Analysis of a time-series of benthic imagery from the South-east Marine Parks Network

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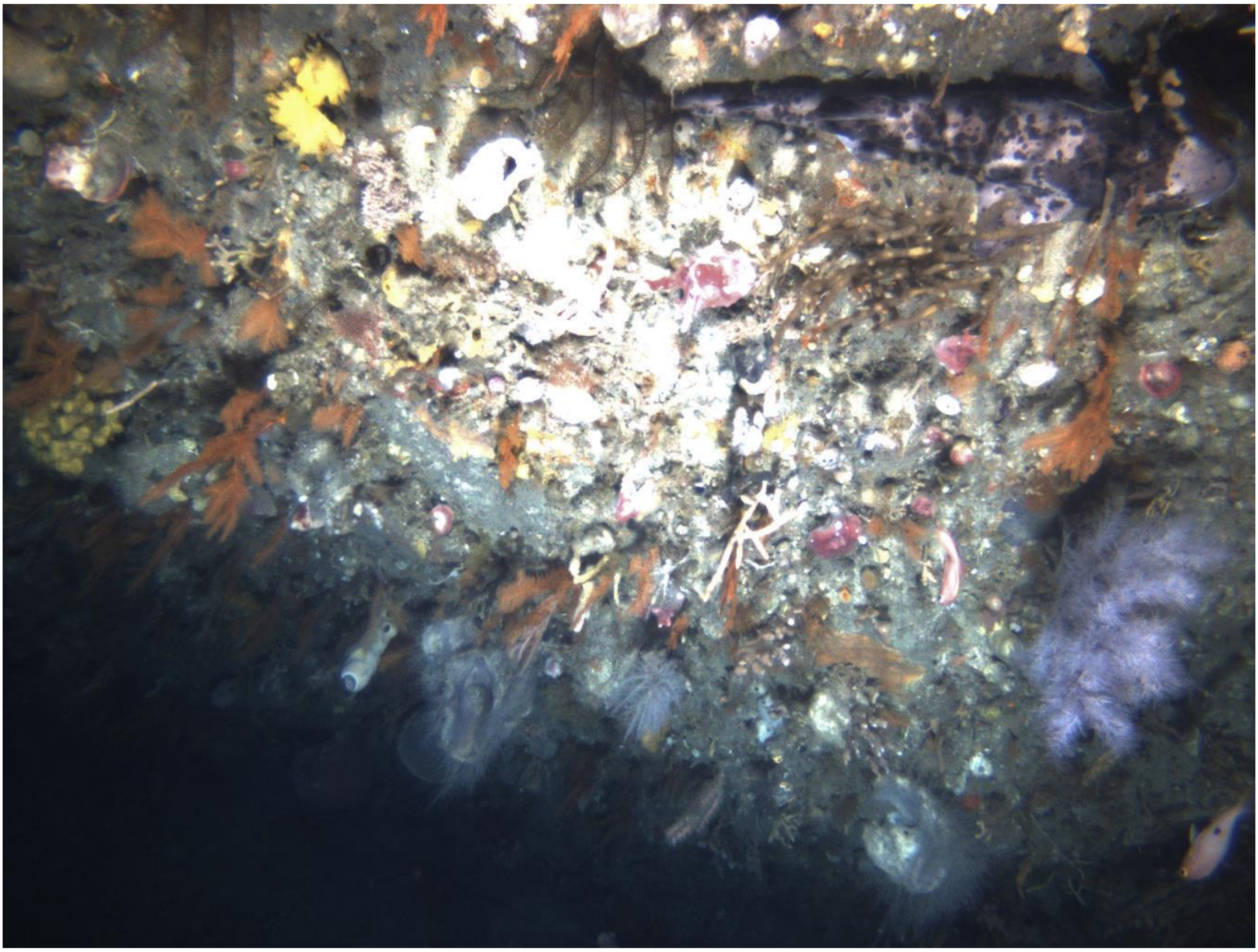

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Acknowledgements

The authors would like to thank all the agencies that have been involved in the ongoing support of the Autonomous Underwater Vehicle (AUV) monitoring program including the Integrated Marine Observing System (IMOS), the National Environmental Science Program (NESP) and Parks Australia. Data was sourced from IMOS which is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent. We are grateful for the support of the Parks Australia management team of Cath Samson, Emily Harris and Hilary Schofield who gave valuable input as the project progressed and feedback on the content of the final report. Many of the AUV deployments and some of the baseline scoring used in this project were supported by the Marine Biodiversity Hub through funding from the Australian Government's National Environmental Science Program (NESP). The NESP Marine Biodiversity Hub partners include the University of Tasmania; CSIRO, Geoscience Australia, Australian Institute of Marine Science, Museum Victoria, Charles Darwin University, The University of Western Australia, Integrated Marine Observing System, NSW Office of Environment and Heritage, and NSW Department of Primary Industries. We would also like to acknowledge the tireless effort of the team of scorers who contributed to acquiring the necessary data to complete this report: Phoebe Gallagher, Kate Fraser, German Soler, Shravan Ram Baskaran, Lisa Miller and Justin Hulls. We also thank Justin Hulls for his help in producing the high-quality maps in the report.

Executive summary

This report provides the first insights into the distribution and changes through time of deep shelf (40 – 200 metre) seafloor habitats, biological communities, and species in Australian Marine Parks across the Southeast Marine Parks Network (the SE Network). Repeat photographic surveys of the seafloor at sites within Huon, Freycinet, Flinders and Beagle Marine Parks using the Integrated Marine Observing System (IMOS) Autonomous Underwater Vehicle (AUV) facility were conducted between 2009 and 2018.. Data from this imagery was used to build knowledge of where different species occur and how their abundances have changed over the survey period. This knowledge is important for ongoing monitoring of these ecosystems, as to be able to distinguish changes that may be because of protecting these ecosystems, or driven by perturbations such as warming events, there must first be an understanding of natural variability. Knowledge of the distribution of important species and how they vary through time is also key in helping researchers and managers decide on appropriate indicators and the design of the ongoing monitoring program to ensure that resources are directed to their best use.

During this project a subset of 100 images for each repeated survey within each marine park site was scored by labelling morphospecies (species that were distinct in terms of shape and colour) occurring in the imagery using a point scoring approach. Random points placed within images were labelled, and the percent cover (a measure of abundance) of each morphospecies over the survey area was calculated across the scored images. This information allowed the imagery to be turned into quantitative data about each morphospecies and how this had changed at each year surveyed. This data was then used to model the trends that had occurred for morphospecies within each marine park and across the entire SE Network and to explore the variability over the time series. Also, the effect of scoring a larger subset of 200 images with point scoring and an alternative method of scoring all individuals for targeted morphospecies was explored at a small subset of sites. A summary of the sites included in this project, a brief description of the site and the scoring completed is presented in Table 1.

Overall, communities were found to be stable over the survey period; however, several individual morphospecies were found to have undergone significant change. Overall increases in the cover of soft bryozoans were found, particularly at Huon and Freycinet Marine Park. Declines in gorgonian red corals were also found, particularly within Freycinet and Flinders Marine Parks. However, it is currently unclear whether these or other trends detected are due to natural cycling in abundances or part of longer-term trajectories. It is recommended that morphospecies which have been found to have trends at this stage of monitoring be evaluated as new data is collected.

The targeted scoring conducted for two morphospecies at two selected sites provided further insights into the dynamics of these ecosystems and allowed a comparison of scoring approaches. Scoring of the cup red smooth morphospecies at the Flinders Western Boundary site showed that there was a significant increase in the number of bleached individuals between the 2013 and 2017. This bleaching followed a significant “marine heatwave” event in 2015/16 and therefore indicates that the bleaching of these and potentially other sponges may provide an indicator of warming events. Comparison of the different scoring approaches at the two targeted scoring sites using 100 and 200 images showed that the full count approach far outperformed the point count approach in the ability to detect change.

Simulation-based power analyses, which test the ability of different sampling designs and approaches to detect trends, were conducted for a range of morphospecies under different future scenarios of change. It was found that for more abundant morphospecies (> 0.5% cover) changes of fifty percent could be detected at the site level. Where morphospecies occurred across several sites, marine park-level changes could be detected for less abundant species by combining the data across multiple sites. This indicates that widespread morphospecies are likely to prove to be better indicators. Incorporating estimates of the variability seen in the time series to date into longer term simulated trajectories highlighted that morphospecies with higher short-term variability were likely to take a lot longer to detect changes in than those that were relatively stable. Also, simulations showed that while sampling every year would allow change to be detected in less time, less frequent revisits were still capable of detecting change.

Key recommendations from this project include:

- A list of suggested SE Network-wide and marine park-level indicators based on the knowledge gained through this project

- That short-term trends found for morphospecies in this project be investigated with future monitoring data to confirm whether significant trends continue in the long-term

- That the targeted scoring approach trialled in this project be adopted as the preferred method for individual morphospecies indicators due to the improvements in the ability to detect change for minimal additional extra scoring time

- Further exploration of the correlation between observed changes and environmental data such as warming events be investigated in order to better understand drivers of change and indicators that are suitable to track those changes

- Effort is made to score currently unscored sites to establish the spatial extent and abundance of morphospecies to aid in assessing their suitability as indicators

- The modelling and simulation approaches outlined in this report be continued and updated with new monitoring data to test whether currently identified trends continue and to adapt monitoring designs, and

- Consideration and identification of reference sites be made for future monitoring efforts to allow comparison of management actions in marine parks with outside areas.

Table E1 – Summary of sites that formed part of the project, including descriptions of habitat and scoring completed. Details of all AUV sites across the SE Network are given in Appendix A

Marine Park	Site Name	Depth (m)	Habitat	When surveyed	Scoring completed	Fauna description
Huon	Huon Marine Park site 1	45-71	Extensive twilight rocky reef; sufficient light to support algal communities	2009, 2010, 2014	100 images with point count scoring each year	Diverse invertebrate communities, including sponges, bryozoans, gorgonians and colonial anenomes; Extensive encrusting coralline algae; Southern rock lobster common in imagery
Huon	Huon Marine Park site 1	45-71	Extensive twilight rocky reef; sufficient light to support algal communities	2009, 2010, 2014	100 images with point count scoring each year	Diverse invertebrate communities, including sponges, bryozoans, gorgonians and colonial anenomes; Extensive encrusting coralline algae; Southern rock lobster common in imagery
Huon	Huon Marine Park site 2	47-72	Extensive twilight rocky reef; sufficient light to support algal communities	2009, 2010, 2014	200 images with point-count scoring each year	Diverse invertebrate communities, including sponges, bryozoans, gorgonians and colonial anenomes; Extensive encrusting coralline algae; Southern rock lobster common in imagery
Freycinet	Freycinet MP Site 2	93-100	Sand dominated below the photic zone (dark), with low relief structure typically covered with a veneer of sand	2010, 2012, 2014, 2016	100 images with point count scoring each year.	Sand dominated region with invertebrate fauna attached to patchy areas of hard substrate including underlying shell beds; dominated by bryozoa/sponge mixed communities.
Flinders	Flinders North West	41-45	Sand dominated twilight reef with patchy areas of hard substrate and low relief features	2013, 2017	100 images with point count scoring each year.	High biodiversity site with a wide variety of sessile invertebrates including gorgonians, soft corals, sponges and bryozoans; large Mopsella gorgonian species likely to be of high conservation value.

Marine Park	**Site Name**	**Depth (m)**	**Habitat**	**When surveyed**	**Scoring completed**	**Fauna description**
Flinders	Flinders Outer Patch Reef	75-94	Sand dominated twilight reef with patchy areas of hard substrate and prominent ledge features which are often sand inundated	2011, 2013, 2017	100 images with point count scoring each year.	Diverse invertebrate community including cup sponges, erect branching sponges, encrusting sponges, gorgonians, ascidians and bryozoans
Flinders	Flinders Canyon Grids North	112-18	Dark reef with flat sandy areas punctuated with high relief rocky walls and boulders	2011, 2013, 2017	100 images with point count scoring each year.	Invertebrate fauna includes a diverse range of sponge species, hard and soft bryozoans and soft corals.
Flinders	Flinders Shallow Grids	62-78	Sand dominated twilight reef with areas of hard substrate including underlying shell beds	2011,2013, 2017	100 images with point count scoring each year.	Invertebrate fauna includes a diverse range of sponge species, gorgonians, hydroids and sea whips.

Introduction

The Institute for Marine and Antarctic Studies (IMAS) and the Integrated Marine Observing System (IMOS) have been undertaking photographic surveys of benthic (seabed) marine biota and habitats in the South-east (SE) Marine Region over the past 12 years using an Autonomous Underwater Vehicle (AUV). These surveys incorporate sites inside marine parks of the SE Network; including Beagle, Flinders, Freycinet, Huon and Tasman Fracture Marine Parks as part of a wider program monitoring changes in coastal and shelf seabed ecosystems. The AUV is used to conduct repeat photographic transect-based surveys in depths beyond SCUBA limits, and in many instances the imagery produced by these surveys has enabled the first initial quantitative description of the flora and fauna of deep coastal/shelf habitats in these areas. Repeat surveys have now been conducted across many marine park sites, providing the opportunity to develop an initial analysis and understanding of the extent that biological assemblages and individual species change in these systems over the sampling period to date (up to ten years). Currently there is little understanding regarding the extent of natural variability across deeper reef systems in the SE Marine Region, information that is critical to identifying changes associated with long-term pressures and protection and interpreting observed changes in the context of natural year to year variation and helping identify suitable indicators for change across these systems.

An understanding of variability is crucial for long-term monitoring programs that aim to detect change, as variability that is not due to the trend of interest will make detecting that change more difficult. For monitoring programs that span multiple sites through time, such as the current AUV program, variability can come from several sources, which at a minimum include:

(i) between site differences (e.g. some sites have higher abundances than others or more suitable habitat)

(ii) trends through time that are the focus of the monitoring program (e.g. a decline in species abundance due to climate change or recovery due to protection)

(iii) inter-annual or other short-term fluctuations that are not due to the trend of interest (e.g. recruitment variability or other natural fluctuations; often referred to as natural variability), and

(iv) residual variance that may come through other sources such as sampling error (Larsen et al. 2001, Urquhart 2012, Perkins et al. 2017).

For even the best-designed monitoring programs, if sources of variability that are not due to the trend of interest are large, detecting change may be impractical or take a very long time at best. For deeper reef systems, on which this study is focused, knowledge of “natural” or “baseline” rates of change is often lacking. Such changes could be due to factors such as the life history parameters of individual species such as growth and fecundity, variability in recruitment events, and the cycles on which disturbance events such as storms occur and rates of recovery from such disturbances. Typically, the only component that will be under the control of management decisions will be choices that affect residual variance, such as those around levels of sampling, the revisit plan in terms of which sites to visit and how often, and the choice of appropriate indicators for change. Therefore, gaining an understanding of variability and how it may affect monitoring outcomes is key in the early stages of establishing monitoring programs as it can help direct resources and make decisions such as the choice of indicators that will affect longer term outcomes.

Selecting appropriate indicators provides a challenging task for deeper water ecosystems where knowledge of baseline variability and likely levels of response to pressures of interest is typically lacking (Hayes et al. 2015). Ideally, indicators should be characteristic of a region or habitat being monitored, respond predictably to a pressure of interest, have low natural variability and be sufficiently abundant that sampling variability introduces minimal additional noise (Noss 1990, Niemi and McDonald 2004). As the SE marine region is a global warming 'hotspot' (Ridgeway 2007, Oliver et al. 2018), the impacts of warming or marine heatwave events (see Oliver et al. 2018) are of particular concern. Also, coupled with large-scale temperature change is the potential for more frequent and/or intense storm events under global climate change. In reporting on the effectiveness of protection, potential recovery from previous fishing pressures such as the impacts of trawling or potting on benthic habitats and species is another trend that is likely to be important to track. For some pressures potential indicators may be more apparent. For example, trawling is likely to have an impact on all structure forming species, and thus these may be expected to recover when this pressure is removed. However, growth rates are likely to differ for different species leading to different rates of recovery. Indicators for the impacts of warming may be more difficult to predict, but evidence from elsewhere in the world shows that temperate octocoral species and some sponges may be particularly susceptible to warming events, with mass mortalities linked to warming in the Mediterranean (Garrabou et al. 2009). However, impacts of warming events may be difficult to predict as different species are likely to have different tolerances to warming and different life history traits linked to different rates of recovery.

Tracking trends in the abundance of key species is at the core of an effective monitoring program (Noss 1990). Individual species are likely to respond to pressures in a more predictable manner based on their inherent biological traits. For example, growth rates or responses to temperature changes are likely to be more consistent for a species, introducing less noise when tracking trends through time than if multiple species are grouped. For marine imagery, identifying to the species level is often unachievable as identifying features may not be discernible from imagery alone. This is particularly the case for imagery scored from deeper waters, where there is likely to be species that are currently not described. For this reason, all biota in this project were scored to the "morphospecies" level, which is the finest taxonomic level achievable with imagery, whereby individual taxa are discerned through morphological characteristics. Morphospecies level scoring is nested within the Collaborative and Automated Tools for Analysis of Marine Imagery (CATAMI) classification scheme (Althaus et al. 2015). This allows for the potential to group morphospecies into lower resolution categories that may provide alternative indicators for ongoing monitoring. This project provides the first quantitative description of the distribution and abundance of these morphospecies within and between marine parks, information that is important for how they may be used as indicators.

Power analysis is a keystone to an effective monitoring program as it allows a determination of the level of sampling effort required to detect changes due to management actions or perturbations of interest. Such an assessment can help managers decide where to best direct resources, including the sampling effort necessary in terms of within site sampling, the number of sites and the temporal revisit plan. These various scenarios have a complex interplay, and simulation-based approaches are preferred for power analyses of monitoring programs as they allow different components of variance to be examined in isolation or combination along with different scenarios of possible change (e.g. Perkins et al. 2017, Perkins et al. 2018, Andersen et al. 2019). Information gained from earlier surveys about baseline rates of changes can also be incorporated into such simulations. Such analyses therefore allow the trade-offs between different sampling designs to be assessed and determine whether changes are likely to be detected for various indicators.

The vast amount of imagery collected by AUVs has been demonstrated to be capable of detecting ecologically important trends in benthic communities (e.g. Perkins et al. 2020a); however, methods are still being developed and the cost-benefits of the various means of allocating sampling effort through space and time still needs further assessment. Scoring of imagery is currently carried out by human annotators, with random points on an image being classified into different morphospecies to build up a percentage cover (an index of abundance) of each morphospecies across the surveyed area. This process is time-consuming and often a bottleneck in turning collected imagery into useable information. Typically, only a small percentage (approximately 5-10%) of imagery is scored for each site and survey period. Scoring of additional imagery provides more information, thereby increasing the statistical power to detect changes through time. It is important to understand the implications of additional scoring on the ability to detect change as this can aid in the direction of future efforts. Furthermore, alternative scoring approaches may provide a way to achieve higher statistical power to detect changes. For example, scoring either total counts or the presence or absence of a smaller subset of identified key morphospecies across all images may allow detection of changes with higher power and less overall scoring time than a point scoring approach.

This project aims were to:

(i) conduct the necessary scoring (annotation) of imagery required to examine changes through time

(ii) analyse the time-series of imagery, providing a description of the biota in each marine park and the magnitude of any changes that have occurred over the survey period, and

(iii) make recommendations for the ongoing monitoring of the benthic communities in the SE Network, including the selection of appropriate indicators and the likely sampling and survey effort required into the future to be able to detect biologically meaningful change.

Project outputs

Key project outputs are:

- A review of the knowledge gained to date about the extent of habitats and key flora and fauna within survey sites at each marine park
- An analysis of temporal changes for key species, communities and associated metrics across the survey time period within each marine park
- Power analysis of potential indicators for ongoing monitoring of each marine park and recommendations regarding the sampling intensity and survey frequency likely to be required to inform the Australian Marine Parks Monitoring, Evaluation, Reporting and Improvement (MERI) system
- Provision of public outreach material including imagery of key biota in each marine park and an article for the Australian Marine Parks Science Atlas

1 Methods

1.1 Overview

This project provides an overview of the time-series of surveys utilising the IMOS AUV facility in the SE Network undertaken to date, identifies important morphospecies and assemblages within each marine park and provides statistical analyses of the resultant time-series of data. While some historical annotation (i.e. scoring) of imagery existed, a significant amount of additional scoring was undertaken to ensure sufficient data was available to conduct analyses of changes through time. The project followed procedures outlined in the standard operating protocol (SOP) for monitoring with AUVs developed by the National Environment and Science Program (NESP) Marine Biodiversity Hub. This included the annotation of all imagery within the online Squidle+ platform which provides open access to all data collected during the project.

1.2 Mapping

Maps were produced using QGIS software to visualise the location of AUV deployments (transects) within each marine park through time. Where statistical analyses revealed significant trends in the cover of morphospecies, detailed maps were also produced showing changes in cover through time. Detailed site level maps were also produced for sites and morphospecies where targeted scoring (see below) was conducted.

1.3 Scoring

A single AUV deployment typically collects 5000 – 10000 images at a site. Many of these images will overlap, but even subsetting to non-overlapping images (e.g. every fifth image) typically results in 1000 – 2000 scorable images. Depending on the amount of hard substrate at a site, a subset of 100 images will typically result in less than 20% of potentially scorable images being annotated. To test the impact of the level of scoring on results three annotation approaches were compared: (1) initial baseline scoring; (2) additional scoring; (3) targeted scoring.

1.3.1 Initial baseline scoring

For initial baseline scoring of each site, it was decided that the focus should be on obtaining a minimum of 100 randomly selected images that contain reef across all transects at each location where repeat data is available. Images were selected randomly, and images that were completely soft sediment were skipped until the target of 100 images was reached. Any image that contained reef or biota associated with hard substrate was included. Each scored image was annotated with 25 random points in the online Squidle + annotation software. This decision was based on previous work (see Perkins et al. 2016) that suggested this level of scoring is likely to be the minimum required to quantify the less rare biota with reasonable precision.

1.3.2 Additional and targeted scoring

To test the impact of additional point scoring, single sites in Flinders, Freycinet and Huon Marine Parks were annotated with an additional 100 images with 25 random points for each survey year across the time-series, creating a total of 200 images for each year at these sites.

