponded to consolidated reef (i.e., 100 % reef cover), 2) mixture of hard and soft substrata, and 3) soft unconsolidated sediments (i.e., bare sediment cover with no epibenthos present).

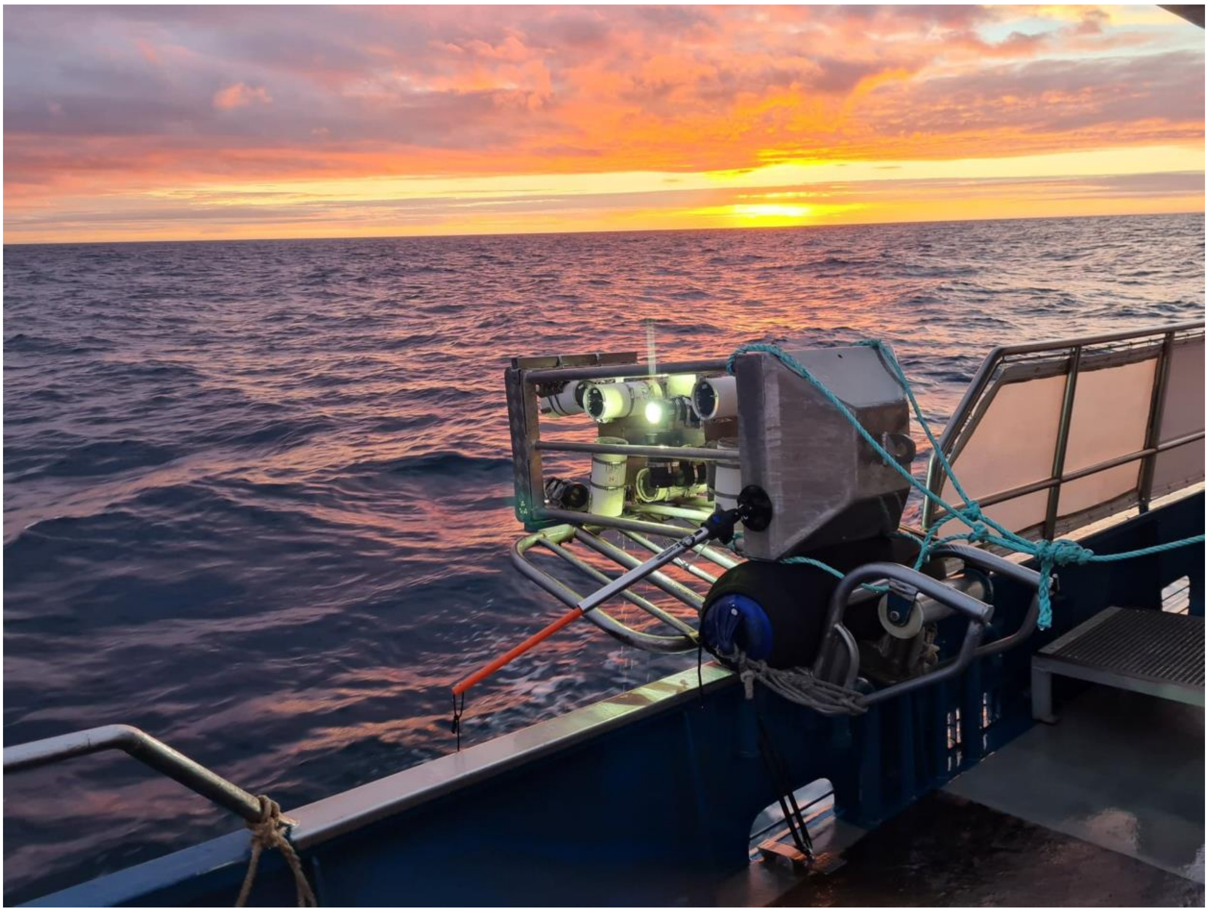

Figure 5. Panoramic camera laying on side in lobster pot tipper ready for deployment.

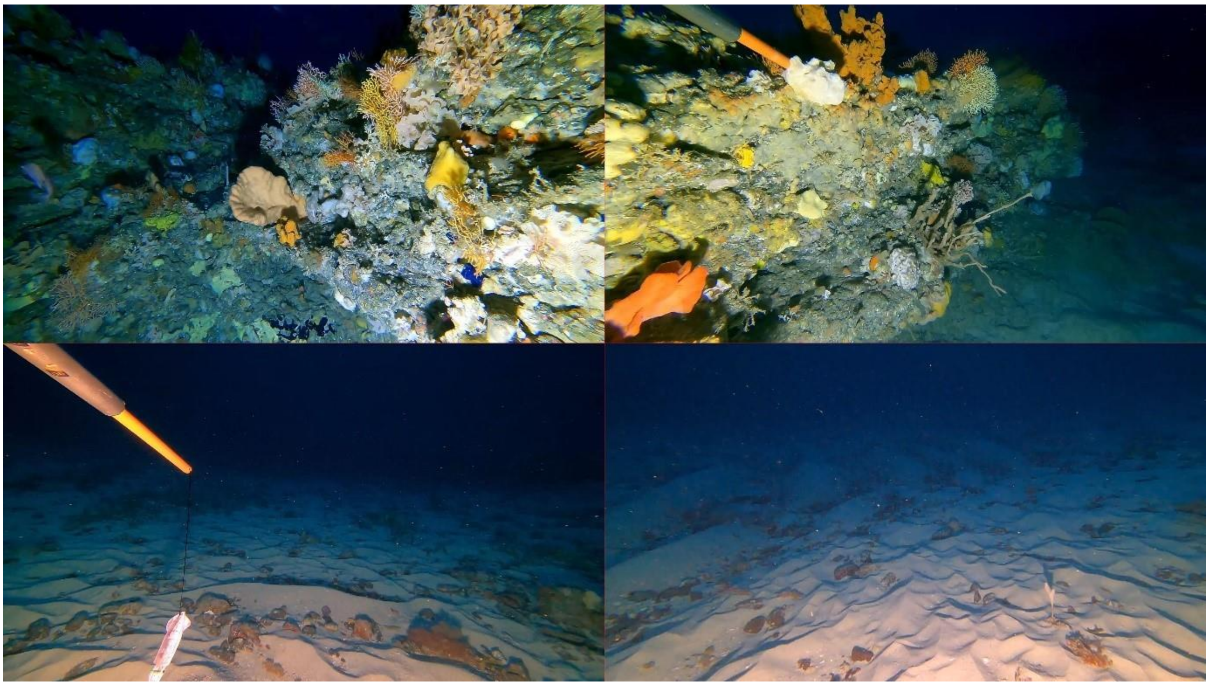

Figure 6. An example of composite POVs (points of views) from the panoramic drop camera that highlights the variability of habitats present at a single site which may be missed using a single fixed POV. The image captures high-profile reef from the north (top left) and east (top right) facing cameras and low profile, sand inundated reef habitats in the west (bottom left) and south (bottom right) facing cameras.

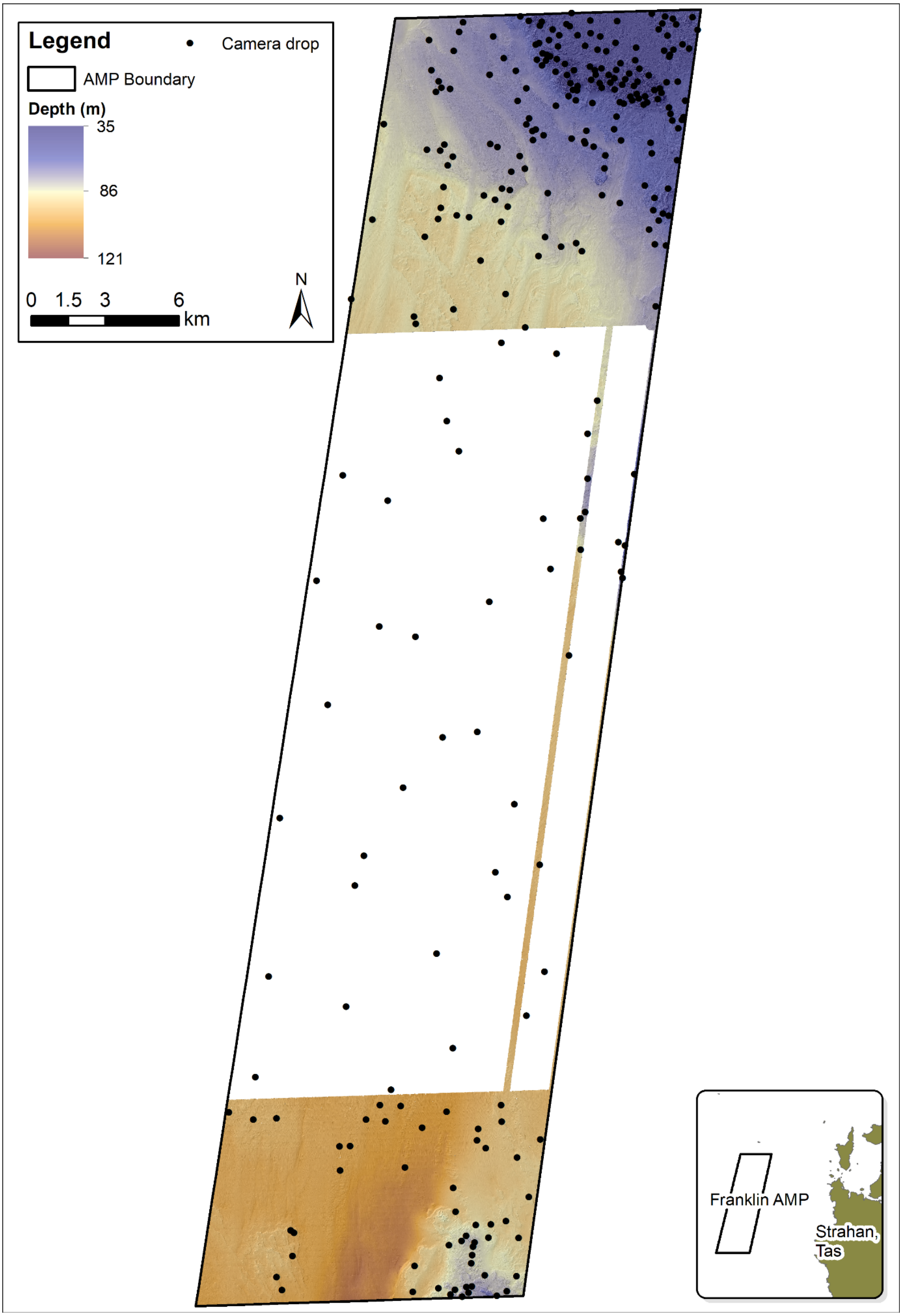

Figure 7. Location of spatially balanced panoramic drop camera deployments used in the Franklin Marine Park to ground-truth habitat distribution based on interpretation of the multibeam sonar data.

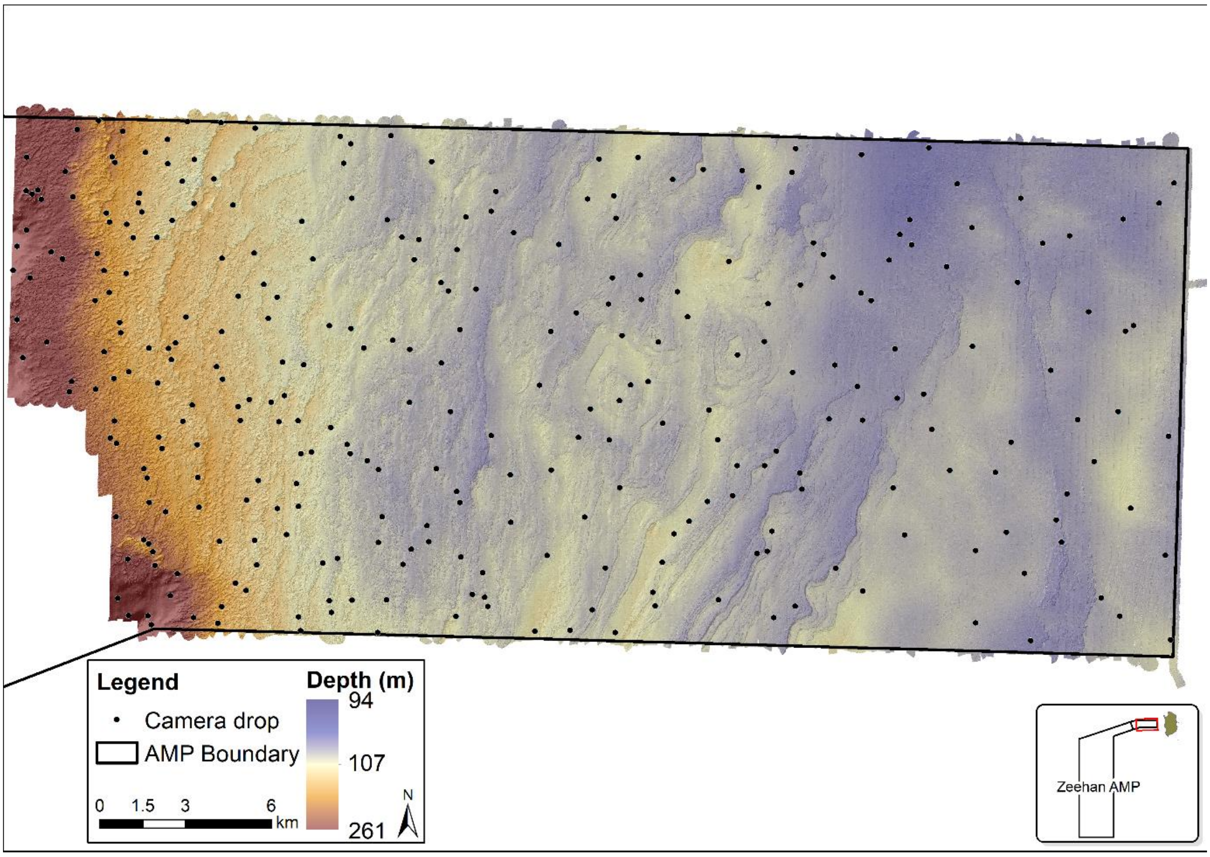

Figure 8. Location of spatially balanced panoramic drop camera deployments used in the Zeehan Marine Park to ground-truth habitat distribution based on interpretation of the multibeam sonar data.

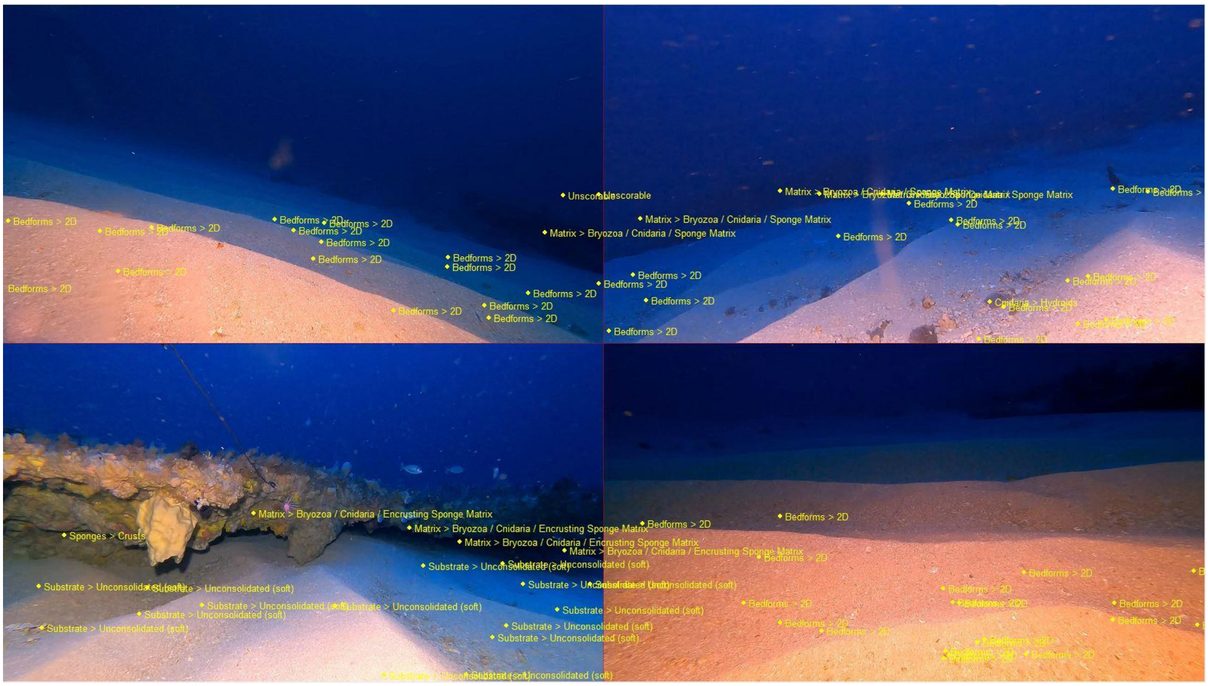

Figure 9. Example of annotation point configuration in the bottom half of each image, with each image representing one of the four cameras used to capture the panorama at single deployment.

Random forest classification of substrata

A Random Forest classification algorithm was used to model habitat distribution in the multibeam (MBES) mapped areas within the marine parks. The approach taken used the non-linear relationships between the drop-camera observations/classifications and the 7 variables derived from the MBES (Table 1). Random Forest models work by creating many decision trees which all 'vote' to give a classification to the dependant variable using different combinations of the independent variables (Biau & Scornet 2016). The Random Forest method has been shown in previous studies to more accurately predict substrata type based on ground-truth data and MBES variables that other common approaches (Misiuk & Brown 2022, Zhang et al. 2022, Che Hasan et al. 2022).

The Random Forest models were trained using the programming software 'R' using the 'RandomForest' package. The imagery-based validation data were partitioned 60:40% for model training and testing, respectively. The models for Franklin were built using 1000 trees, a node size of 10 and a maximum of five features considered at each split. The models for Zeehan were built using 4 trees, a node size of 10 and a maximum of 1 feature considered at each split. These values were selected using the *train()* function in the 'caret' package.

Evaluation of model performance

Model performance was assessed using the internal accuracy statistics (out-of-bag) of Random Forest, which ranges from 0-100% with lower values consider better. The partitioned testing samples were used to evaluate the model performance based on 10-fold cross-validation to calculate overall accuracy, which is the proportion of observed values correctly predicted, and the kappa statistic, which measures the consistency of the model predictions (McHugh 2012). Overall accuracy ranges from 0-100% with higher values considered better. Kappa ranges from 0-1, with higher values also considered better. User's and Producer's accuracies are also provided to communicate the map accuracy from the point of view of the map maker (the user) and the map maker (the producer). The User's accuracy indicates how often the class (in this case the classification of habitat type) predicted on the map will be present on the ground. This is referred to as reliability. The Producer's accuracy is how often are real features on the ground correctly shown on the classified map or the probability that a certain class of an area on the ground is classified as such.

Depth thresholds of 30-70m and 70-200m were then applied to the model to split reef habitats into mesophotic and rariphotic reefs, respectively, following Parks Australia's Natural Value Ecosystems classification (Hayes et al. 2021).

Results

Substrata classification

Franklin Marine Park

The results of automated habitat mapping for the Franklin MP indicate that the newly mapped area of the park (~282 km^2: 42% of park), is dominated by shelf unvegetated sediments (166km^2), followed by 59.6 km^2 of a patchwork of mixed shelf reefs and shelf unvegetated sediments, and 56.6km^2 of rocky reefs (Figure 10). Mesophotic rocky reefs represent ~ 12.5% of the mapped reef, while rariphotic shelf reefs represent 7.5%. For the mixed reef and sediment class, 16.4% and 4.7% were in the rariphotic and mesophotic zones, respectively. Notably, these results only apply for the mapped area of the park, hence, when the middle 58% is completed, it is likely the estimated relative cover of soft sediments in the park will increase markedly, as the limited ground-validation in this area indicated it to be predominantly shelf unvegetated sediments, with exception of the small isolated reef structure located midway down the eastern boundary of the MP, and some limited points showing a mixed habitat classification (Figure 10). Based on rough estimates derived solely from drop camera observations, the unmapped area can be categorised as follows: approximately 78% comprises shelf unvegetated sediments, 14% is a combination of mixed rariphotic shelf reefs and shelf unvegetated sediments, and the remaining 8% consists of mesophotic rocky reefs.

Due to the small sample size of reef imagery relative to mixed or soft sediment habitats in the evaluation dataset, the mesophotic and rariphotic reef classes were combined in model training and validation, with models then trained to represent three substrata classes, including rocky reef, mixed substrata and unvegetated soft sediments. The overall accuracy and kappa values for Franklin MP suggested moderate prediction accuracies of 71% and 0.55, respectively, based on subsequent validation from the retained imagery (Figure 10; Table 2). Among observations withheld from the model training, 11 were predicted as rocky reef, 2 as mixed substrata, and none as unvegetated shelf sediments, resulting in a User's Accuracy (UA) of 78.6% for the rocky reefs category, 66.7% for mixed substrata, and 62.5% for unvegetated soft sediments. The Producer's Accuracy (PA) was 84.6% for rocky reefs, 40.0% for mixed substrata, and 100% for unvegetated soft sediments.

Multibeam mapping and drop-camera validation interpretation: For reef systems mapped within the Franklin MP, their overall structure displayed considerable variation in depth range and complexity (Figure 11). On the northern margin, reef habitat extended into the mesophotic zone, with a shallow region peaking at around 35 m (see also Appendix B1). The mesophotic component was typically of high-profile structure, and is interpreted to be basalt bedrock, based on local geology and bedforms (Figure 11, see also appendix B2). As these reefs transitioned from the mesophotic to the rariphotic zones, the systems tended to become flat pavement (likely of limestone origin) that was often sand inundated with outcropping ridges (Figure 11). A small outcrop of lowish-profile rariphotic rocky reef structure (likely a step-feature on pavement) was mapped in the south of the MP in approximately 80 m depth (bottom-left image in Figure 11), that transitioned to sand inundated pavement reefs that were evident throughout the 80-100 m depth range, interspersed with soft sediment (Figure 11, see also Appendix B3).

Figure 12 provides examples of the sessile biota associated with the mapped substrata classes, ranging from bare rippled sediments in the centre and south to the high-profile reefs covered in sponges and gorgonians in the mesophotic regions of the north and mid-eastern margin (see also Appendix A1). Typically, the lower-profile rariphotic reefs had an intermediate cover of sessile invertebrates, usually sponge-dominated, with partial sand-inundation presumably limiting the overall cover on this habitat (see also Appendix A3). A notable feature of the biota in the park was the presence of tall *Ecklonia radiata* kelp forests on the shallowest portion of the upper mesophotic rocky reefs in the north (see also Appendix A2).

The soft sediments within the park were usually markedly rippled and often bare (Figure 12), an indication that the sediments were likely quite mobile at the depths found within this park, due to the strong influence of oceanic swells. Hence regular wave disturbance likely limited the ability of sessile invertebrates to colonise this habitat.

Zeehan Marine Park

The model-based habitat mapping results for the Zeehan MP indicates that, the newly mapped area of the park (~717 km^2 of the continental shelf region of the multiple use zone), is dominated by shelf unvegetated sediments (544 km^2), followed by 173 km^2 mixed rariphotic shelf reefs and shelf unvegetated sediments, and only 0.02 km^2 of distinct rariphotic rocky reefs (Figure 13). It is important to emphasise that the Zeehan MP exhibits a considerable heterogeneity in reef habitats and where, except for the distinct step-features in the reefs themselves, most of the reef structures are partially sand inundated, and hence appear as mixed reef/sediment. To capture a comprehensive assessment of the reef habitat within the MP, it may be more appropriate to combine the rocky reef and mixed rocky reef class areas with the understanding that there are really no extensive regions of sand-free reef within the shelf area of this park, unlike the more complex reef systems found in the north of the Franklin MP. The exception to this may be several isolated and more complex reef structures located on the shelf break itself.

Like the Franklin MP, the distribution of the mapped reefs displayed considerable variation, ranging in depths from 100 m on the inner margin to over 200 m at the shelf break to upper slope. However, these systems typically showed little complexity or elevation above the surrounding sediment, and from limited rock samples that came up on the camera frame, were likely predominantly composed of limestone (Figure 15). The inner third of the shelf region was dominated overall by soft sediment, and where reef was present it primarily consisted of sediment-inundated flat pavement rariphotic reefs (Figure 14). The coverage of low-profile pavement reef increased in the mid-section of the mapped area, with the rariphotic reefs typically showing prominent elongated (often multi-kilometre length-scale) step-like formations at likely bedding planes in the sedimentary bedrock. These step-features typically range in height from 1-3 m (see also Appendix B4). In the outer third of the mapped area the limestone pavement became notably more fragmented into distinct elevated blocks (Figure 14, Appendix B5). This area exhibited more pronounced step-like features and lesser coverage of sand, with steps often up to 3 m in height (Figure 14, Appendix B5, A6-7) that presumably reduced the extent of sand migration over otherwise flat surfaces. Typically, the step-features found in the mid to outer sections of the shelf were not undercut to form ledge/cave-like structures, but rather were steeply sloping walls with little crevice structure, limiting the availability of shelter for fish or mobile invertebrates.

One other feature of note was the presence of several reef outcrops on the upper slope in depths of approximately 150 m, with elevations in excess of 10 m and extending over distances of several hundred metres (e.g. Figure 3 in Davey et al. 2002, Appendix B5). Given the elevation of these systems it is likely they may be a different geological bedform from the more widespread limestone pavement on the shelf itself, but that remains to be validated by direct rock sampling. There was insufficient image-based validation on these features to provide further description.

The soft sediment habitat in the shelf waters of the park was typically strongly rippled by the high exposure of this region to oceanic swells (Figure 15, Appendix A4) despite the significant depth across much of the shelf area (between 97-120 m). Hence, most of the soft-sediment habitat had little biological cover and was predominantly bare sand. However, as a significant area of the shelf region was covered in sand-inundated pavement reef, there were several areas where validation imagery did show some emergent sessile invertebrate cover amongst sand, likely attached to an underlying hard rock pavement (Figure 15).