To test the impact of targeted scoring, for a subset of "key" morphospecies identified at two of these sites, detailed scoring across all non-overlapping images (i.e. subset to every fifth image) was undertaken. Upon discussion with Parks Australia, it was decided that the sites for additional scoring and targeted scoring were:

- Flinders Marine Park: Western Boundary site due to high diversity and potential change noted in condition of cup sponges and the observed decline in the bramble coral (likely to be *Asperaxis kareni*) over the time series. Detailed scoring involved the count of all red cup sponges and the tagging of cup sponges that exhibit > 50% bleaching, and the counting of all bramble coral colonies within images.
- Freycinet Marine Park: Joe's Reef site due to high diversity and previous research conducted at this site. Target species for detailed scoring are large black octocorals and massive purple sponges.
- Huon Marine Park: Huon site 2 to provide a southern example site that is shallower and contains a mixture of invertebrate and algal species. Only point scoring of an additional 100 images at each time point was conducted here.

The time taken to complete these tasks was also recorded so that a cost-benefit analysis could be conducted and the various trade-offs with the different approaches compared.

1.4 Data analysis

1.4.1 Description of sites and biological communities present

A combination of examination of the raw percent cover data and multivariate analysis was used to provide a general quantitative description of the habitats and flora and fauna within each marine park site, identification of key dominant morphospecies, and any morphospecies that are likely to be of high conservation value. Natural values definition used by Parks Australia are used to describe the habitats, where "twilight reefs" refer to reefs on the continental slope where light penetration is greatly reduced (between 30 and 70 m), and "dark shelf reefs" refer to reefs below the mesophotic zone (typically 70 – 200m).

As a general description, details of the top 30 morphospecies scored at each site are provided, along with species accumulation curves for each site. "Biological matrix" categories (e.g. bryozoa/cnidaria/sponge matrix) were excluded from this description as they were typically dominant and made it difficult to plot other morphospecies on the same scale. Instead the percent cover of biological matrix categories at each site are provided in the written description.

Species accumulation curves plot the number of species recorded against the number of images scored and were calculated across the entire time-series of point scoring data at each site. Therefore, at sites where additional point scoring was conducted, additional images were available to produce the curves. These curves show how well the level of scoring is capturing the biodiversity (in terms of species richness) at each site. Ideally these curves should show an asymptote, with curves still climbing indicating further effort is required to adequately describe a site.

A multivariate analysis using PRIMER v6 software was conducted to allow the comparison of assemblages within and between marine parks over time. A multivariate multi-dimensional scaling (MDS) plot was produced to allow visualisation of how assemblages within sites through time grouped together in multivariate space. Similarity percentage (SIMPER) analysis was used to examine the characteristic morphospecies for each site and how they compare across sites.

1.4.2 Comparison of variability of individual morphospecies across the time series to date

To compare the variability observed in the cover of morphospecies seen to date a measure called population variability (PV) was used. PV, developed by Heath (2006) provides a method of examining variability in population abundance over time that allows comparisons among populations experiencing different dynamics. Alternate measures such as the coefficient of variation (CV = mean/standard deviation) measure departures from the mean abundance in the time series, thereby making the assumption of a normal (Gaussian) distribution in abundance over time. However, biological populations often undergo extreme fluctuations and rare events, in which case the mean will not reflect abundance in any given year. PV on the other hand doesn't make this assumption and has been demonstrated to be more robust to non-Gaussian behaviour and to also be more appropriate for quantifying variability in short time series (Heath 2006).

PV is calculated by considering all pair-wise comparisons, C, between sampling events in a time series:

$$C = \frac{n(n-1)!}{2}$$

Then, for each pairwise comparison in time steps z_i and z_j the difference function $D(z)$ is calculated:

$$D(z) = 0 \text{ if } z_i = z_j$$

$$D(z) = 1 - \frac{\min(z_i, z_j)}{\max(z_i, z_j)}$$

In this way the abundances at every time step are compared, yielding a distribution of proportional differences $D(z)$. Finally, the average is taken over the time series to yield PV:

$$PV = \frac{\sum_z D(z)}{C}$$

PV values are between zero, indicating complete stability and approach 1 as differences in population sizes through time approach infinity. As PV uses proportions, the values are independent of the mean (i.e. average abundance/cover) and allow comparison of variability across morphospecies with different covers.

PV was calculated for a subset of morphospecies within each marine park. Model-based estimates of cover (see section below) were used rather than estimates from the raw data as these estimates take into account sampling across depth and in space (i.e. spatial correlation) which is particularly important where sampling covered different spatial extents (e.g. in Huon Marine Park). 0ne thousand joint posterior sample draws for the fixed effects of the intercept (mean), year and depth coefficient estimates were taken from the model outputs, and the average cover calculated for each year sampled was then used for the z values for calculating PV. Posterior samples from a Bayesian model (see below) allow the exploration of the range of possible estimated coefficient values.

1.4.3 Analysis of temporal trends for dominant morphospecies

Multivariate analysis of trend

To test for any significant overall changes in assemblages within marine parks over the survey period, a permutational multivariate analysis of variance (PERMANOVA) test in PRIMER v6 software was conducted. For this analysis, factors of "year" and marine park (AMP) were considered. PERMANOVA was used to compare the groupings of AMP and year to test whether the centroids for each year/AMP combination are equivalent. Significance was determined at the p = 0.05 level.

Model-based estimates of trend

Prior work has highlighted that most species scored in AUV imagery are rare (i.e. not recorded very often). Tracking trends in the cover of morphospecies that are rare is problematic as considerable noise is introduced in quantifying the cover within any given survey period. Previous research has suggested that morphospecies with > 0.5% cover are likely to provide higher power for detecting meaningful biological changes (e.g. Perkins et al. 2016, Monk et al. 2018). Therefore, for this project analysis of temporal trends in individual morphospecies was focussed on more dominant morphospecies, with site-level cover of at least 0.5% for at least one year during the survey period. This resulted in a short list of 37 morphospecies (Table 2.4.1). For analysis, all soft bryozoans were merged as preliminary analysis highlighted similar site level trends and there was sometimes difficulty in identifying different colour morphs due to lighting.

Table 1.4.1 List of 37 morphospecies for which analysis of temporal trends within each marine park were conducted. All species included had at least 0.5% cover within a site in a survey period. Bryozoa soft were merged for analysis. Details of the marine parks and number of sites where the morphospecies was found to be present are provided. Example images of each morphospecies is provided in section 3.4.

Morphospecies	Marine Parks where present (number of sites present)
Arborescent Grey Sponge	Huon (2), Freycinet (1), Flinders (4)
Arborescent Orange Sponge	Huon (2), Freycinet (1), Flinders (5)
Arborescent Orange Thin Sponge	Huon (2), Freycinet (1), Flinders (5)
Ascidian Colonial Purple	Freycinet (1)
Bramble Coral	Freycinet (1), Flinders (5)
Branching Gray Fine Repent Like	Huon (2), Freycinet (1), Flinders (3)
Bryozoa Soft (all morphospecies merged)	Huon (2), Freycinet (2), Flinders (5), Beagle (1)
Bryozoa Stumpy Hard	Freycinet (1), Flinders (4)
Calcareous Encrusting Red Algae	Huon (2)
Coral Orange Solitary (Caryophyllia like)	Freycinet (1), Flinders (4)
Cup Red Smooth	Huon (2), Freycinet (1), Flinders (4)
Cup Yellow	Huon (2), Freycinet (1), Flinders (5)
Encrusting Beige Oscula	Huon (2), Freycinet (2), Flinders (5), Beagle (1)
Encrusting Beige Smooth	Huon (2), Freycinet (2), Flinders (5), Beagle (1)
Encrusting Black	Huon (2), Freycinet (2), Flinders (5)
Encrusting Blue	Huon (2), Freycinet (2), Flinders (3)
Encrusting Light Orange	Huon (2), Freycinet (1), Flinders (5)
Encrusting Orange	Huon (2), Freycinet (2), Flinders (5)
Encrusting Purple Lumpy	Huon (1), Freycinet (1), Flinders (4), Beagle (1)
Encrusting White	Huon (2), Freycinet (2), Flinders (5), Beagle (1)
Encrusting Yellow Smooth	Huon (2), Freycinet (2), Flinders (5)
Epizoanthus sp.	Huon (2), Freycinet (1), Flinders (1)
Fan Pink	Huon (2), Freycinet (1), Flinders (5), Beagle (1)
Gorgonian Red	Huon (2), Freycinet (1), Flinders (4)
Hydroid White	Huon (1), Freycinet (2), Flinders (4), Beagle (1)

Lumpy White	Huon (2), Freycinet (1), Flinders (4), Beagle (1)
Massive Blue Shapeless	Huon (2), Freycinet (1), Flinders (4)
Massive Purple	Huon (2), Freycinet (1), Flinders (3), Beagle (1)
Non-Calcareous Encrusting Red Algae	Huon (2)
Palmate Grey	Huon (2), Freycinet (1), Flinders (4)
Purple Massive	Huon (1), Freycinet (1), Flinders (3)
Repent Orange	Huon (2), Freycinet (1), Flinders (5)
Repent Yellow	Huon (2), Freycinet (2), Flinders (5), Beagle (1)
Simple Beige Lumpy	Huon (2), Freycinet (1), Flinders (3), Beagle (1)
Simple Beige Lumpy Shapeless	Huon (1), Freycinet (1), Flinders (5), Beagle (1)
Unstalked Crinoids	Huon (1), Freycinet (1), Flinders (1), Beagle (1)

Previous research has shown that statistical modelling of AUV imagery needs to account for the fact that data collected as images from repeat transects across time and space are unlikely to be independent (Perkins et al. 2018, Perkins et al. 2020a). Therefore, models that can account for the spatial and temporal correlation when assessing changes across time should ideally be used, otherwise conclusions drawn and confidence in those conclusions may be erroneous.

The approach taken here follows that outlined in Perkins et al. (2020a), with an adaption to binomial data. The models use each image collected in time and space as the basis for analysis, while accounting for the correlation in space and time between images. For these analyses all point scoring data was used, that is the initial baseline point scoring as well as the additional point scoring where it was conducted (but excluded the targeted scoring).

To assess temporal changes in the 37 morphospecies temporal change was assessed through two model specifications: (i) Linear trends across the entire SE Network (i.e. all marine parks), treating each marine park as a random factor in the model; and (ii) Linear trends within each marine park, treating sites within the park as a random factor. By treating marine parks and sites as random factors, the variation between marine parks and sites is accounted for while allowing the estimation of the overall trend. Depth was included as a covariate in all models as it is known to be an important driver for many marine species. All models assumed a binomial distribution for the data, that is, images represent a set of Bernoulli trials (the number of points) where successes are denoted by points falling on the morphospecies of interest. Therefore, results are on the log-odds scale, with coefficients estimating changes in the log-odds of presence. To estimate the magnitude of an effect the formula $(\exp(\beta_i) - 1) * 100$ can be used to calculate the percentage change in odds-ratio for the ith covariate.

The model output includes an estimate for the "year" effect with the sign (positive or negative) of the mean estimate indicating the direction of the estimated trend. Similarly, an estimate of the depth coefficient is provided. Note that the year trend estimated is a linear trend over the survey period. Non-linear trends, such as a low initial cover, a large increase in the middle time period and then low cover in the last survey (or vice-versa) may result in an overall non-significant linear trend.

Non-linear trends can be modelled but require more than the three time points that are currently available.

The model is Bayesian, which requires specification of prior distributions for each parameter. The same priors used in Perkins et al. (2020a) were used. The output of a Bayesian model provides posterior distributions for each parameter based on the prior distribution conditioned by the empirical data. Strong evidence of a trend is only given to parameter estimates that do not include zero in the estimated 95% credible interval of the posterior distribution. The further a distribution is away from zero (either positive or negative), the stronger the evidence for a trend. Posterior estimates are given for the fixed effects of the intercept (the overall mean), the linear year effect and the depth effect. To highlight where strong evidence for a positive or negative trend exists, those estimates are highlighted in red for a negative linear trend and green for a positive linear trend. Where the year effect is not highlighted there is no evidence for an overall or marine park trend in the data collected to date.

1.4.4 Power analysis

Power analysis is important for monitoring programs to ensure that sampling designs provide sufficient information to detect changes when they happen. For monitoring programs such as the AUV monitoring program the sampling design includes choices around: (1) within image sampling effort (the number of points used or the alternative scoring approach), (2) within site sampling effort (how many images scored), (3) the number of sites, and (4) the revisit plan to sites through time. The baseline or background variability of the abundance of an indicator will add further noise to the trend that the monitoring program is aiming to detect. Additionally, biologically meaningful trends are often uncertain without the knowledge of the natural cycles that an indicators abundance goes through. There is therefore a complex interplay between many factors that will affect the power to detect change, and it is impossible to test the interplay between all different combinations of these factors.

The power analyses conducted in this report are aimed to illustrate several plausible scenarios of change, and to test the ability of realistic sampling efforts to detect these changes. A simulation approach is taken, where information gathered from the scored data is used as the basis to project forward trends in the abundance of some example morphospecies. Sampling designs are then simulated to mimic potential sampling efforts and the resultant data is analysed in the same way as is done with the empirical data. When many simulations are run (e.g. 1000) then the proportion of simulations where the trend is detected can be used as a measure of statistical power. Typically, high statistical power is considered to be achieved at 80% with a significance (alpha) level of 0.05. That is, when the probability of making a type II error, in this case accepting that a null hypothesis of no change is true, is less than 20%. Therefore, in a simulation framework this equates to the proportion (ideally > 80%) of simulations where a simulated significant change is detected.

The scenarios tested were:

1. A 50% decline in cover from the last survey to the next survey, simulating for example removal following a storm event, for:
    a. Arborescent Grey sponges
    b. Arborescent Orange sponges
    c. The cover of all structure forming morphospecies including erect sponges, cup sponges and corals

2. A 75% decline over 30 years, simulating a gradual chronic decline within Flinders Marine Park for:
    a. Red Cup Smooth sponges
    b. Bramble Corals
3. Testing of between a 50% and 5% (in 5% increments) decline in cover of all structure forming species within Flinders Marine Park for all structure forming morphospecies in order to test what level of change could be detected with 80% power

For scenario 1, power was tested using both 100 and 200 images each year. Model-based estimates of cover from the final year of survey at each site were used as the basis for simulation. A random selection of images was selected along the transect line at each site representing a subsequent survey. Prediction of the probability of presence was then made using the spatial model at each randomly selected image location. The probability of presence was then adjusted by 50% to represent the new probability under a scenario of decline. 25 random binomial draws were then taken using this adjusted probability of presence, representing the use of 25 random points and thus simulating the binomial variability of point sampling. Models were then refit using the last survey and the simulated following survey, including a year effect. For each simulation it was tested whether the change was detected. A total of 100 simulations was used, and the proportion of times that a significant effect was detected was used as a measure of power. Models were fit for each site and also a marine-park-level model where data from all sites within each marine park was used to test whether a trend could be detected across all sites.

For scenario 2 an estimate of the temporal variability seen in the time series to date was incorporated into the simulation. Non-spatial generalised linear mixed models were used to do this. This was done as a larger number of simulations was required which would have made the computational demands of using the spatial models unfeasible. An estimate of temporal variance was made by modelling the time series of data at each site within Flinders Marine Park and setting year as a random effect. This makes the assumption that all variability seen to date is "baseline" and could be expected to be seen into the future. Once again, the last survey year at each site was used as a starting point. A random draw of the temporal variance was taken with a mean zero and standard deviation equal to the square root of the temporal variance. This was added (or subtracted) from the binomial probability, which was then adjusted by the simulated change. The simulated change was a linear 75% decline over 30 years, which equates to approximately 2.6% per year, with a 50% decline reached at year 20. 100 images with 25 points were simulated in each year. Using Flinders Marine Park allowed the model to be fit for each site and across all sites. Also, the power to detect the change was tested through time with a revisit schedule of every year, every 3 years and every 5 years. Models were fit at each simulated time-step, and whether a linear trend in time was detected was tested at each time, with the proportion of simulations at each time where an effect was found quantifying power. This time 1000 simulations were used as the non-spatial model made this feasible.

For scenario 3 200 images were used at each site within Flinders Marine Park. Model-based estimates of cover from the final year of survey at each site were used as the basis for simulation. A random selection of images was selected along the transect line at each site representing a subsequent survey. Prediction of the probability of presence was then made using the spatial model at each randomly selected image location. The probability of presence was then adjusted under a number of scenarios between 50% and 5% in 5% increments to represent the new probability under differing scenarios of decline. 25 random binomial draws were then taken using this adjusted probability of presence, representing the use of 25 random points and thus simulating the binomial variability of point sampling. Models were then refit using the last survey and the simulated following survey, including a year effect. For each simulation it was tested whether the change was detected. A total of 100 simulations was used, and the proportion of times that a significant effect was detected was used as a measure of power. Models were fit for each site and also a marine-park-level model where data from all sites within Flinders Marine Park was used to test whether a trend could be detected across all sites for the given level of change.

1.4.5 Analysis of targeted scoring data

For the targeted scoring data, a spatio-temporal model similar to that used for the point count data was employed. However, as the data from targeted scoring was count data (i.e. a counting of all individuals within each image), a Poisson regression was used rather than a binomial regression. Once again, a significant linear trend in abundance over the survey period was assessed through the posterior distribution of the fixed "year" effect.

1.4.6 Comparison of scoring approaches

At each of the targeted scoring sites data collected through a point count approach with 200 images, and a total count of all individuals allowed for a comparison of different scoring approaches. To compare these different approaches in terms of sampling effort, the targeted scoring data was reduced to the same number of images (i.e. 200 images). Where possible, the exact same images were used. However, as the targeted scoring images were a subset of every fifth image, and the point scoring images were a random selection, a perfect match could not always be made. In these instances the nearest image was used instead.

To compare the different approaches a simulation-based power analysis was again conducted. For each of the 2 morphospecies at each of the targeted scoring sites a 50% decline in cover was simulated as described above. 100 simulations were used to assess the power to detect the decline in cover. As the time taken to score using the different approaches was recorded, a comparison of what might be achieved in a comparable amount of time was also made.

2 Results

Results of analyses for each marine park are outlined below. First, maps of the AUV survey work conducted to date in each marine park are provided along with the scoring conducted during the project. A general description of each site is provided, including habitat and biological community descriptions and species accumulation curves. This is followed by multivariate analysis of community change through time and an analysis of the trends in dominant morphospecies within the time series within each marine park. Finally, the results of power analyses and the targeted scoring are presented.

2.1 Description of marine parks, sites, and biological communities present

2.1.1 Huon Marine Park

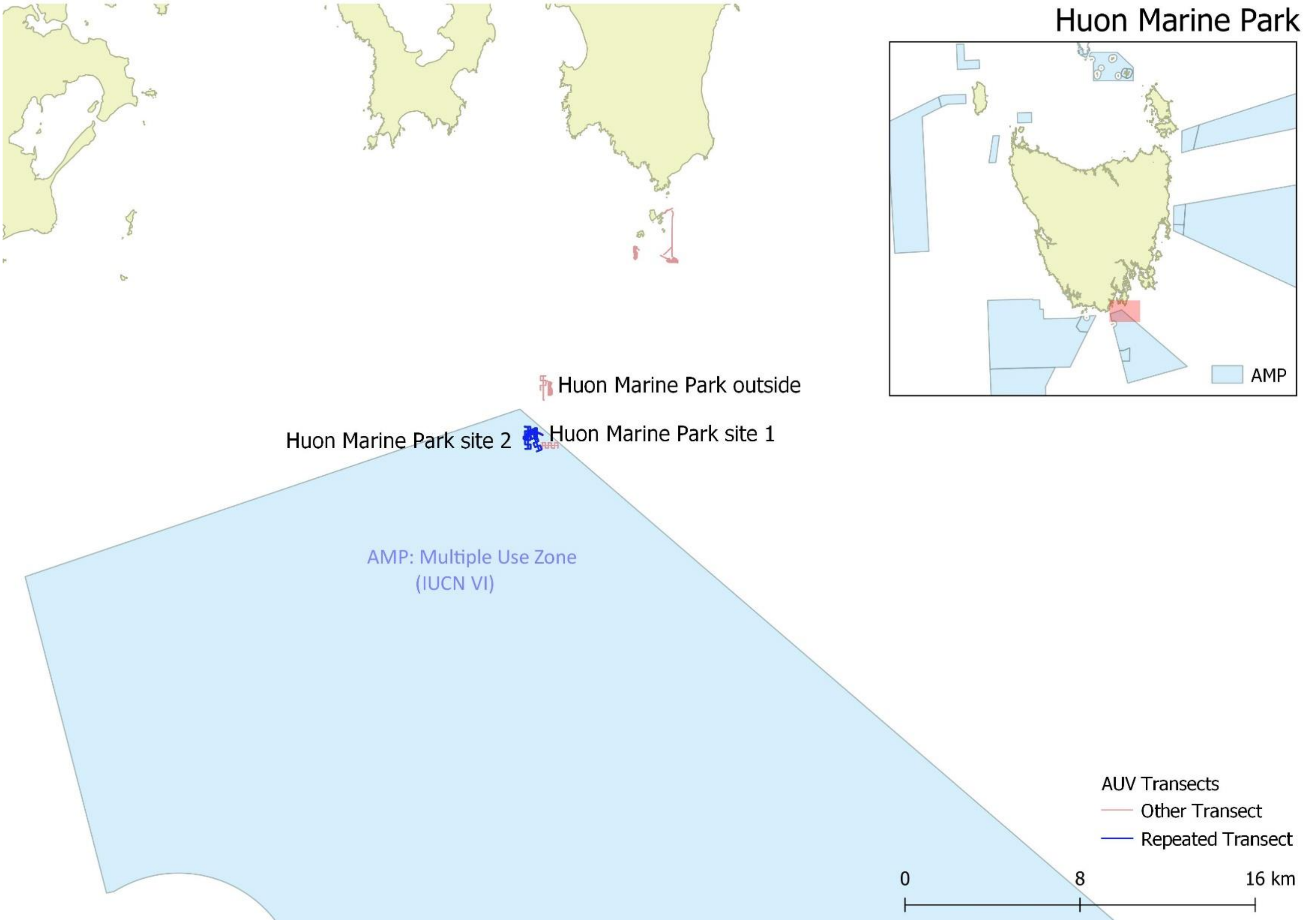


Figure 2.1.1 *Overview map of Huon Marine Park. Details of non-repeated transects not included in this study are given in Appendix A.*

2.1.1.1 Huon Marine Park site 1

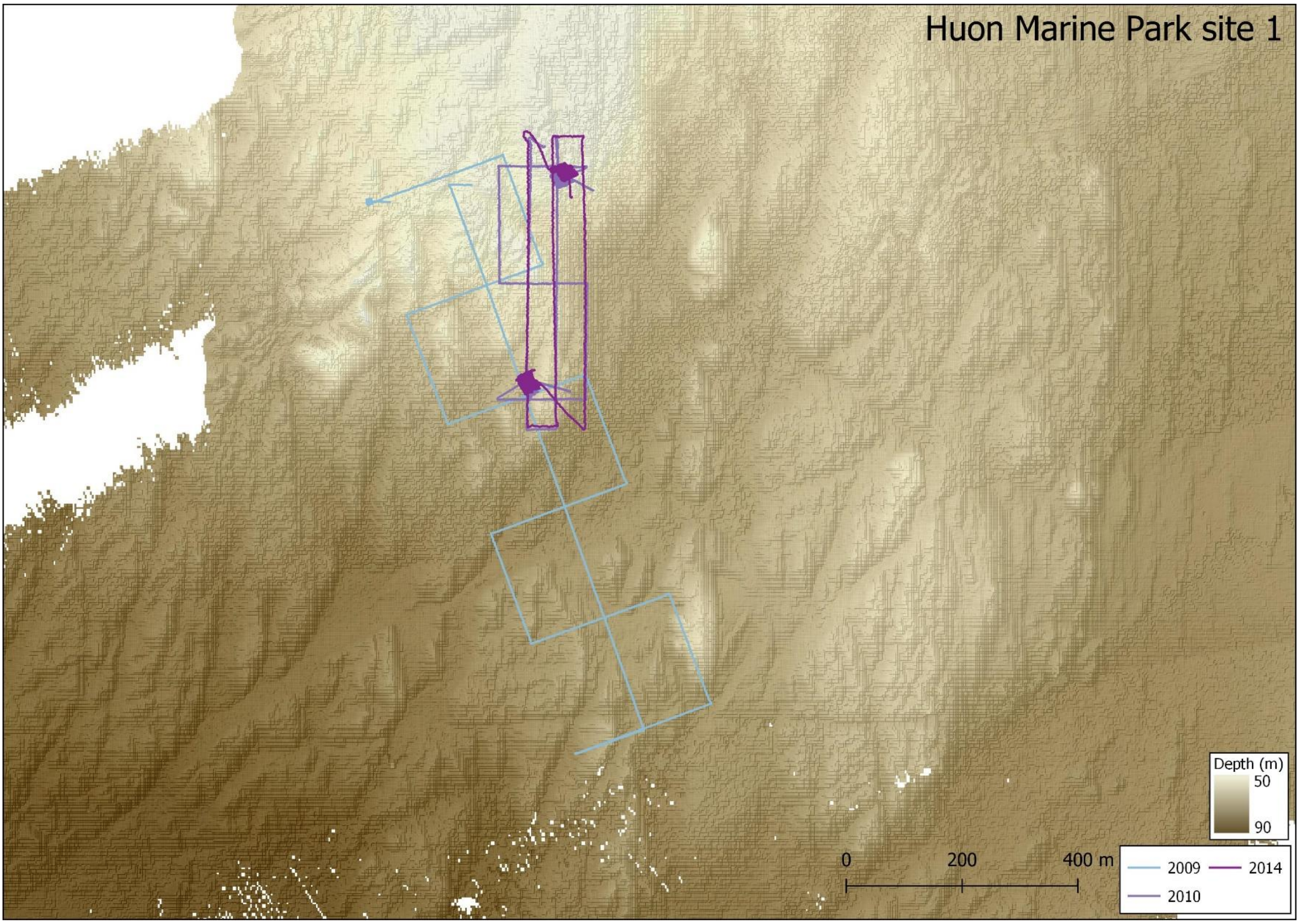


Figure 2.1.2 *Site level map of Huon Marine Park site 1.*

Description of habitat

Huon Marine Park site 1 is a twilight rocky reef (45 -71 m) with sufficient light to support algal communities. It is dominated by medium to high profile rocky reef interspersed with smaller sand patches. Large rock outcrops > 2m in height are present along with complex boulder habitat. The initial survey (2009) extends to greater depths (approximately 80 m), while subsequent surveys are focussed on the shallower portion of the site (45 - 60 m).

Description of biological community

This site is relatively shallow (45 – 70 m) and thus much of the reef receives sufficient light to support algal communities. Both calcareous and non-calcareous encrusting red alga form dominant components of the ecosystem along with soft bryozoans, small red gorgonian fans, colonial anemones and a wide variety of sponge morphospecies (Figure 3.1.3). Encrusting white sponge was very common throughout the survey period and was often seen as small flecks among the biological matrix. The physical height of many of the morphospecies was low compared to that seen in other marine parks. The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 57% over the time-series of data collected at this site. Example images from Huon Marine Park site 1 are contained in Appendix B.

Multivariate SIMPER analysis revealed that characteristic morphospecies for Huon Marine Park site 1 included encrusting algae, encrusting white sponge, red gorgonian, cup red smooth, palmate grey, laminar grey fungi and fan peach thick sponges.

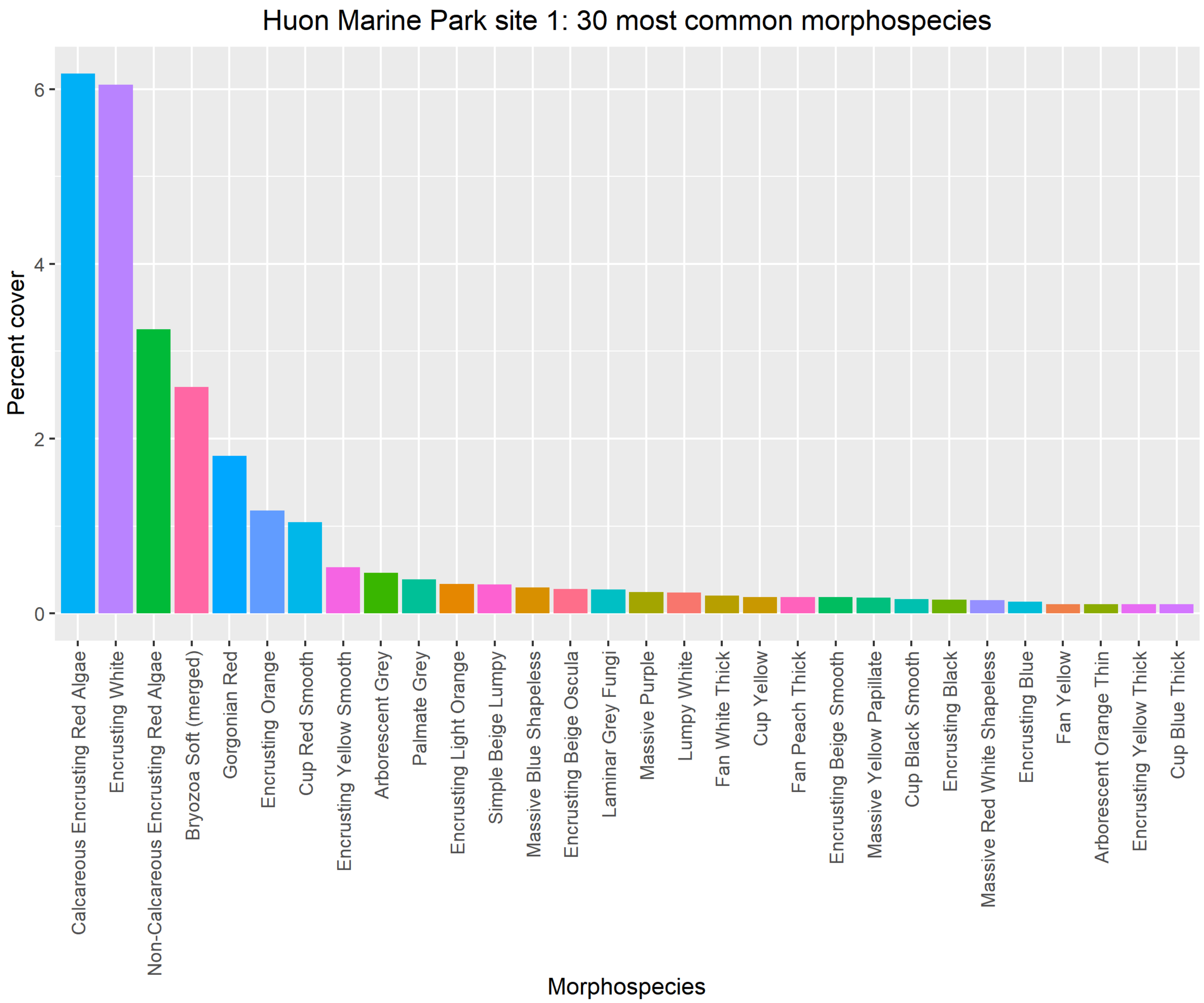


Figure 2.1.3 *Top 30 morphospecies scored at Huon Marine Park Site 1. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

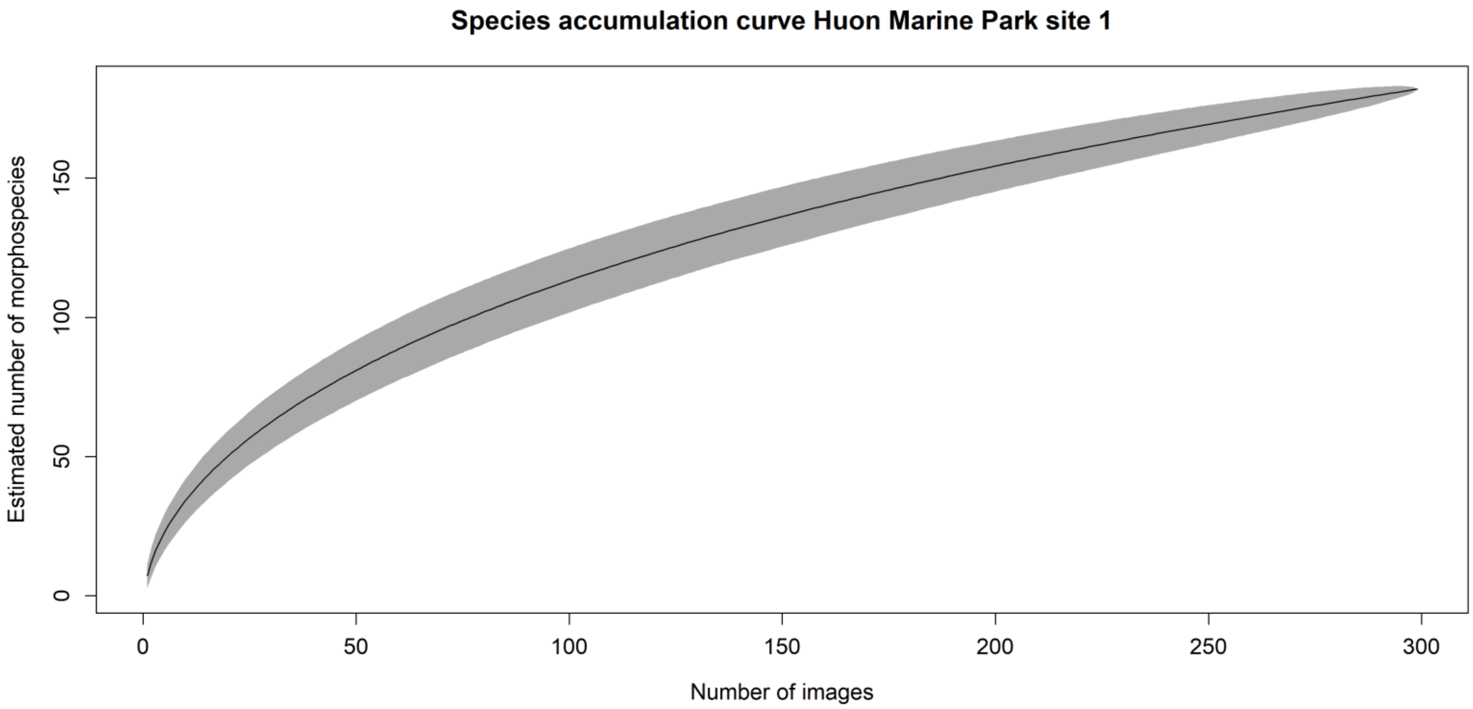


Figure 2.1.4 *Species accumulation curve for Huon Marine Park site 1.*

The species accumulation curve (Figure 3.1.4) reveals that the 300 images scored across time have captured a significant proportion of the species richness at this site. However, the curve is still climbing suggesting that there may be more than 200 morphospecies in total at this site.

2.1.1.2 Huon Marine Park site 2

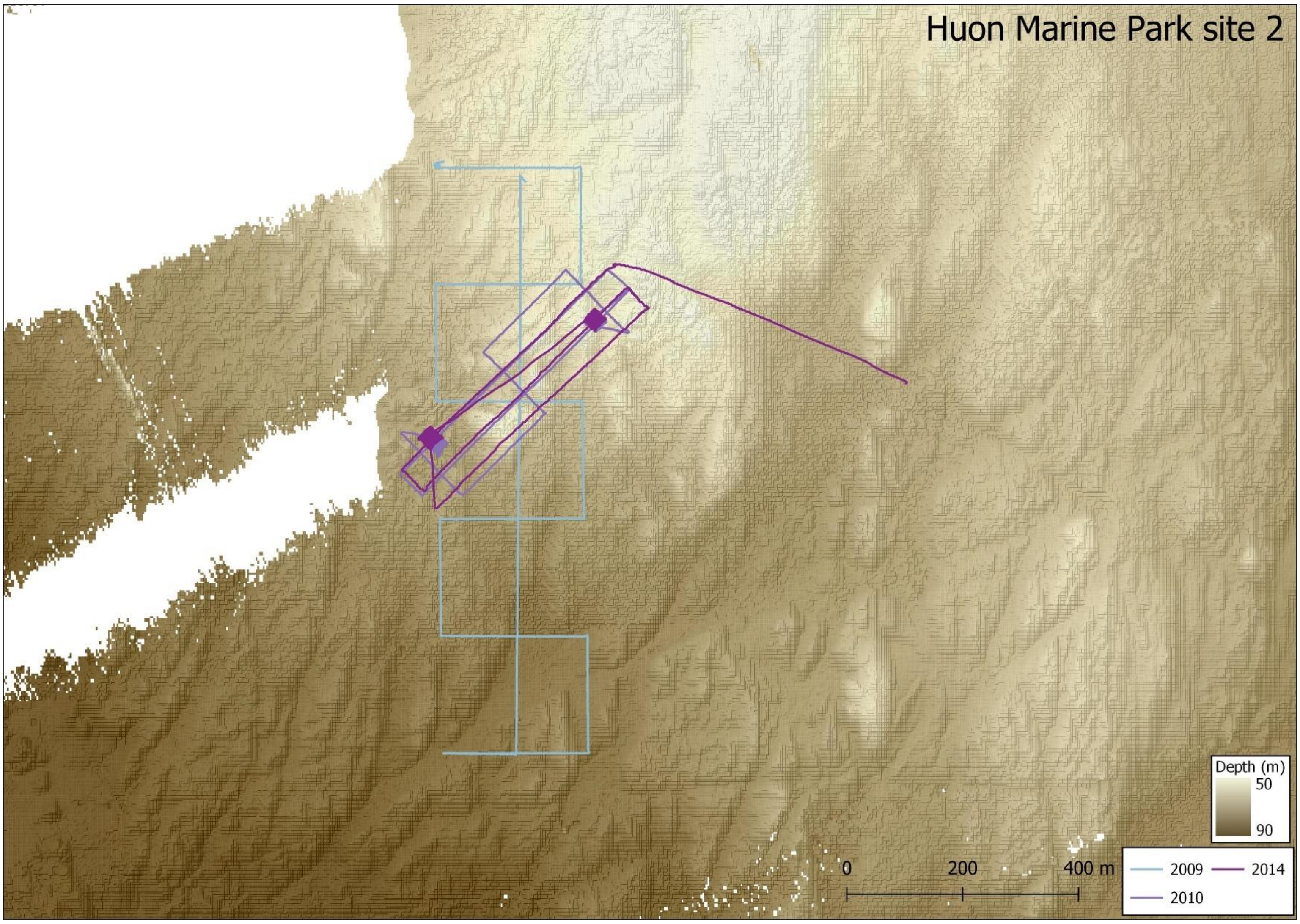


Figure 2.1.5 *Site level map of Huon Marine Park site 2.*

Description of habitat

Huon Marine Park site 2 is a twilight rocky reef (47 - 72 m) with sufficient light to support algal communities. Habitat is similar to site 1, and is also dominated by medium to high profile rocky reef interspersed with smaller sand patches. Large rock outcrops > 2m in height are present along with complex boulder habitat. The initial survey (2009) extends to greater depths (approximately 80 m), while subsequent surveys are focussed on the shallower portion of the site (45 - 60 m).

Description of biological community

The biological community at Huon Marine Park site 2 is similar to that found at site 1. This site is also relatively shallow (45 – 70 m) and contains significant cover of encrusting algal species. Both calcareous and non-calcareous encrusting red alga form dominant components of the ecosystem along with soft bryozoans, small red gorgonian fans, and a wide variety of sponge morphospecies (Figure 3.1.6). Encrusting white sponge was very common throughout the survey period, and had higher overall cover compared to site 1. The physical height of many of the morphospecies was low compared to that seen in other marine parks. The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 53% over the time-series of data collected at this site. Example images from Huon Marine Park site 2 are contained in Appendix B.

Multivariate SIMPER analysis revealed that characteristic morphospecies for Huon Marine Park site 2 were the same as for site 1, and included encrusting algae, encrusting white sponge, red gorgonian, cup red smooth, palmate grey, laminar grey fungi and fan peach thick sponges.

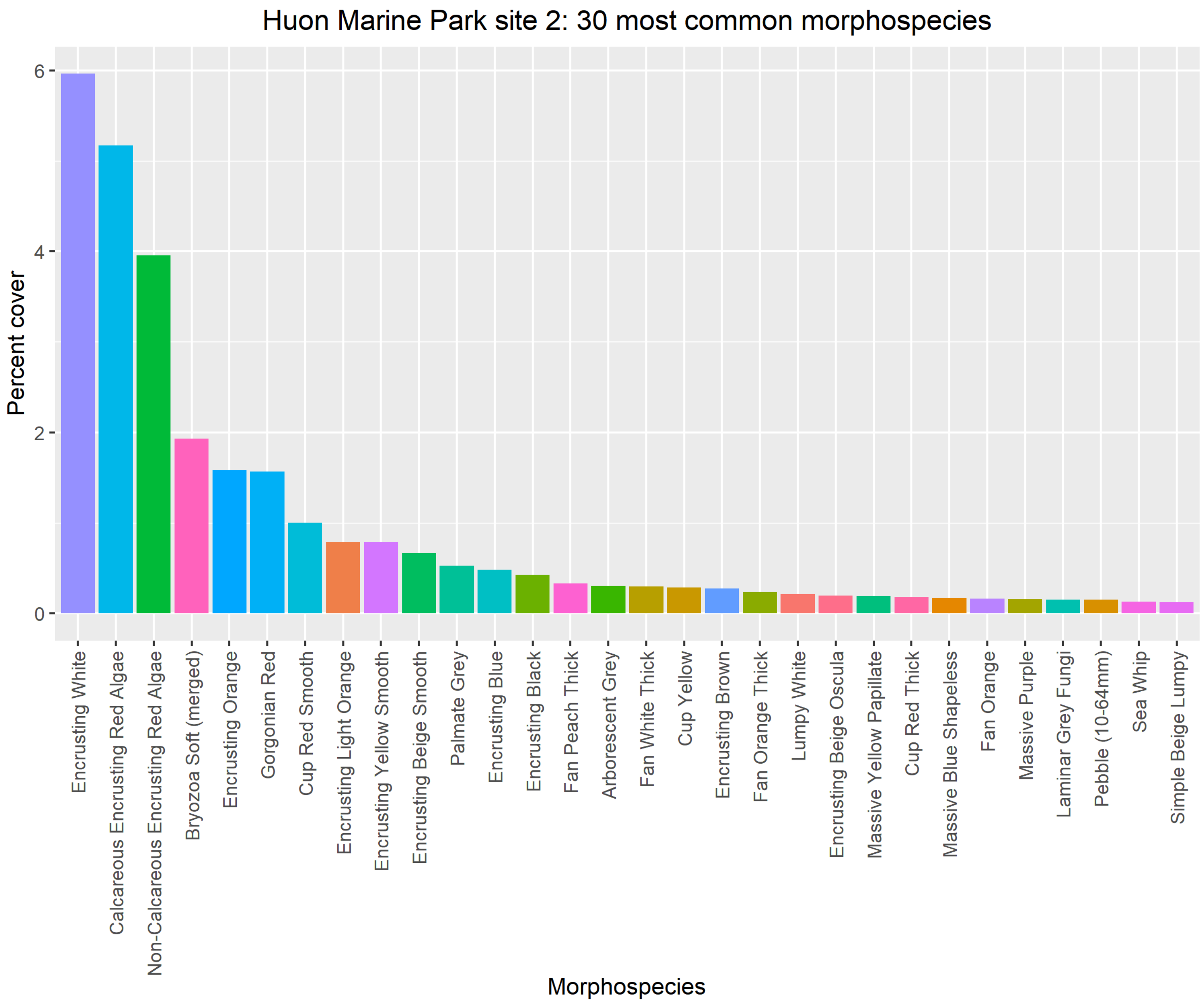


Figure 2.1.6 *Top 30 morphospecies scored at Huon Marine Park Site 2. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