The accuracy of the model-based habitat mapping for the Zeehan MP, as assessed by validation imagery withheld from the model training, indicated slightly lower prediction accuracies than generated for the Franklin MP, with moderate overall prediction accuracy and kappa values of 71% and 0.47, respectively (Figure 15; Table 2). Among the observed samples, 3 were predicted as rariphotic shelf reefs, 1 as mixed substratum, and none as unvegetated soft sediments, resulting in a UA of 33.3% for rariphotic shelf reefs, 67.9% for mixed substrata, and 79.2% for unvegetated soft sediments. The PA was 75% for rocky reef, 55.9% for mixed substrata, and 80.9% for unvegetated soft sediments.

Figure 15 provides examples of the sessile biota associated with the three mapped substrata classes in the Zeehan MP, ranging from bare rippled sediments in the east to undercut high-profile reefs covered in sponges, hard bryozoans and tube worms in the deeper regions of the west (see also Appendix A4-9).

Table 2. Confusion matrix showing class error for substrata classes in Franklin and Zeehan MPs (UA. user's accuracy = precision, PA. producer's accuracy = recall). See methods section for how to interpretate these.

Franklin AMP		**Observed**			
		Rocky reefs	**Mixed substrata**	**Unvegetated soft sediments**	**UA (%)**
Predicted	Rocky reefs	11	2	0	78.58
	Mixed substrata	3	4	3	66.67
	Unvegetated soft sediments	0	0	5	62.50
	PA (%)	84.62	40.00	100.00	
			Overall (%)	71.43	
			Kappa	0.55	
			OBB (%)	29.50	
Zeehan AMP			**Observed**		
		Shelf reefs	**Mixed substrata**	**Unvegetated soft sediments**	**UA (%)**
Predicted	Shelf reefs	3	1	0	33.33
	Mixed substrata	5	19	10	67.86
	Unvegetated soft sediments	1	8	38	79.17
	PA (%)	75	55.88	80.85	
			Overall (%)	70.58	
			Kappa	0.47	
			OBB (%)	39.56	

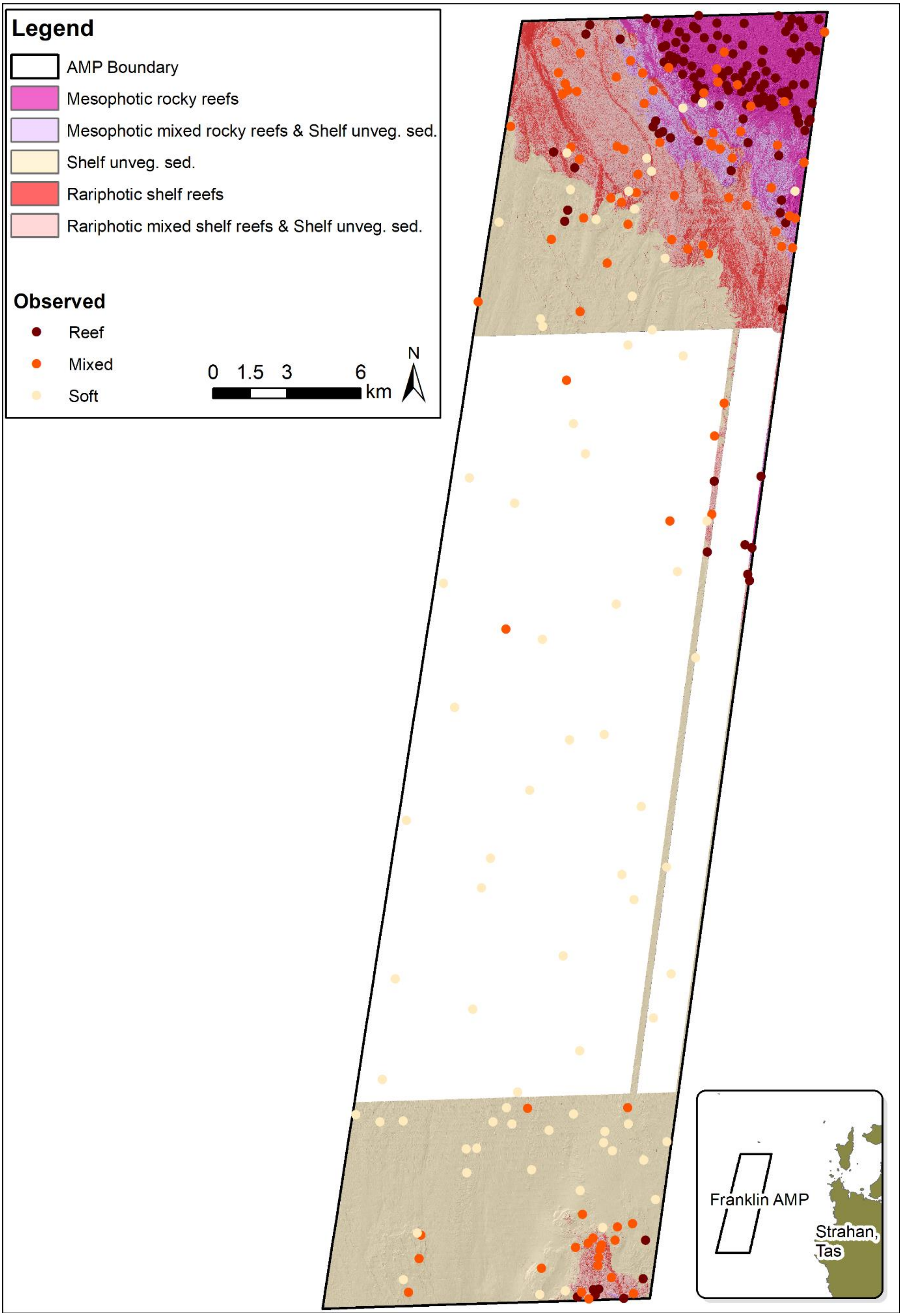

Figure 10. Predicted substrata in Franklin MP based on random forest classification using MBES covariates and drop camera truthing. Note that the drops within the region where MBES was not collected were dropped from the classification process.

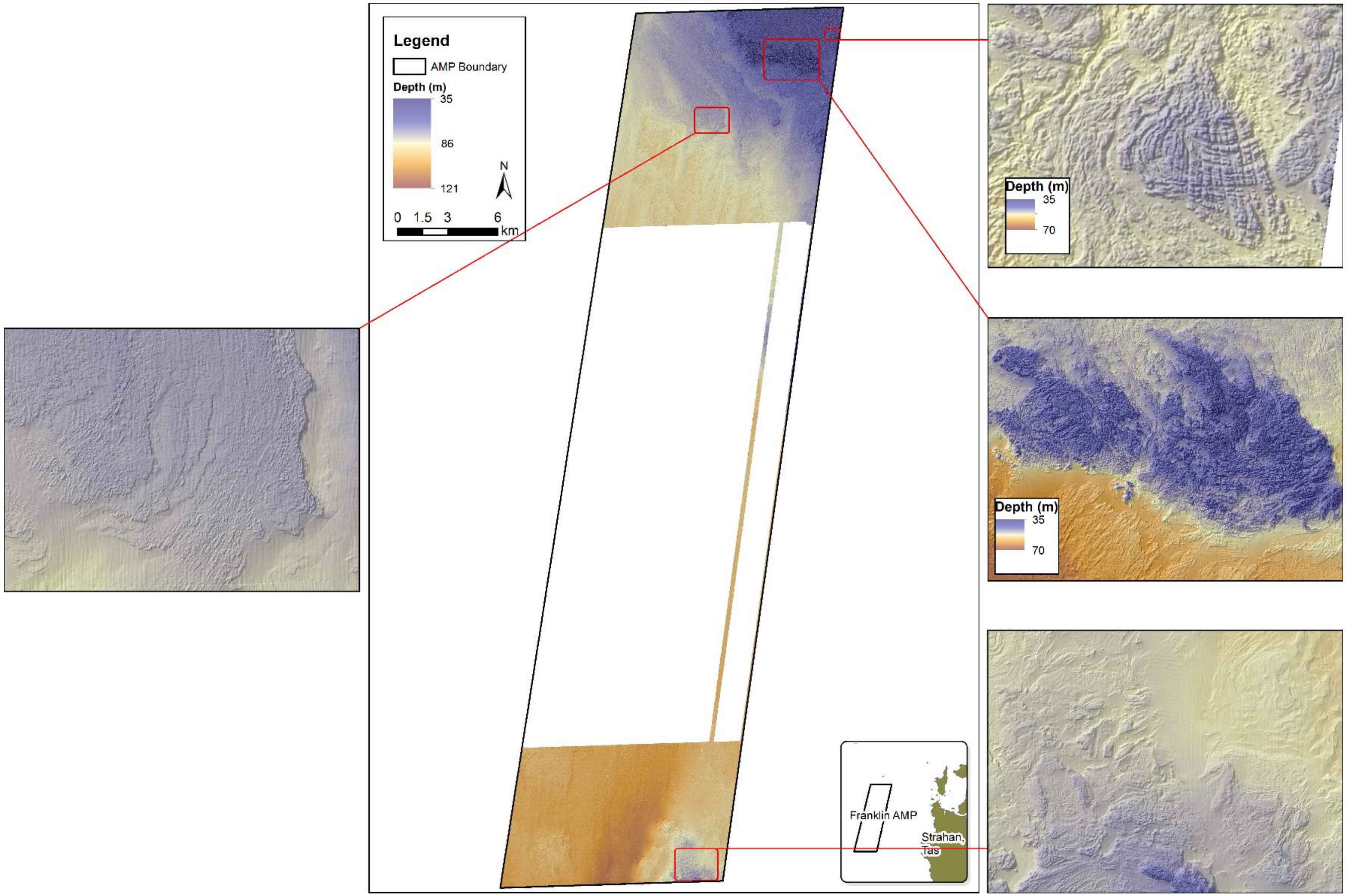

Figure 11. Zoom examples showing the structure of the different mesophotic and rariphotic rocky reef mapped across the Franklin MP. Left panel shows the flat pavement rariphotic rocky reef systems outcropped in approximately 80 m that were often sand-inundated. Top right panel shows potential lava flows incising the low-profile mesophotic rocky reefs in the northern region of the MP. Middle right panel shows the high-profile mesophotic rocky reefs the northern region of the MP. Bottom right panel shows the rariphotic reef systems outcropped in approximately 80-100 m depth.

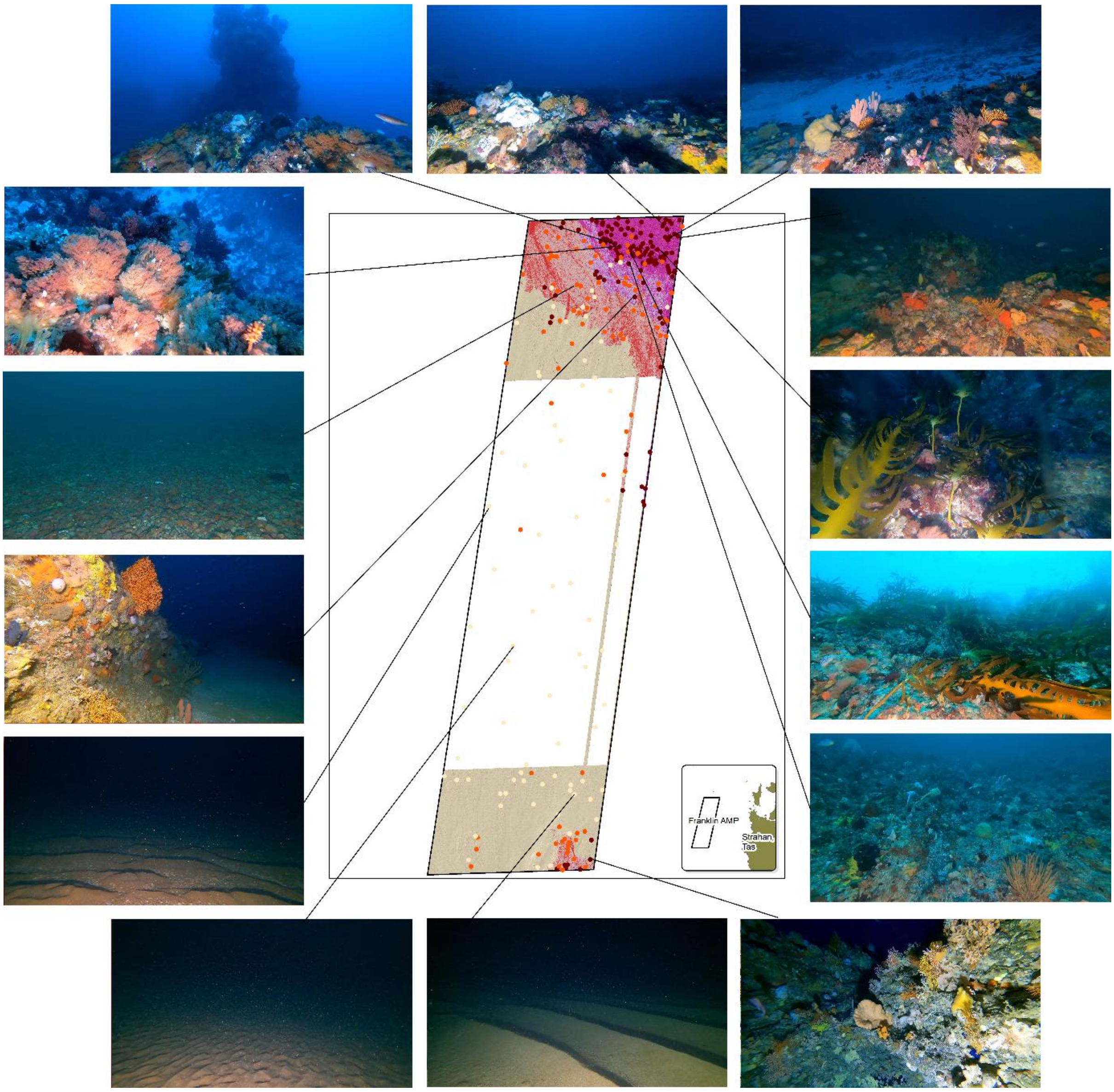

Figure 12. Examples of the sessile biota associated with the mapped substrata classes in the Franklin MP ranging from bare rippled sediments in the centre and south to the high-profile reefs covered in sponges and gorgonians in the deeper regions of the north and south-east. Tall Ecklonia radiata kelp forests were also a feature of the upper mesophotic rocky reefs in the north.

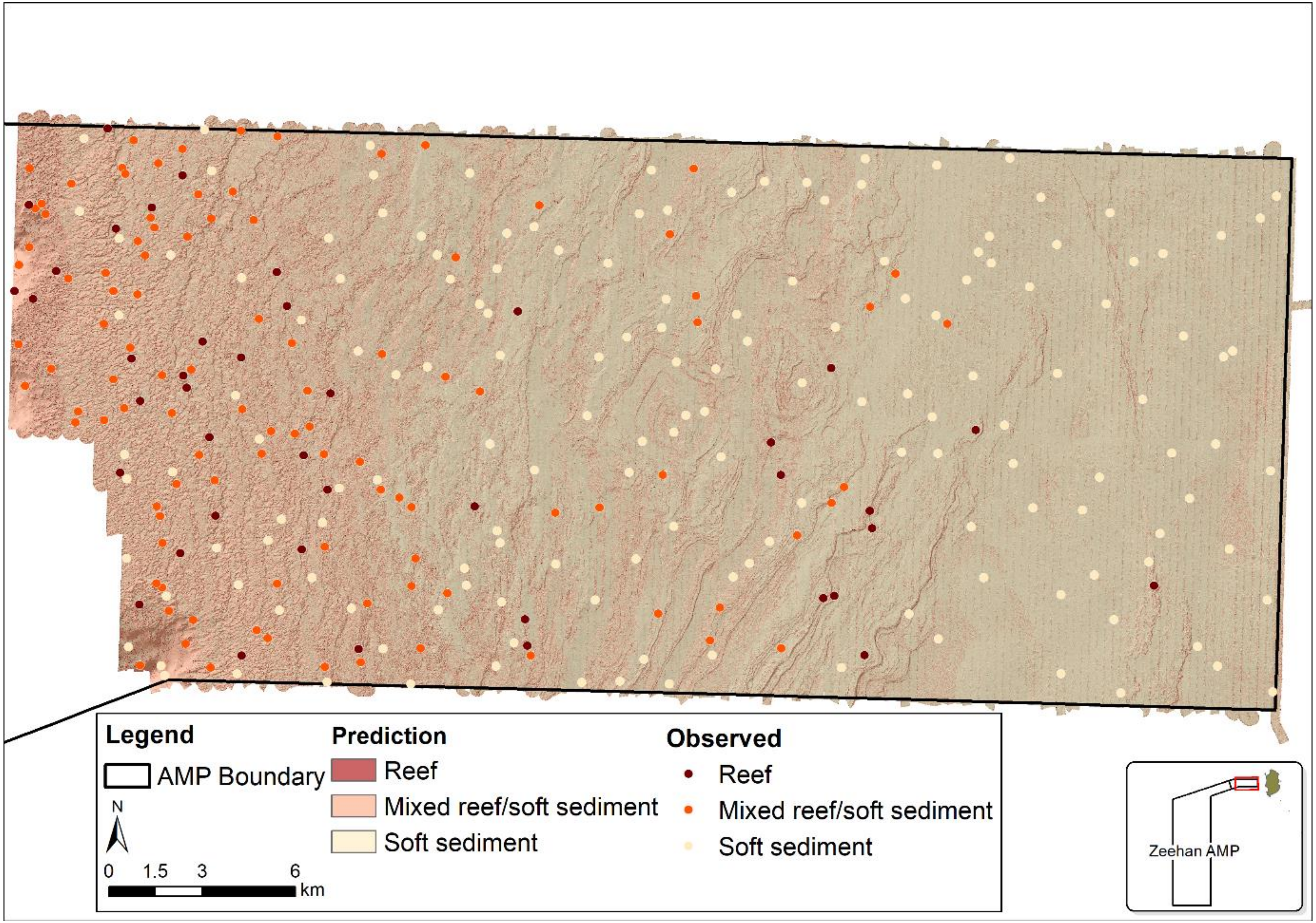

Figure 13. Predicted substrata in Zeehan MP based random forest classification using MBES covariates and drop camera truthing.

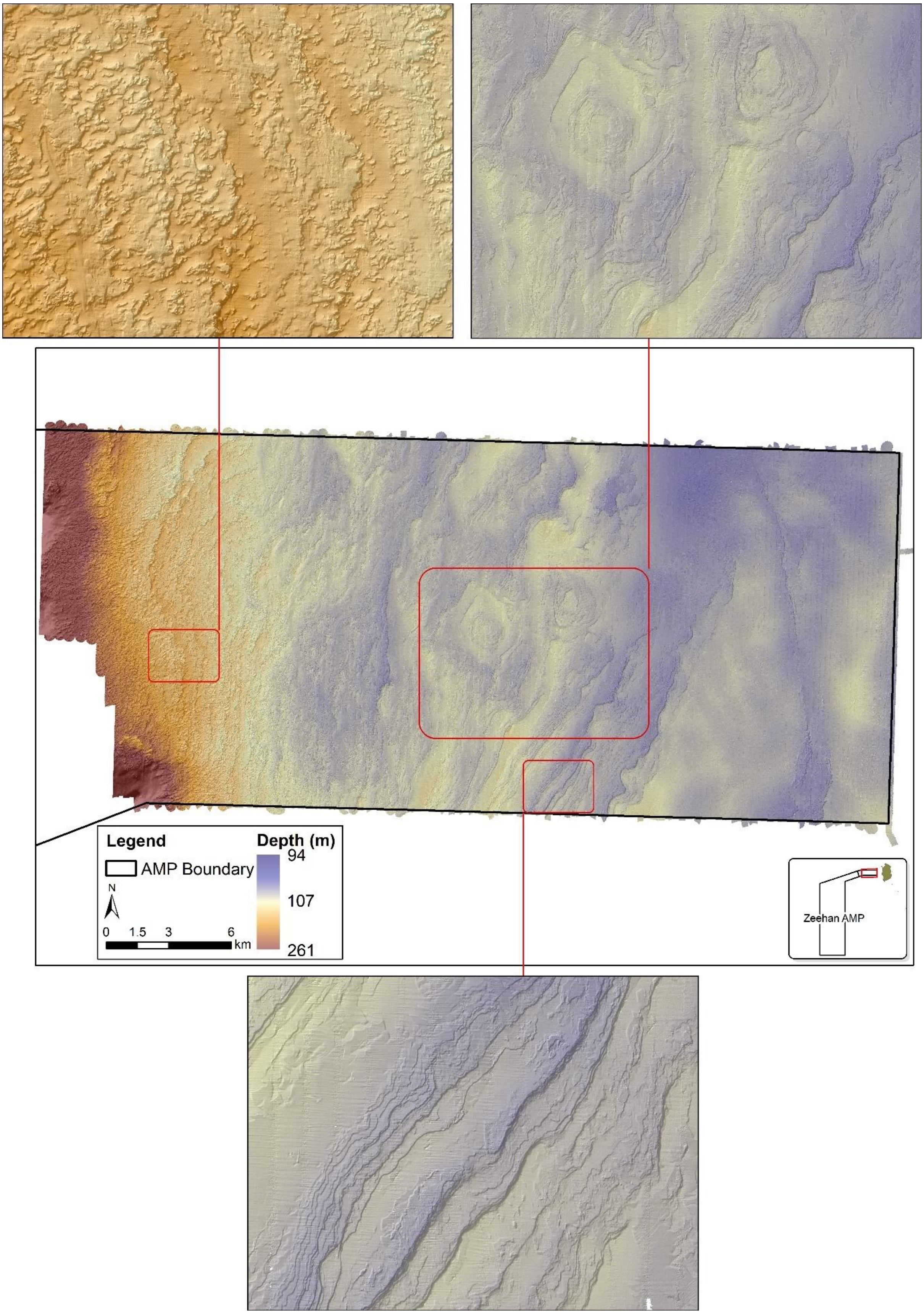

Figure 14. Zoom examples showing the structure of the different rariphotic rocky reef mapped across the Zeehan MP. Top left shows the distinctively fractured elevated limestone blocks in the outer region of the shelf. Top right shows interesting circular sand inundated limestone pavement located mid-shelf. Bottom centre shows long linear sand-inundated step-features pavement rariphotic rocky reefs in the mid-third.

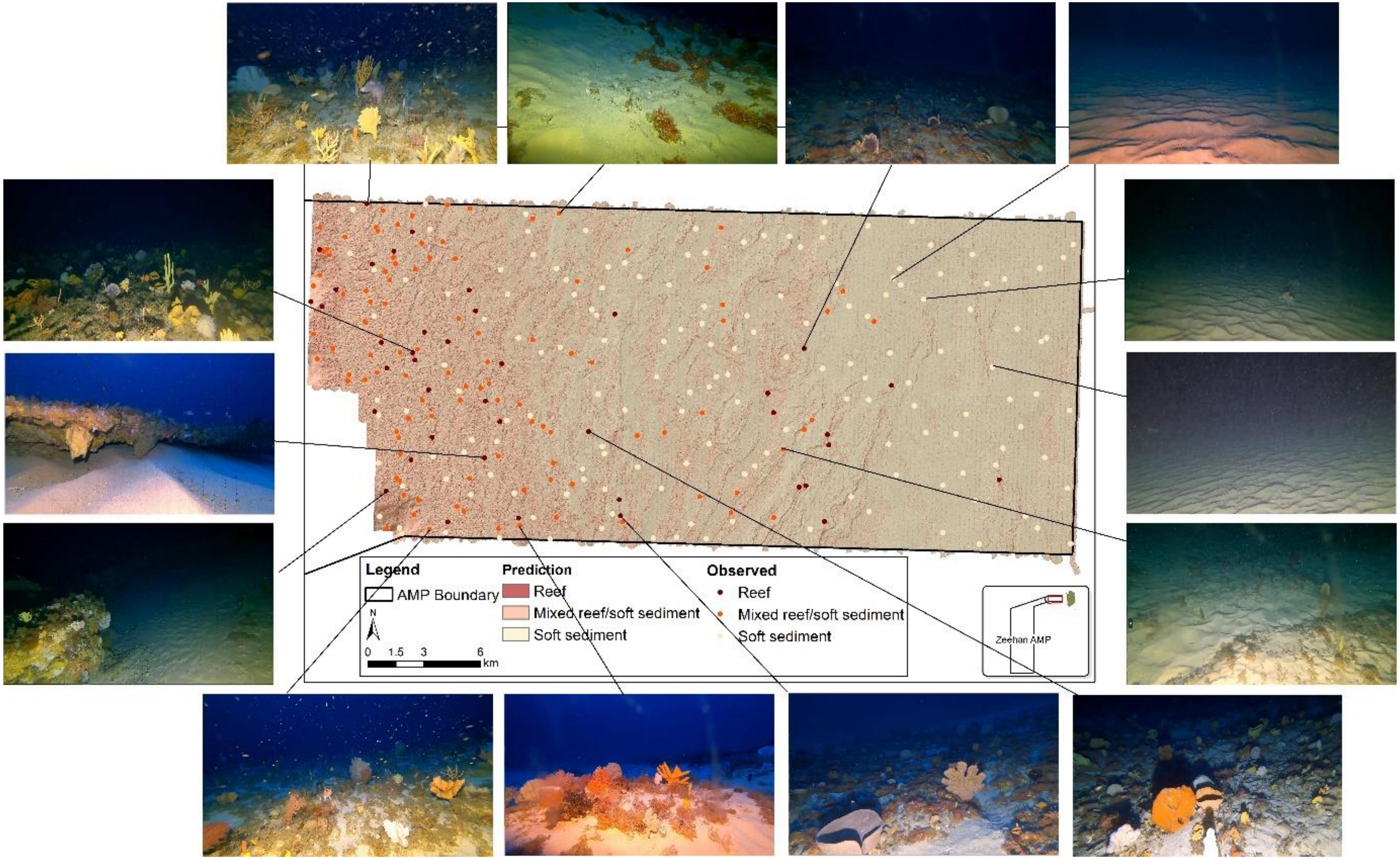

Figure 15. Examples of the sessile biota in Zeehan MP associated with the three mapped substrata classes, ranging from bare rippled sediments in the east to undercut high-profile reefs covered in sponges, hard bryozoans and tube worms in the deeper regions of the west.