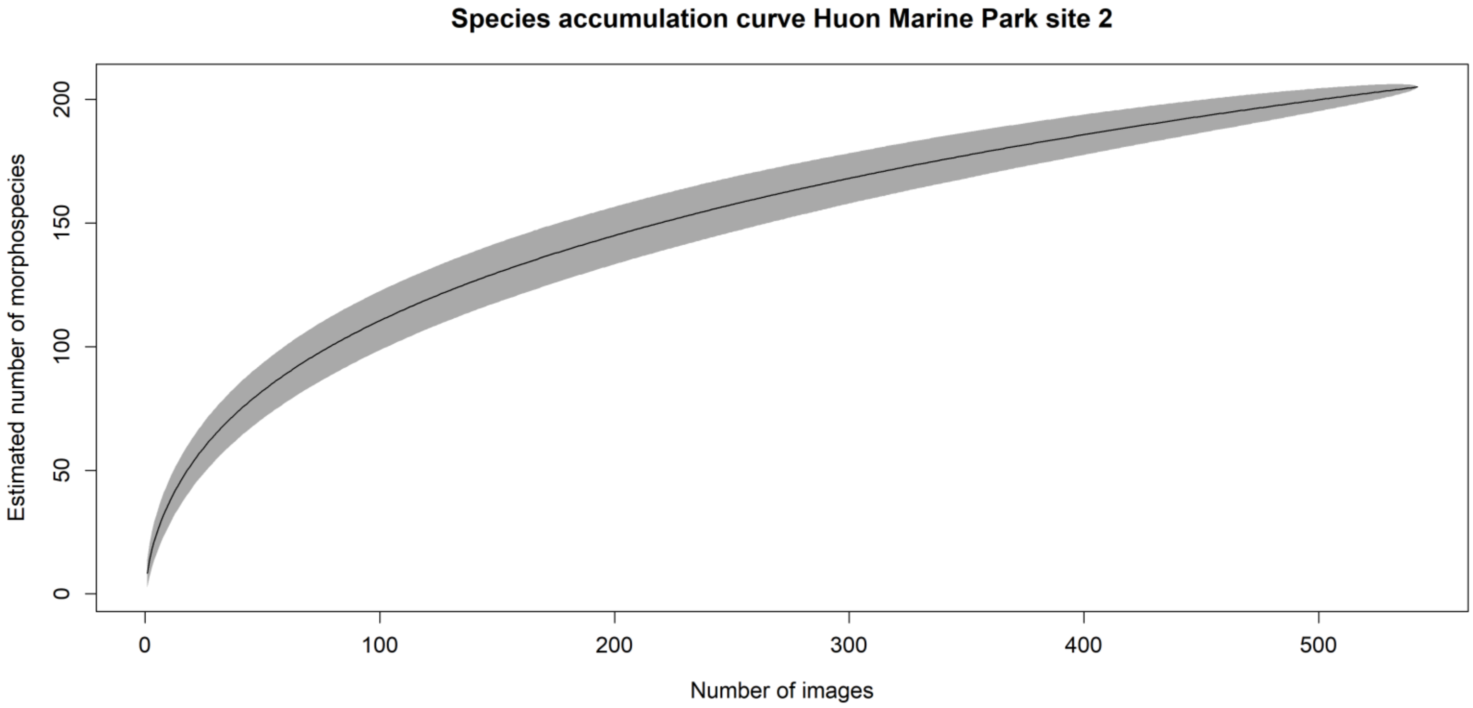


Figure 2.1.7 *Species accumulation curve for Huon Marine Park site 2.*

The species accumulation curve reveals that the 600 images scored across time have captured a significant proportion of the species richness at this site, with the curve beginning to asymptote and a total of around 200 morphospecies being observed (Figure 3.1.7). Given the similar species composition to site 1, it appears 700-800 images may capture most morphospecies within Huon Marine Park.

2.1.2 Freycinet Marine Park

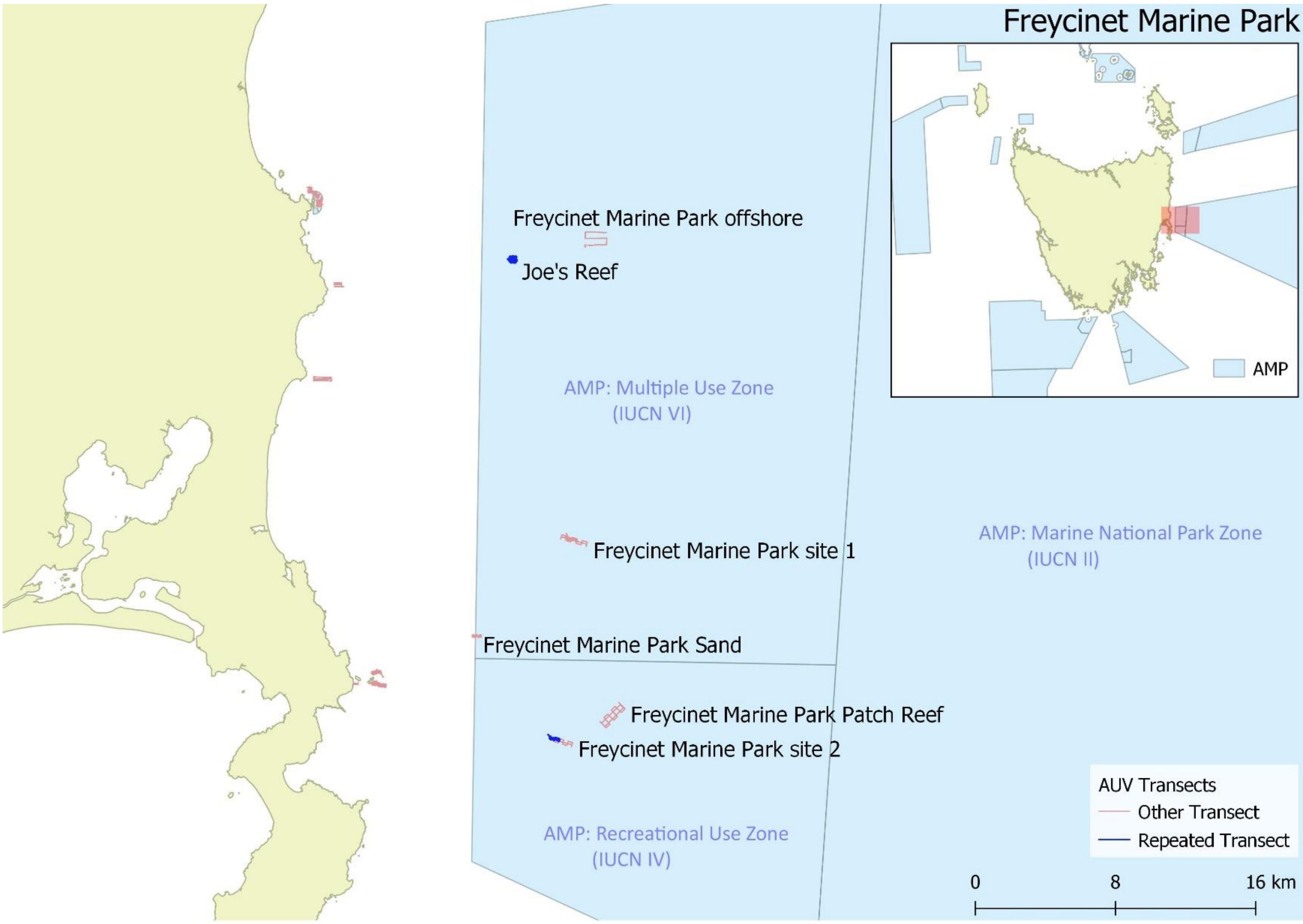


Figure 2.1.8 *Overview map of Freycinet Marine Park. Details of non-repeated transects not included in this study are given in Appendix A.*

2.1.2.1 Joe's Reef

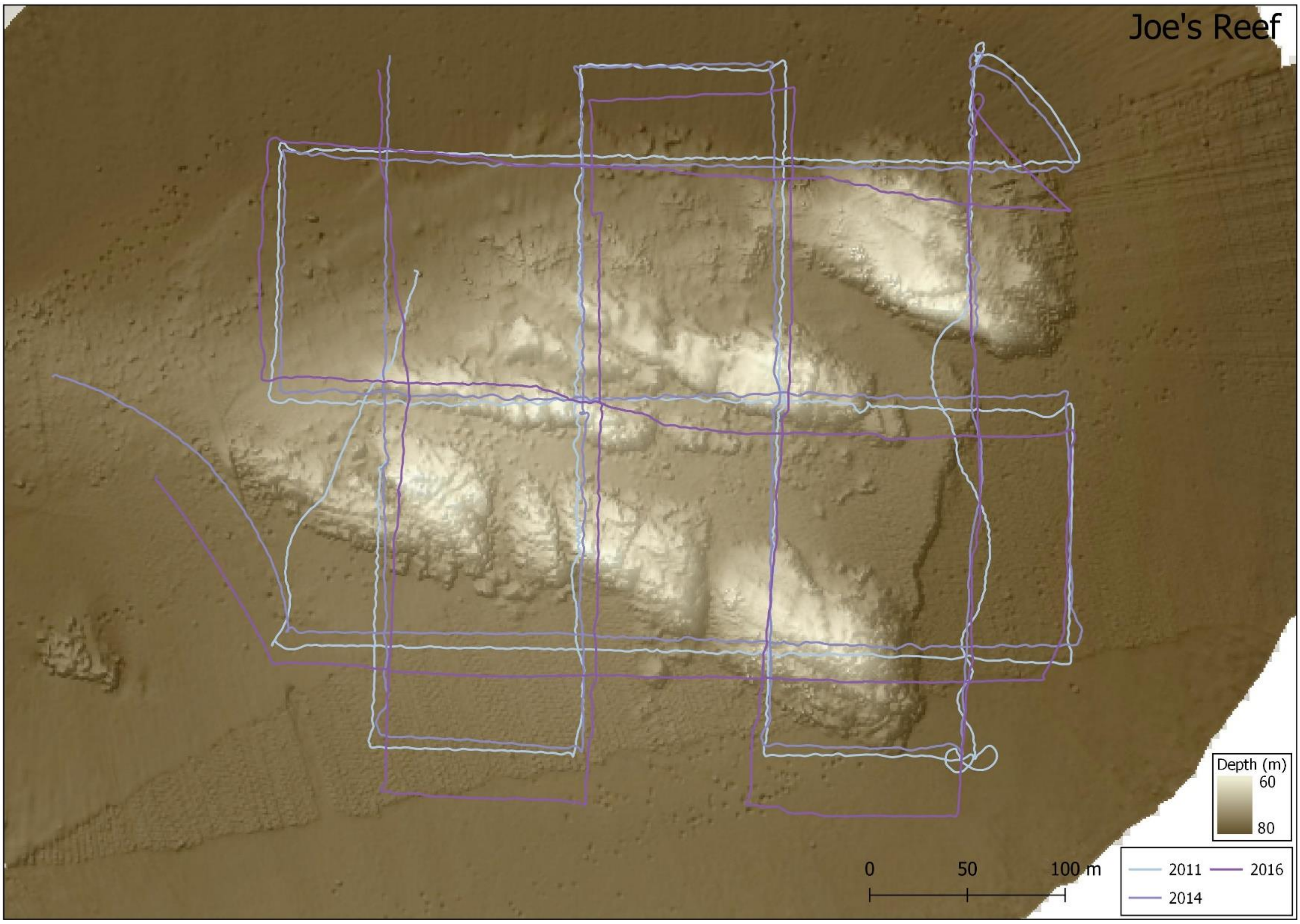


Figure 2.1.9 *Site level map of Joe's Reef.*

Description of habitat

Joe's Reef is a high relief granite reef surrounded by sandy substrate lying approximately 10 km offshore. It is twilight-dark shelf reef (59-83 m), lying in depths at the limits of the photic zone, so little to no algal species are present. Several distinct outcrops rising almost 20 metres from the surrounding seafloor are interspersed with lower relief areas that contain sandy substrate and mixed habitats with boulders, cobbles and lower relief reef that is often covered with a veneer of sand.

Description of biological community

Joe's Reef contains a high diversity of invertebrate fauna including gorgonians, mushroom corals, hydroids and a large variety of sponges form predominant space occupiers (Figure 3.1.10). Many of the structure forming species are larger at this site, as the site is deeper and less likely to experience disturbance through storm events. The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 32% over the time-series of data collected at this site.

Large tree-like black corals are a rare but distinctive biological feature of this site. Black corals tend to be long-lived are of high conservation value at this site. Example images from Joe's Reef are contained in Appendix B.

Multivariate SIMPER analysis revealed that characteristic morphospecies for Joe's Reef included red gorgonians, coral orange solitary (Caryophyllia like), repent yellow sponges and encrusting orange sponges.

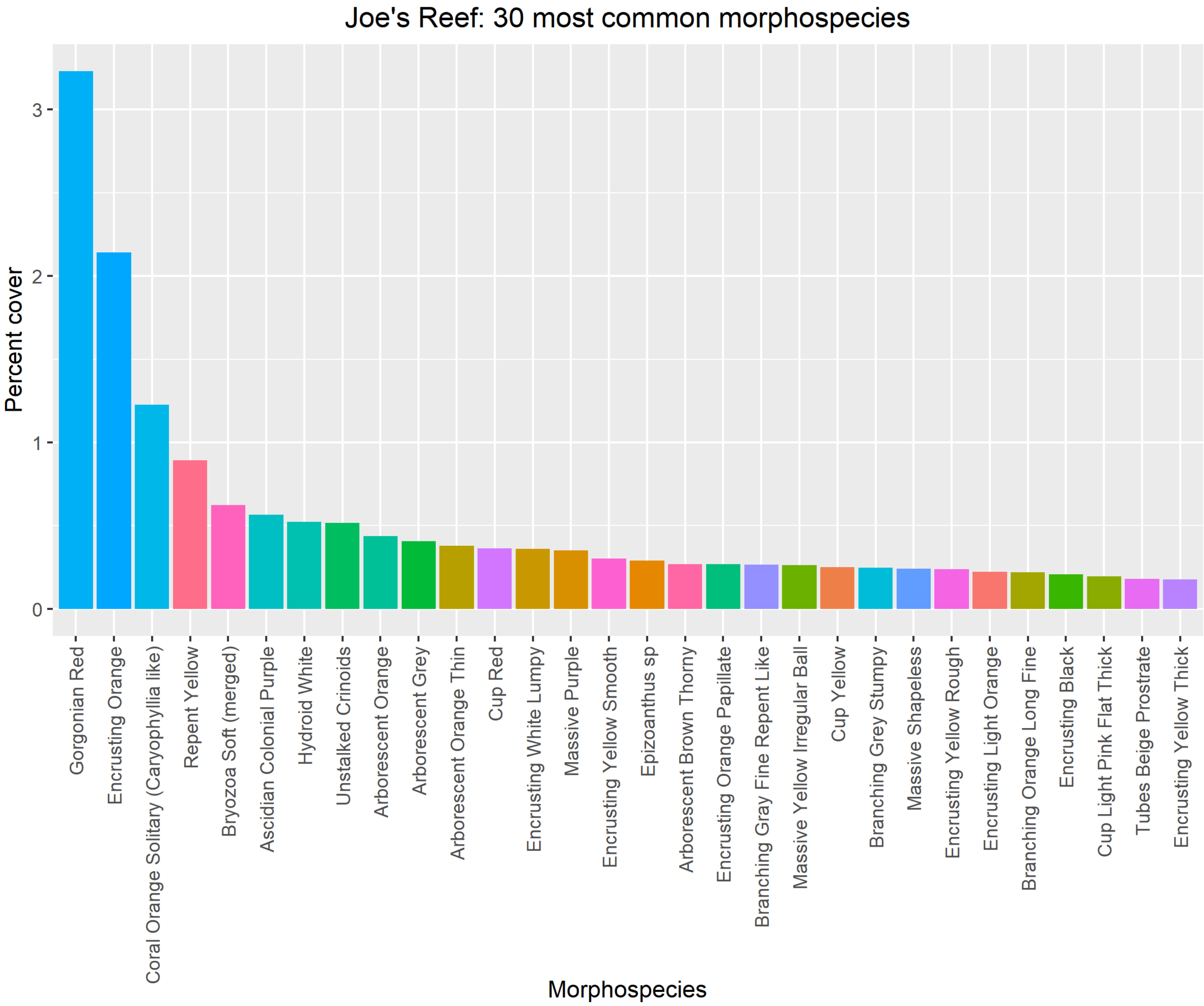


Figure 2.1.10 *Top 30 morphospecies scored at Joe's Reef. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

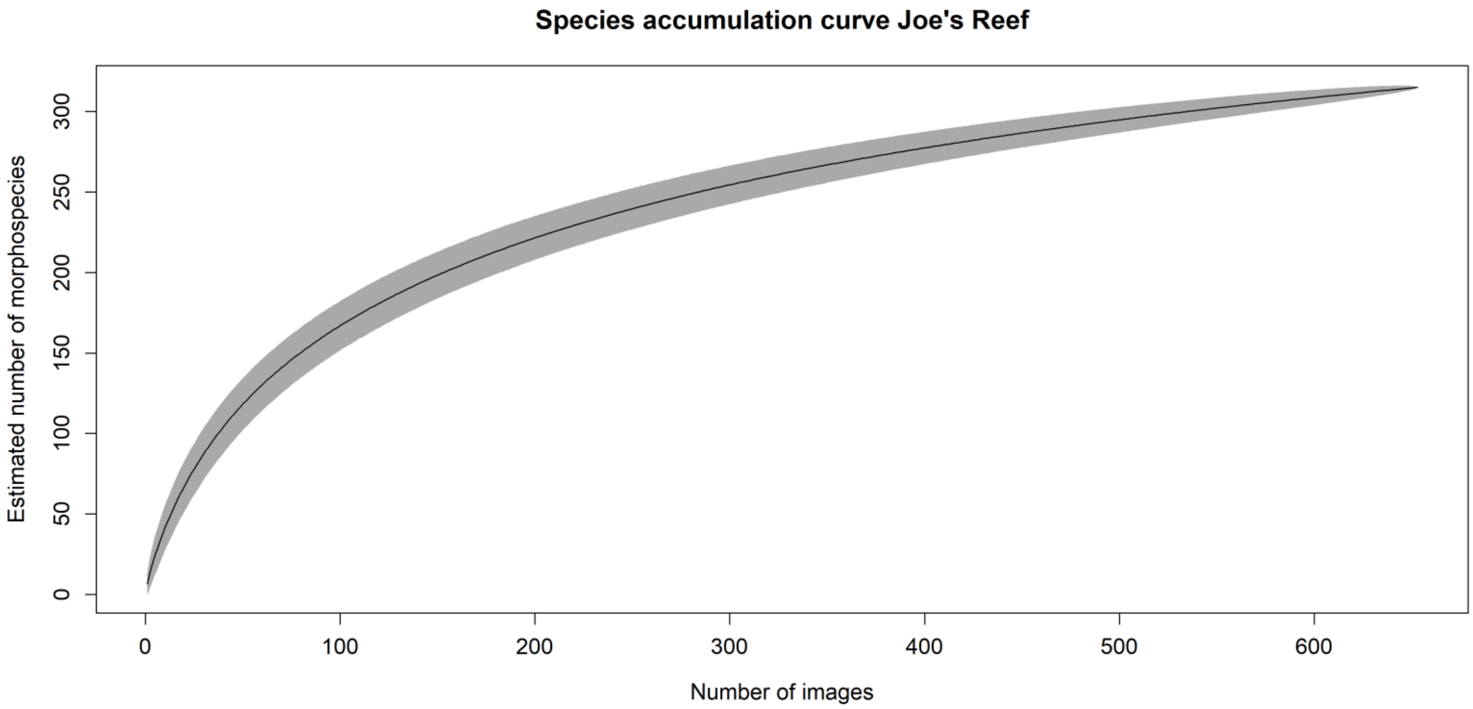


Figure 2.1.11 *Species accumulation curve for Joe's Reef.*

The species accumulation curve reveals that the 600-700 images scored across time have captured a significant proportion of the species richness at this site, with the curve beginning to asymptote and a total of in excess of 300 morphospecies being observed (Figure 3.1.11). This large number of morphospecies recorded at this site reveal it is of high conservation importance from a biodiversity perspective.