Spatial patterns in the cover of sessile assemblages

For the Franklin MP, a total of 213 morphospecies were observed by drop-camera deployments during the survey (Table 3; Figure 12). A total of 159 sponge morphospecies were recorded, followed by 20 Cnidarian morphospecies, 17 Bryozoan morphospecies, 6 Ascidian morphospecies and 5 Macroalgae morphospecies (Table 3). Morphospecies richness generally decreased across a gradient from mesophotic rocky reefs to mixed mesophotic shelf reefs shelf unvegetated sediments, to rariphotic shelf reefs, to mixed rariphotic shelf reefs, to shelf unvegetated sediments (Table 3). The mixed small invertebrate matrix category, the common kelp *Ecklonia radiata* and combined species of red macroalgae provided the majority (>50% combined) of the cover on the mesophotic rocky reefs. Apart from the algal categories and mixed invertebrates, no individual morphospecies exceeded 1% cover. The cover of individual morphospecies of sponges, bryozoan and cnidarian was generally <0.1 % of the total cover, irrespective of habitat category, which is a pattern typical of these ecosystems (Table 3). However, several foliaceous bryozoans and a pink octocoral did exceed 0.2% cover on some hard substrate categories.

Slightly more (264) morphospecies were observed during the drop-camera surveys in the Zeehan MP (Table 3; Figure 15). Sponges again dominated the community, with 208 morphospecies recorded, followed by Cnidarian (22) morphospecies, Bryozoan (17) morphospecies, 6 Ascidian and one Macroalgae morphospecies as drift algae (Table 4). Typically for deeper shelf regions, the mixed small invertebrate matrix provided the majority (between ~20-50%) of the cover across the three habitats mapped. Irrespective of habitat, individual sponge, bryozoan and cnidarian morphospecies cover was again usually <0.1 % (Table 3). Despite this, a number of sponge morphospecies in particular did exceed 0.2% cover on hard habitats. These include a range of foliaceous bryozoan species, several branching, laminar and encrusting sponges, a cup sponge and a black octocoral. Of note was the locally abundant hard bryozoan species *Adeona grisea* (Appendix A5) that was found at 0.27% cover in both hard and soft habitats, forming a distinct cluster in the mid-shelf section of the park. Also of note was an unidentified fanworm species (Appendix A6) that while only forming approximately 0.09% cover overall on both hard and soft substrates, was a locally restricted but conspicuous component of the fauna towards the outer shelf region of the park.

Table 3. Mean cover of component morphospecies recorded in each habitat class in the Franklin and Zeehan Marine Parks. Standard deviate is reported in parentheses. All morphospecies are derived from the Australian Morphospecies Catalogue.

Franklin AMP						Zeehan AMP		
Morphospecies	**Mesophotic rocky reefs (109 drops)**	**Mixed Mesophotic shelf reefs & Shelf unvegetated sediments (20 drops)**	**Rariphotic shelf reefs (17 drops)**	**Mixed Rariphotic shelf reefs & Shelf unvegetated sediments (74 drops)**	**Shelf unvegetated sediments (61 drops)**	**Rariphotic shelf reefs (41 drops)**	**Mixed Rariphotic shelf reefs & Shelf unvegetated sediments (102 drops)**	**Shelf unvegetated sediments (160 drops)**
ascidians colonial ascidian clavelina like white	0.02 (0.25)	0	0	0	**0**	0	0	0
ascidians colonial ascidian stalked purple pyura like	0.01 (0.12)	0	0	0	**0**	0	0	0
ascidians colonial ascidian stalked yellow thorny pyura like	0.01 (0.12)	0	0	0	**0**	0	0	0
ascidians colonial ascidian white translucent colonial	0.01 (0.12)	0	0	0	**0**	0	0	0
ascidians colonial unidentifiable	0.08 (0.47)	0.06 (0.27)	0	0	**0**	0	0	0
ascidians solitary unidentifiable	0.08 (0.63)	0	0	0	**0**	0	0	0
bryozoa branching bryozoa stumpy hard	0	0	0	0.02 (0.16)	**0**	0	0	0
bryozoa dendroid unidentifiable	0.01 (0.12)	0	0	0	0	0	0	0
bryozoa fenestrate bryozoa *Adeona grisea*	0.07 (0.34)	0.06 (0.27)	0	0.16 (0.53)	0	0.27 (0.71)	0.09 (0.4)	0.27 (0.71)

bryozoa fenestrate bryozoa celleporaria like	0	0	0	0.06 (0.27)	0		0.06 (0.39)	0	0.06 (0.39)
bryozoa fenestrate bryozoa hard sparce	0	0.06 (0.27)	0	0	0		0	0	0
bryozoa fenestrate bryozoa lace	0.01 (0.12)	0	0	0.06 (0.36)	0		0.06 (0.27)	0.01 (0.12)	0.06 (0.27)
bryozoa fenestrate unidentifiable	0.05 (0.3)	0	0.38 (1.41)	0.04 (0.32)	0		0	0.01 (0.12)	0
bryozoa foliaceous bryozoa soft amathia like	0.26 (1.03)	0.39 (1.84)	0.31 (0.9)	0.18 (0.75)	0		0.15 (0.5)	0.22 (0.84)	0.15 (0.5)
bryozoa foliaceous bryozoa soft beige fluffy	0.02 (0.17)	0	0.06 (0.28)	0.06 (0.27)	0		0	0.01 (0.12)	0
bryozoa foliaceous bryozoa soft dark red	0.26 (1.37)	0	0.06 (0.28)	0.08 (0.31)	0		0.09 (0.43)	0.02 (0.18)	0.09 (0.43)
bryozoa foliaceous bryozoa soft grey pink	0.11 (0.61)	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
bryozoa foliaceous bryozoa soft orange	0.04 (0.27)	0	0	0.02 (0.16)	0		0	0.02 (0.18)	0
bryozoa foliaceous bryozoa soft orthoscuticella like	0.23 (0.85)	0.06 (0.27)	0.06 (0.28)	0.16 (1.13)	0		0.64 (1.65)	0.16 (0.65)	0.64 (1.65)
bryozoa foliaceous bryozoa soft pinky white	0.01 (0.12)	0	0	0	0		0	0.04 (0.37)	0
bryozoa foliaceous bryozoa unknown soft	0.66 (1.62)	0.74 (1.62)	0.5 (1.31)	0.31 (1.13)	0		0.06 (0.27)	0.04 (0.21)	0.06 (0.27)
bryozoa foliaceous retiflustra like	0.01 (0.12)	0	0	0	0		0	0	0
bryozoa foliaceous unidentifiable	0.22 (1.42)	0	0.06 (0.28)	0.08 (0.5)	0		0	0	0

cnidaria black octocorals bramble acabaria sp	0.11 (0.46)	0.06 (0.27)	0.25 (1.12)	0.02 (0.16)	0		0.15 (0.8)	0	0.15 (0.8)
cnidaria black octocorals bramble asperaxis karenae	0.02 (0.17)	0	0	0	0		0	0	0
cnidaria black octocorals gorgonian black fan	0.02 (0.25)	0	0	0	0		0	0	0
cnidaria black octocorals gorgonian pink	0.02 (0.25)	0	0	0	0		0	0	0
cnidaria black octocorals gorgonian pink pteronisis like	0.04 (0.27)	0.23 (0.74)	0.06 (0.28)	0	0		0	0.04 (0.21)	0
cnidaria black octocorals gorgonian red mopsella like	0.08 (0.5)	0	0.13 (0.38)	0.1 (0.47)	0		0	0.01 (0.12)	0
cnidaria black octocorals gorgonian red pteronisis like	0.02 (0.17)	0.06 (0.27)	0.06 (0.28)	0.06 (0.48)	0		0	0.05 (0.3)	0
cnidaria black octocorals grey fan	0.02 (0.25)	0	0	0.06 (0.27)	0		0	0	0
cnidaria black octocorals peach fan	0	0	0.06 (0.28)	0	0		0	0	0
cnidaria black octocorals soft blue	0.01 (0.12)	0	0	0	0		0	0	0
cnidaria black octocorals unidentifiable	0.02 (0.25)	0	0	0	0		0.24 (1.13)	0.01 (0.12)	0.24 (1.13)
cnidaria dusky grey bushy	0	0	0	0.02 (0.16)	0		0	0	0
cnidaria hydroid branching black feathers	0.01 (0.12)	0	0	0	0		0	0	0

cnidaria hydroid branching brown feathers	0	0	0	0.02 (0.16)	0		0.09 (0.33)	0	0.09 (0.33)
cnidaria hydroid branching white feathers	0	0	0	0	0		0.06 (0.27)	0.15 (0.76)	0.06 (0.27)
cnidaria hydroid brown feathers	0.02 (0.17)	0	0.06 (0.28)	0	0		0	0	0
cnidaria hydroid dark grey	0.02 (0.17)	0	0.06 (0.28)	0	0		0	0.01 (0.12)	0
cnidaria hydroid red brown mossy	0.02 (0.25)	0	0	0	0		0	0	0
cnidaria hydroid small red	0	0	0	0	0		0	0.01 (0.12)	0
cnidaria hydroid white	0.02 (0.17)	0	0	0	0		0.12 (0.61)	0.01 (0.12)	0.12 (0.61)
cnidaria unidentifiable	0	0.11 (0.53)	0	0	0		0	0	0
cnidaria zoanthids parazoanthus spp	0.08 (0.4)	0	0.06 (0.28)	0.14 (0.69)	0		0	0	0
invertebrate matrix	55.71 (20.98)	32.82 (17.18)	54.94 (14.61)	19.48 (14.14)	0.37 (2.05)		48.67 (18.11)	21.15 (12.26)	48.67 (18.11)
macroalgae brown *Ecklonia radiata*	3.4 (12.1)	0.91 (3.16)	0	0	0		0	0	0
macroalgae brown unidentifiable	0.12 (0.88)	0.85 (2.97)	0	0	0		0	0	0
macroalgae unidentifiable	0	0.11 (0.37)	0	0	0		0	0	0
macroalgae red sonderopelta spp peyssonnelia spp	0.05 (0.3)	0	0	0	0		0	0	0
macroalgae red unidentifiable	1.88 (3.46)	0.68 (2.24)	0	0.1 (0.57)	0		0	0.01 (0.12)	0

sponges balls globular orange tethya like	0	0	0	0	0	0	0.01 (0.12)	0
sponges balls papillate black ball	0	0	0	0	0	0	0.01 (0.12)	0
sponges balls ball papillate brown	0	0.11 (0.53)	0	0	0	0	0	0
sponges balls ball white	0.01 (0.12)	0	0	0	0	0	0	0
sponges balls knobby yellow ball	0.01 (0.12)	0	0	0	0	0	0	0
sponges balls smooth orange ball	0.01 (0.12)	0.11 (0.53)	0	0	0	0	0	0
sponges balls unidentifiable	0.01 (0.12)	0	0.13 (0.56)	0	0	0	0	0
sponges balls yellow smooth ball	0.02 (0.17)	0	0	0.02 (0.16)	0	0	0	0
sponges balls yellow smooth large oscula	0.02 (0.17)	0	0.06 (0.28)	0	0	0	0	0
sponges barrels barrel black	0	0	0.06 (0.28)	0	0	0	0	0
sponges barrels barrel pink white smooth mouth	0.01 (0.12)	0	0	0	0	0	0	0
sponges barrels barrel pink lumpy	0.01 (0.12)	0	0	0	0	0	0	0
sponges barrels barrel purple thick	0	0.06 (0.27)	0	0	0	0	0	0
sponges barrels barrel thick blue	0.01 (0.12)	0	0	0	0	0	0	0
sponges balls yellow smooth ball	0	0	0	0	0	0.06 (0.27)	0	0.06 (0.27)
sponges barrels barrel orange rotund	0	0	0	0	0	0	0.01 (0.12)	0

sponges barrels barrel thick yellow	0	0	0	0	0	0	0.01 (0.12)	0
sponges barrels barrel white	0	0	0	0	0	0.06 (0.27)	0.01 (0.12)	0.06 (0.27)
sponges barrels unidentifiable	0.01 (0.12)	0	0	0.27 (1)	0	0	0	0
sponges branching arborescent black	0.01 (0.12)	0	0	0	0	0	0	0
sponges branching arborescent brown thorny	0	0	0.06 (0.28)	0	0	0	0	0
sponges branching arborescent grey	0.02 (0.17)	0	0	0	0	0	0	0
sponges branching arborescent orange	0.02 (0.17)	0	0.13 (0.56)	0.02 (0.16)	0	0	0	0
sponges branching arborescent purple	0.02 (0.17)	0	0	0	0	0	0	0
sponges branching arborescent tan	0.23 (0.97)	0.06 (0.27)	0	0	0	0	0.02 (0.25)	0
sponges branching arborescent white	0.02 (0.25)	0	0	0.02 (0.16)	0.02 (0.15)	0.09 (0.43)	0	0.09 (0.43)
sponges branching arborescent white short	0.02 (0.25)	0	0.06 (0.28)	0.04 (0.22)	0	0.06 (0.39)	0.05 (0.3)	0.06 (0.39)
sponges branching arborescent yellow	0.1 (0.75)	0	0.06 (0.28)	0.1 (0.53)	0	0.52 (1.01)	0.07 (0.46)	0.52 (1.01)
sponges branching branching beige spindles	0	0	0.06 (0.28)	0	0	0	0	0
sponges branching branching beige stumpy	0.01 (0.12)	0.06 (0.27)	0	0	0	0	0.02 (0.25)	0
sponges branching branching brown short	0.01 (0.12)	0	0	0	0	0	0	0

sponges branching branching brown thin	0.04 (0.37)	0	0.13 (0.38)	0.02 (0.16)	0		0	0	0
sponges branching branching gray fine repent like	0	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges branching branching grey repent like	0	0	0	0	0		0	0	0
sponges branching branching dark purple	0	0.06 (0.27)	0	0	0		0	0	0
sponges branching branching orange fingers	0.02 (0.17)	0.11 (0.53)	0	0	0		0	0	0
sponges branching branching orange frilly	0	0	0	0	0		0	0.01 (0.12)	0
sponges branching branching orange lumpy	0	0	0	0.04 (0.32)	0		0.03 (0.2)	0	0.03 (0.2)
sponges branching branching purple	0.01 (0.12)	0	0	0	0		0	0.01 (0.12)	0
sponges branching branching purple stumpy	0.01 (0.12)	0	0	0	0		0	0	0
sponges branching branching white pointed	0	0	0	0	0		0.03 (0.2)	0.01 (0.12)	0.03 (0.2)
sponges branching branching white stubby	0	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges branching branching yellow stumpy	0	0	0	0	0		0	0.01 (0.12)	0

sponges branching branching yellow thick pointed	0	0	0	0	0		0.55 (1.4)	0.05 (0.3)	0.55 (1.4)
sponges branching branching yellow thick pointed	0	0.06 (0.27)	0	0	0		0	0	0
sponges branching branching yellow thorny	0	0	0	0.02 (0.16)	0		0	0	0
sponges branching unidentifiable	0.23 (0.62)	0.06 (0.27)	0.44 (1.17)	0.08 (0.39)	0		0.21 (0.55)	0.11 (0.36)	0.21 (0.55)
sponges branching yellow branching column	0.01 (0.12)	0	0	0	0		0	0.01 (0.12)	0
sponges creeping ramose ramose single cream	0.01 (0.12)	0	0	0	0		0	0	0
sponges creeping ramose repent complex brown	0.01 (0.12)	0	0	0	0		0	0	0
sponges creeping ramose repent simple brown	0	0	0	0.02 (0.16)	0		0	0	0
sponges creeping ramose repent yellow	0	0	0	0.02 (0.16)	0		0	0	0
sponges creeping ramose repent lumpy shapeless grey	0	0	0	0	0		0	0.02 (0.25)	0
sponges creeping ramose repent orange	0	0	0	0	0		0	0.01 (0.12)	0
sponges creeping ramose repent yellow	0	0	0	0	0		0	0.01 (0.12)	0

sponges creeping ramose white tempura	0.01 (0.12)	0.06 (0.27)	0	0	0		0	0	0
sponges cryptic cryptic short yellow tubes	0	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
sponges cups cup beige shallow irregular	0.01 (0.12)	0	0	0	0		0	0.01 (0.12)	0
sponges cups cup beige small	0.01 (0.12)	0	0	0	0		0	0	0
sponges cups cup black smooth	0.01 (0.12)	0	0	0	0		0	0	0
sponges cups cup blue	0.01 (0.12)	0	0	0	0		0	0	0
sponges cups cup brown irregular	0.01 (0.12)	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges cups cup lavender thin smooth	0	0	0	0	0		0.12 (0.47)	0.02 (0.25)	0.12 (0.47)
sponges cups cup orange	0.06 (0.61)	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges cups cup red	0	0	0	0	0		0	0.01 (0.12)	0
sponges cups cup stalked purple	0.04 (0.27)	0	0	0	0		0	0	0
sponges cups cup white	0	0	0	0.02 (0.16)	0		0.06 (0.27)	0.01 (0.12)	0.06 (0.27)
sponges cups cup yellow	0.01 (0.12)	0	0.13 (0.38)	0	0		0.24 (0.64)	0.05 (0.3)	0.24 (0.64)
sponges cups cup yellow thick	0.01 (0.12)	0	0	0	0		0	0	0
sponges cups unidentifiable	0	0.06 (0.27)	0	0	0		0.03 (0.2)	0.01 (0.12)	0.03 (0.2)

sponges encrusting encrusting beige smooth	0.1 (0.45)	0	0.13 (0.56)	0	0		0.15 (0.64)	0.07 (0.35)	0.15 (0.64)
sponges encrusting encrusting black	0.13 (0.82)	0.06 (0.27)	0	0	0		0	0.01 (0.12)	0
sponges encrusting encrusting black thick	0.06 (0.32)	0	0	0	0		0	0	0
sponges encrusting encrusting blue	0	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
sponges encrusting encrusting brown	0.26 (0.79)	0.11 (0.53)	0	0.12 (0.81)	0		0.03 (0.2)	0.1 (0.38)	0.03 (0.2)
sponges encrusting encrusting brown oscula	0.08 (0.86)	0	0	0	0		0	0	0
sponges encrusting encrusting dark red	0.24 (0.72)	0.11 (0.53)	0.06 (0.28)	0.02 (0.16)	0		0	0.01 (0.12)	0
sponges encrusting encrusting grey smooth	0.22 (0.64)	0.11 (0.37)	0	0	0		0.15 (0.64)	0.02 (0.25)	0.15 (0.64)
sponges encrusting encrusting light orange	0.02 (0.17)	0	0	0.02 (0.16)	0		0	0.02 (0.18)	0
sponges encrusting encrusting orange	0.34 (0.82)	0.11 (0.37)	0.38 (0.71)	0.06 (0.27)	0		0.03 (0.19)	0.04 (0.28)	0.03 (0.19)
sponges encrusting encrusting orange beige	0.04 (0.37)	0	0	0	0		0	0	0
sponges encrusting encrusting pink lumpy	0.04 (0.27)	0	0	0	0		0	0	0
sponges encrusting encrusting purple lumpy	0.01 (0.12)	0.06 (0.27)	0	0	0		0	0	0

sponges encrusting encrusting white	0.1 (0.48)	0.06 (0.27)	0	0	0		0.09 (0.43)	0	0.09 (0.43)
sponges encrusting encrusting white granular	0.02 (0.25)	0	0	0	0		0.09 (0.59)	0	0.09 (0.59)
sponges encrusting encrusting white lumpy	0.07 (0.46)	0	0	0	0		0	0	0
sponges encrusting encrusting yellow orange thick	0.01 (0.12)	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
sponges encrusting encrusting yellow rough	0.18 (0.84)	0	0.19 (0.84)	0.08 (0.64)	0		0.18 (0.82)	0.05 (0.3)	0.18 (0.82)
sponges encrusting encrusting yellow smooth	0.17 (0.65)	0.11 (0.37)	0.25 (0.65)	0.12 (0.38)	0		0.06 (0.27)	0.11 (0.59)	0.06 (0.27)
sponges encrusting encrusting yellow thick	0	0	0	0.02 (0.16)	0		0.03 (0.2)	0.02 (0.25)	0.03 (0.2)
sponges encrusting unidentifiable	0.12 (0.54)	0	0.06 (0.28)	0	0		0	0	0
sponges laminar dark purple laminar	0	0.11 (0.53)	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges laminar fan brown thin	0	0	0	0	0		0	0.02 (0.18)	0
sponges laminar fan cream	0.02 (0.17)	0	0	0.02 (0.16)	0		0.12 (0.61)	0.01 (0.12)	0.12 (0.61)
sponges laminar fan light pink lumpy	0	0	0	0	0		0	0	0
sponges laminar fan orange	0.05 (0.24)	0	0.06 (0.28)	0.02 (0.16)	0		0.03 (0.2)	0.01 (0.12)	0.03 (0.2)
sponges laminar fan orange flat	0.06 (0.36)	0	0	0.04 (0.22)	0		0	0.01 (0.12)	0

sponges laminar fan orange thick	0.04 (0.21)	0	0.06 (0.28)	0.04 (0.22)	0		0.06 (0.27)	0	0.06 (0.27)
sponges laminar fan pink textured surface	0.01 (0.12)	0	0	0	0		0	0	0
sponges laminar fan thick pink	0.04 (0.21)	0	0.19 (0.46)	0.04 (0.22)	0		0	0	0
sponges laminar fan white riffled	0.01 (0.12)	0	0	0	0		0	0	0
sponges laminar fan light pink lumpy	0	0	0	0	0		0.09 (0.43)	0	0.09 (0.43)
sponges laminar fan orange thin blade	0	0	0	0	0		0	0.01 (0.12)	0
sponges laminar fan orange thorny	0	0	0	0	0		0.03 (0.2)	0.01 (0.12)	0.03 (0.2)
sponges laminar fan peach	0	0	0	0	0		0	0.02 (0.18)	0
sponges laminar fan peach thick	0	0	0	0	0		0	0.01 (0.12)	0
sponges laminar fan white frilly	0	0	0	0	0		0	0.01 (0.12)	0
sponges laminar fan white thick	0.16 (0.51)	0.11 (0.53)	0.19 (0.61)	0.04 (0.22)	0		0.3 (1.04)	0.02 (0.18)	0.3 (1.04)
sponges laminar fan white thin	0.04 (0.21)	0	0.06 (0.28)	0.06 (0.48)	0		0.03 (0.2)	0.04 (0.28)	0.03 (0.2)
sponges laminar fan yellow	0.02 (0.17)	0.11 (0.53)	0.06 (0.28)	0.02 (0.16)	0		0.12 (0.47)	0	0.12 (0.47)
sponges laminar fan yellow thick	0.06 (0.32)	0	0.06 (0.28)	0	0		0.15 (0.5)	0.04 (0.28)	0.15 (0.5)
sponges laminar laminar apricot stalked	0.01 (0.12)	0	0	0	0		0	0	0
sponges laminar laminar blue spikey	0	0	0.13 (0.56)	0	0		0	0	0

sponges laminar laminar brown ruffle	0.06 (0.32)	0	0.06 (0.28)	0	0		0	0	0
sponges laminar laminar grey fungi	0.07 (0.34)	0.11 (0.37)	0.19 (0.46)	0.06 (0.27)	0		0.21 (0.73)	0	0.21 (0.73)
sponges laminar laminar grey rough	0	0.11 (0.53)	0	0.02 (0.16)	0		0.03 (0.2)	0	0.03 (0.2)
sponges laminar laminar grey round stalk	0	0	0.06 (0.28)	0	0		0	0	0
sponges laminar laminar grey thin folded	0.02 (0.25)	0	0.06 (0.28)	0	0		0	0	0
sponges laminar laminar orange irregular	0.02 (0.17)	0	0	0	0		0	0.04 (0.28)	0
sponges laminar laminar red frilly	0	0.06 (0.27)	0	0	0		0	0	0
sponges laminar laminar terracotta fan thick	0	0	0	0.02 (0.16)	0		0	0.02 (0.25)	0
sponges laminar laminar white irregular	0.04 (0.21)	0	0.06 (0.28)	0	0		0.03 (0.2)	0.01 (0.12)	0.03 (0.2)
sponges laminar laminar white small	0.05 (0.24)	0	0	0.04 (0.22)	0		0.24 (0.57)	0.02 (0.18)	0.24 (0.57)
sponges laminar laminar white thin	0.01 (0.12)	0	0	0.06 (0.48)	0		0	0.01 (0.12)	0
sponges laminar laminar yellow fine	0	0	0.06 (0.28)	0.02 (0.16)	0		0.06 (0.27)	0	0.06 (0.27)
sponges laminar laminar yellow foam	0	0	0	0	0		0	0.01 (0.12)	0
sponges laminar laminar yellow frilly	0.05 (0.3)	0	0	0	0		0	0.01 (0.12)	0

sponges laminar laminar yellow irregular	0.06 (0.5)	0	0	0	0		0.15 (0.64)	0.04 (0.28)	0.15 (0.64)
sponges laminar unidentifiable	0.19 (0.62)	0	0.13 (0.38)	0.27 (0.61)	0		0.09 (0.59)	0.02 (0.17)	0.09 (0.59)
sponges palmate arborescent orange fan	0.05 (0.3)	0	0	0.04 (0.32)	0		0	0	0
sponges palmate arborescent orange flat	0.08 (0.4)	0	0.06 (0.28)	0	0		0.03 (0.2)	0.04 (0.37)	0.03 (0.2)
sponges palmate arborescent yellow flat	0	0	0	0.02 (0.16)	0		0.06 (0.27)	0	0.06 (0.27)
sponges palmate fan white thin	0	0	0	0	0		0.06 (0.27)	0	0.06 (0.27)
sponges palmate palmate grey	0.01 (0.12)	0.06 (0.27)	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges palmate palmate grey stalked fingers	0	0	0.06 (0.28)	0.02 (0.16)	0		0	0	0
sponges palmate palmate orange flat	0	0	0	0.02 (0.16)	0		0	0	0
sponges palmate palmate purple	0.04 (0.37)	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
sponges palmate unidentifiable	0.02 (0.17)	0.06 (0.27)	0	0.02 (0.16)	0		0.12 (0.38)	0.01 (0.12)	0.12 (0.38)
sponges simple bronze bumpy oscula massive laminar like	0	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
sponges simple creme brulee	0.08 (0.4)	0	0	0	0		0	0	0