2.1.2.2 Freycinet Marine Park site 2

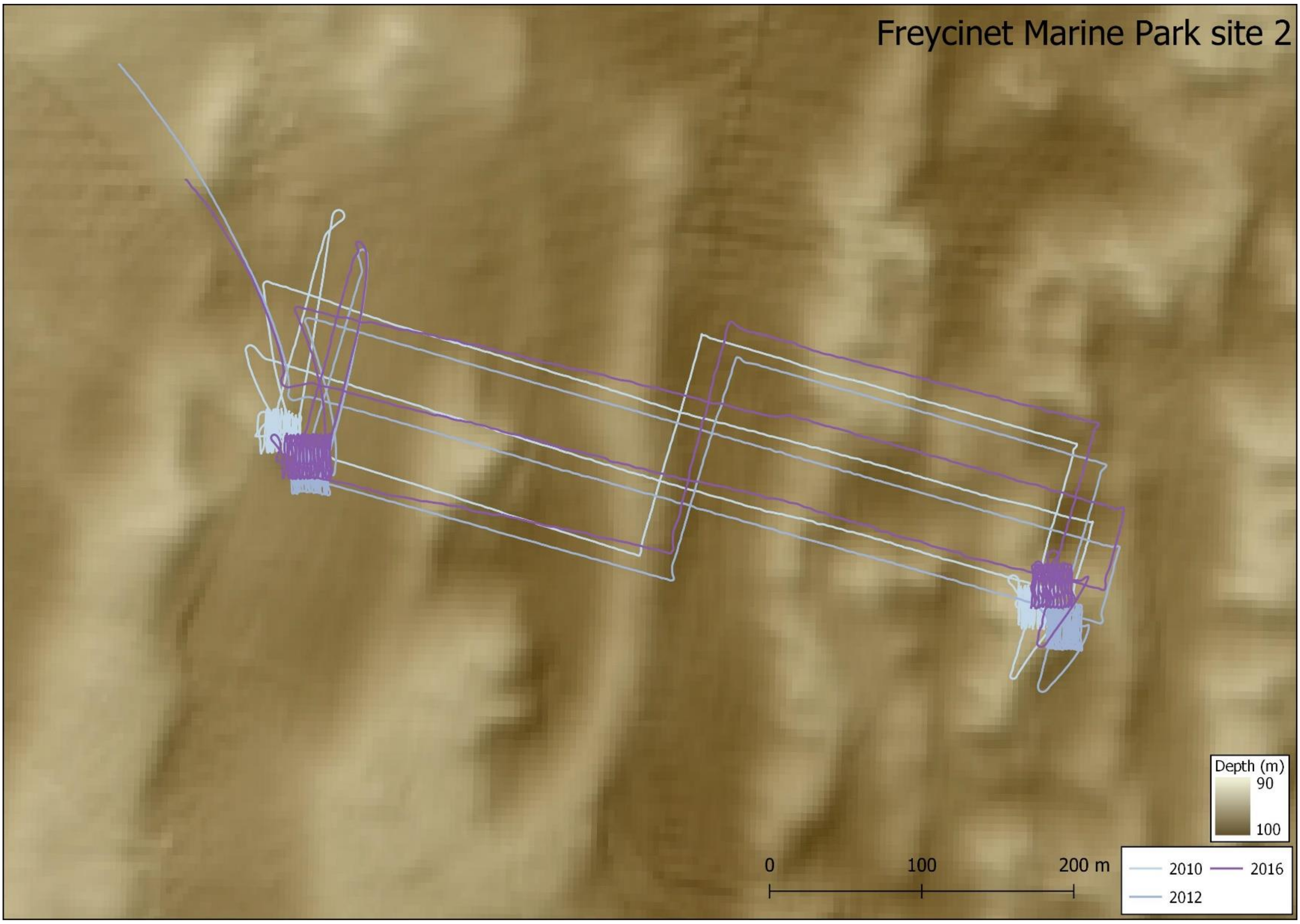


Figure 2.1.12 *Site level map of Freycinet Marine Park site 2.*

Description of habitat

Freycinet Marine Park site 2 is a dark shelf reef lying below the photic zone (93-100 m). It is a low relief sand dominated site with almost no hard substrate evident in the imagery collected to date. Sessile fauna evident in imagery are likely to be attached to shells or other small pieces of biogenic rubble or may be attached to hard substrate that is covered by a veneer of sand.

Description of biological community

There is low overall cover of individual morphospecies with the dominant fauna being encrusting sponges, bryozoans, ascidians and sea pens (Figure 3.1.13). The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 20% over the time-series of data collected at this site. Example images from Freycinet Marine Park site 2 are contained in Appendix B.

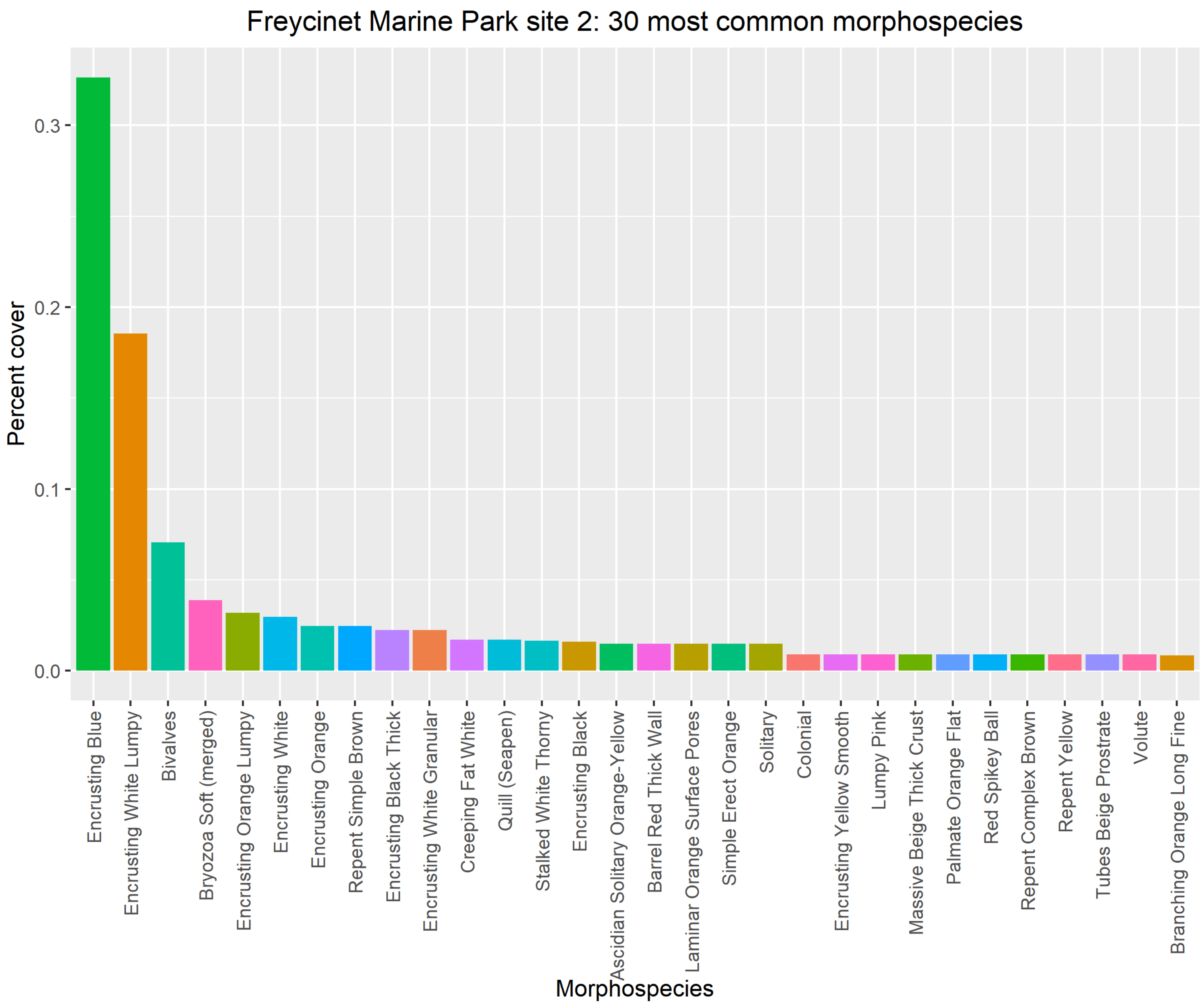


Figure 2.1.13 *Top 30 morphospecies scored at Freycinet Marine Park Site 2. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

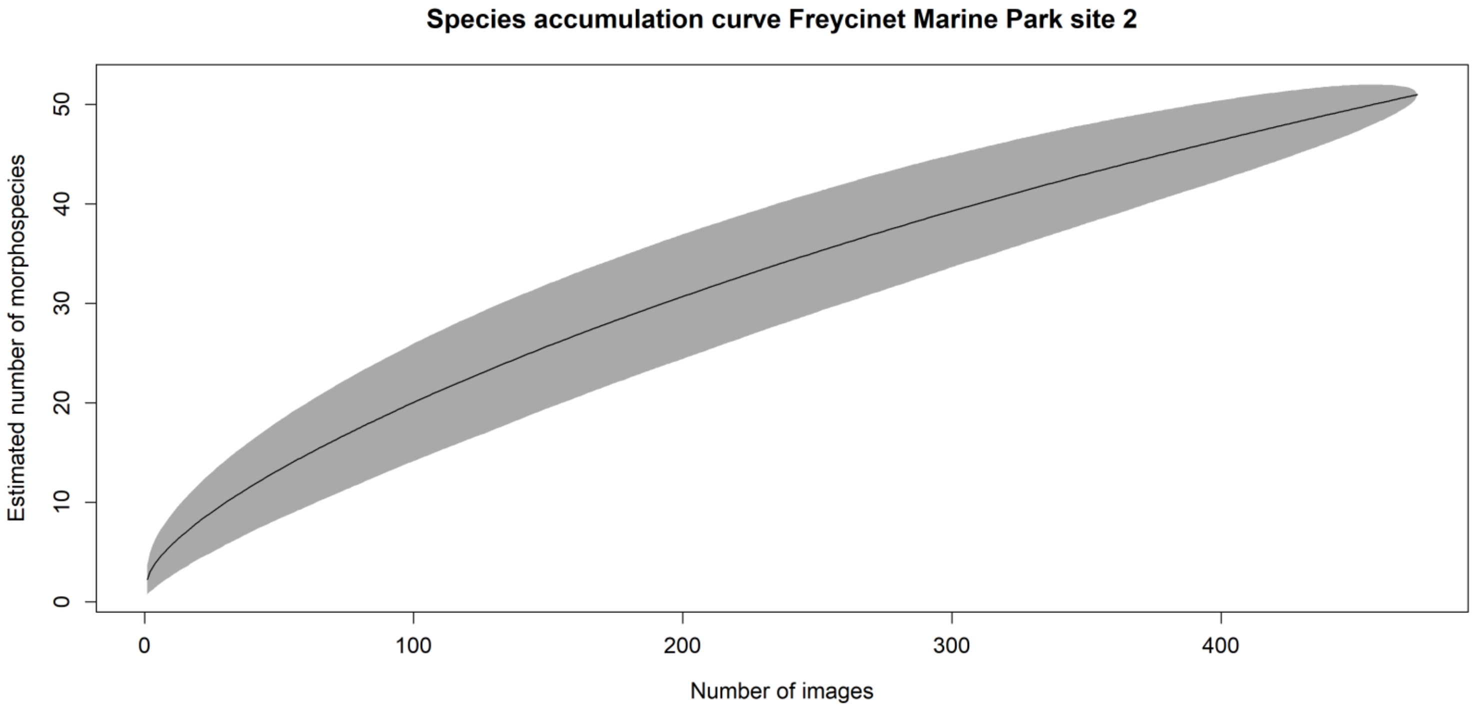


Figure 2.1.14 *Species accumulation curve for Freycinet Marine Park site 2.*

The species accumulation curve reveals that the 400-500 images scored across time have captured a significant proportion of the species richness at this site (Figure 3.1.14). However, the curve is still climbing suggesting that there may be more than 80 morphospecies in total at this site. This site had the lowest number of recorded morphospecies across all the sites scored.

2.1.3 Flinders Marine Park

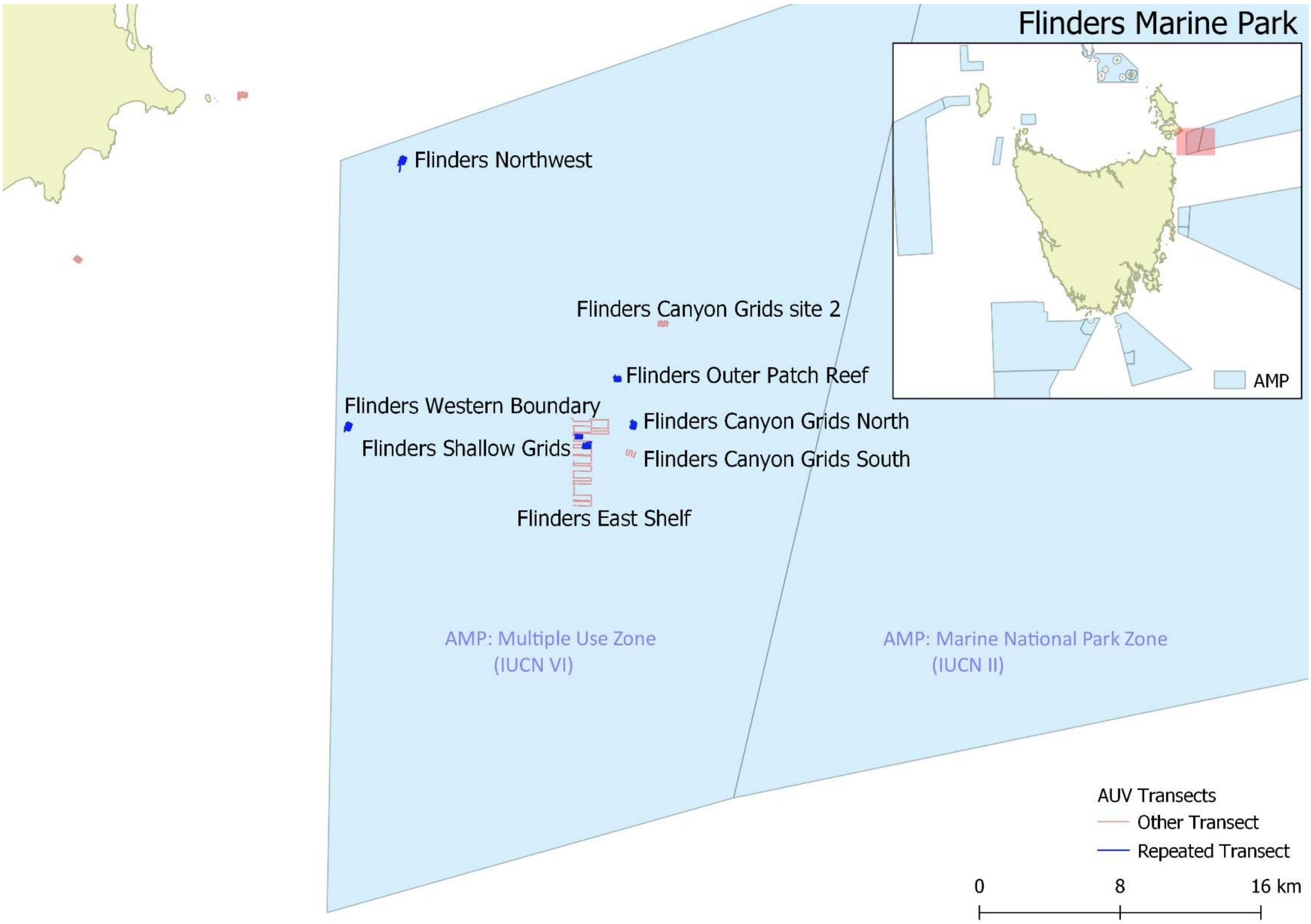


Figure 2.1.15 *Overview map of Flinders Marine Park. Details of non-repeated transects not included in this study are given in Appendix A.*

3.1.3.1 Flinders Northwest

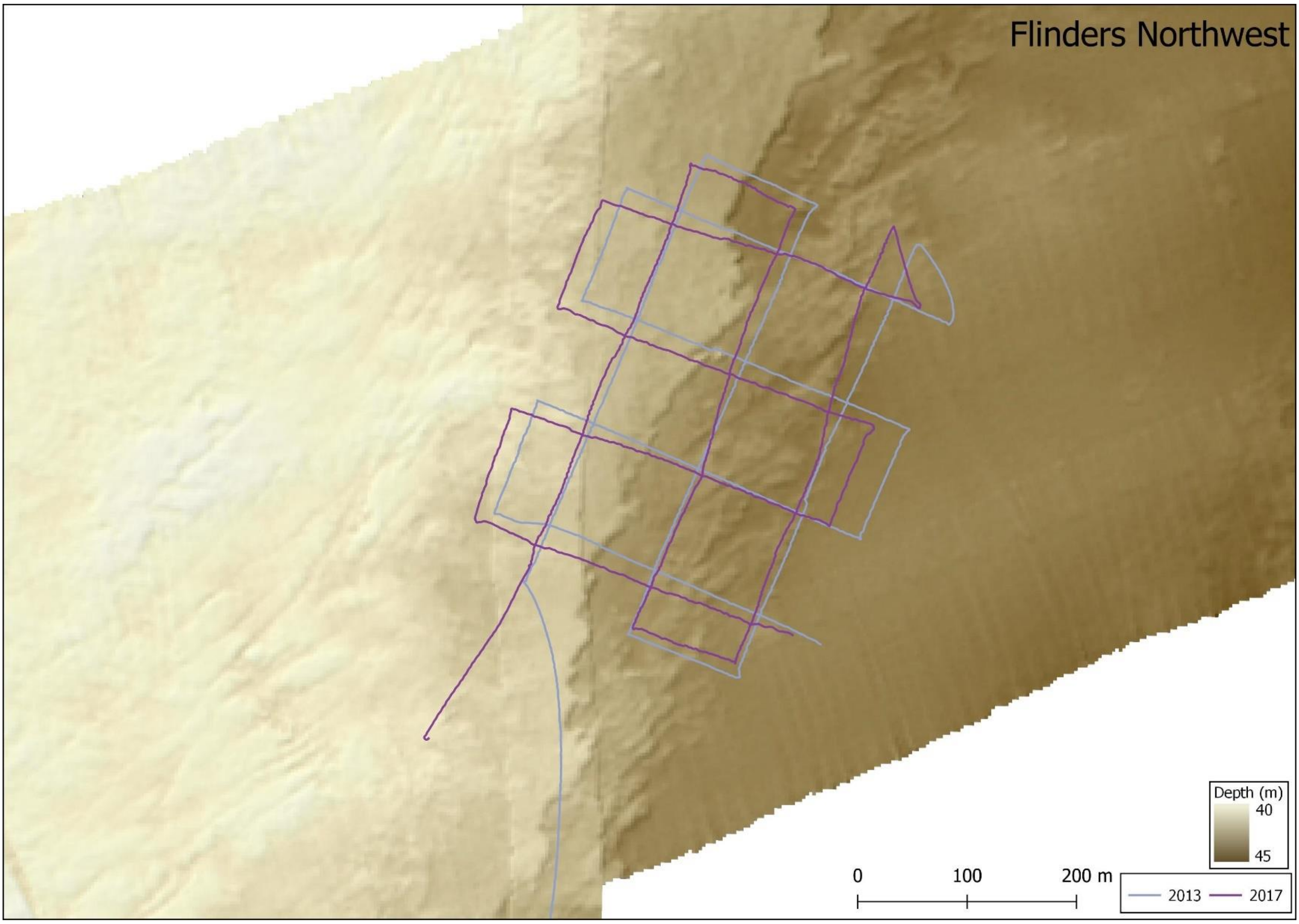


Figure 2.1.16 *Site level map of Flinders Northwest.*

Description of habitat

Flinders Northwest is a mixed habitat twilight rocky reef (41-45 m) shelf site dominated by low relief (< 1m) rocky reef ledge features and sand habitats. Reef features are often covered in a veneer of sand, while sand substrate is often rippled. This indicates a dynamic envirnoment that may be frequently subject to currents or storm events.

Description of biological community

This is a very high diversity site, indicated by the high species richness seen in the species accumulation curve (Figure 18) and the low dominance of any single morphospecies. Many different sponge forms are present as well as a variety of cnidarians and hydroids (Figure 3.1.17). The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 18% over the time-series of data collected at this site. Example images from Flinders Northwest are contained in Appendix B.

SIMPER analysis revealed that cup red smooth, encrusting purple lumpy, and soft bryozoa are characteristic species for this site.

This site contains large gorgonian fans (Mopsella sp. like) which are likely to be of high conservation value. Similarly to the black corals at Joe's reef, these gorgonians are low in overall cover. Soft corals (Capnella like) were also noted in low abundance at this site and may be of conservation value as this morphospecies was not observed at other sites in Flinders Marine Park or across the SE Network.s

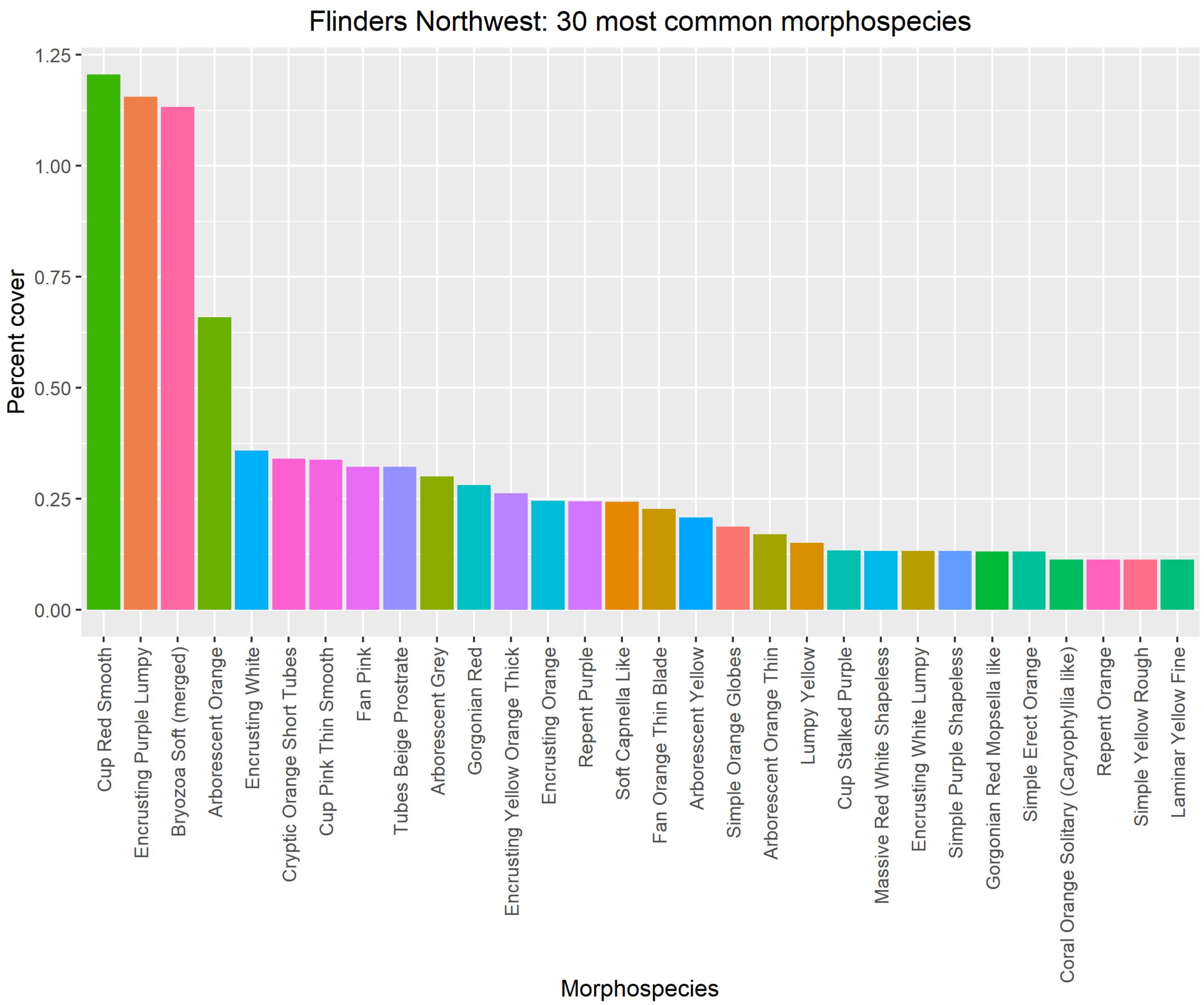


Figure 2.1.17 *Top 30 morphospecies scored at Flinders Northwest. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