sponges simple irregular sand sponge yellow	0.02 (0.17)	0.06 (0.26)	0	0.02 (0.16)	0		0	0.02 (0.25)	0
sponges simple light yellow oscula laminar like	0.01 (0.12)	0	0	0	0		0	0	0
sponges simple light yellow with white tentacles	0.01 (0.12)	0	0.13 (0.56)	0.02 (0.16)	0		0.03 (0.2)	0	0.03 (0.2)
sponges simple lumpy opaque yellow	0	0	0	0	0		0	0.02 (0.18)	0
sponges simple lumpy orange	0.05 (0.3)	0	0	0	0		0	0	0
sponges simple lumpy pink	0.02 (0.17)	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
sponges simple lumpy white	0.05 (0.3)	0.06 (0.27)	0.06 (0.28)	0	0		0	0.04 (0.21)	0
sponges simple lumpy yellow	0.01 (0.12)	0.06 (0.27)	0	0.02 (0.16)	0		0.24 (0.7)	0.05 (0.24)	0.24 (0.7)
sponges simple massive beige shapeless	0.16 (0.57)	0.23 (0.83)	0	0.1 (0.57)	0		0.12 (0.61)	0.02 (0.25)	0.12 (0.61)
sponges simple massive blue shapeless	0	0	0	0	0		0.03 (0.2)	0.01 (0.12)	0.03 (0.2)
sponges simple massive blue	0.01 (0.12)	0	0	0	0		0	0	0
sponges simple massive brown	0.11 (0.53)	0	0.06 (0.28)	0	0		0	0.02 (0.25)	0
sponges simple massive cream laminar like	0.01 (0.12)	0	0	0	0		0	0	0

sponges simple massive cream papillate	0.01 (0.12)	0	0	0.02 (0.16)	0		0	0	0
sponges simple massive dark grey	0.05 (0.3)	0	0.06 (0.28)	0	0		0.03 (0.2)	0.02 (0.18)	0.03 (0.2)
sponges simple massive dark purple	0.08 (0.36)	0.06 (0.27)	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges simple massive grey laminar like	0.08 (0.4)	0.06 (0.27)	0.06 (0.28)	0.08 (0.45)	0		0.12 (0.61)	0.01 (0.12)	0.12 (0.61)
sponges simple massive orange	0.05 (0.24)	0	0	0	0		0	0.01 (0.12)	0
sponges simple massive orange ball	0.01 (0.12)	0	0	0	0		0	0	0
sponges simple massive orange holey	0.01 (0.12)	0	0	0	0		0	0	0
sponges simple massive purple	0.04 (0.27)	0	0	0	0		0	0	0
sponges simple massive red	0.29 (0.78)	0.11 (0.53)	0.06 (0.28)	0.06 (0.36)	0		0	0.04 (0.21)	0
sponges simple massive red white shapeless	0.02 (0.17)	0	0.06 (0.28)	0	0		0	0.01 (0.12)	0
sponges simple massive red yellow	0.02 (0.25)	0	0	0	0		0	0	0
sponges simple massive white	0.17 (0.63)	0.06 (0.27)	0	0.02 (0.16)	0		0.09 (0.33)	0.01 (0.12)	0.09 (0.33)
sponges simple massive white holey	0.01 (0.12)	0	0.13 (0.56)	0	0		0	0	0
sponges simple massive white shapeless	0.29 (0.76)	0.06 (0.27)	0.5 (1.03)	0.1 (0.41)	0		0.46 (1.21)	0.17 (0.64)	0.46 (1.21)
sponges simple massive yellow frilly	0.01 (0.12)	0.06 (0.27)	0.13 (0.56)	0.02 (0.16)	0		0.09 (0.43)	0	0.09 (0.43)

sponges simple massive yellow holey	0	0	0	0	0		0	0.01 (0.12)	0
sponges simple massive yellow knobby	0.02 (0.17)	0	0	0	0		0	0.05 (0.35)	0
sponges simple massive yellow papillate	0	0	0.13 (0.56)	0	0		0	0.01 (0.12)	0
sponges simple massive yellow shapeless	0.29 (0.68)	0.06 (0.27)	0.25 (0.65)	0.2 (0.61)	0		0.52 (0.97)	0.12 (0.45)	0.52 (0.97)
sponges simple simple beige laminar like	0.04 (0.21)	0	0	0	0		0	0	0
sponges simple simple beige lumpy	0.02 (0.25)	0.17 (0.8)	0	0	0		0	0	0
sponges simple simple beige lumpy shapeless	0.01 (0.12)	0	0.06 (0.28)	0.06 (0.48)	0		0	0.01 (0.12)	0
sponges simple simple beige shapeless	0.02 (0.25)	0	0	0	0		0.06 (0.27)	0.01 (0.12)	0.06 (0.27)
sponges simple simple beige small oscula	0.01 (0.12)	0	0	0	0		0	0	0
sponges simple simple beige smooth	0	0	0.06 (0.28)	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges simple simple blue shapeless oscula	0	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges simple simple blue shapeless	0.02 (0.25)	0	0	0	0		0	0	0

sponges simple simple erect cream	0	0	0	0	0		0.09 (0.33)	0.01 (0.12)	0.09 (0.33)
sponges simple simple erect orange	0.01 (0.12)	0	0	0.02 (0.16)	0		0.06 (0.27)	0	0.06 (0.27)
sponges simple simple erect white	0.02 (0.17)	0	0.06 (0.28)	0	0		0	0.02 (0.25)	0
sponges simple simple grey brain	0.02 (0.17)	0	0	0	0		0	0	0
sponges simple simple grey creep	0.01 (0.12)	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges simple simple orange smooth	0	0	0	0	0		0.12 (0.38)	0.09 (0.36)	0.12 (0.38)
sponges simple simple pink oscula	0	0	0	0	0		0.09 (0.33)	0	0.09 (0.33)
sponges simple simple white rough	0	0	0	0	0		0.09 (0.33)	0.01 (0.12)	0.09 (0.33)
sponges simple simple yellow lumpy	0	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges simple simple yellow rough	0	0	0	0	0		0.09 (0.33)	0.07 (0.46)	0.09 (0.33)
sponges simple smooth black massive	0	0	0	0	0		0.06 (0.39)	0.01 (0.12)	0.06 (0.39)
sponges simple unidentifiable	0	0	0	0	0		0.79 (1.11)	0.26 (0.65)	0.79 (1.11)
sponges simple yellow oscula laminar like	0	0	0	0	0		0	0.02 (0.18)	0
sponges simple simple orange globes	0	0.06 (0.27)	0	0	0		0	0	0
sponges simple simple orange rough	0.02 (0.17)	0	0	0	0		0	0	0

sponges simple yellow shapeless smooth	0.37 (0.95)	0.23 (0.63)	0.13 (0.56)	0.2 (1.31)	0		0.27 (0.66)	0.2 (0.61)	0.27 (0.66)
sponges stalked unidentifiable	0	0	0.06 (0.28)	0	0		0	0	0
sponges tubes and chimneys chimney yellow large	0	0	0	0	0		0.03 (0.2)	0.02 (0.18)	0.03 (0.2)
sponges tubes and chimneys chimney grey single	0.01 (0.12)	0	0	0	0		0	0	0
sponges tubes and chimneys tube beige irregular	0	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges tubes and chimneys tube white lumpy	0	0	0	0	0		0	0.01 (0.12)	0
sponges tubes and chimneys tubes white fan	0	0	0	0	0		0	0.01 (0.12)	0
sponges tubes and chimneys chimney white tall	0.02 (0.17)	0	0	0	0		0	0	0
sponges tubes and chimneys chimney yellow large	0.01 (0.12)	0	0	0	0		0	0	0
sponges tubes and chimneys chimney yellow single rough	0.01 (0.12)	0	0	0.02 (0.16)	0		0	0	0
sponges tubes and chimneys tubular orange	0.01 (0.12)	0	0	0	0		0.03 (0.2)	0	0.03 (0.2)
sponges tubes and chimneys unidentifiable	0	0	0.06 (0.28)	0	0		0	0	0

sponges tubes and chimneys tubular solitary	0	0	0	0	0		0.06 (0.39)	0	0.06 (0.39)
worms tube worms fanworm sabella like	0.01 (0.12)	0	0	0	0		0.09 (0.43)	0.07 (0.43)	0.09 (0.43)
worms tube worms unidentifiable	0	0.34 (1.6)	0	0	0		0.03 (0.2)	0	0.03 (0.2)
unknown	0.14 (0.44)	0.11 (0.37)	0.25 (0.87)	0	0		0.24 (0.64)	0.04 (0.21)	0.24 (0.64)
Bare rock	0.04 (0.37)	0	0	0	0		0	0.05 (0.5)	0
Bare soft sediment	26.54 (16.27)	57.13 (20.17)	34.81 (13.8)	74.6 (17.79)	99.61 (2.19)		39.66 (20.74)	74.71 (14.35)	39.66 (20.74)
Morphospecies richness	**172**	**57**	**68**	**75**	**1**		**99**	**112**	**99**

Spatial patterns in the abundance of demersal fish assemblages

A total of 8,470 fish were observed by drop-camera deployments in the Franklin MP during the survey (Table 4). The most abundant resident fish identified to species level were *Caesioperca lepidoptera* (Figure 16), *Meuschenia scaber* (Figure 17), *Caesioperca rasor* (Figure 18) and *Pseudolabrus rubicundus* (Figure 19). However, some individuals could not be identified to species, including many *Caesioperca* individuals, but as a Genus (where identification was possible), *Caesioperca* spp (Figure 20) were particularly abundant. Other species, such as *Helicolenus percoides* (Figure 21) and *Nemadactylus macropterus* (Figure 22) were also present but in lower numbers. Notably, many of the species observed in the park were strongly reef-associated, particularly on the mesophotic reef, including *C. lepidoptera, C. rasor, Meuschenia scaber, Pseudolabrus rubicundus a*nd *Trachinops caudimaculatus* (Figure 23). Very few individual species were sighted over soft sediments, with the only species being seen in large numbers being passing pelagic species.

In the Zeehan MP, a total number of 4,988 individual fish were observed during the drop-camera timed surveys (Table 4). The most abundant resident species identified to species level were *Caesioperca lepidoptera*, *H. percoides*, followed by *M. scaber*, *N. macropterus* and *Paratrachichthys macleayi. Neosebastes scorpaenoides* were also present but in smaller quantities (Table 4). Most of the more abundant species were associated with reef or mixed habitat, shown below in species distribution plots for key species. These include *C. Lepidoptera* (Figure 24)*, H. percoides* (Figure 28)*, M. scaber* (Figure 25)*, P. macleayi* (Figure 29), *P. rubicundus* (Figure 30) and *Thamnaconus degeni* (Figure 31). The possible exception was *N. macropterus* (Figure 26, Appendix A8), which, while displaying a significant affinity for reef and mixed habitat, was also regularly found over soft sediments. The highly targeted species *Latris lineata* (Figure 32, Appendix A8) was observed in small numbers in the deeper regions of the mapped area near the shelf break and is likely to be found to be quite abundant here with sampling techniques such as BRUVs.

Table 4. Abundance of fish species in each observed substrata for Zeehan MP. Number of drops completed in each habitat are provided in parentheses to show variation in sampling effort between habitats.

	Franklin AMP						Zeehan AMP			
Scientific Name	**Mesophotic rocky reefs (109 drops)**	**Mixed Mesophotic shelf reefs & Shelf unvegetated sediments (20 drops)**	**Rariphotic shelf reefs (17 drops)**	**Mixed Rariphotic shelf reefs & Shelf unvegetated sediments (74 drops)**	**Shelf unvegetated sediments (61 drops)**	**Total (281 drops)**	**Rariphotic shelf reefs (41 drops)**	**Mixed Rariphotic shelf reefs & Shelf unvegetated sediments (102 drops)**	**Shelf unvegetated sediments (160 drops)**	**Total (303 drops)**
Acanthaluteres vittiger	9	0	0	0	0	9	0	0	0	0
Anguilla australis	0	0	0	0	0	0	0	0	1	1
Antigonia rubicunda	0	0	0	0	0	0	1	0	0	1
Aracana aurita	1	0	1	0	0	2	1	0	2	3
Aracana ornata	0	0	0	0	1	1	0	0	0	0
Argentina australiae	0	0	0	0	2	2	0	0	1	1
Arripis georgianus	0	0	0	0	0	0	0	0	2	2
Arripis truttaceus	0	0	0	1	0	1	0	0	0	0
Asymbolus rubiginosus	1	0	0	0	0	1	0	0	0	0
Bathytoshia brevicaudata	1	0	0	0	0	1	0	0	0	0

Blenniidae, gobiidae, tripterygiidae spp	0	0	0	0	0	0	0	0	1	1
Brachaluteres jacksonianus	1	0	0	2	0	3	0	0	0	0
Caesioperca lepidoptera	696	54	392	113	3	1258	728	793	118	1639
Caesioperca rasor	639	73	1	9	1	723	2	0	0	2
Caesioperca spp	2557	490	12	75	0	3134	2	21	0	23
Callanthias australis	0	0	0	0	0	0	2	2	0	4
Calliurichthys scaber	0	0	0	0	0	0	0	0	1	1
Centroberyx affinis	1	0	0	0	0	1	0	0	0	0
Centroberyx gerrardi	0	0	0	0	0	0	1	0	0	1
Centroberyx lineatus	0	0	31	0	0	31	1	0	0	1
Cephaloscyllium laticeps	0	0	0	0	1	1	0	0	0	0
Cheilodactylus nigripes	53	3	2	1	0	59	0	0	0	0
Cheilodactylus spectabilis	2	0	0	0	0	2	0	0	0	0
Cyttus australis	0	0	0	1	0	1	1	0	0	1

Dicotylichthys punctulatus	2	0	0	0	0	2		0	0	0	0
Dinolestes lewini	0	0	0	0	0	0		1	0	0	1
Diodon nicthemerus	1	0	1	0	0	2		0	0	0	0
Dipturus cerva	0	0	0	0	0	0		0	0	1	1
Enoplosus armatus	2	0	0	0	0	2		0	0	0	0
Eubalichthys gunnii	4	0	0	0	0	4		1	1	0	2
Eupetrichthys angustipes	3	0	0	0	0	3		0	0	0	0
Figaro boardmani	1	0	0	0	0	1		0	0	0	0
Foetorepus calauropomus	0	0	0	0	0	0		0	0	2	2
Genypterus blacodes	0	0	0	1	0	1		0	0	0	0
Gnathophis habenatus	0	0	0	0	0	0		0	0	3	3
Helicolenus percoides	4	1	3	2	0	10		31	37	13	81
Heterodontus portusjacksoni	0	0	0	1	0	1		0	0	0	0
Latris lineata	0	0	0	0	0	0		4	3	2	9
Lepidoperca pulchella	0	0	0	0	0	0		1	0	0	1

Lepidotrigla modesta	0	0	0	1	0	1		0	0	2	2
Lepidotrigla mulhalli	0	0	0	1	0	1		0	0	0	0
Lepidotrigla spp	0	0	0	0	0	0		0	0	1	1
Lepidotrigla vanessa	0	0	0	2	2	4		2	2	4	8
Leptomithrax gaimardii	0	0	0	0	0	0		1	0	3	4
Meuschenia australis	3	0	0	0	1	4		0	0	0	0
Meuschenia freycineti	2	0	0	0	0	2		0	1	0	1
Meuschenia scaber	329	31	26	44	3	433		16	78	10	104
Mustelus antarcticus	1	0	0	0	1	2		0	0	0	0
Narcinops tasmaniensis	0	0	0	0	0	0		0	0	1	1
Nemadactylus macropterus	0	0	1	1	2	4		32	219	58	309
Nemadactylus valenciennesi	2	0	0	0	0	2		0	0	1	1
Neosebastes scorpaenoides	6	3	10	8	4	31		6	7	18	31
Notolabrus tetricus	14	1	0	0	0	15		0	0	0	0
Octopus berrima	0	0	0	0	0	0		0	1	0	1

Octopus pallidus	0	0	0	0	0	0		0	1	0	1
Order clupeiformes - undifferentiated spp	0	0	0	210	1981	2191		400	0	200	600
Parapercis allporti	0	0	0	2	2	4		0	16	8	24
Paratrachichthys macleayi	0	15	0	1	0	16		41	203	19	263
Paraulopus nigripinnis	0	0	0	0	0	0		1	3	0	4
Parequula melbournensis	15	3	1	18	0	37		0	0	0	0
Pempheris multiradiata	2	2	0	0	0	4		0	0	0	0
Pentaceropsis recurvirostris	4	0	0	0	0	4		1	0	0	1
Plagiogeneion macrolepis	0	0	0	0	0	0		1	0	0	1
Platycephalus aurimaculatus	0	0	0	0	0	0		0	1	0	1
Platycephalus bassensis	0	0	0	0	0	0		0	0	1	1
Platycephalus spp	0	0	0	0	0	0		0	4	1	5
Pseudolabrus rubicundus	164	19	14	15	0	212		33	27	2	62
Pseudophycis spp	2	0	1	1	1	5		2	4	1	7

Pterygotrigla polyommata	0	0	0	0	0	0		1	0	2	3
Scorpis aequipinnis	1	0	0	0	0	1		0	0	0	0
Sepia apama	7	1	3	3	1	15		0	0	0	0
Sepioteuthis australis	11	0	0	3	0	14		1	1	1	3
Seriolella brama	0	0	0	0	0	0		0	0	1	1
Siphonognathus beddomei	1	0	0	0	0	1		0	0	0	0
Spiniraja whitleyi	0	0	0	0	1	1		0	1	0	1
Thamnaconus degeni	2	0	0	0	0	2		18	31	9	58
Thyrsites atun	0	0	0	0	0	0		0	0	1	1
Trachinops caudimaculatus	21	0	0	0	0	21		0	0	0	0
Trachurus spp	0	0	0	0	149	149		0	496	1195	1691
Trygonoptera testacea	0	0	0	0	0	0		0	2	3	5
Unidentifiable fish spp	5	0	0	2	6	13		3	2	3	8
Upeneichthys vlamingii	13	2	3	3	0	21		0	0	0	0
Urolophus paucimaculatus	0	0	0	2	2	4		0	1	2	3
Total	**4583**	**698**	**502**	**523**	**2164**	**8470**		**1336**	**1958**	**1694**	**4988**

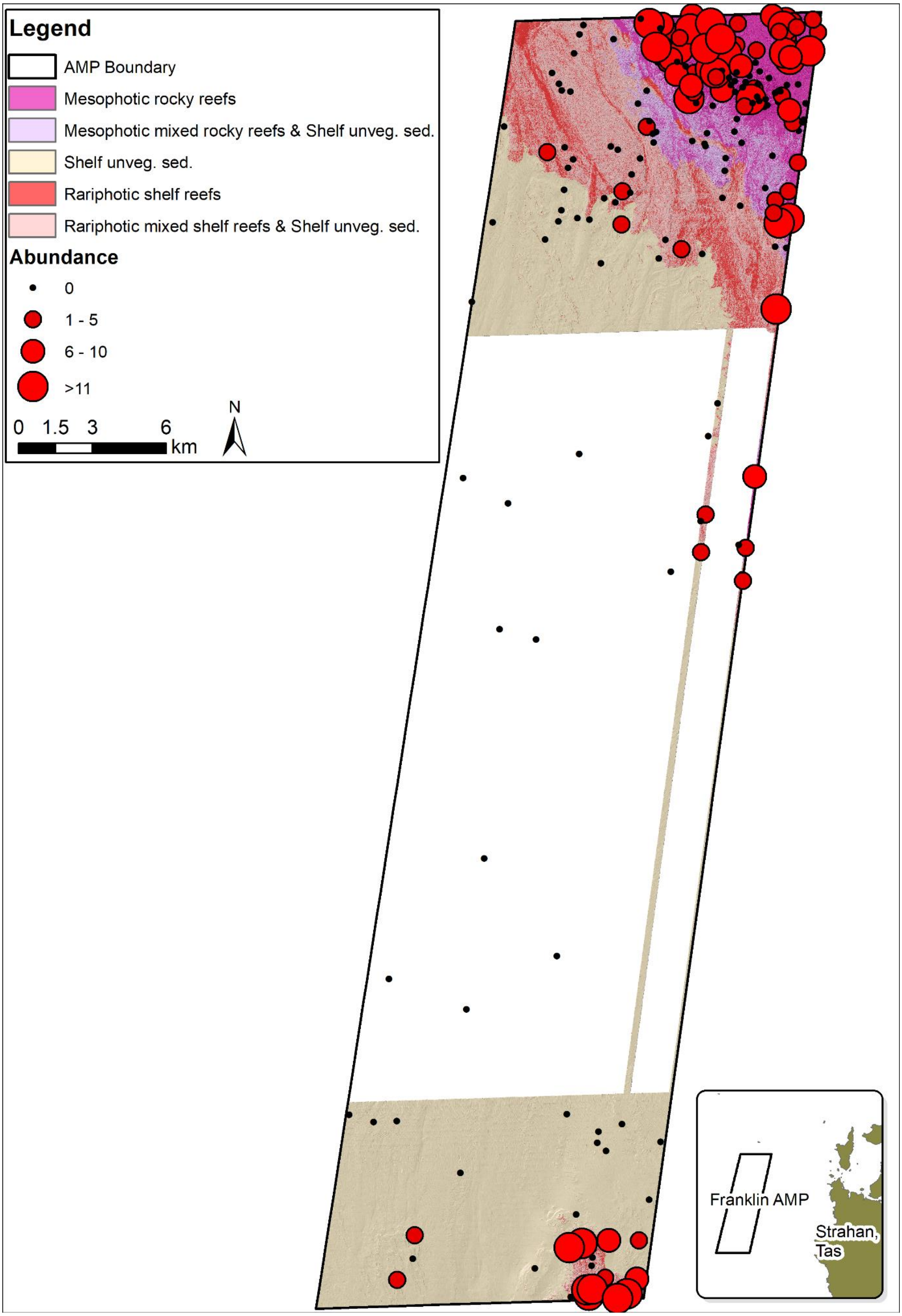

Figure 16. Abundance distribution of Butterfly perch (Caesioperca lepidoptera) in Franklin MP.

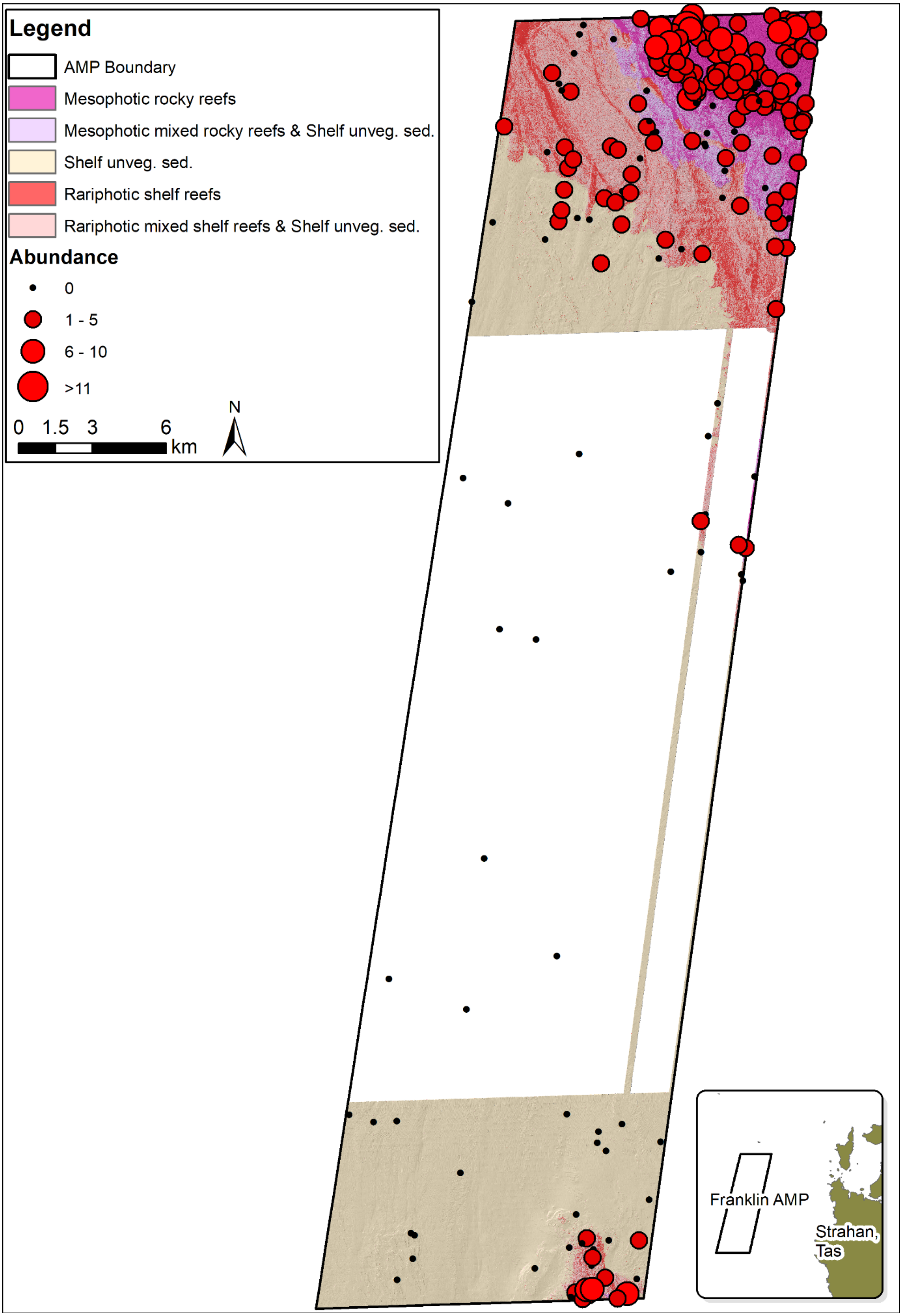

Figure 17. Abundance distribution of Cosmopolitan leatherjacket (Meuschenia scaber) in Franklin MP.

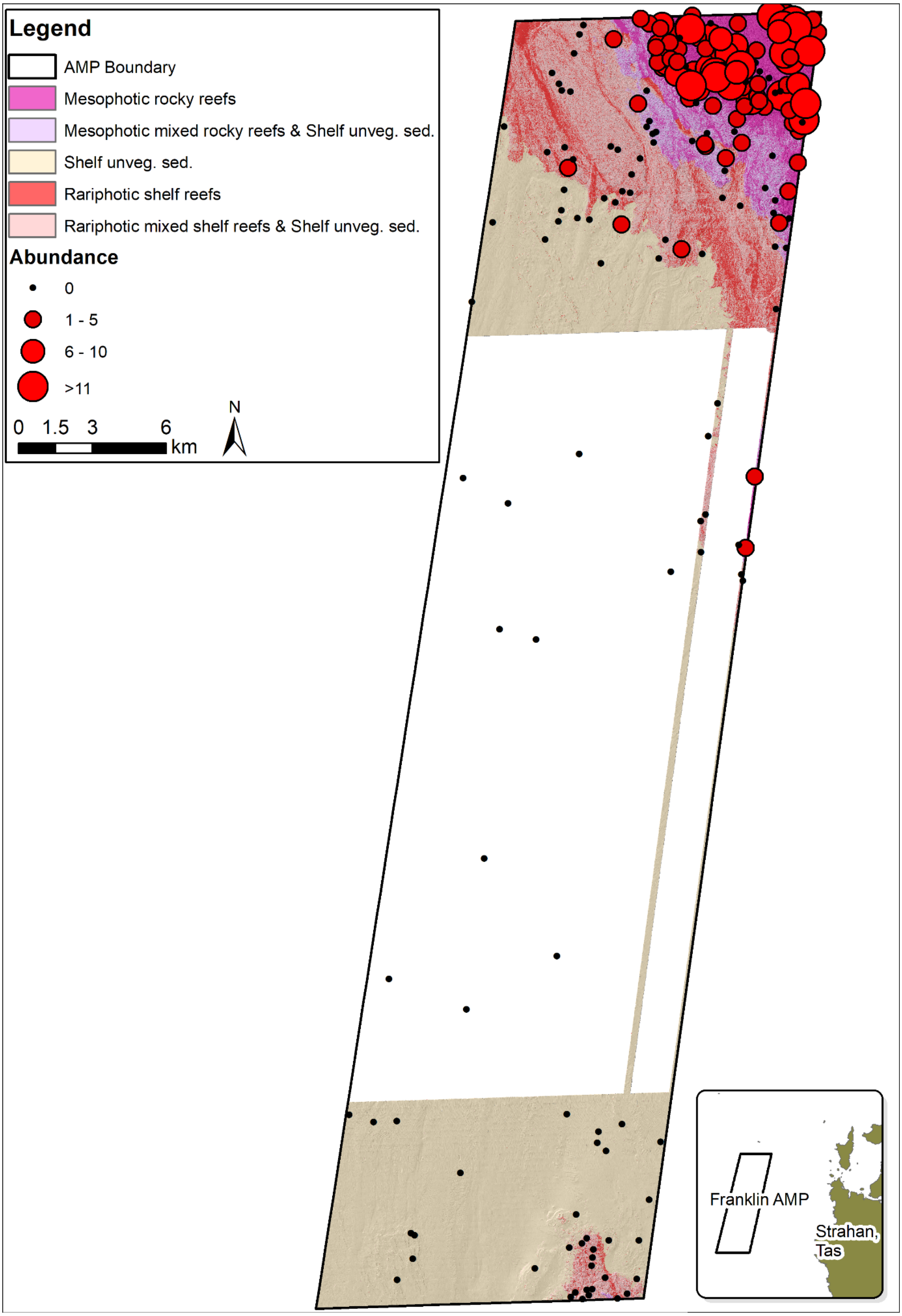

Figure 18. Abundance distribution of Butterfly perch (Caesioperca rasor) in Franklin MP.

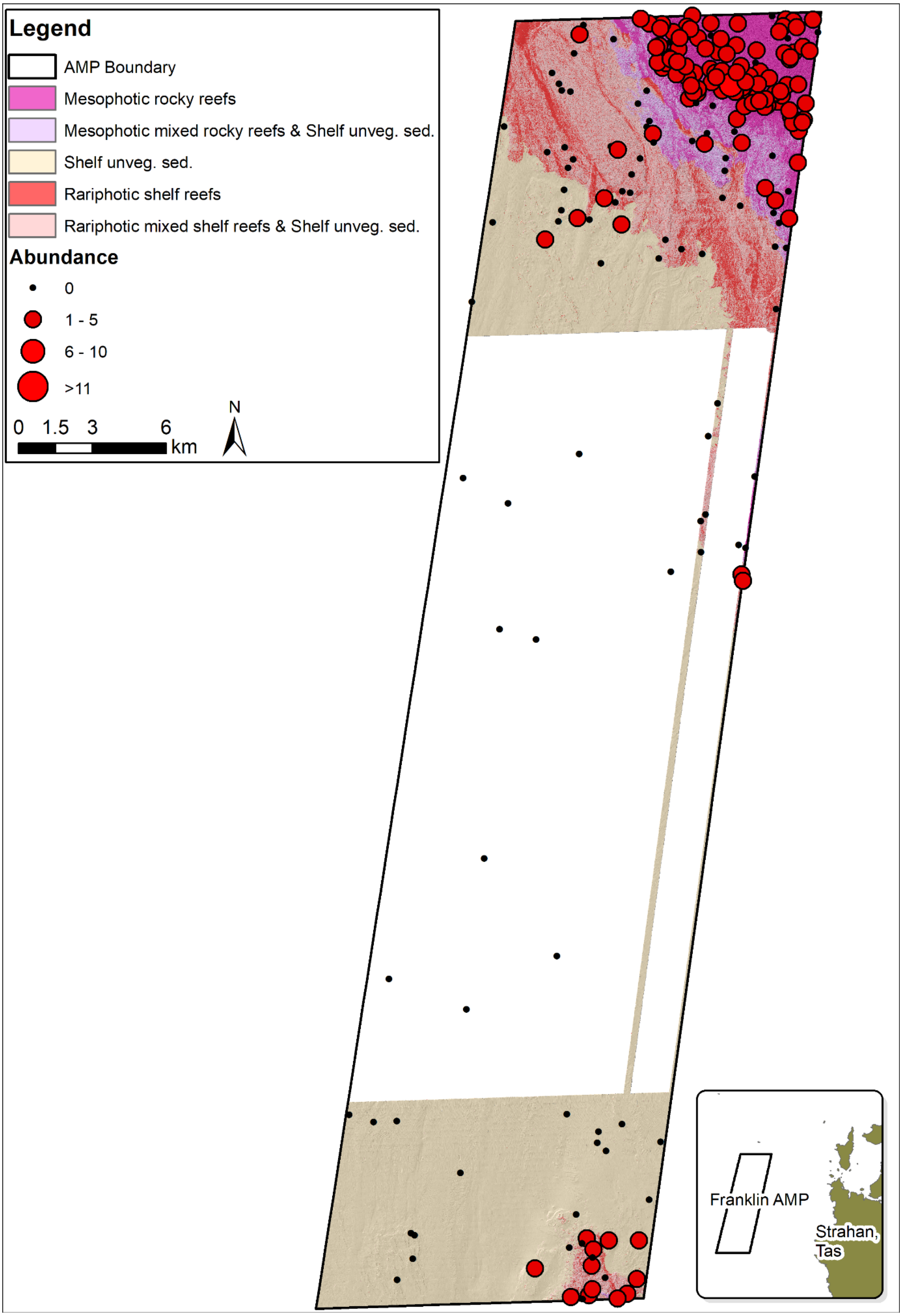

Figure 19. Abundance distribution of Rosy wrasse (Pseudolabrus rubicundus) in Franklin MP.

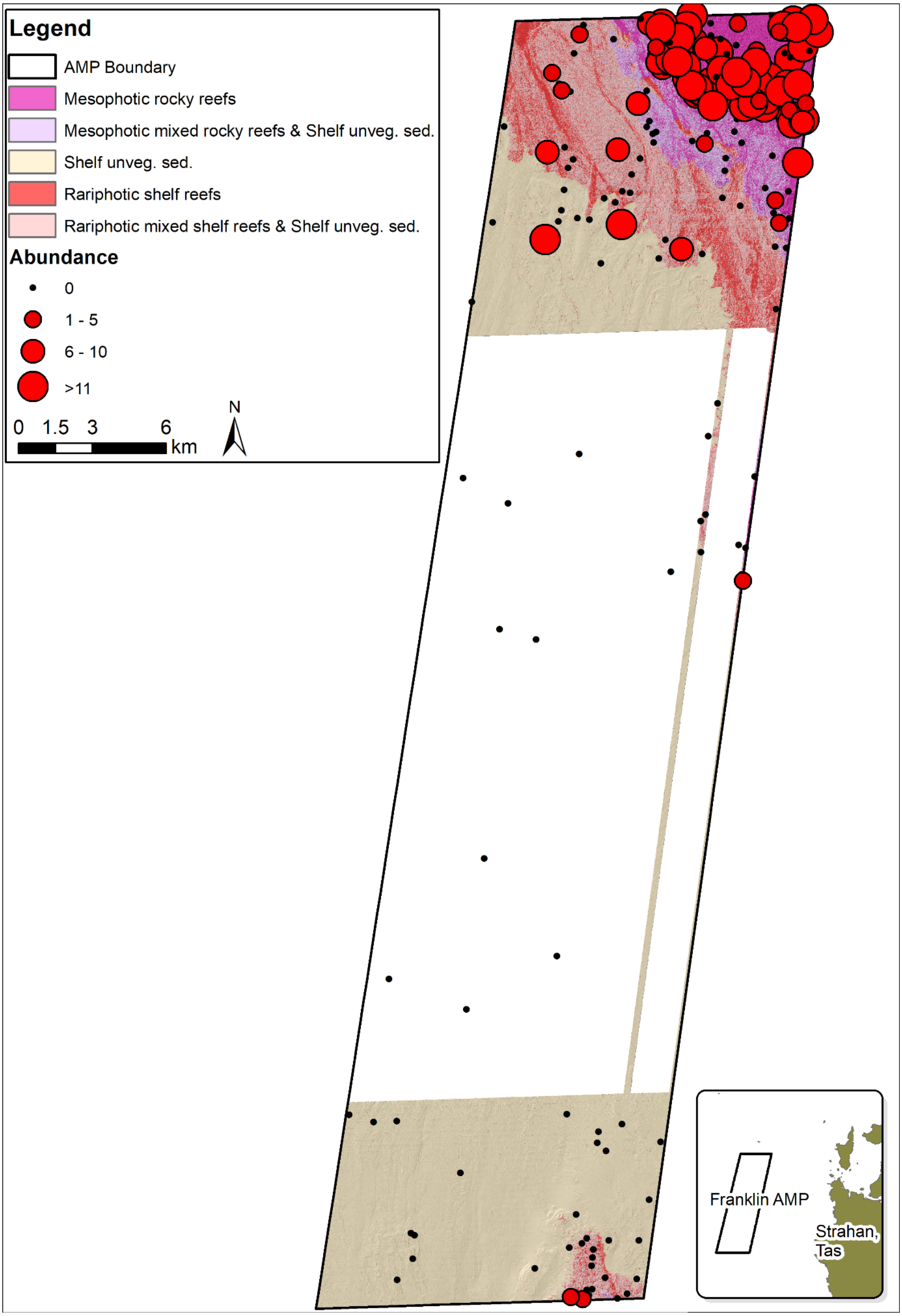

Figure 20. Abundance distribution of perch (Caesioperca spp) in Franklin MP.

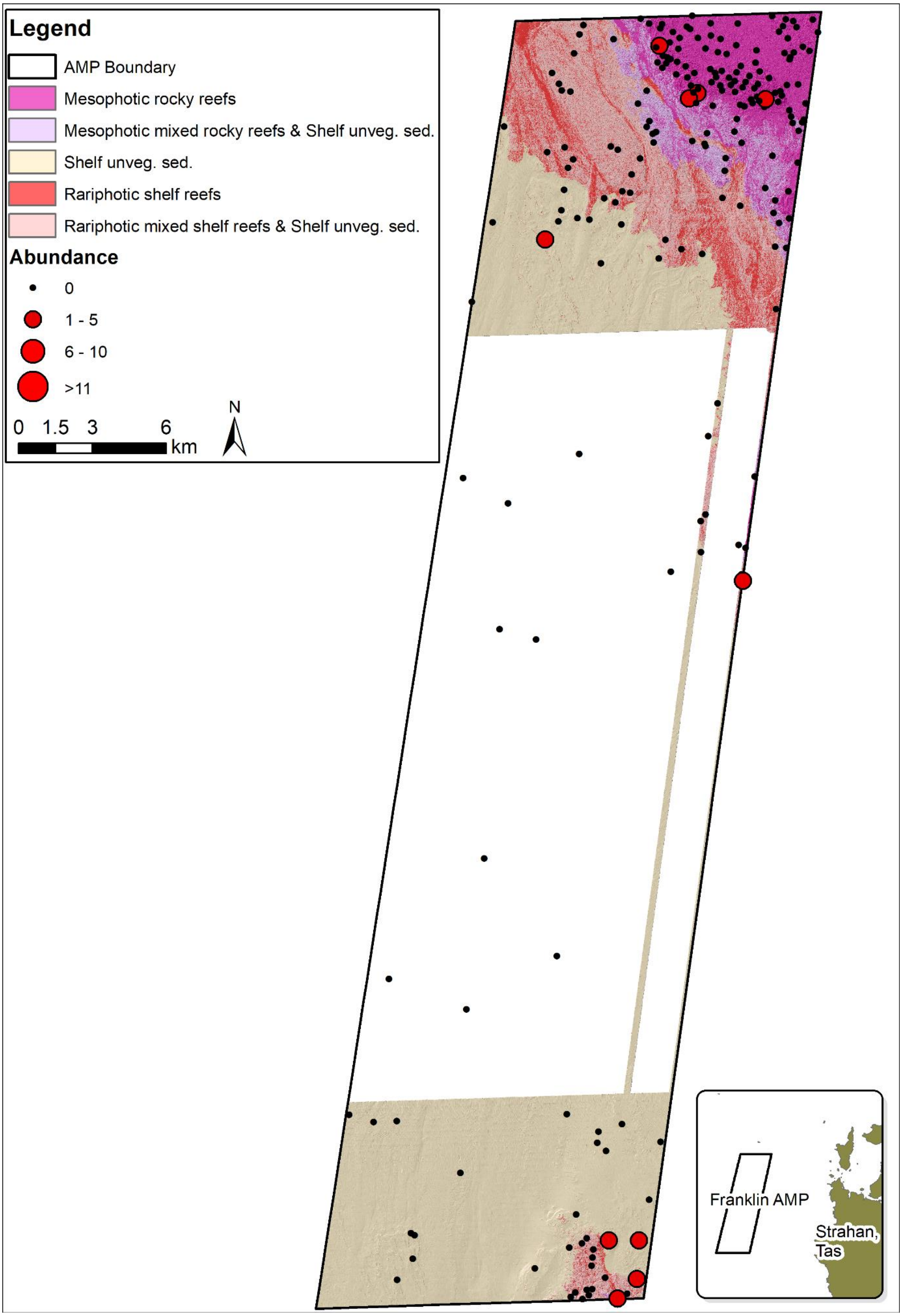

Figure 21. Abundance distribution of Ocean reef perch (Helicolenus percoides) in Franklin MP.

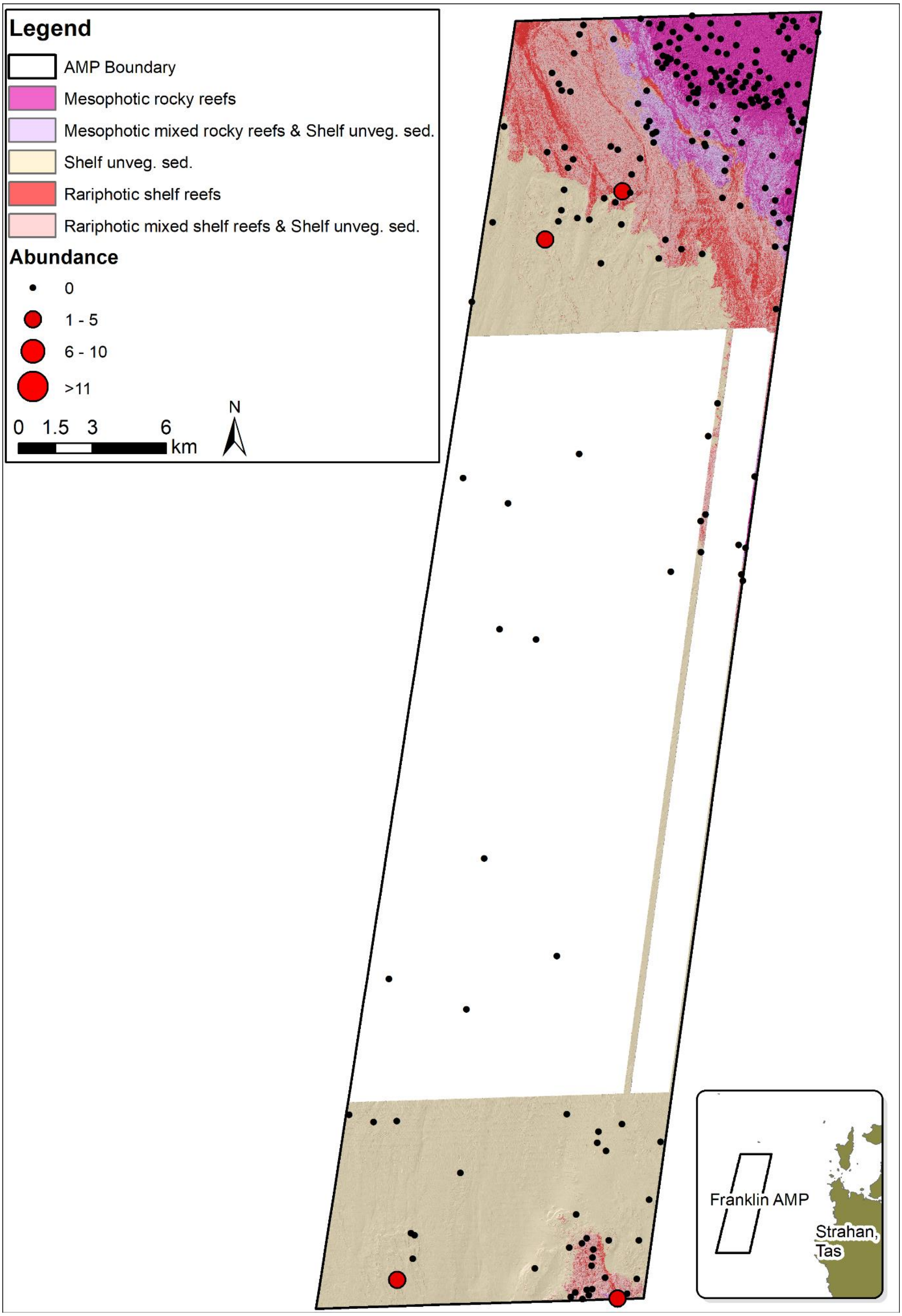

Figure 22. Abundance distribution of Jackass morwong (Nemadactylus macropterus) in Franklin MP.

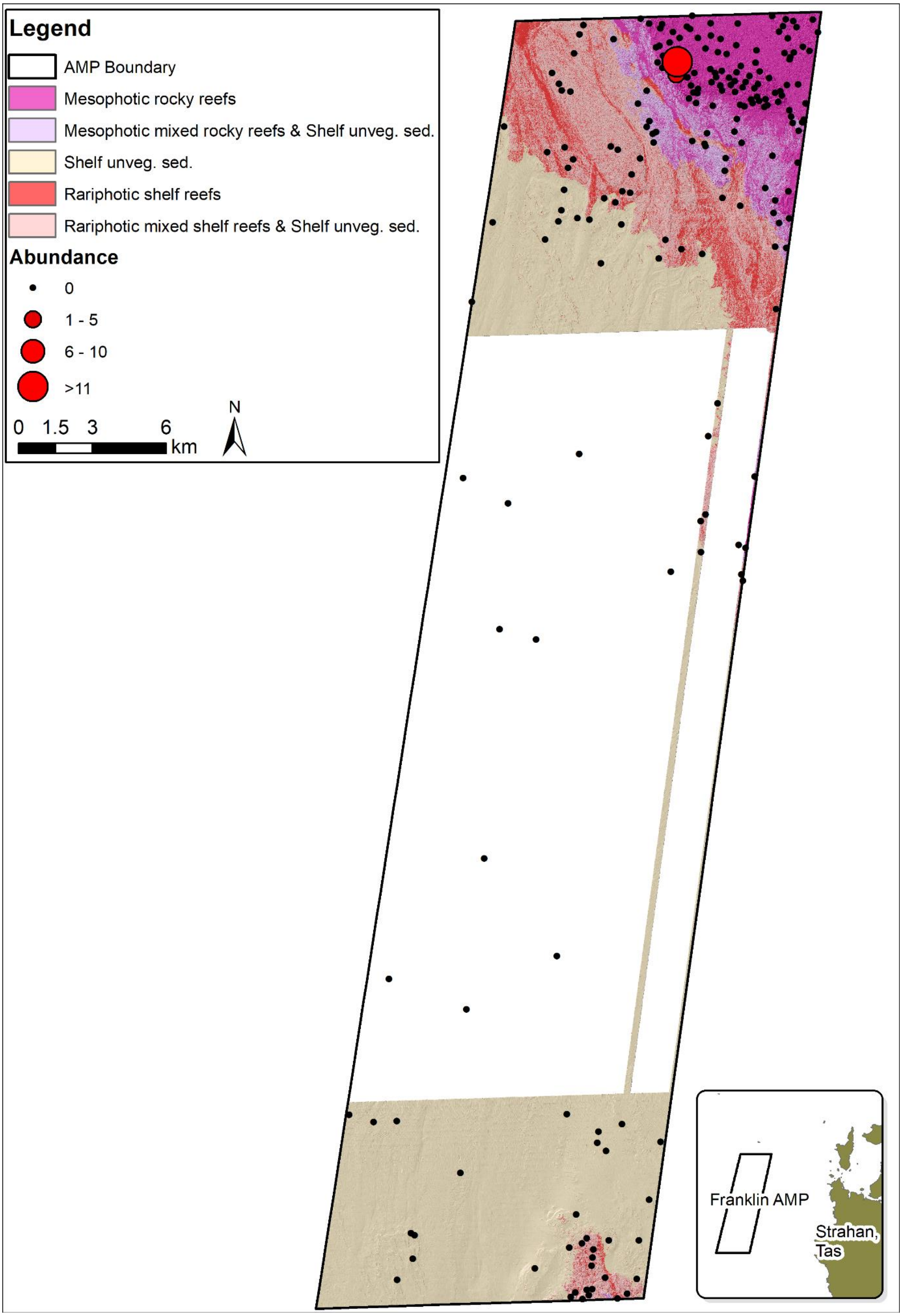

Figure 23. Abundance distribution of Southern hulafish (Trachinops caudimaculatus) in Franklin MP.

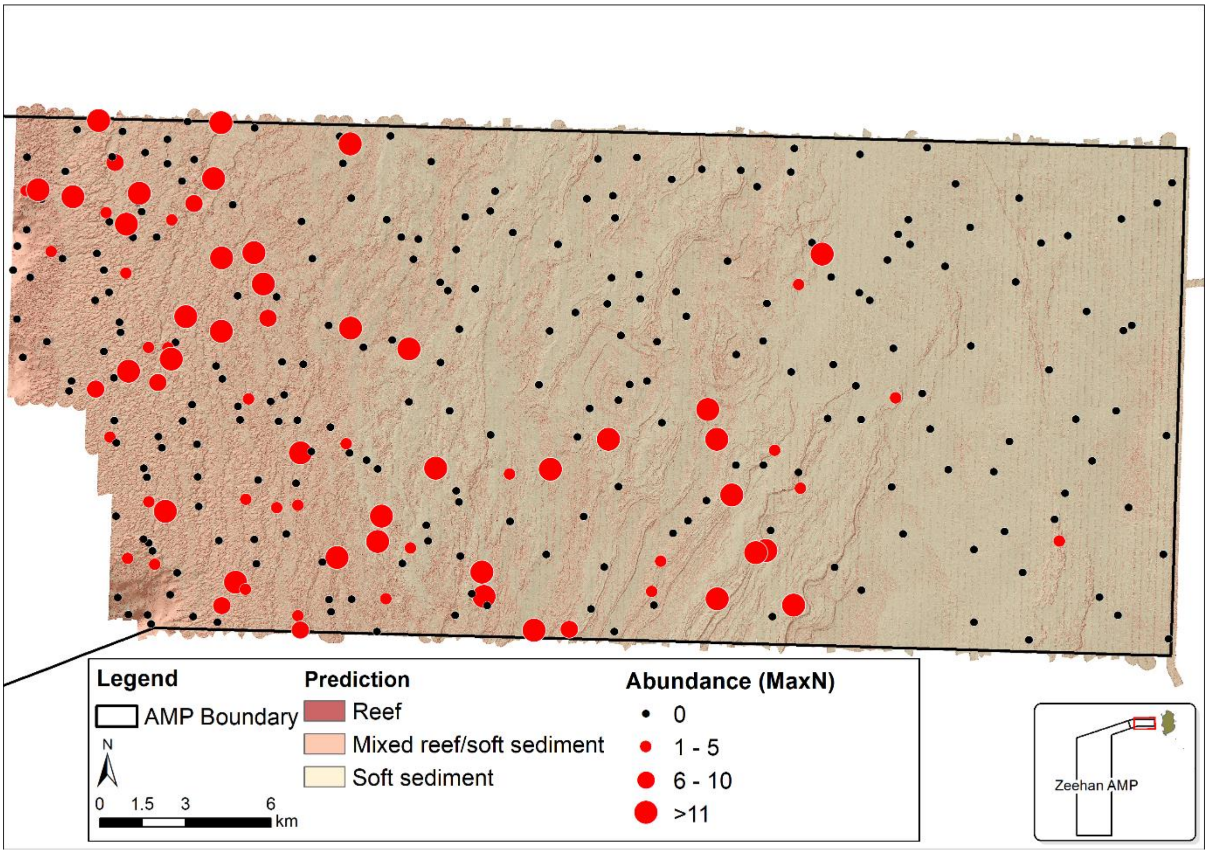

Figure 24. Abundance distribution of Butterfly perch (Caesioperca lepidoptera) in Zeehan MP.