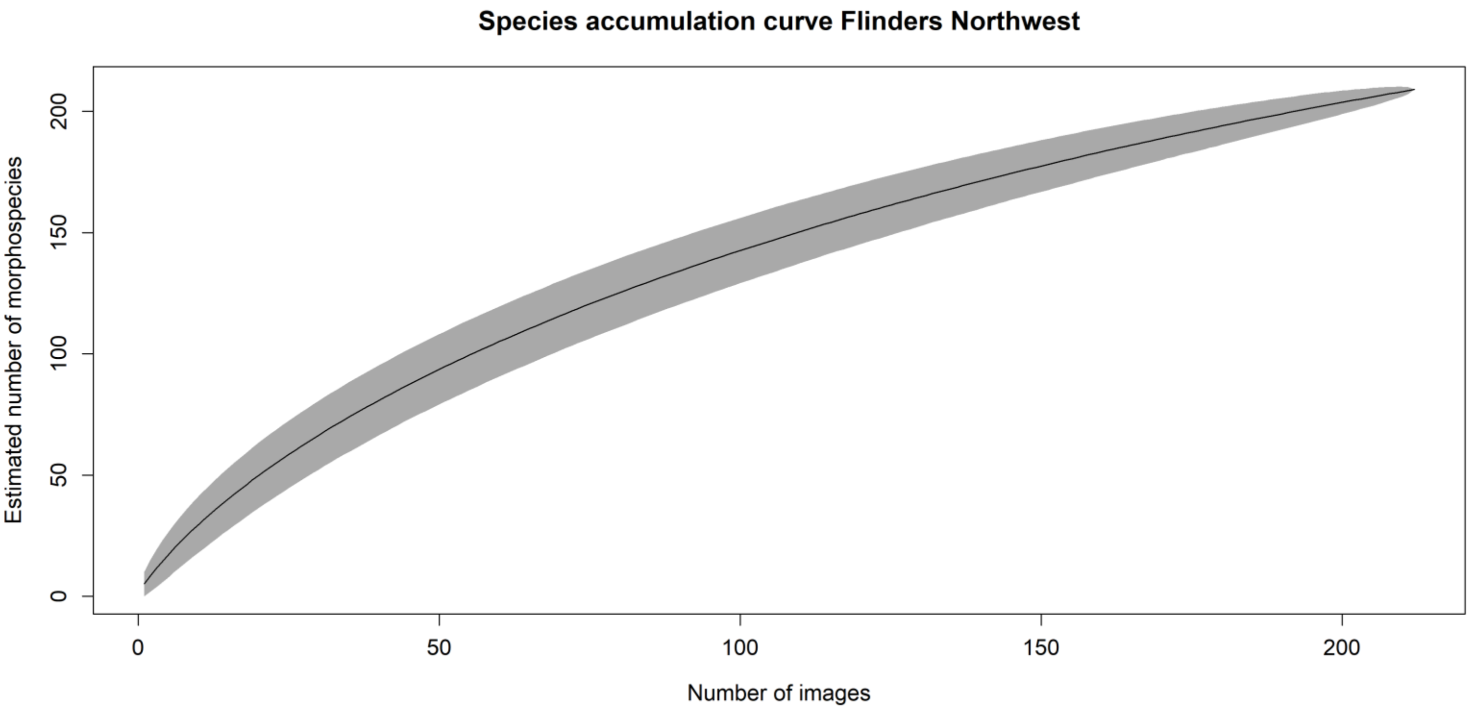


Figure 2.1.18 *Species accumulation curve for Flinders Northwest.*

The species accumulation curve reveals that the 200 images scored across time have not captured the species richness at this site, with the curve still climbing at 200 morphospecies (Figure 3.1.18). This large number of morphospecies recorded in only two years of survey work at this site reveal it is likely of high conservation importance from a biodiversity perspective.

3.1.3.2 Flinders Outer Patch Reef

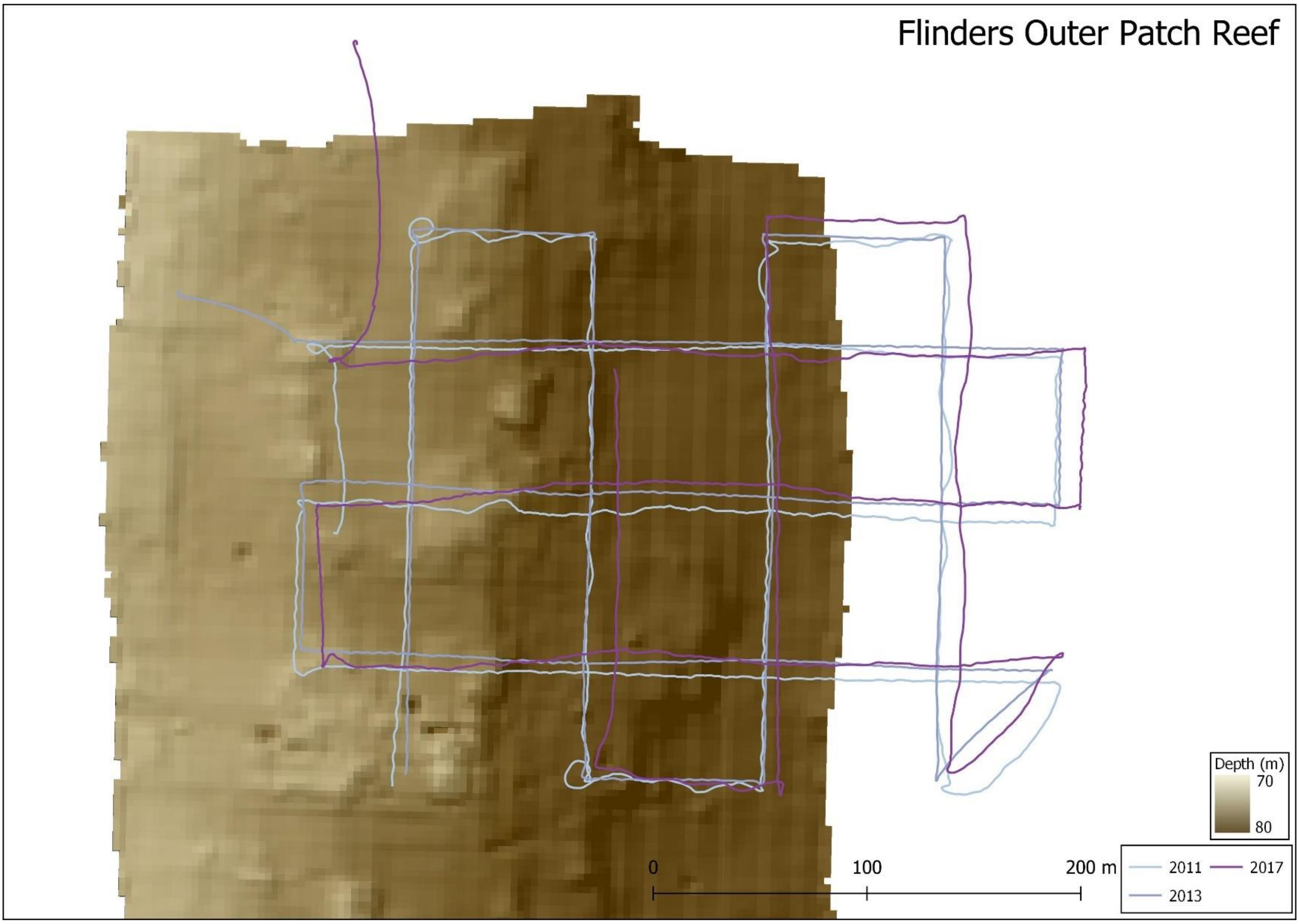


Figure 2.1.19 *Site level map of Flinders Outer Patch Reef.*

Description of habitat

Flinders Outer Patch Reef is a mixed habitat dark shelf reef (75 - 94 m) shelf site dominated by sand with rounded rocky outcropping features of low to medium relief (1 – 2 m). Reef features are often covered in a veneer of sand as are lower relief areas of hard substrate.

Description of biological community

This site is similar to other sites within Flinders that show high diversity invertebrate communities associated with rocky ledge features. These features have a range of cnidarian, bryozoan and sponge morphospecies (Figure 3.1.20). The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 16% over the time-series of data collected at this site. Example images from Flinders Outer Patch Reef are contained in Appendix B.

SIMPER analysis revealed that hard and soft bryozoans, repent yellow sponges, cup yellow sponges, bramble coral and sea whips are characteristic morphospecies for this site.

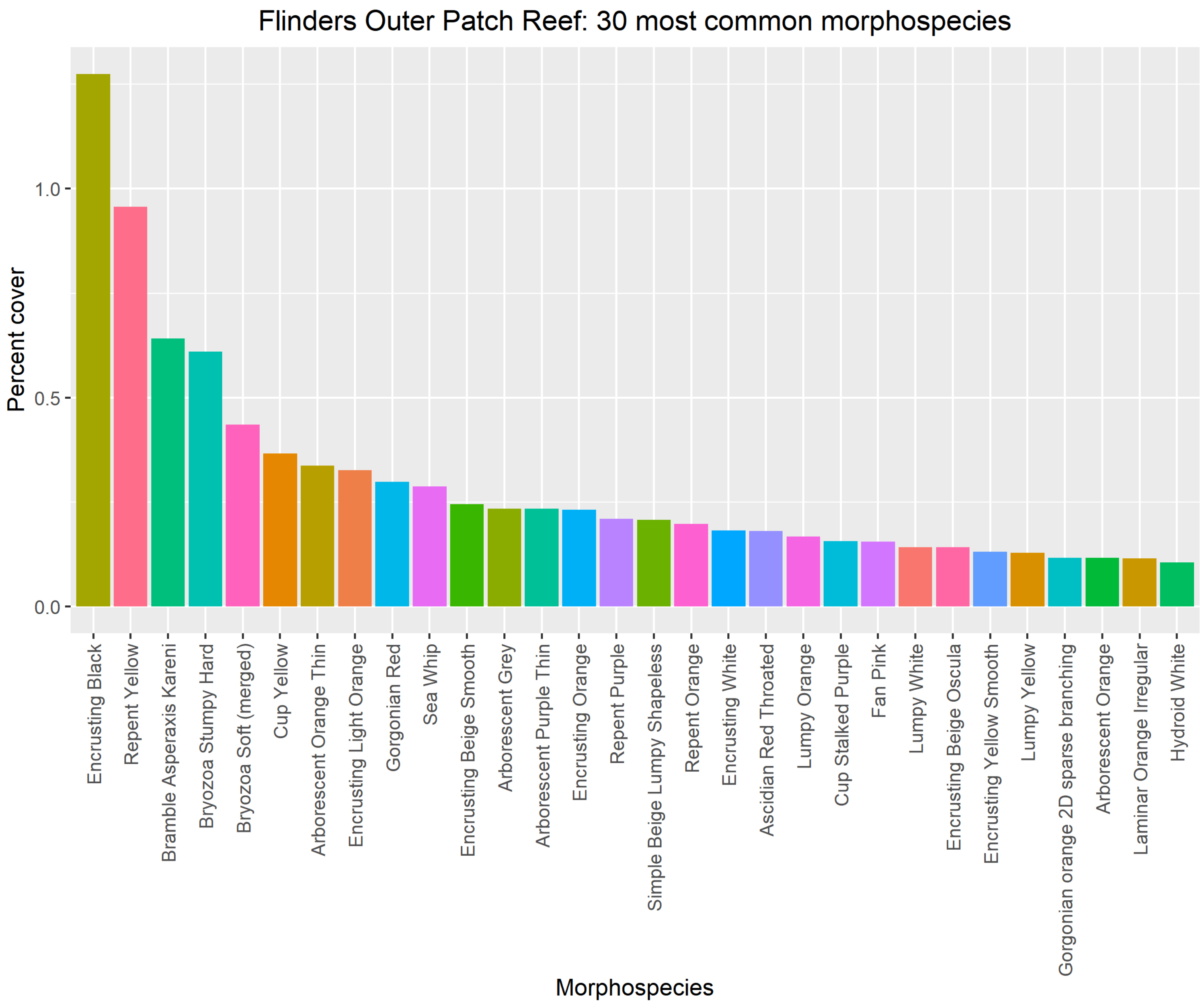


Figure 2.1.20 *Top 30 morphospecies scored at Flinders Outer Patch Reef. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

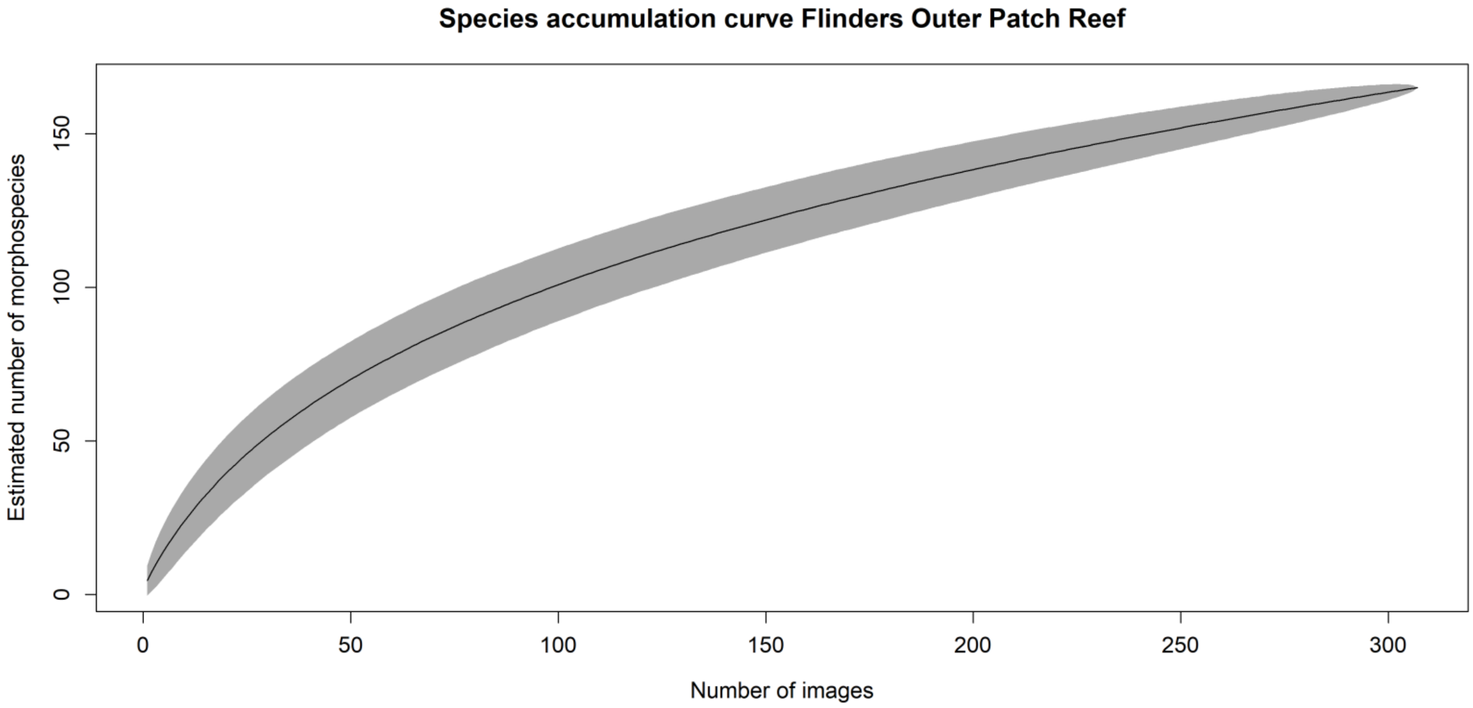


Figure 2.1.21 *Species accumulation curve for Flinders Outer Patch Reef.*

The species accumulation curve reveals that the 300 images scored across time have captured a significant proportion of the species richness at this site (Figure 3.1.21). However, the curve is still climbing suggesting that there may be more than 200 morphospecies in total at this site.

3.1.3.3 Flinders Western Boundary

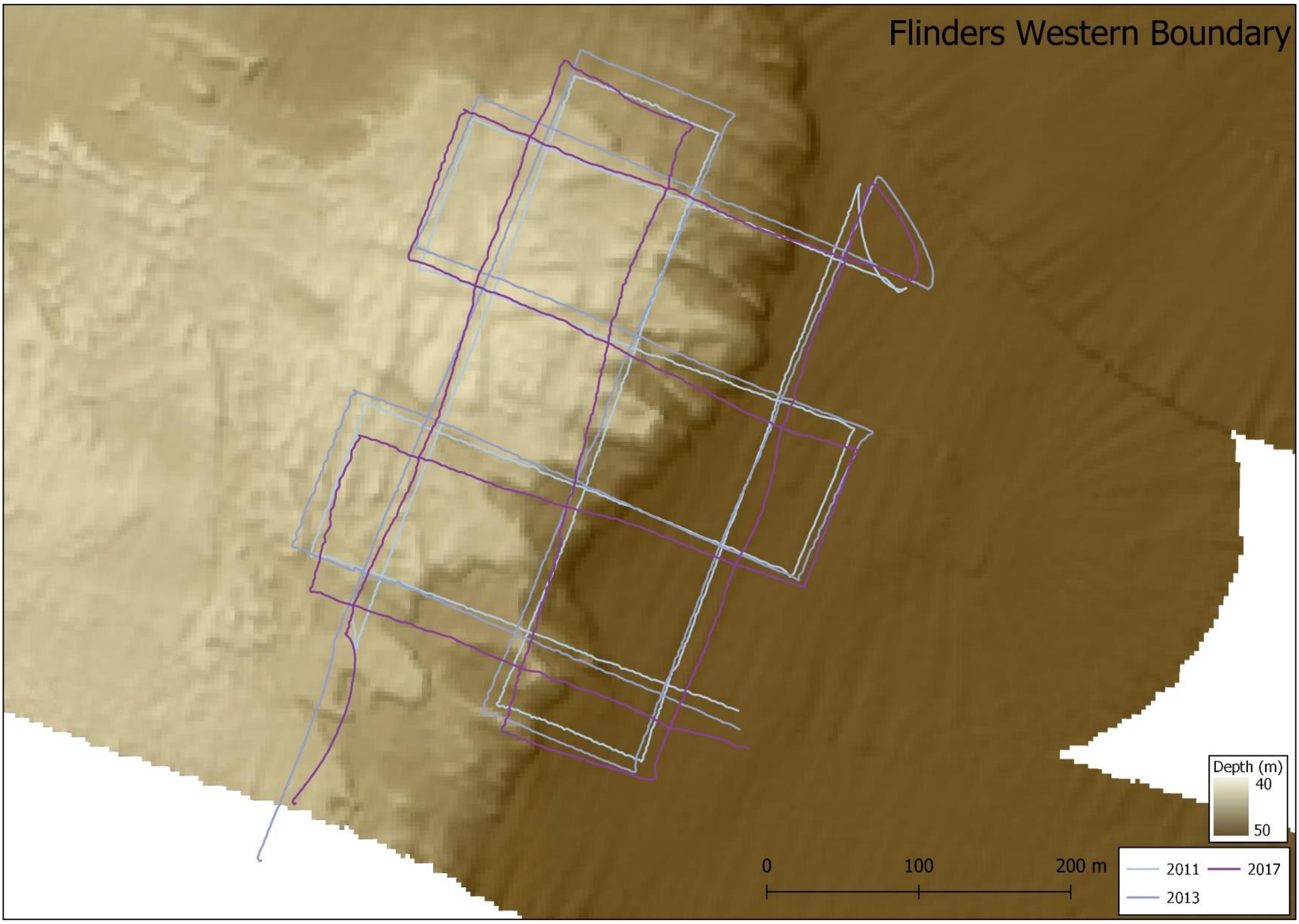


Figure 2.1.22 *Site level map of Flinders Western Boundary.*

Description of habitat

Flinders Western Boundary is a mixed habitat twilight rocky reef (43-52 m) shelf site dominated by low relief (< 1m) rocky reef features and sand habitats punctuated by edges where there are drop-offs of 1-2 m height. Soft substrate areas typically contain shell fragments and biogenic rubble. Reef ledges are often covered in a veneer of sand.

Description of biological community

This site also displays a high diversity in sessile invertebrates including bryozoans, cnidarians and sponges (Figure 3.1.23). A relatively high cover of cup sponges, especially the cup red smoooth morphospecies is a feature of this site. The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 37% over the time-series of data collected at this site. Example images from Flinders Western Boundary are contained in Appendix B.

SIMPER analysis revealed that a variety of sponges including cup red smooth, arborescent grey, encrusting purple lumpy, fan pink and tubes beige prostrate along with bramble coral are characteristic for this site.