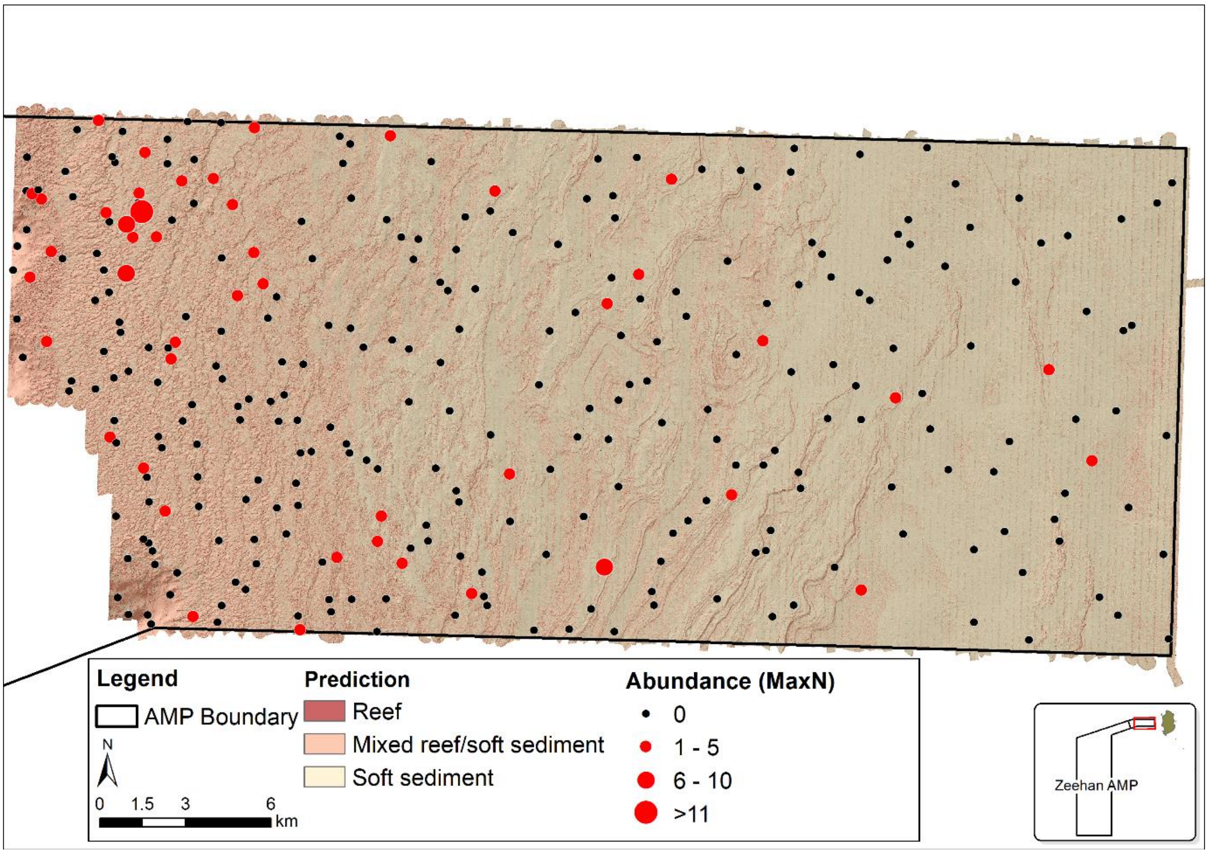

Figure 25. Abundance distribution of Cosmopolitan leatherjacket (Meuschenia scaber) in Zeehan MP.

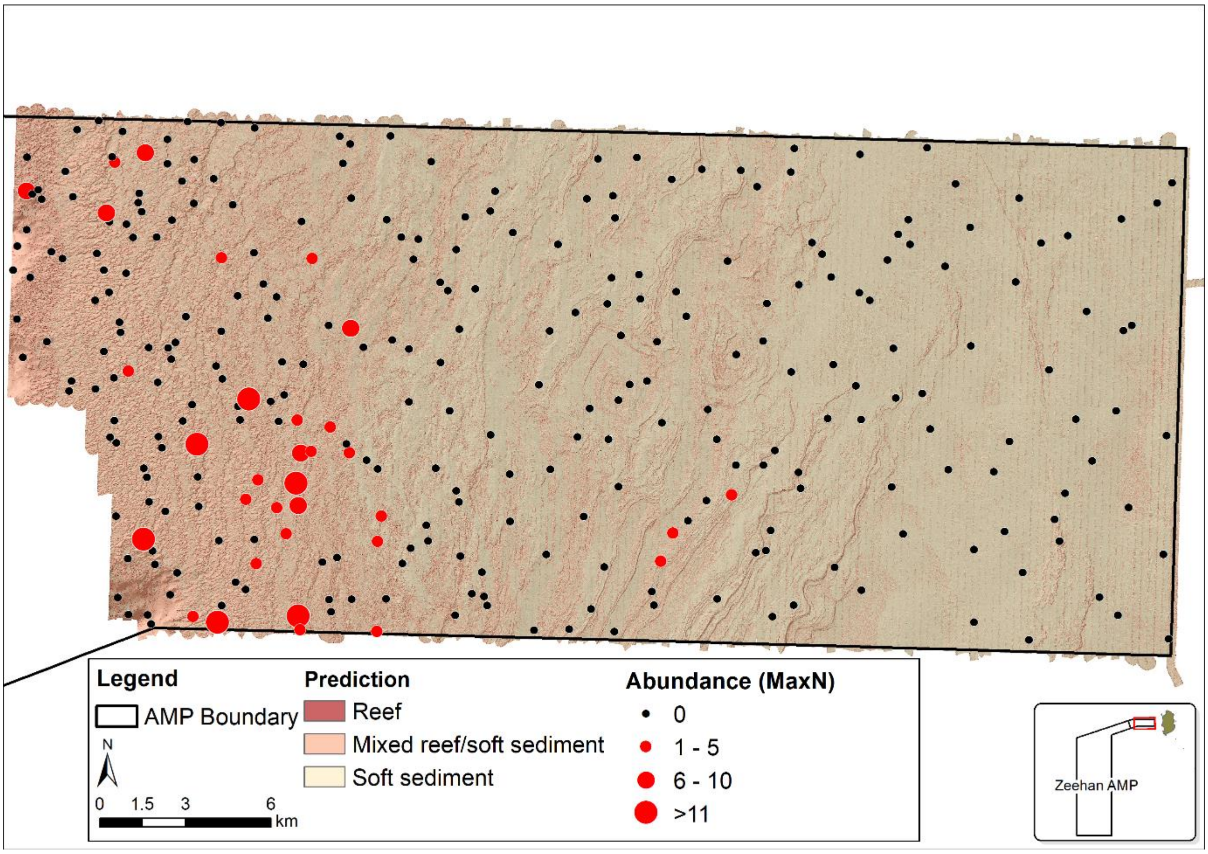

Figure 26. Abundance distribution of Jackass morwong (Nemadactylus macropterus) in Zeehan MP.

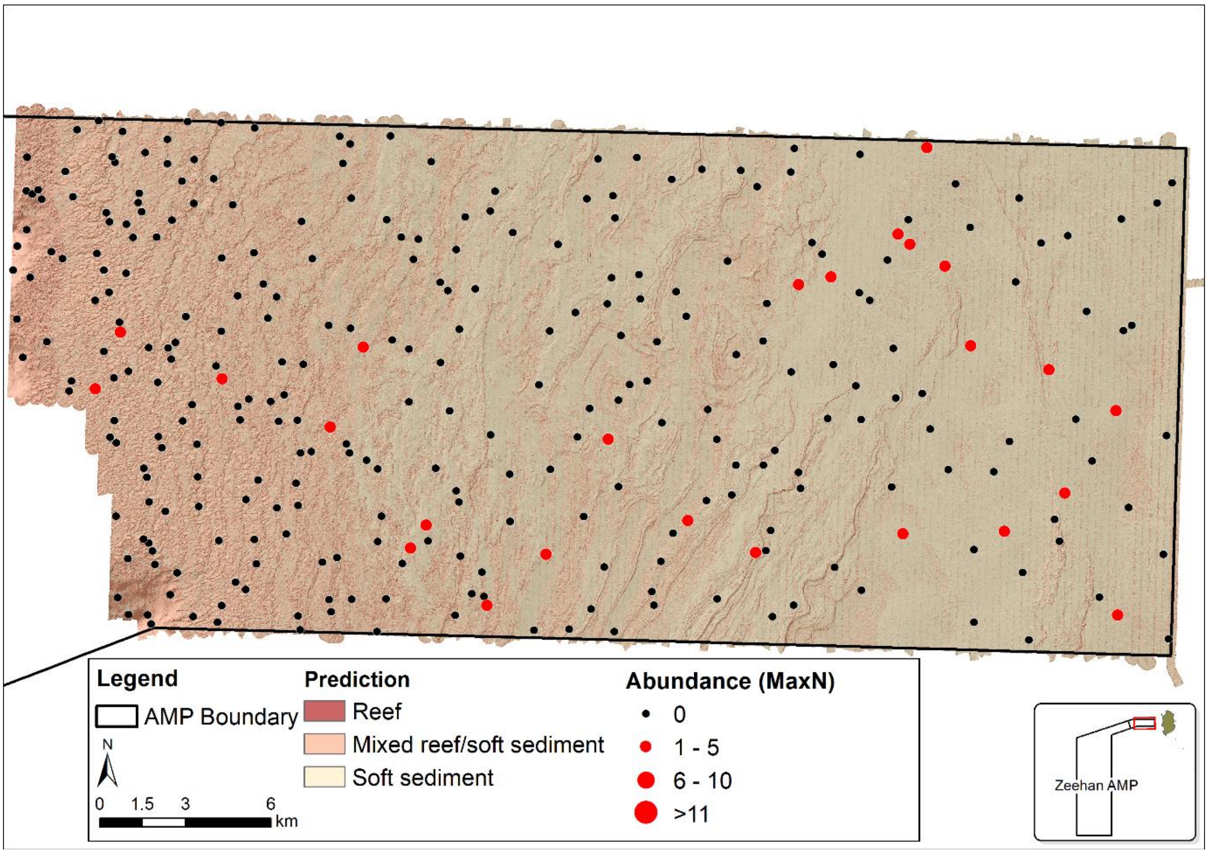

Figure 27. Abundance distribution of Gurnard perch (Neosebastes scorpaenoides) in Zeehan MP.

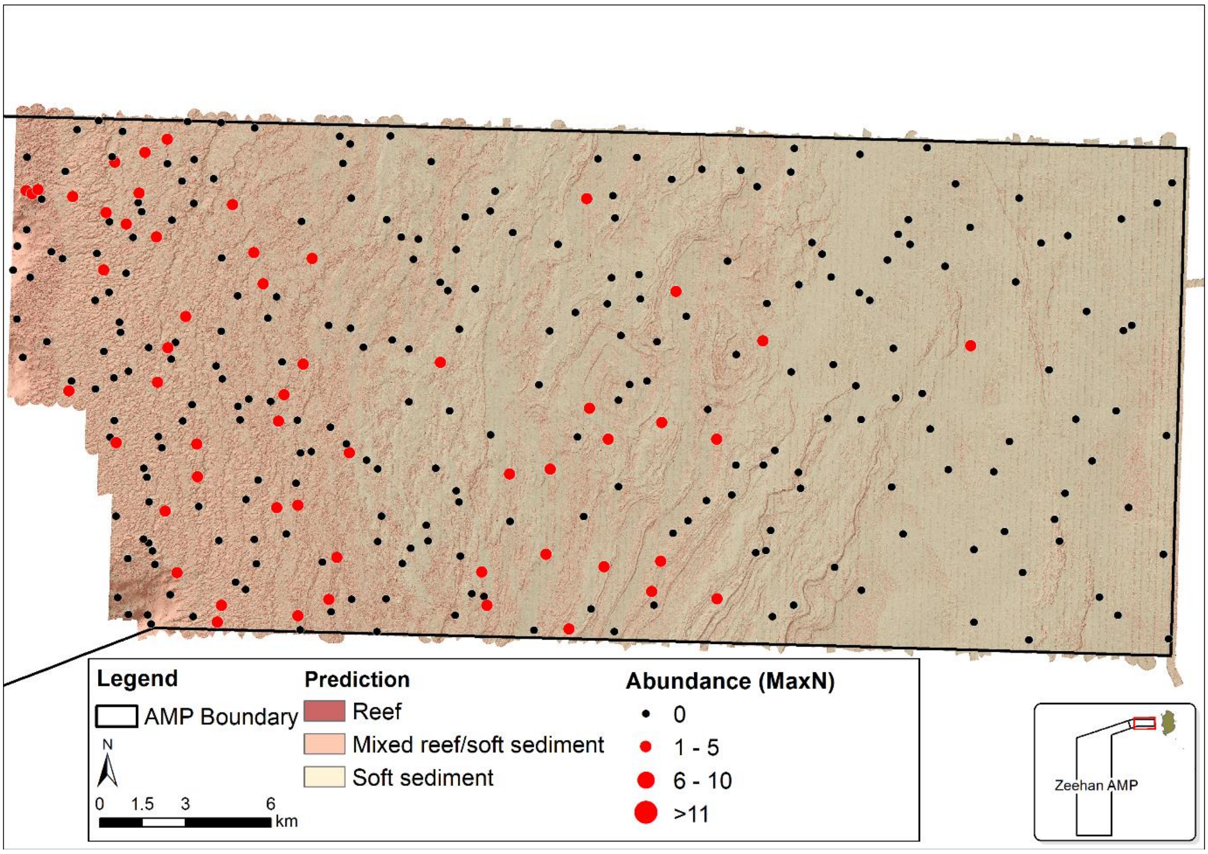

Figure 28. Abundance distribution of Ocean reef perch (Helicolenus percoides) in Zeehan MP.

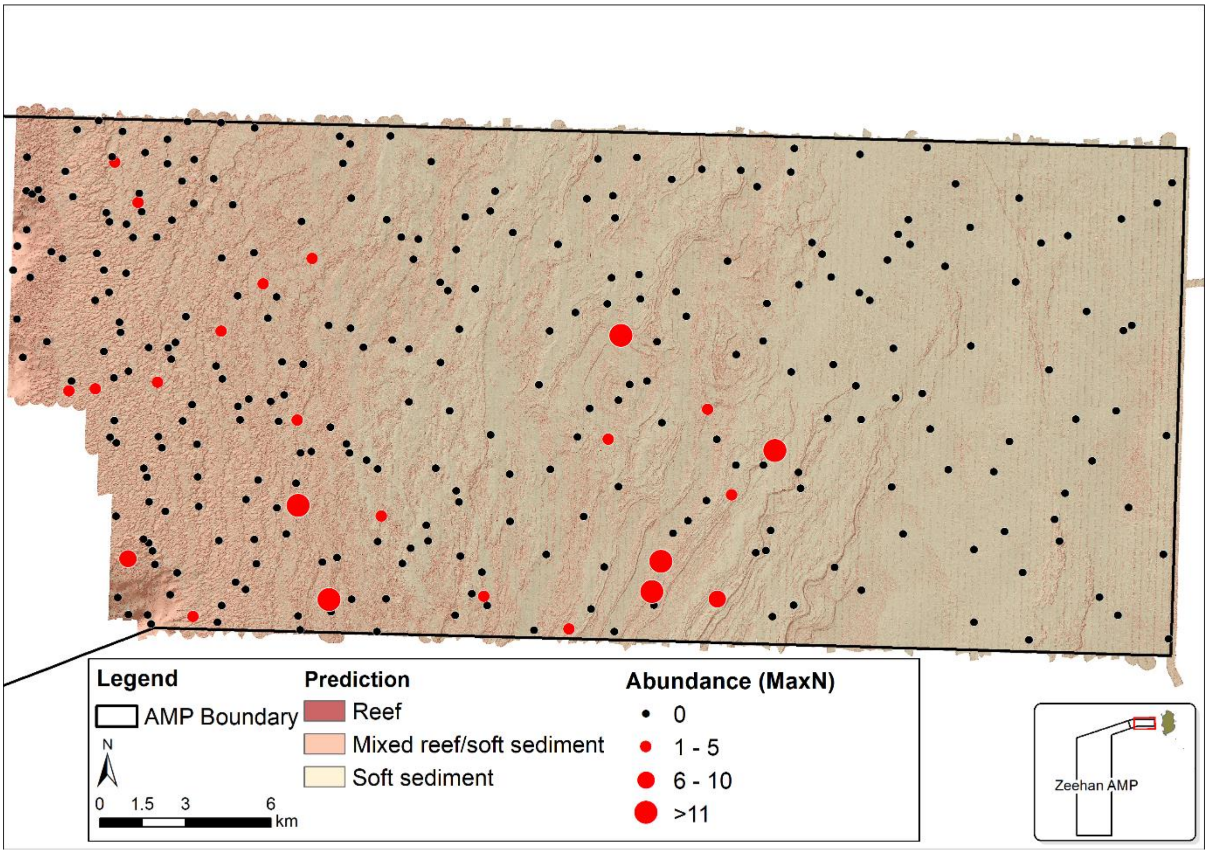

Figure 29. Abundance distribution of Sandpaper fish (Paratrachichthys macleayi) in Zeehan MP.

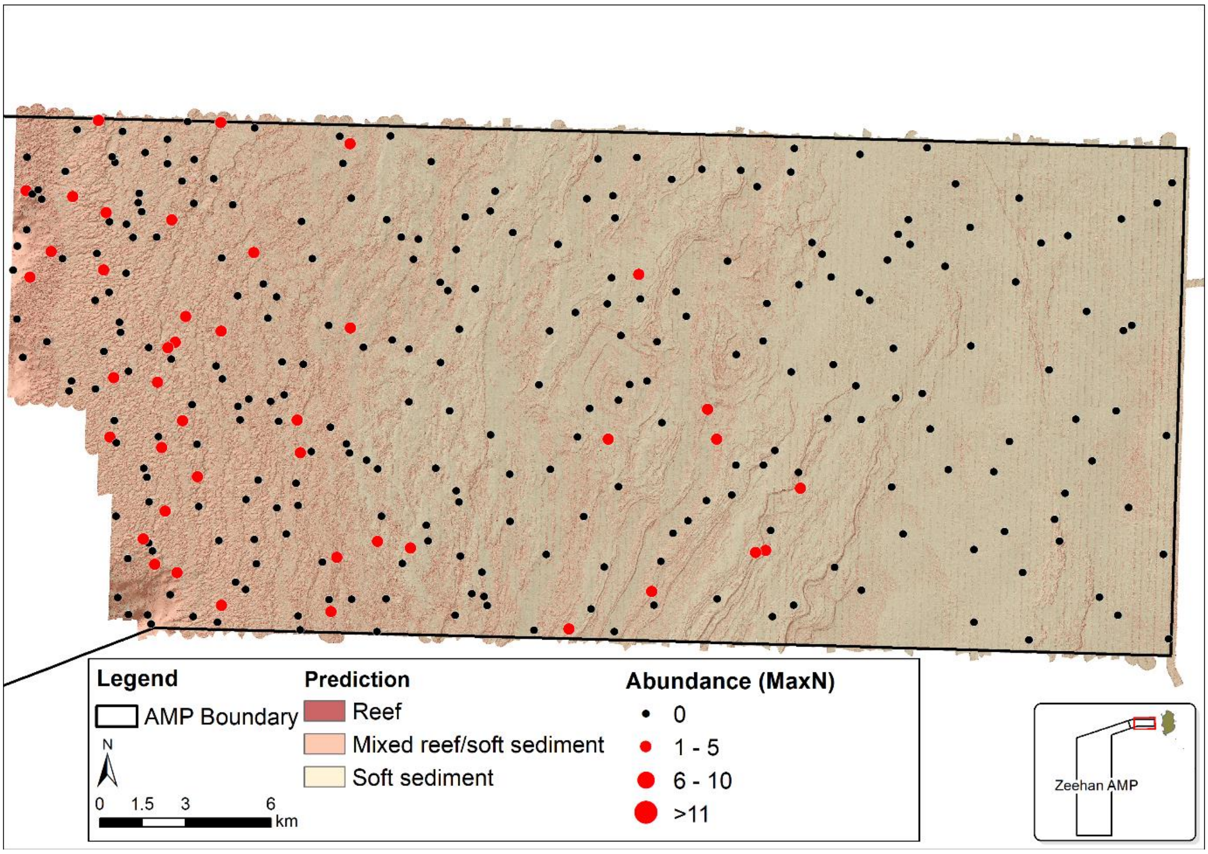

Figure 30. Abundance distribution of Rosy wrasse (Pseudolabrus rubicundus) in Zeehan MP.

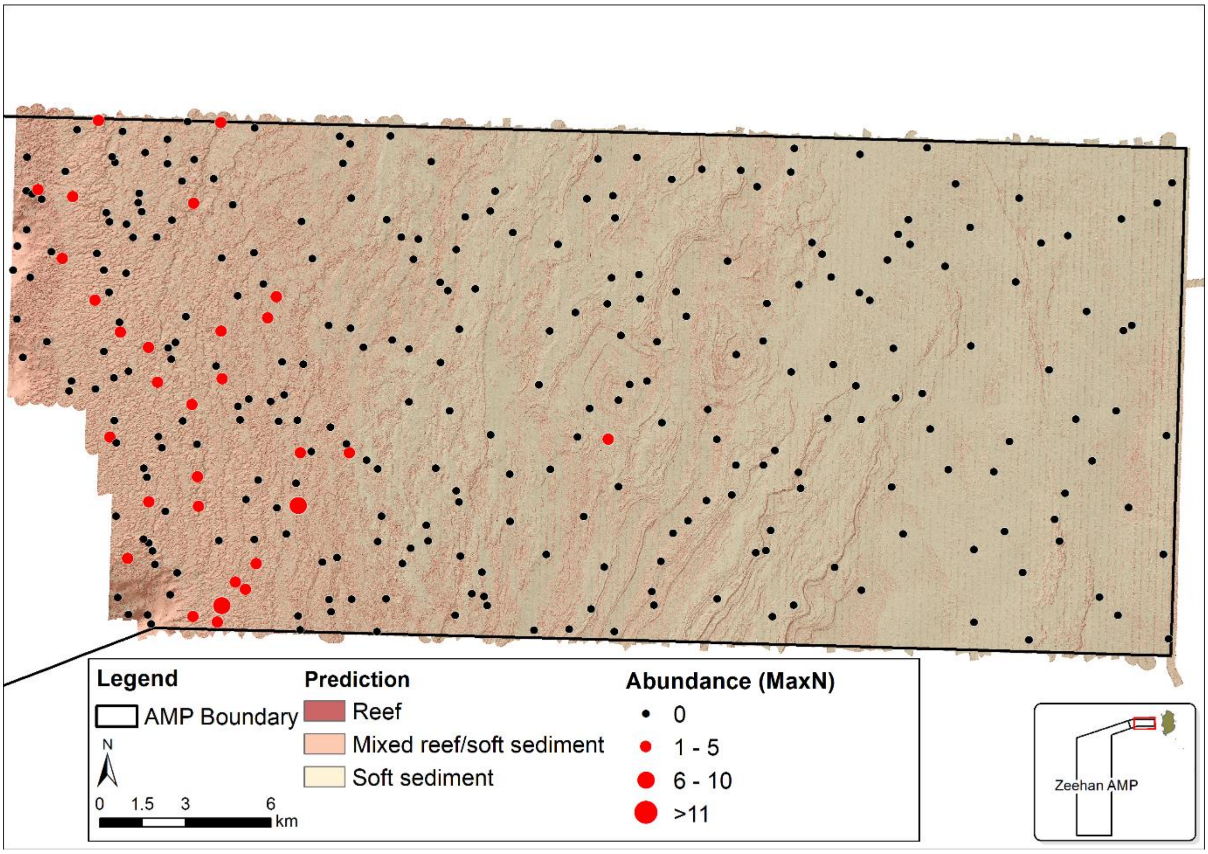

Figure 31. Abundance distribution of Degen's leatherjacket (Thamnaconus degeni) in Zeehan MP.

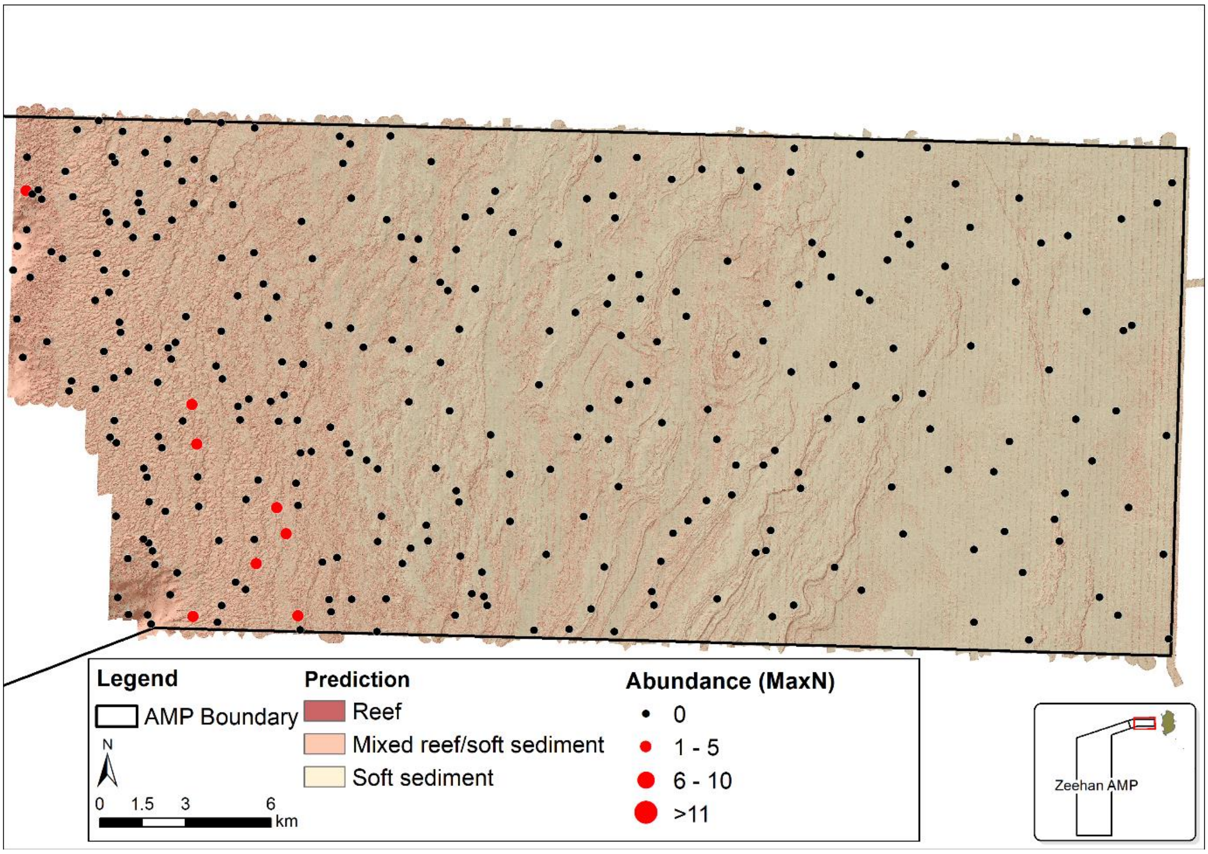

Figure 32. Abundance distribution of striped trumpeter (Latris lineata) in Zeehan MP.