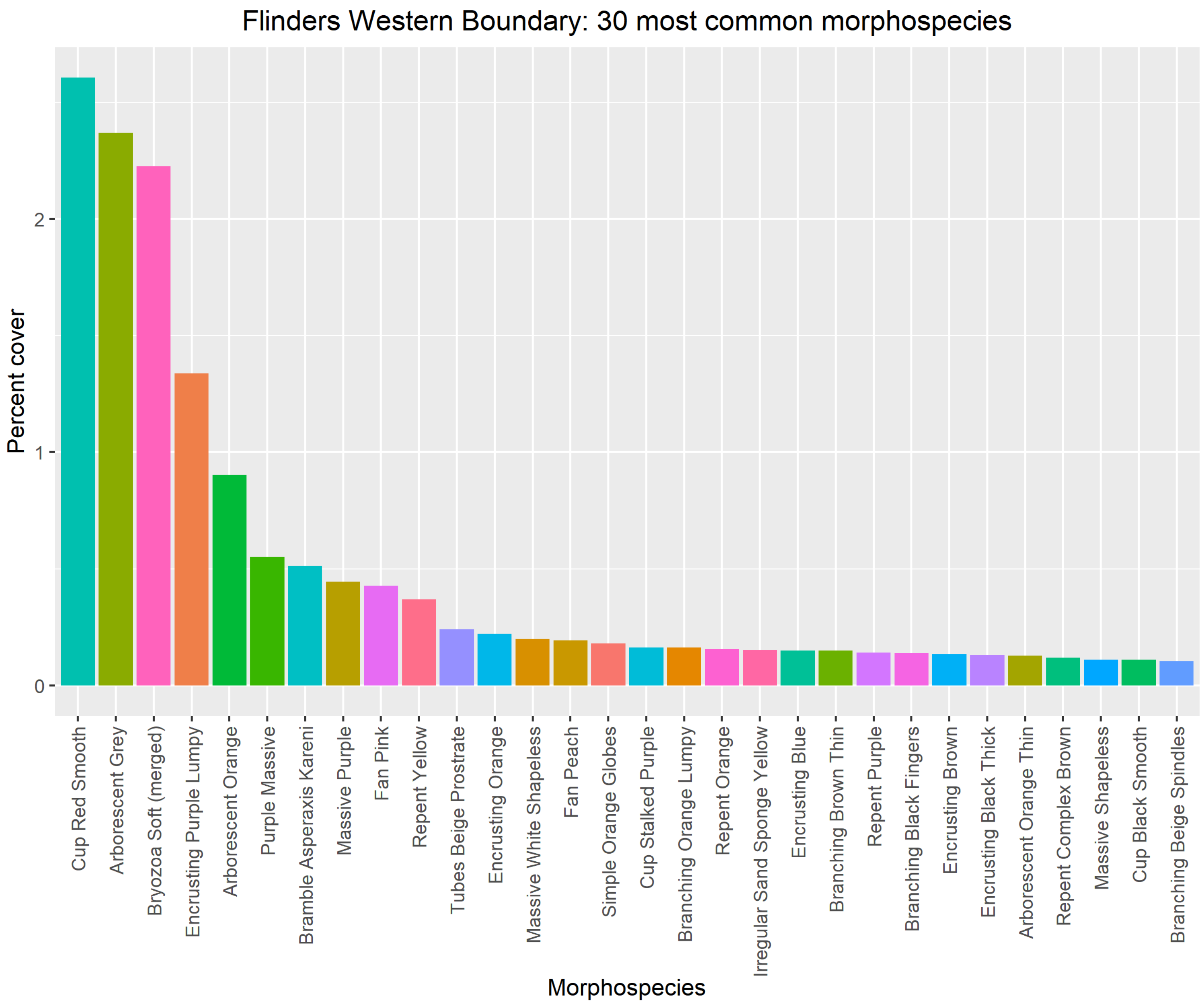


Figure 2.1.23 Top 30 morphospecies scored at Flinders Western Boundary. Substrate categories, mobile species and biological matrix categories were excluded.

Species accumulation curve

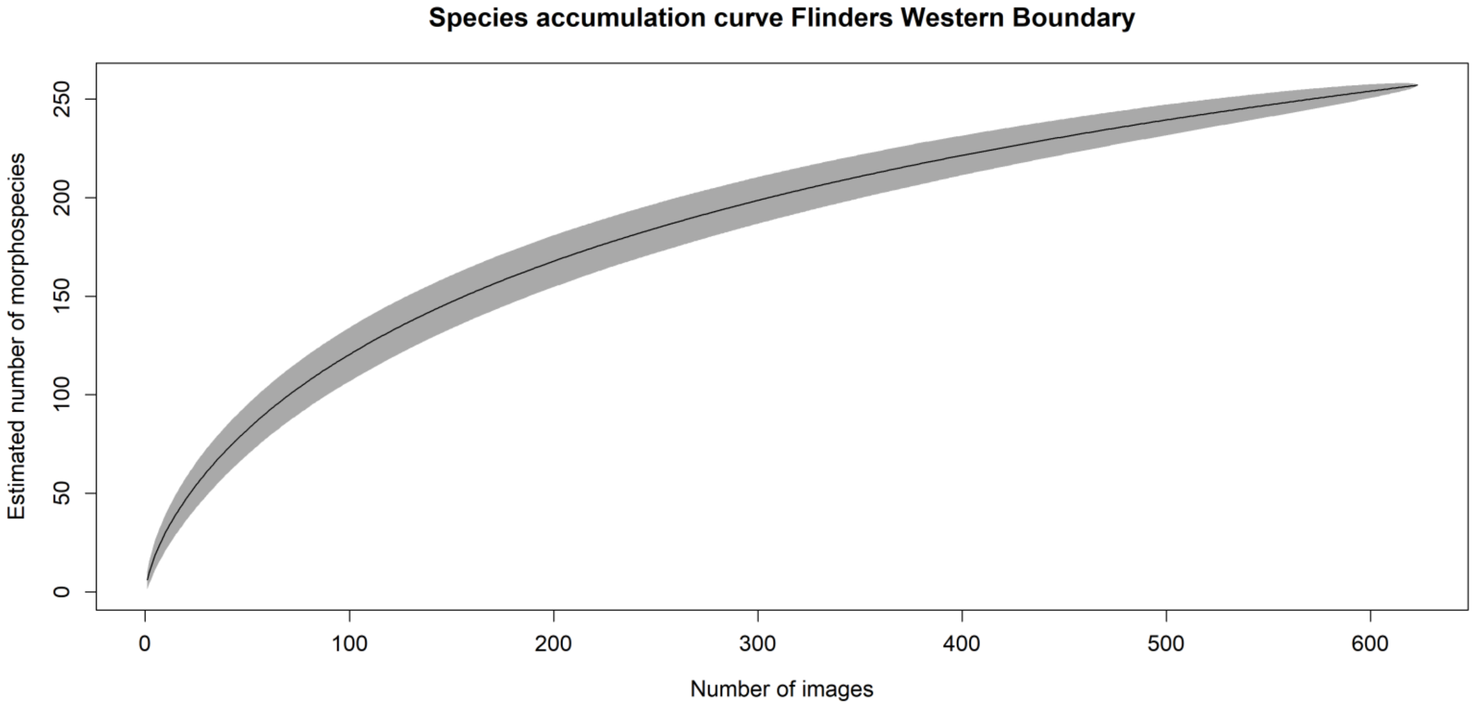


Figure 2.1.24 *Species accumulation curve for Flinders Western Boundary.*

The species accumulation curve reveals that the 600-700 images scored across time have captured a significant proportion of the species richness at this site, with the curve beginning to asymptote and a total of in excess of 250 morphospecies being observed (Figure 3.1.24). This large number of morphospecies recorded at this site reveal it is of high conservation importance from a biodiversity perspective.

3.1.3.4 Flinders Shallow Grids

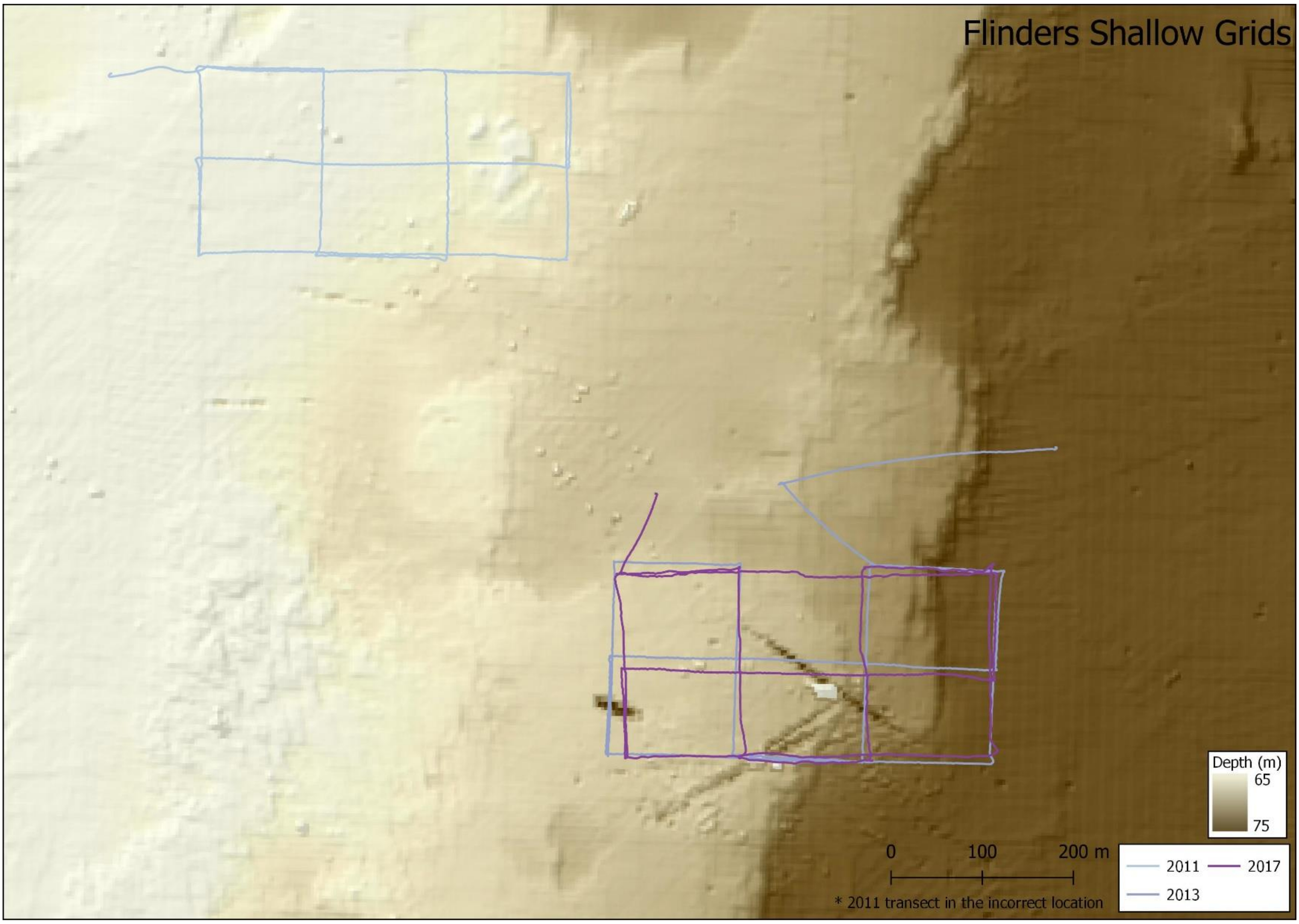


Figure 2.1.25 *Site level map of Flinders Shallow Grids.*

Description of habitat

The Flinders Shallow Grids site is a mixed habitat twilight-dark shelf reef (62 – 78 m) dominated by sand habitats punctuated by rocky reef edges where there are drop-offs of 1-2 m height and hard substrate is exposed. Rock substrate areas around the edges are typically covred in a sand veneer. Note that an AUV transect was deployed in an incorrect location in 2011.

Description of biological community

The Flinders Shallow Grids site is sand dominated with sessile invertebrates restricted to smaller areas of hard substrate. Hard and soft bryozoans, sea whips, gorgonians and a variety of sponge morphospecies predominate (Figure 3.1.26). The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 9% over the time-series of data collected at this site. Example images from Flinders Shallow Grids are contained in Appendix B.

SIMPER analysis revealed that soft and hard bryozoa, repent yellow sponges, sea whips and irregular sand sponge yellow were characteristic morphospecies at this site.

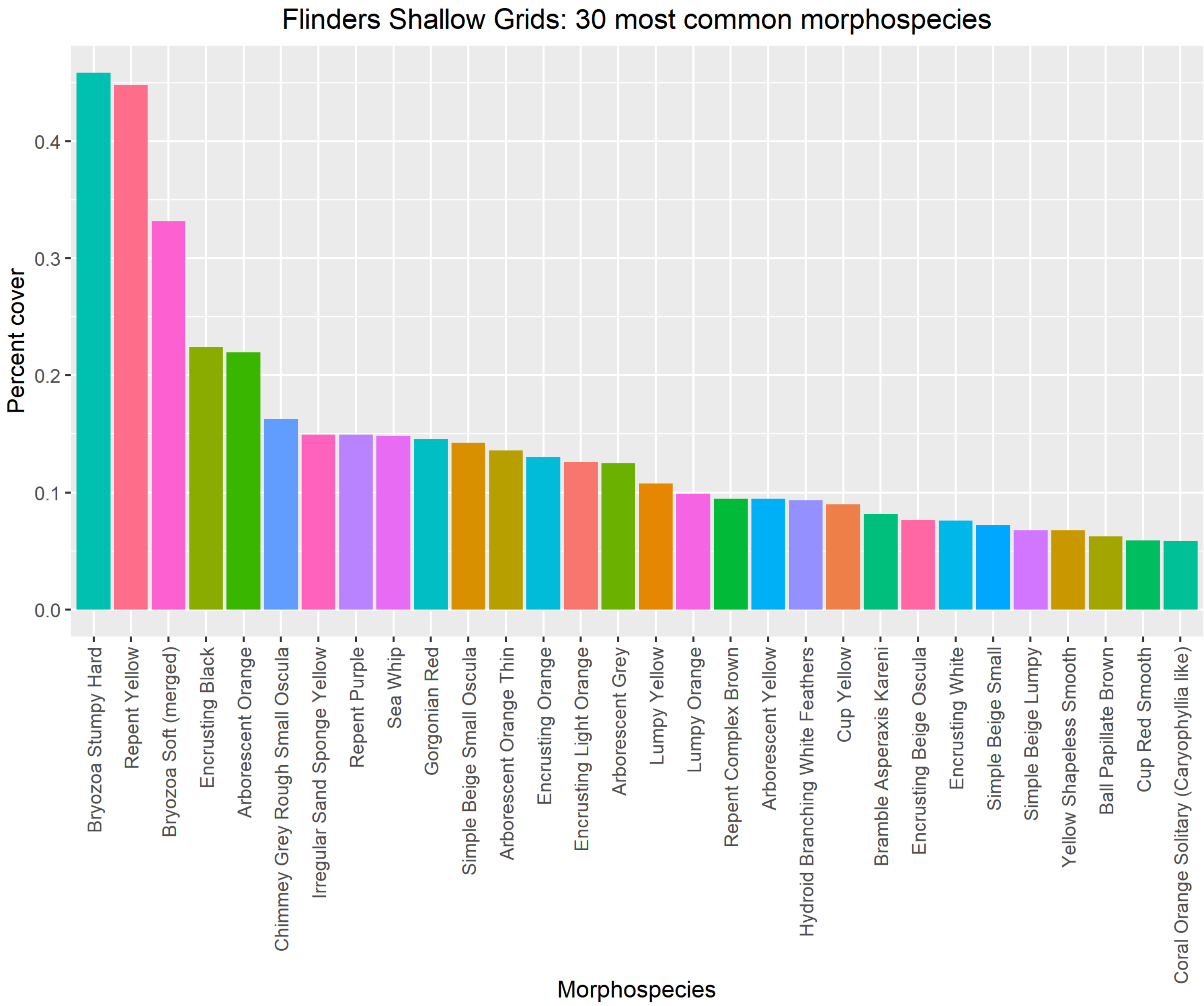


Figure 2.1.26 *Top 30 morphospecies scored at Flinders Shallow Grids. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

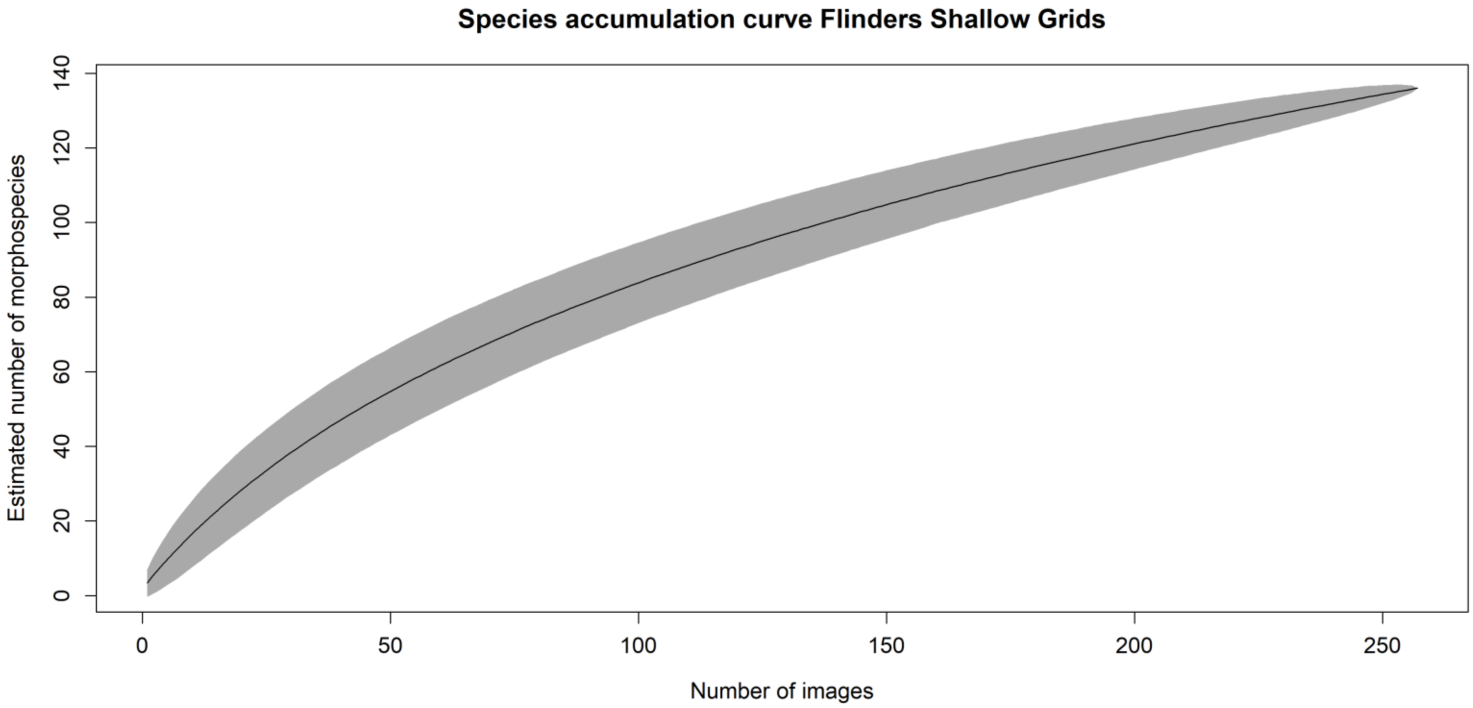


Figure 2.1.27 *Species accumulation curve for Flinders Shallow Grids.*

The species accumulation curve reveals that the 300 images scored across time have not yet captured all the species richness at this site with the curve still not reaching an asymptote at 140 morphospecies (Figure 3.1.27).

3.1.3.5 Flinders Canyon Grids North

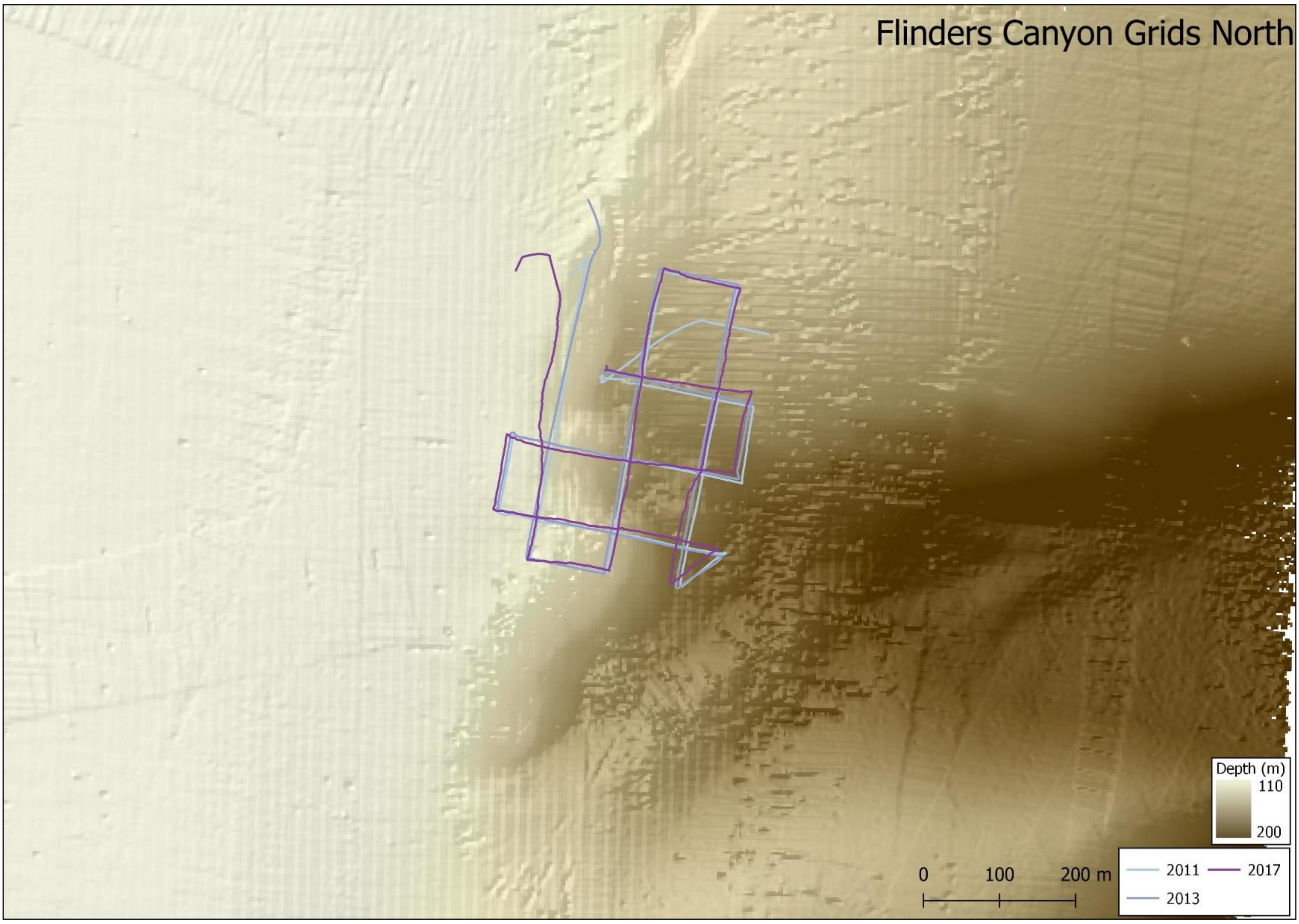


Figure 2.1.28 *Site level map of Flinders Canyon Grids North.*

Description of habitat

The Flinders Canyon Grids North site is a mixed habitat deeper dark shelf (112 - 181 m) site with soft substrate habitats punctuated by steep drop-off areas. Drop-off aeas often have exposed hard substrate. Areas with large boulders and exposed rocky outcrops are also present and contain higher diversity of invertebrate fauna. Soft substrate often contains biogenic rubble such as dead pieces of hard bryozoan colonies.