Discussion

The shelf seabed mapping of the two western Tasmanian AMPs undertaken in this study provides significant new insights into the bathymetry and habitat distributions in this region, and hence contributes to ongoing management in these AMPs, and to a wide range of other conservation and resource management applications. This work provides an understanding of the range of geomorphological features present, as well as the forces that shape them. For example, soft sediments in both the Franklin MP (ranging from around 70-120 m) and in the Zeehan MP (ranging from 97-120 m) were often strongly rippled, showing the significant influence of the major oceanic swells that impact this highly exposed region, and the disturbed nature of this habitat (low stability). In the Franklin MP the mapping revealed the presence of a significant (mesophotic) reef feature on the northern margin, one rising from around 70 m to as shallow as 35 m, with the edge of a similar (mesophotic) feature intersecting the mid-eastern margin of the park. These features appear to be of volcanic origin (presumably basalt) due to both the observed seabed morphology and the direct link with adjacent features such as Black Pyramid Rock that lies 8 km to the north of the MP, which is also predominantly of volcanic origin. These mesophotic reefs are quite notable in their overall high density of sponge cover, likely related to their high relief (preventing sand inundation) and the reef topography that would accelerate current flow in their proximity. A key feature of the northern reef was the presence of the common kelp *Ecklonia radiata* on the shallowest parts that protruded into depths where sufficient light was available to support macroalgae. This was one of only two locations in the South-east MP Network where kelp canopy is found, the other being the inner NW region of the Huon MP.

The mapping also revealed significant areas of what is presumably limestone pavement in the Franklin MP and in the Zeehan MP. In the Franklin MP this limestone pavement was found in both in the southern mapped area as well as underlying the shallower reefs in the far north of the park. This pavement was often sand-inundated, somewhat limiting growth of sessile invertebrate assemblages. But in places where edges are exposed, for example at bedding planes, there could be areas of higher relief, less sand-inundation and higher cover of invertebrates. Despite the overall presence of pavement reef and more complex reef in some areas, soft-sediment habitat covered much of the Franklin MP, including the central unmapped region, based on drop-camera validation undertaken in that area.

In the Zeehan MP the limestone pavement (geology confirmed by rock fragments caught in the camera system occasionally) was far more extensive than found in the Franklin MP, representing a significant component of the overall shelf region of the park. In the inner third of the shelf area of the park this pavement was of limited extent, often sand-inundated and grading to soft-sediments which was the more dominant habitat feature in this sector. In the middle third of the shelf area of the park the limestone pavement increased to become the dominant habitat feature, with very notable step-features of 1-3 m in height that often ran for several kilometres and presumably represent erosion of bedding planes in the limestone bedrock. Typically, though, in-between these step-features, the pavement was quite low-profile at scales of hundreds of metres to kilometres. These were often also sand-inundated. In the outer third of the shelf area of the park, the limestone pavement was the dominant feature, but became notably more fractured, forming numerous block structures (10s to 100s of metres to km scale) that were typically flat-topped, rising between 1-3 m at each step feature. This increased structure appeared to restrict the extent of sand-inundation of the pavement and to provide numerous reef walls to support invertebrate growth.

Within the Zeehan MP, at the shelf break, several higher profile reef systems were mapped, with elevations of up to 10 m, that may represent a different underlying geology providing overall higher relief. However due to their small size (several hundred metres scale) there was insufficient imagery-based validation to better understand their complexity.

Importantly, knowledge of the underlying habitat features of these MPs and the resulting habitat prediction maps that were generated, provides a better understanding of the overall drivers of biodiversity in the parks, as well as the overall abundance and distribution of key species. While this was not an intended core component of this study, a combination of associated student projects and researcher interest, coupled with the standardised use of 5-minute camera drops per sample location, also allowed development of an initial understanding of the sessile invertebrate, macroalgal and benthic/demersal fish species present, along with their habitat relationships. For fishes, the more complex reef systems in the Franklin MP, including reef extension into the mesophotic zone, drove the distribution of many of the more abundant species, including vast numbers of buttterfly perch (*Caesioperca lepidoptera*), a planktivorous species, and rosy wrasse (*Pseudolabrus rubicundus*) a microcarnivorous species. The comparably more complex reef of the Franklin MP is likely to contribute to the higher diversity of species seen, relative to the Zeehan MP. In the Zeehan MP, most of the fish sightings were associated with the reef and mixed reef/sediment habitats, with *C. lepidoptera* dominating, presumably because as a planktivore it could be supported at depth by pelagic food sources. Notably, large swarms of krill (*Nyctiphanes australis*) were sighted in most camera deployments in this park at the time of sampling, possibly representing a significant food resource for resident species.

A core observation in the Zeehan AMP was the marked abundance of Jackass Morwong (*Nemadactylus mactopterus*) across the shelf region of the park, all based on unbaited observations, suggesting this park is a significant refuge for this trawl-targeted species given benthic trawling is excluded from the park. Likewise, commercially targeted striped trumpeter (*Latris lineata*) were sighted across all habitats on the outer shelf region of the park, suggesting they are likely quite abundant there, with a significant preference for the outer shelf in this region.

Despite the pavement reefs in the Zeehan MP having numerous step-features, particularly in the outer third, drop-camera observations revealed that they were rarely undercut to form crevice structures that would form shelter habitat for fishes or mobile invertebrates like lobsters. Instead, these steps were generally steep smooth walls, that differ markedly from similar step-like features found in the shelf waters of the Flinders MP in northeast Tasmanian waters, where they are typically strongly undercut to form crevices and/or have broken away to form boulder fields along the ledge margin (Monk et al. 2016). This difference is important in explaining differences in species distribution, including the likely distribution and abundance of rock lobsters, as rock lobsters were regularly sighted in ledge crevices in the Freycinet MP but were not seen on any of the camera-drops in the Zeehan MP. Hence, given the observed lack of reef complexity in the Zeehan MP and the sand-inundated nature of much of this reef, it is likely that this MP is not core habitat for this species. The same is likely to apply to the pavement reef areas of the Zeehan MP although the more complex volcanic reef systems there may be more suitable, and possibly a focus of future surveys.

Overall, the combination of bathymetry, habitat maps, drop camera imagery and observations of fish species present, help inform the likely distribution of fishing activities within the shelf area of the parks surveys. As discussed above, it is unlikely that significant lobster fishing activities would be undertaken in the Zeehan MUZ due to the absence of suitable habitat across most of the shelf that would make fishing this remote region for lobsters to be uneconomical. However, it is possible that the more fractured pavement towards the outer shelf may support some lobster bycatch associated with the giant crab fishery that is known to operate in the outer shelf to upper slope region of the park. Likewise, this outer slope area was shown to be suitable habitat for striped trumpeter, that while also being uneconomical to fish as a core targeted species due to the remoteness of this area, it is likely this species is targeted by commercial giant crab vessels while operating in that area. During the 12 days of surveys undertaken in the park MUZ over Feb-Mar 2022 the only fishing activities observed were two squid vessels operating continuously on the MUZ boundaries, and one giant crab vessel operating at the shelf break. In the Franklin MP no commercial or recreational fishing activities were observed in the park over 10 days of survey and as discussed above, while some complex reef was observed in the northern section of the park that may support a lobster population, no lobsters were observed in drop camera deployments in that area or more widely across the park, nor were any striped trumpeter observed. While both species are likely found within this park, it is likely that overall fishing pressure is quite low in most areas except for the northernmost reef system that appears to be part of a continuous system extending into the park from Black Pyramid Rock to the north.

Initial observations indicate that the sessile invertebrate and algal assemblages were also influenced by the habitats present. As discussed above, the more complex reefs extending into the mesophotic zone in the Franklin MP provided a sand-free and light influenced habitat that supported *Ecklonia radiata* kelp cover as well as dense and diverse invertebrate assemblages dominated by sponges. On the lower profile reef, a small mixed invertebrate matrix and sponges dominated the cover, but these were somewhat limited by sand-inundation. Based in the extent or significant rippling, soft sediments were generally likely to be quite mobile under the influence of large oceanic swells, so there was usually little emergent invertebrate cover because of the high disturbance regime. In the Zeehan MP, while a similar mix of deep low-profile reef and soft sediments was present, several zones of characteristic invertebrate cover were observed, including one characterised by large numbers of a species of fan worm that was not able to be identified to species level by use of the imagery alone (although not often picked up by the point annotation method), and one characterised by a characteristic bryozoan (likely *Adeona grisea*) that forms large solid and erect flat sheets (see Appendix A5).

To our knowledge, the generation of model-based habitat maps at whole of MP scale (at least for the shelf components) in this project is the first time this has been undertaken at such scale in Australia, based on a mix of comprehensive multibeam data (gridded at 2 m x 2m cells) and high-density image-based ground validation. The nature of the cross-shelf habitats involved, with many shelf reefs being low-profile and sand-inundated (often gradually grading from exposed reef to soft sediment with increasing sand depth), means that this process is imperfect, and some boundaries are likely somewhat "fuzzy" given the uncertainty involved. In addition, the highly fractured nature of some areas, especially the outer shelf region of the Franklin MP means that reef systems are not readily described by simplistic polygons, but rather, they form complex mosaics of reef and soft sediment at tens of metre scales, with the resulting habitat maps representing this complexity with a moderate to high degree of accuracy based on ground validation. Given that the known position of such validation imagery can also have location errors up to ten metres or so, clearly small-scale errors in both prediction and model validation will not be able to be improved using the current methods. While simpler, larger habitat polygons could be generated to represent "average" habitats at larger scales to simplify understanding by AMP and resource management, at this stage the fine scale maps provide a closer approximation of reality and a starting point for discussions around how to best represent habitat distribution in deep shelf waters.

Finally, this study represented the first whole of park (as least for shelf waters) habitat mapping of an AMP using a drop camera system. It demonstrated that the logistics of undertaking such surveys can be both possible and cost-effective in gaining an initial visual understanding of habitat distribution at whole of park scales. This approach to understanding habitat distribution may be critical to planning and undertaking initial biological inventory and monitoring programs within the AMP network, particularly where sampling is intended to be effectively targeted on important habitat features, but where there is no prior knowledge of the likely distribution of these features in individual parks. It has become clear over the past decade that, due to cost, equipment/vessel access, time and funding constraints, prior multibeam mapping programs may not be possible in the timeframe needed to gain the initial knowledge of likely habitat distribution needed to plan subsequent biological surveys to understand and manage the biological values of the parks. This study also is the first time the entire shelf region within a park in the AMP network (Zeehan MP) has been mapped by a full coverage high resolution multibeam sonar survey, as well as being subsequently and extensively ground-truthed to allow generation of validated model-based habitat maps, demonstrating an ideal multi-step approach to combined bathymetric and habitat mapping for the AMP network and shelf waters in general.

Data access

From the work to date, all hydrographic mapping data has been submitted to AusSeabed marine data portal (https://portal.ga.gov.au/persona/marine) for ongoing repository and future public access, with the underlying data report by Davey et al. (2022) available online from CSIRO and the University of Tasmania- https://figshare.utas.edu.au/articles/report/Hydrographic_Survey_of_Zeehan_and_Franklin_Marine_Parks_West_Coast_Tasmania/23171318). The model-based habitat maps are available from Seamap Australia (https://seamapaustralia.org/map/) or on request from the authors, examples of ground-truth imagery of habitat, benthic sessile assemblages and fishes are also linked to Seamap Australia. Currently, all drop-camera imagery is archived at IMAS, and available on request. Imagery and annotation data for habitats will be loaded into SQUIDLE+ and fish data will be made publicly available on GlobalArchive.

Future recommendations

Due to adverse weather conditions, not all areas of the Franklin MP could be surveyed using multibeam sonar, and despite the more significant habitat composition being captured by the current mapping, ideally the remaining mid-section of the park would be mapped as a priority to underpin future biological sampling, particularly if spatially-balanced designs are to be utilised to gain a 'whole of park' quantification of the cover/abundance of key species. This is particularly the case for capturing the complex reef system that intersects the eastern margin of the park. This could ideally be coupled with simultaneous mapping of the inner shelf reef systems in the Huon MP and the inner shelf component of the Freycinet MP to provide a cost-effective program that can be undertaken in a range of weather conditions. Ultimately, by mapping the remainder of the Franklin Park, the knowledge gained will allow better understanding of the current habitat assets, and where required, allow for whole of park inventory of key species in subsequent monitoring programs. This may be important to validate or invalidate the extent of potential current pressures such as lobster fishing in this park, when coupled with appropriate biological surveys. Hence leading to improved management prioritisation for future monitoring and management requirements. Ideally, any future program may additionally map appropriate adjacent reference areas to underpin studies examining park management effectiveness relative to adjacent open access areas.

The panoramic drop camera proved to be a reliable tool for the initial exploration and accurate mapping of substrata within the AMPs as well as for gaining an important pilot scale understanding of the distribution of the more common sessile invertebrates and benthic fishes and their spatial distributions and habitat relationships. However, if the sessile invertebrate fauna and algal cover is to be adequately mapped or quantified to provide an inventory and baseline for future monitoring, additional benthic imagery replication in the form or Autonomous Underwater Vehicle, Remote Operated Vehicle or drop camera surveys are required to achieve sufficient sample sizes to be able to reliably quantify abundances for future use in monitoring programs.

To provide a more comprehensive assessment of demersal fish assemblages and the biodiversity of sessile biota, it is recommended to conduct appropriate biological baseline surveys utilising baited remote underwater video and autonomous underwater vehicles. Such surveys would significantly enhance the current very low level of understanding and knowledge of the marine ecosystems within these AMPs. It would allow appropriate bioregional comparison with other parks in the South-east Marine Parks Network where similar baselines have been established as well as provide an initial understanding of the species and habitats present that may require ongoing monitoring and management to ensure planned conservation outcomes are being met. For example, a detailed BRUV-based survey would also allow proper assessment of the extent that lobsters are found in these parks (as lobsters are highly bait attracted). This would then ideally be followed up by a targeted lobster potting survey if significant numbers were encountered, to better understand the spatial distribution of commercial fishing interests in the parks as well as the likelihood of that fishing interest being present based on species abundance. Currently the available data on such species, as well as their associated fishing effort, is very difficult to obtain based on state agency sources that are limited in access, constrained by reporting-block sizes (that overlap park boundaries) and further constricted by restrictions around providing data in areas with few vessels operating (5 boat rule). Hence a direct biological survey soon would significantly improve this understanding of assets vs pressures and allow a more confident prioritisation of monitoring effort between AMPs in the region.

Likewise, in addition to lobsters, such a study would inform the distribution and abundance of other commercially and recreationally targeted species such as striped trumpeter, jackass morwong and potentially giant crabs, and the extent that they may be supporting fisheries within the park that may need ongoing management awareness and monitoring. At this stage, while there is some understanding anecdotally that striped trumpeter are targeted on the outer shelf as a result of vessels being in the area for giant crab fishing, this knowledge needs improving for management purposes, in addition to better understanding the distribution and abundance of fished stocks themselves.

For some species, including soft sediment sessile invertebrates and fishes such as jackass morwong, a combination of AUV (or ROV)-based seabed imaging survey and associated BRUV-base surveys would also allow an initial understanding of potential responses to the current level of protection offered by these parks from benthic trawling. This is the one activity excluded from the MUZ in both parks and the abundance of jackass morwong shown in the drop-camera surveys suggests the potential for species such as this to have benefited from current levels of protection. Ideally this possibility is tested by adequate comparisons of trawlable species and habitats within the parks with adjacent fished area, allowing the conservation effectiveness of current management arrangements to be assessed.

Finally, given the effectiveness of the drop camera-based validation that allows prior multibeam mapping to be readily translated into habitat maps, this approach would ideally be applied to a range of other AMPs where either (1) MBES datasets are available, but lack adequate ground-truthing to generate subsequent reliable habitat maps or (2) improved habitat distribution knowledge is required to plan future inventory or monitoring programs where MBES surveys are unlikely to be feasible in the near future due to logistical constraints or costs. Example areas in the SE network include the shelf region of the Huon, Beagle and Flinders MPs.

Key recommendations:

- Complete multibeam sonar mapping of the Franklin MP, ideally as a wider survey improving knowledge in Huon and Freycinet MPs as well. Allowing sound quantitative future monitoring designs.
- Undertake BRUV-based surveys in the Franklin and Zeehan MP MUZs to provide an initial baseline of fish assemblages present, a bioregional contrast with other MPs in the region and to assess the presence and relative abundance of a range of targeted species, information that may better inform the nature and extent of fishing pressure in these parks.
- If significant lobsters are found (unexpected in Zeehan) in BRUV surveys, undertake a targeted potting survey to better understand fishery assets and likely pressures (which may include giant crab in outer shelf surveys) to inform future management.
- Undertake an AUV or ROV-based survey in the MUZ of both parks targeting both reef and sift sediment habitats across the shelf to better understand reef associated sessile invertebrate biodiversity and bioregional relationships with other AMPs in the network, as well as evaluating potential responses to protection from trawling in soft sediments allowing understanding of current zoning effectiveness.
- Undertake initial biological surveys soon to better understand likely effects of immediate pressures (including oil and gas exploration) and to better inform future prioritisation of ongoing monitoring within the wider SE Marine Park network based on an improved understanding of biological assets and pressures in these parks relative to others within the network.

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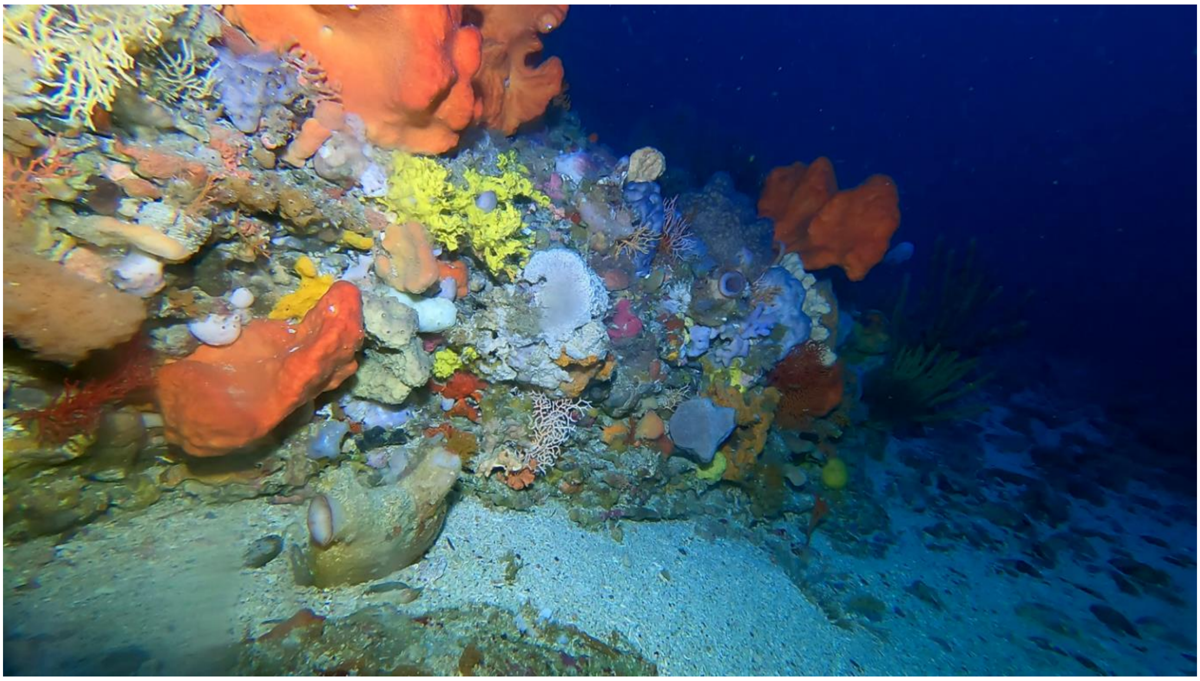
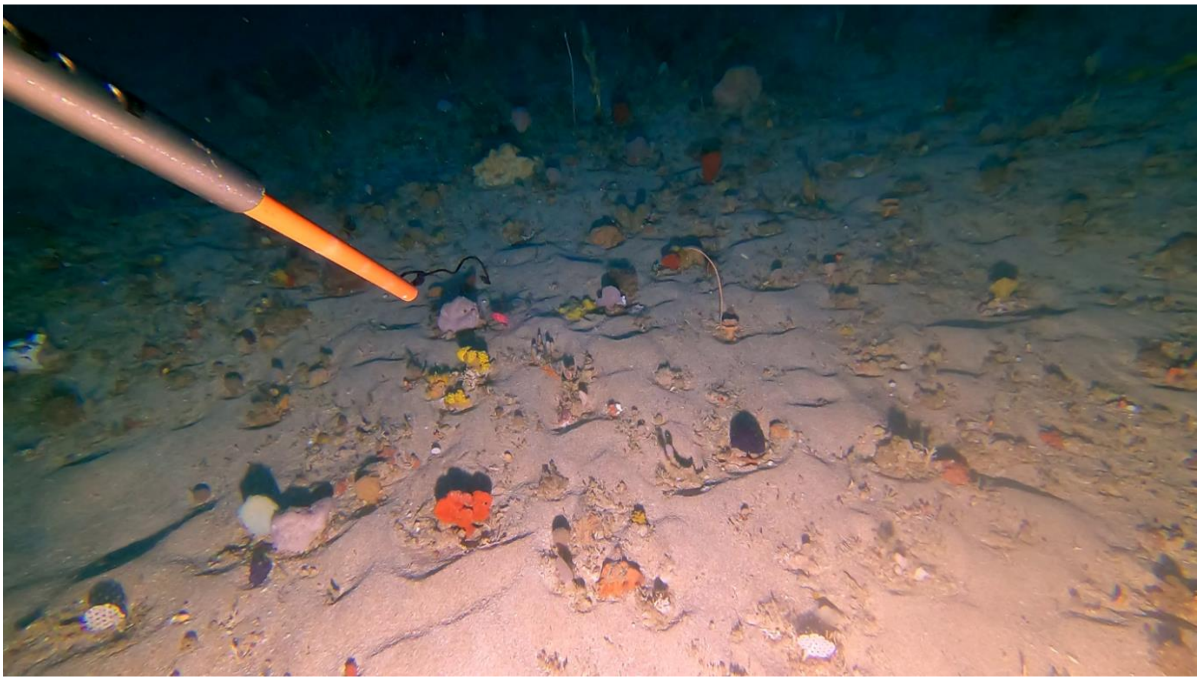
Appendices

Appendix A. Seabed habitat features and associated biota in the Franklin and Zeehan Marine Parks.

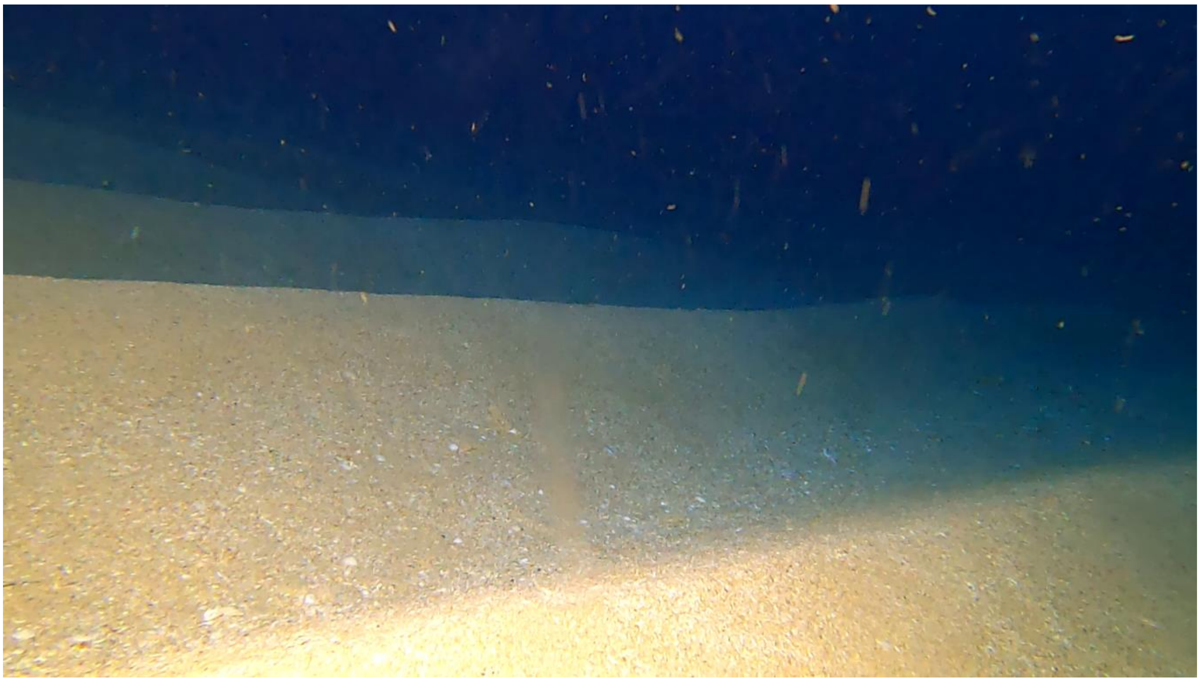


Appendix A1. A high diversity sessile invertebrate community on the high-profile reef system in the northern section of the Franklin Marine Park

Appendix A2. The common kelp Ecklonia radiata on shallow (35 m) mesophotic reef in the northern section of the Franklin MP

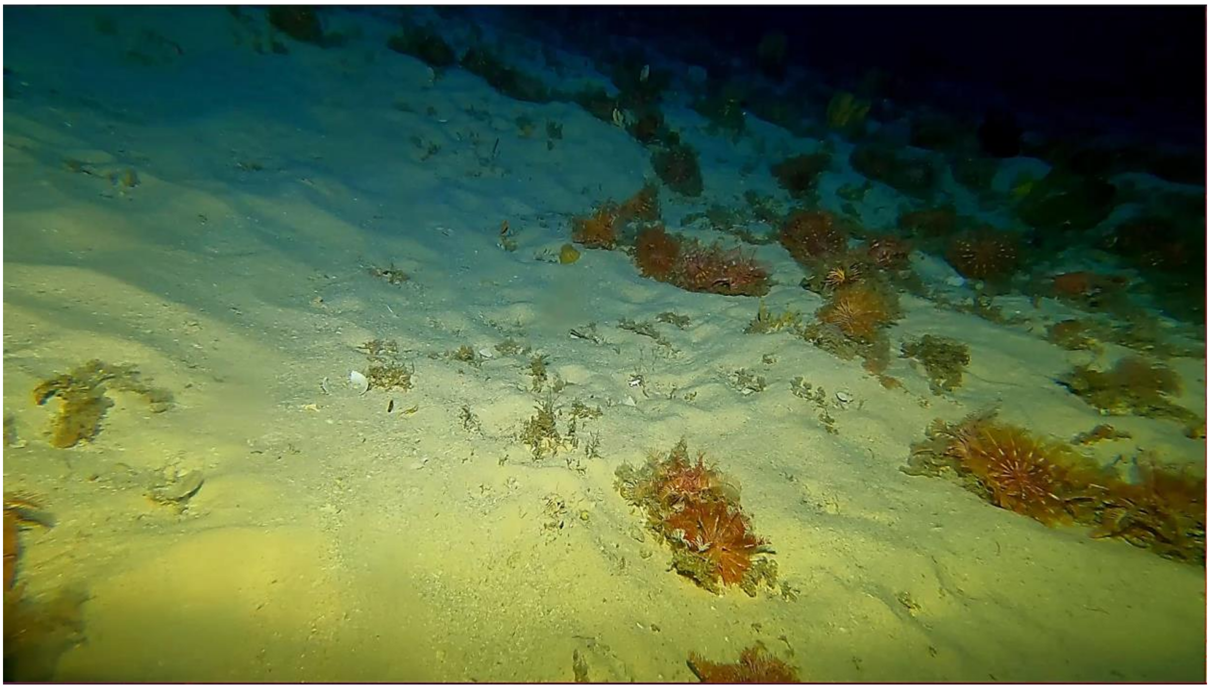


Appendix A3. Sand inundated pavement reef in approximately 80 m depth in the southern section of the Franklin Marine Park

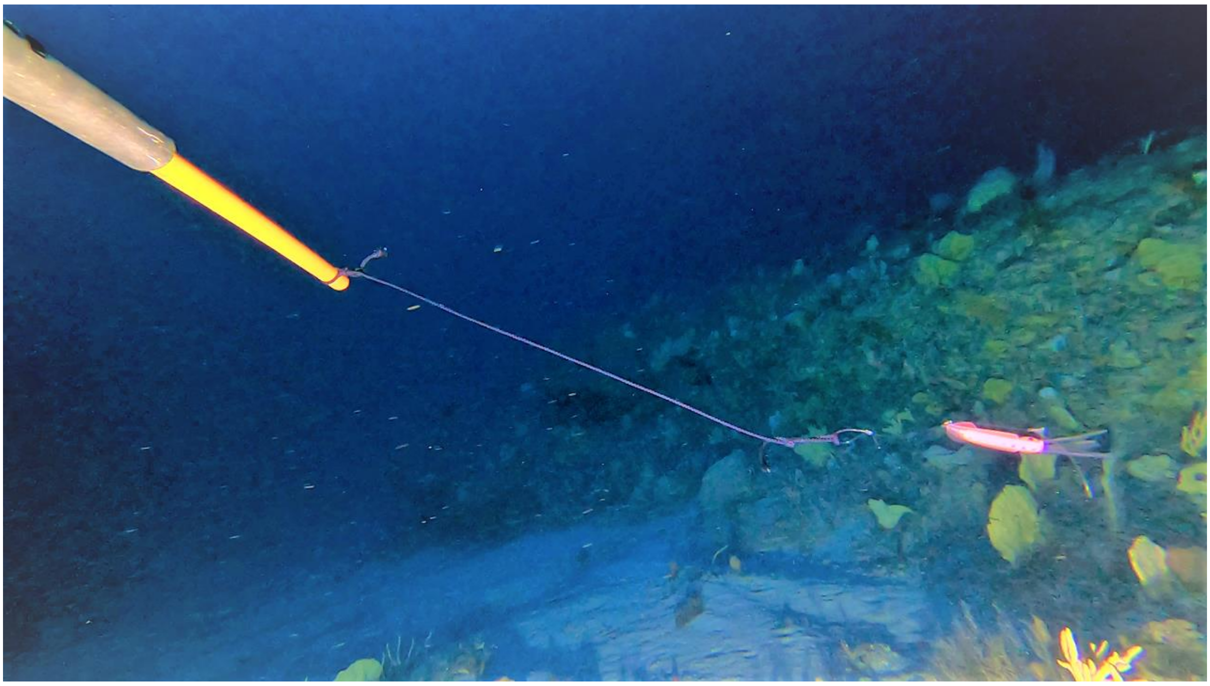


Appendix A4. Rippled soft-sediment features at 100 m depth, typical of the eastern section of the Zeehan Marine Park influenced by high energy oceanic swells.

Appendix A5. Low profile pavement reef (presumed to be limestone based on rock samples) at 100 m depth in the inner-mid section of the Zeehan Marine Park showing typical cover of sessile invertebrates, including a plate-like hard bryozoan (Adeona grisea) that was abundant in this region.

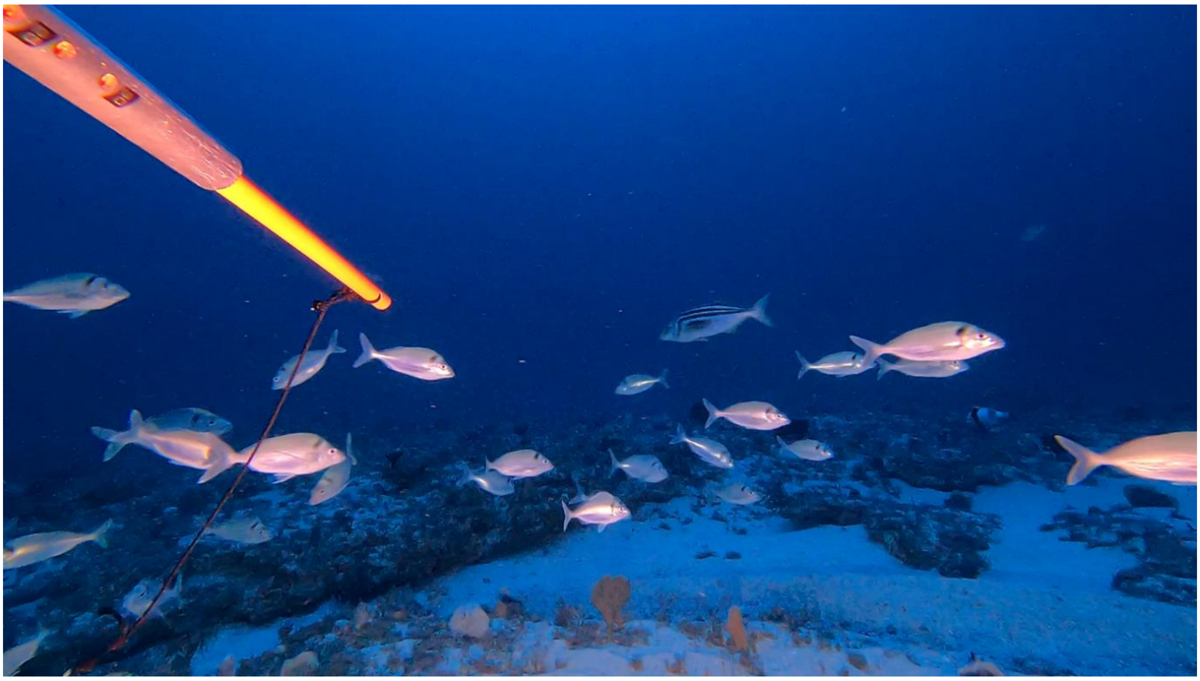


Appendix A6. Low profile pavement reef (presumed to be limestone based on rock samples) at 110 m depth in the outer-mid section of the Zeehan Marine Park showing fan worm that was abundant in this region.



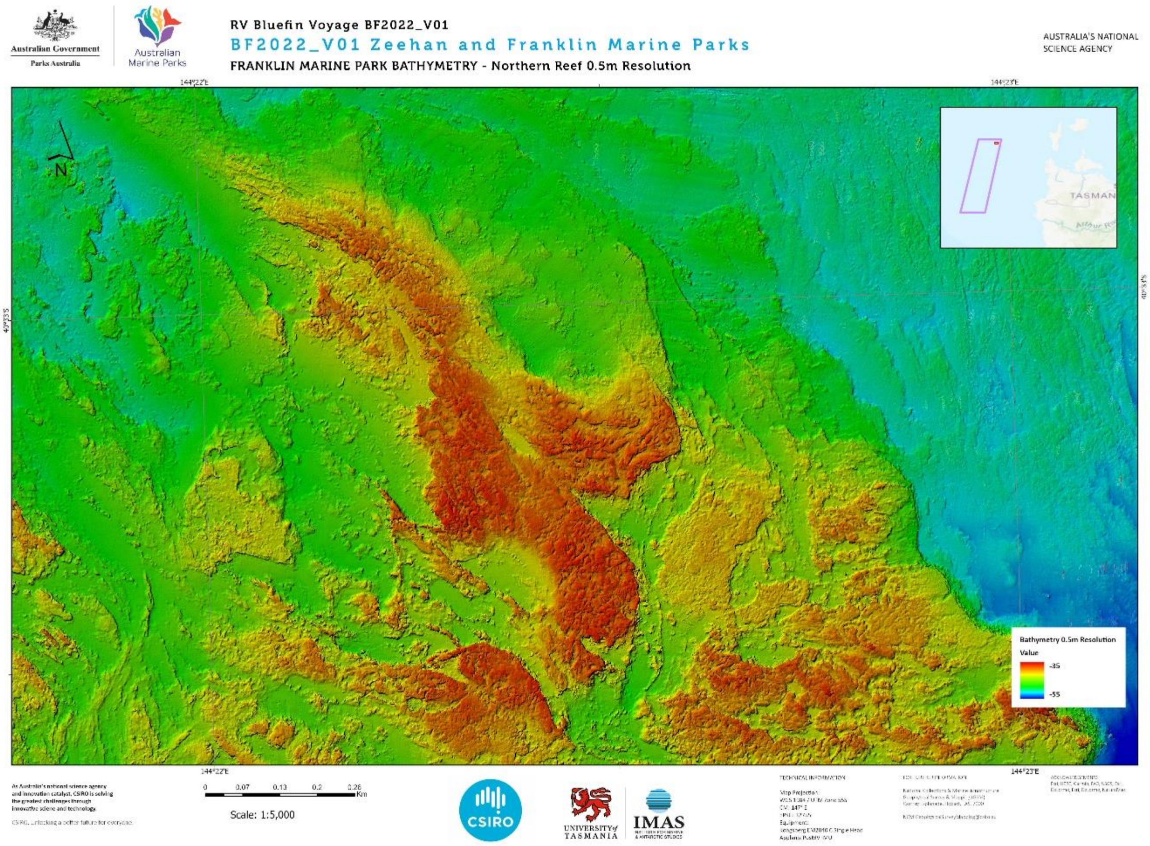
Appendix A7. A typical step-feature (ledge) at pavement reef margins in the mid to outer shelf region of the Zeehan Marine Park. Note the absence of any crevice structure.

Appendix A8. A typical pavement reef step feature (ledge) in the outer shelf area of the Zeehan Marine Park. Note the lack of crevice-like features and the adjacent rippled soft sediment caused by the influence of high energy oceanic swells.

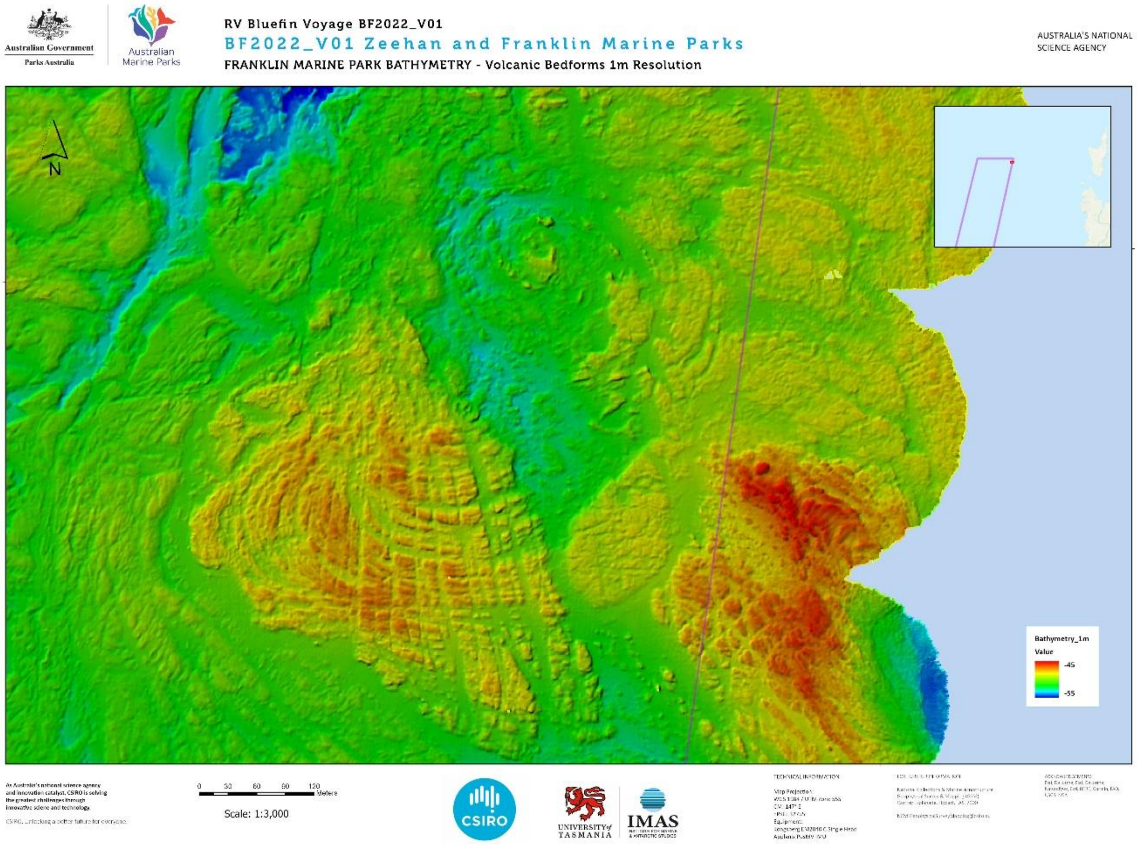

Appendix A9. Typical pavement reef and mixed reef/sediment habitat in the outer shelf region of the Zeehan Marine Park. Showing a fish assemblage of striped trumpeter and jackass morwong.

Appendix B. Fine scale maps of distinct habitat features identified from multibeam sonar surveys in the Franklin and Zeehan Marine Parks.

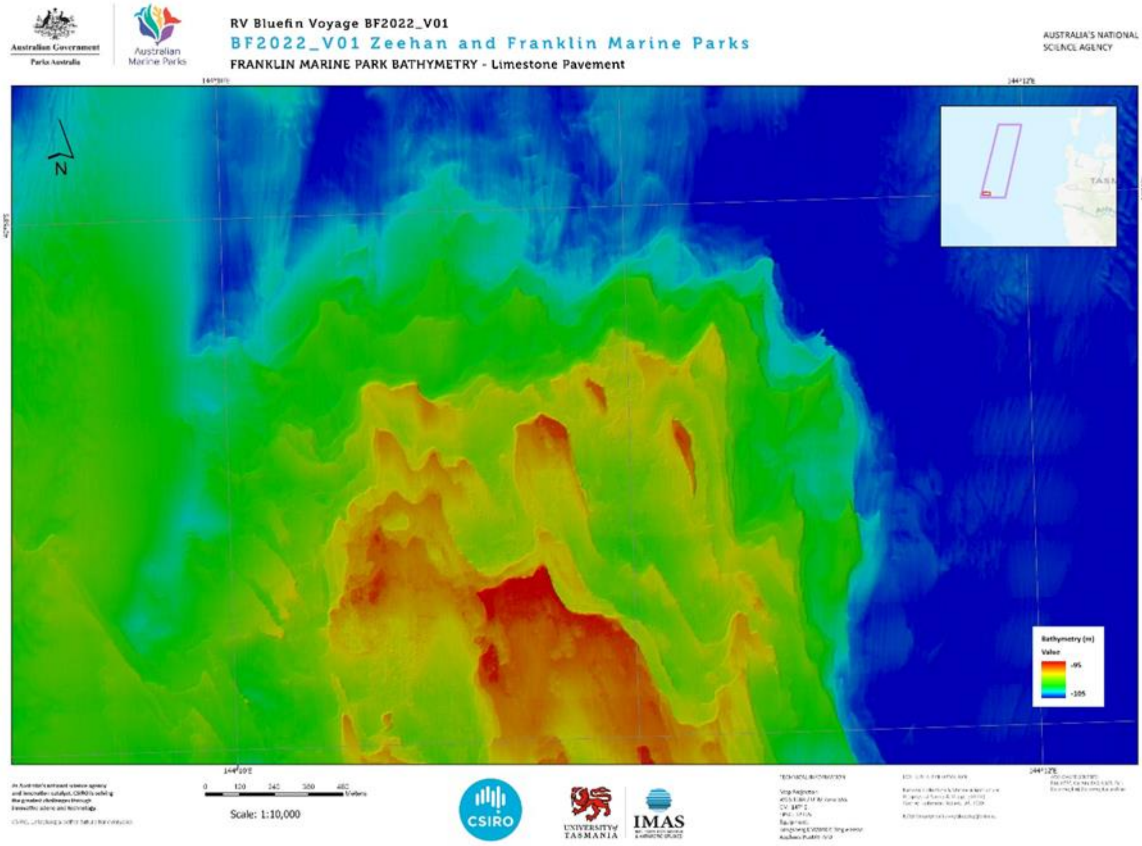
Maps produced by Craig Davey, CSIRO.



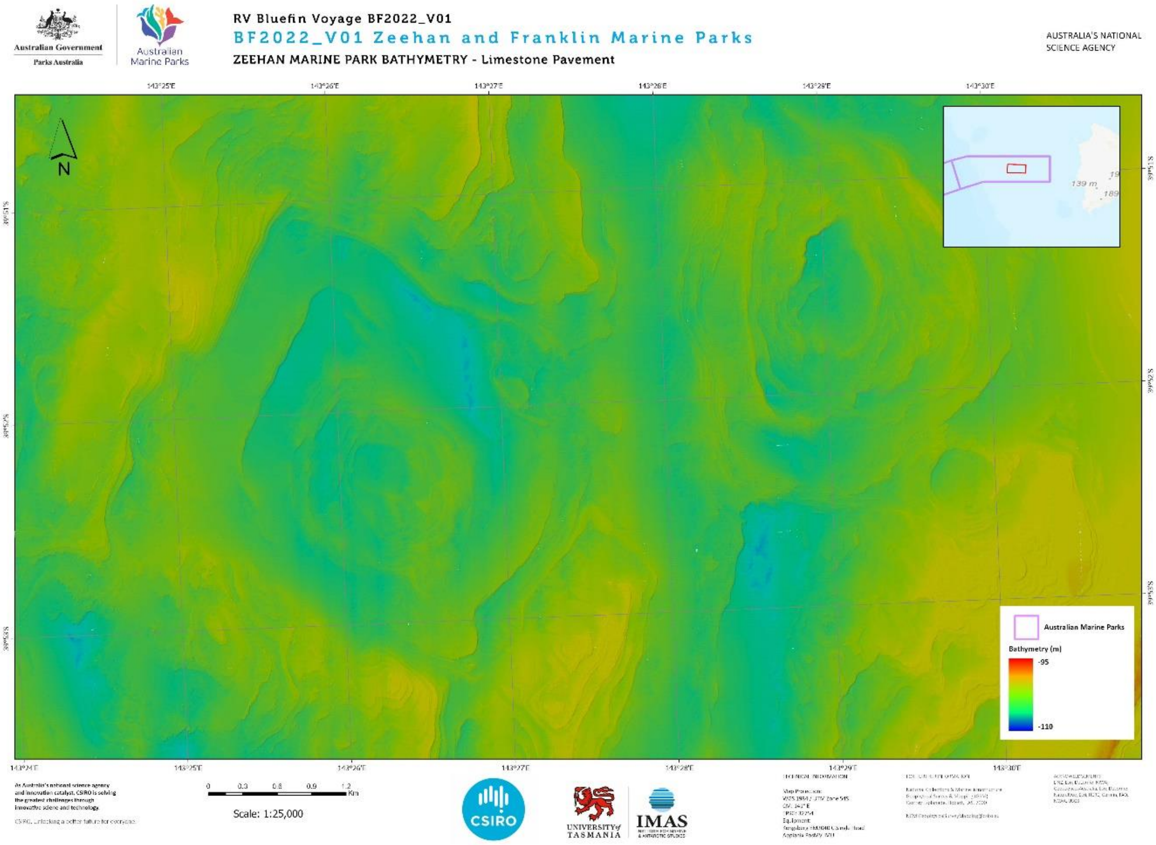
Appendix B1. High profile rocky reef, potentially of volcanic origin, in the northern section of the Franklin Marine Park. Areas shown as red are all likely to be in depths where kelp growth is likely.



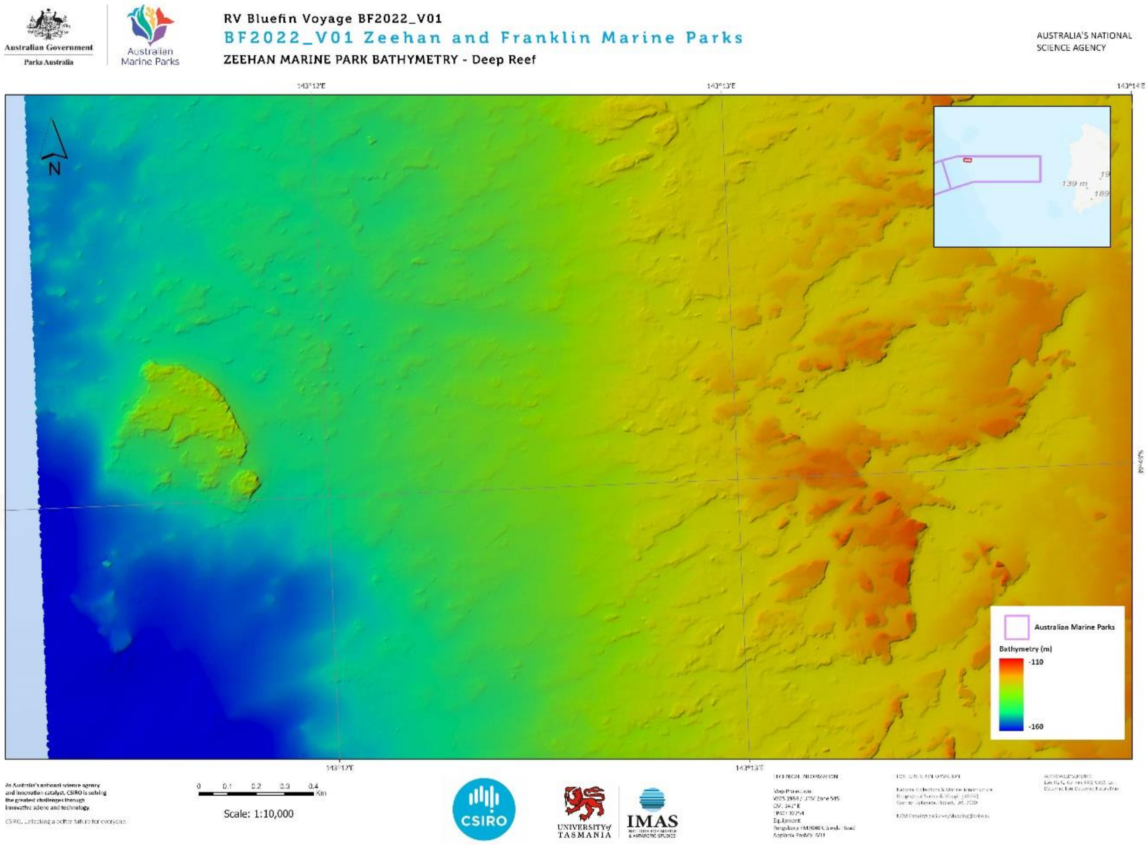
Appendix B2. Section of the northern mesophotic reef in the Franklin Marine Park showing circular bedform features that are interpreted to be historic lava flows of Tertiary Basalt from adjacent vents. This geology mirrors adjacent coastal geology at Mt Cameron West, and Black Pyramid Rock to the north of the park. Mapping of the vessel transit from the park to Black Pyramid Rock shows this reef feature to be continuous from the park boundary to the rock. See insert for specific location.



Appendix B3. Fine scale example of low profile pavement reef (interpreted to be of limestone origin) in the southern region of the Franklin Marine Park. See insert for specific location.



Appendix B4. Fine scale example of low profile pavement reef in the mid section of the Zeehan Marine Park, with associated soft sediments. Note the distinct step features. Interpreted to be similar limestone pavement to that found in western section of the park and in the Franklin Marine Park.



Appendix B5. Fine scale example of a shelf break reef in the Zeehan Marine Park (mid left margin) and the fractured limestone shelf pavement found towards the shelf-break (mid area to left margin) section of the park.