Description of biological community

This is a deep canyon-head site (112- 181 m) and thus is dominated by sessile invertebrates with no algal species. Encrusting sponges are dominant features as well as a variety of hard and soft bryozoans, soft corals and octocorals (Figure 3.1.29). The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 30% over the time-series of data collected at this site. Example images from Flinders Canyon Grids North are contained in Appendix B.

SIMPER analysis revealed that hard bryozoa, encrusting white, light orange and yellow smooth sponges, repent yellow and orange sponges and massive white holey sponges were characteristic at this site.

Soft corals (Capnella like) were noted on the upper canyon slopes and may be of high conservation value as the morphospecies observed here was not observed at other sites in Flinders Marine Park.

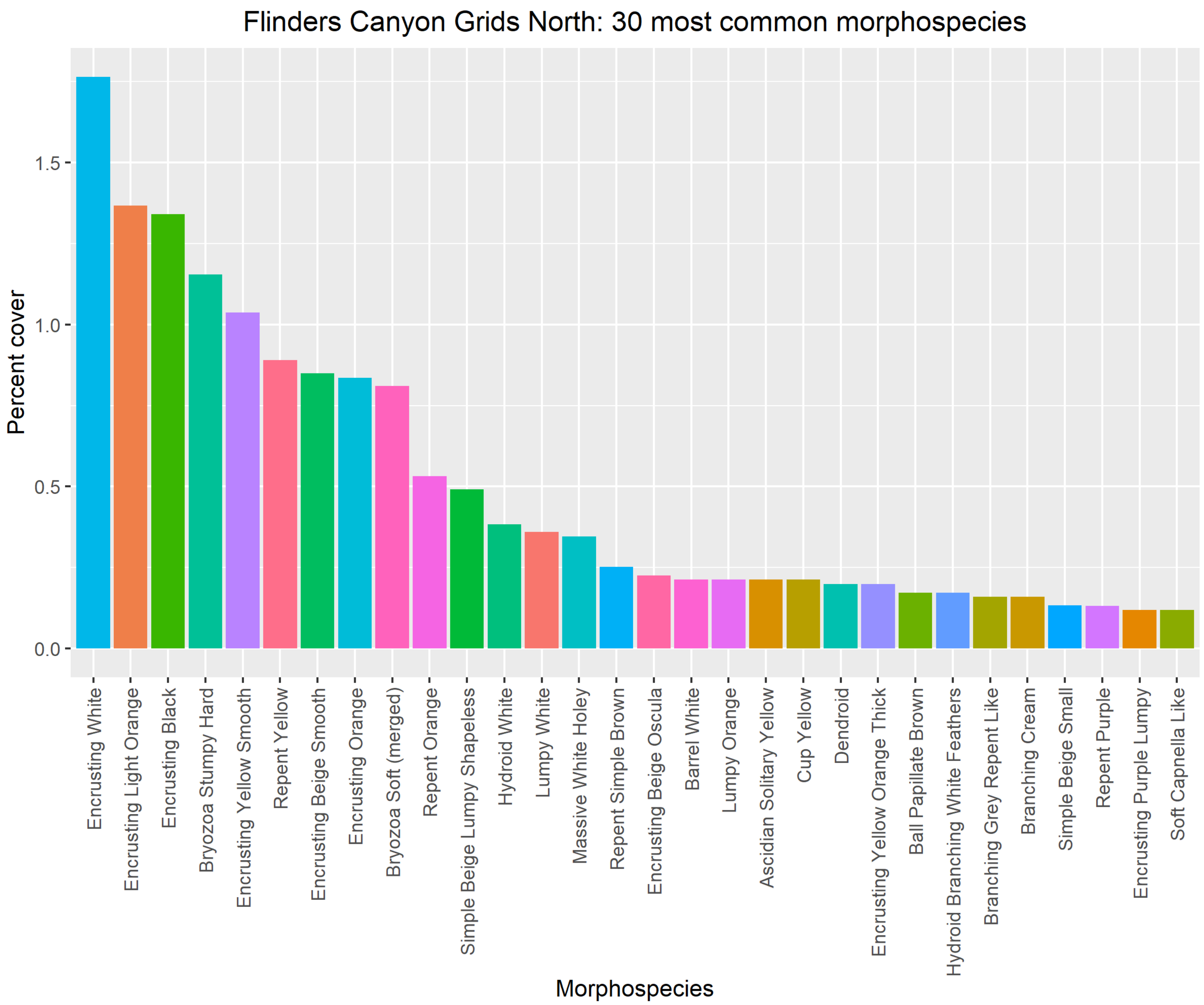


Figure 2.1.29 *Top 30 morphospecies scored at Flinders Canon Grids North. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

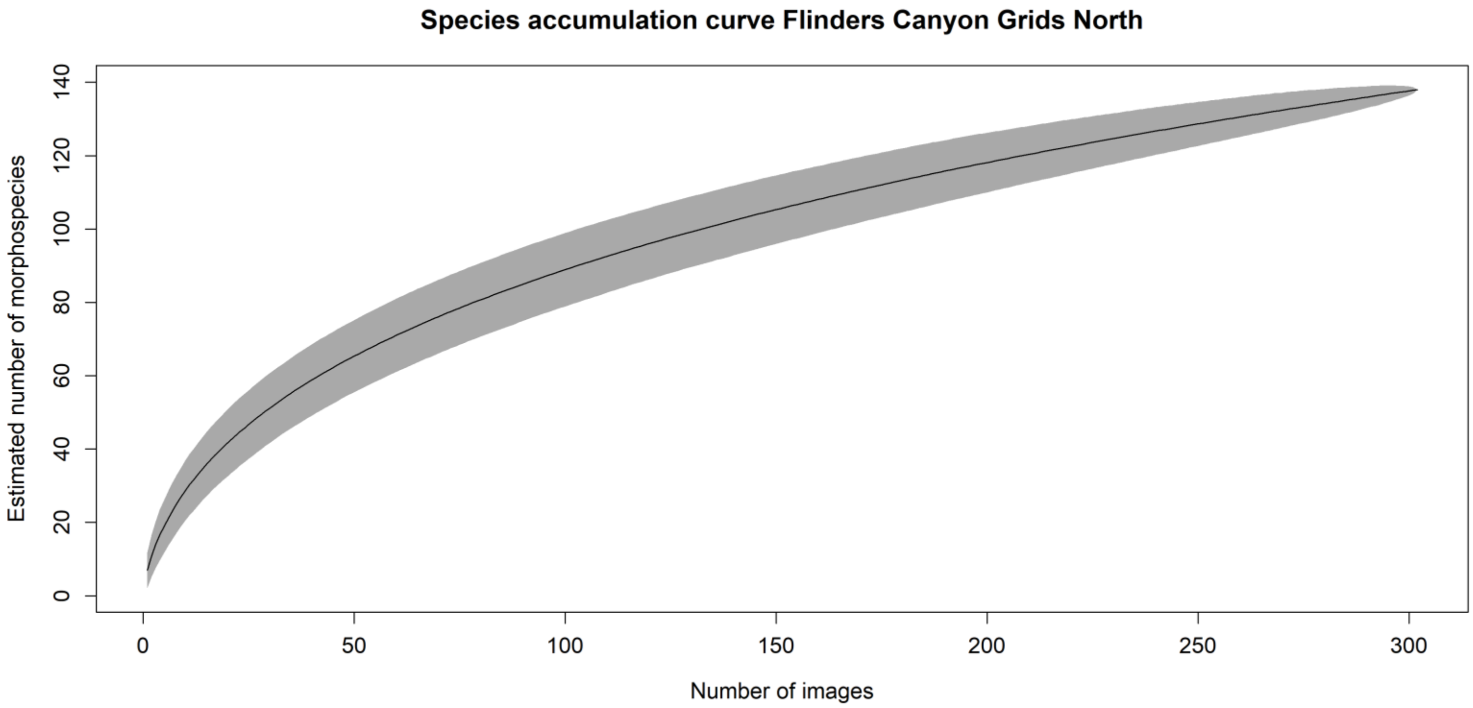


Figure 2.1.30 *Species accumulation curve for Flinders Canyon Grids North.*

The species accumulation curve reveals that the 300 images scored across time have captured a significant proportion of the species richness at this site (Figure 3.1.30). However, the curve is still climbing suggesting that there may be up to 200 morphospecies in total at this site.

2.1.4 Beagle Marine Park

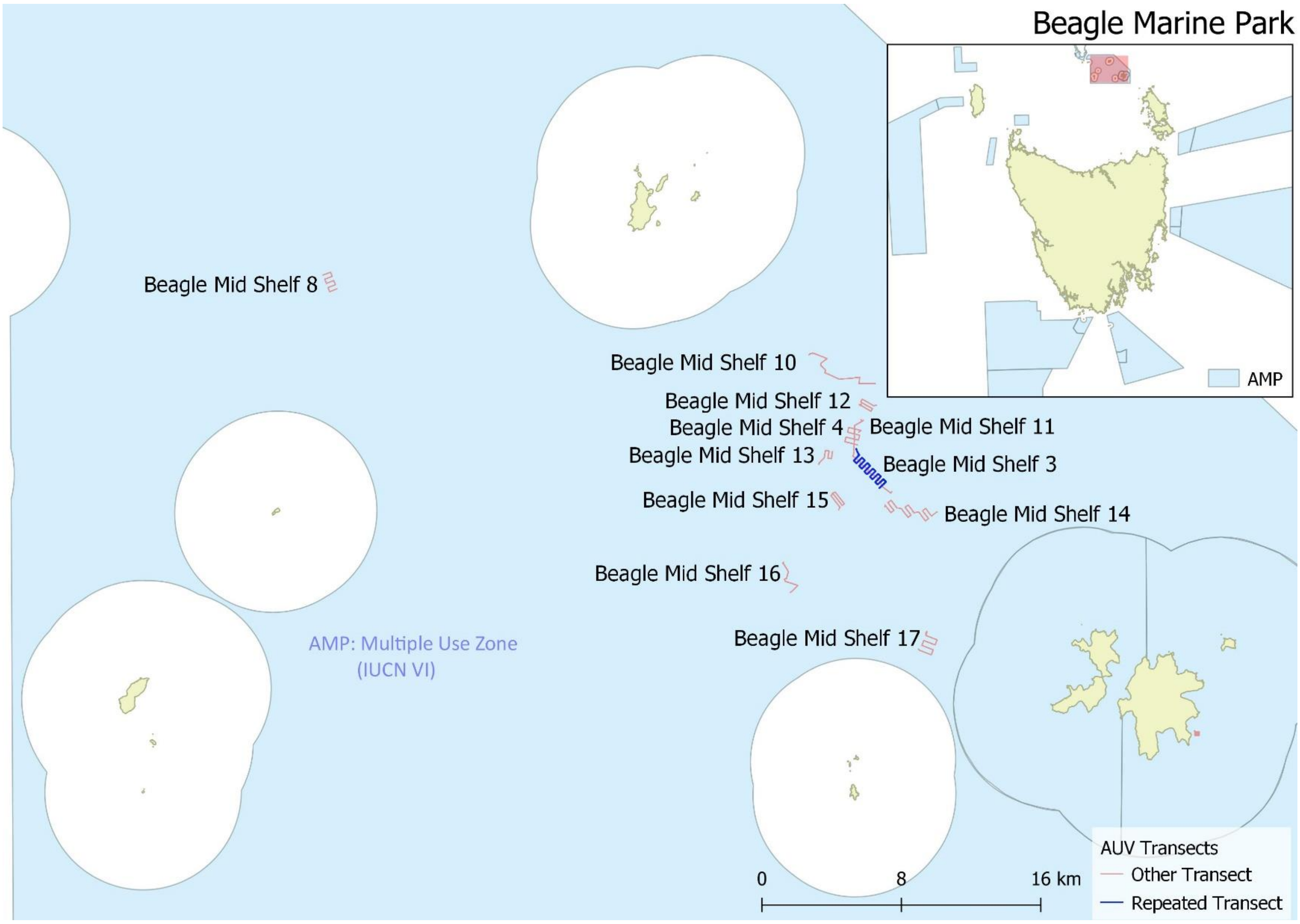


Figure 2.1.31 *Overview map of Beagle Marine Park. Details of non-repeated transects not included in this study are given in Appendix A.*

3.1.4.1 Beagle Mid Shelf 3

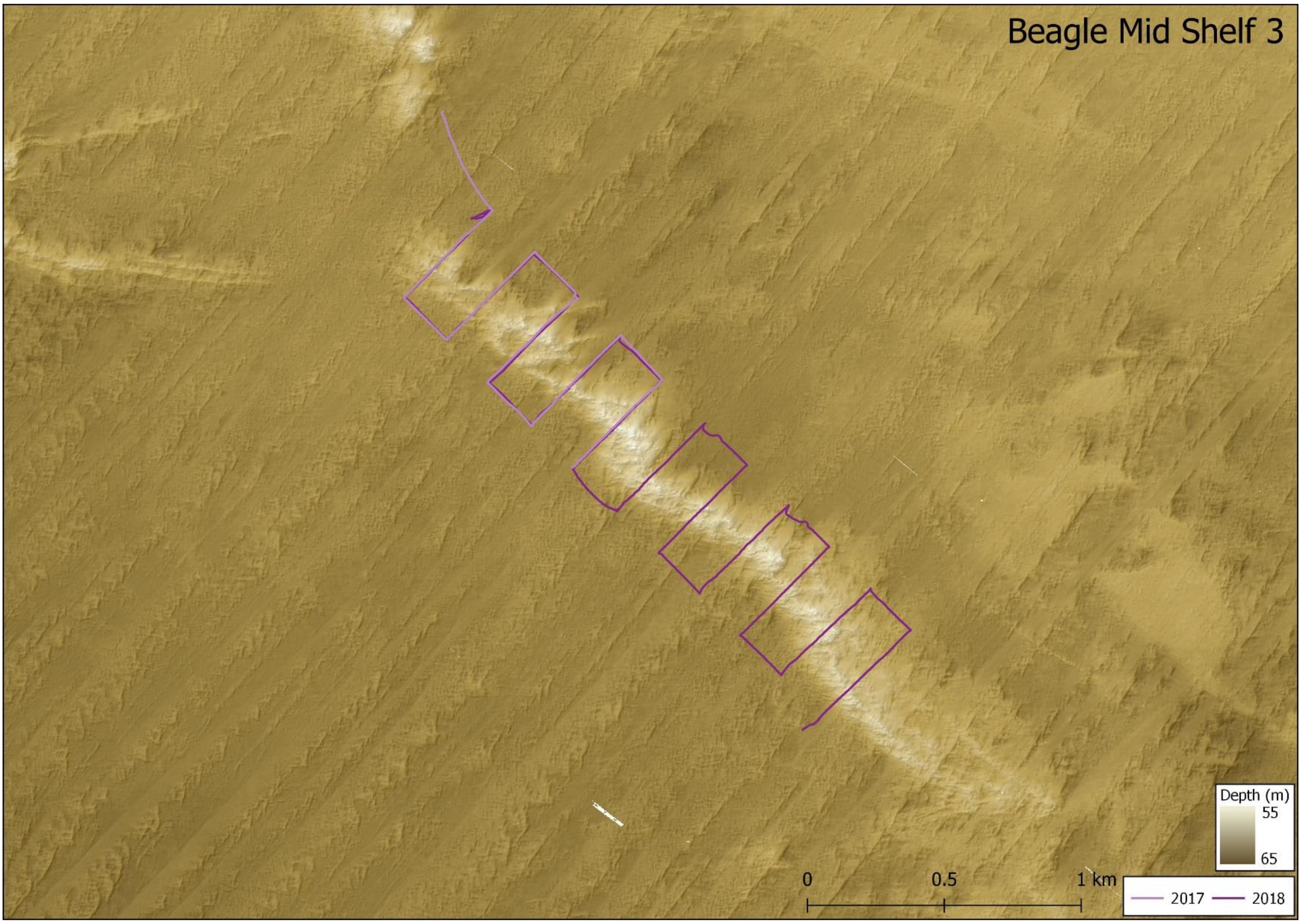


Figure 2.1.32 *Site level map of Beagle Mid-Shelf 3.*

Description of habitat

The Beagle Mid Shelf 3 site is a mixed habitat twilight reef (55-65 m) shelf site with soft substrate habitat and a low relief (< 1 m) outcropping hard substrate feature. Hard substrate is often covered with a veneer of sand, while soft substrate areas often contain biogenic rubble and shell fragments and underlying screwshell and shellhash beds.

Description of biological community

The Beagle Mid-Shelf 3 contains a mix of hard and soft bryozoa, hydroids, ascidians and a variety of different sponge morphospecies (Figure 3.1.33). The mean cover of the biological matrix (bryozoa/cnidaria/sponge matrix) category at this site was an average of 3% over the time-series of data collected at this site. Example images from Beagle Mid Shelf 3 are contained in Appendix B.

SIMPER analysis revealed that characteristic species were soft bryozoa, hydroid white, encrusting beige oscula and the hard bryozoa (Celleporaria like).

Rarer, but potentially important species from a conservation perspective as they may be more susceptible to disturbance such as warming events include large gorgonian (Mopsella like) fans, soft corals (Capnella like) and bramble coral (Acabaria sp).

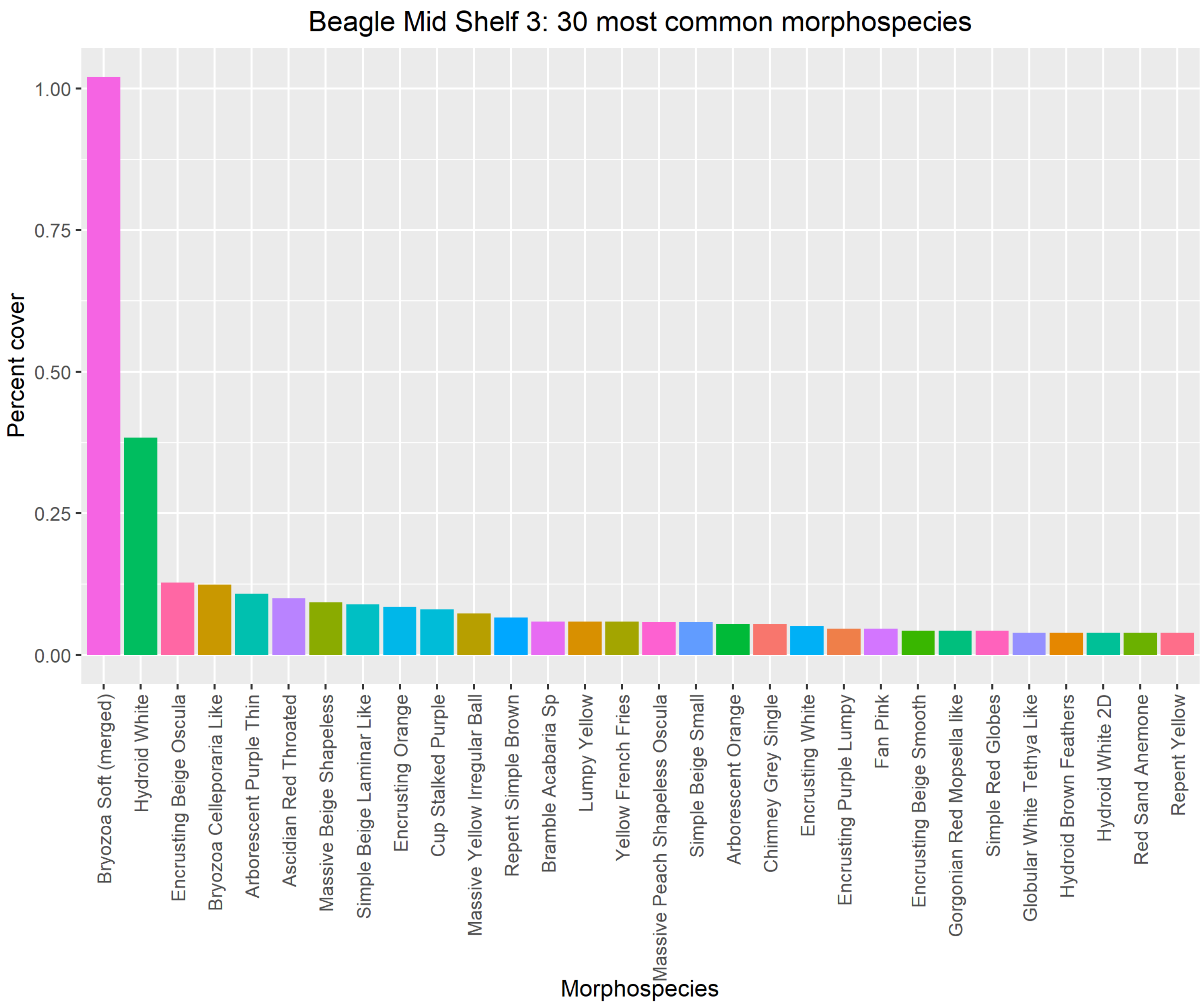


***Figure 2.1.33** Top 30 morphospecies scored at Beagle Mid Shelf 3. Substrate categories, mobile species and biological matrix categories were excluded.*

Species accumulation curve

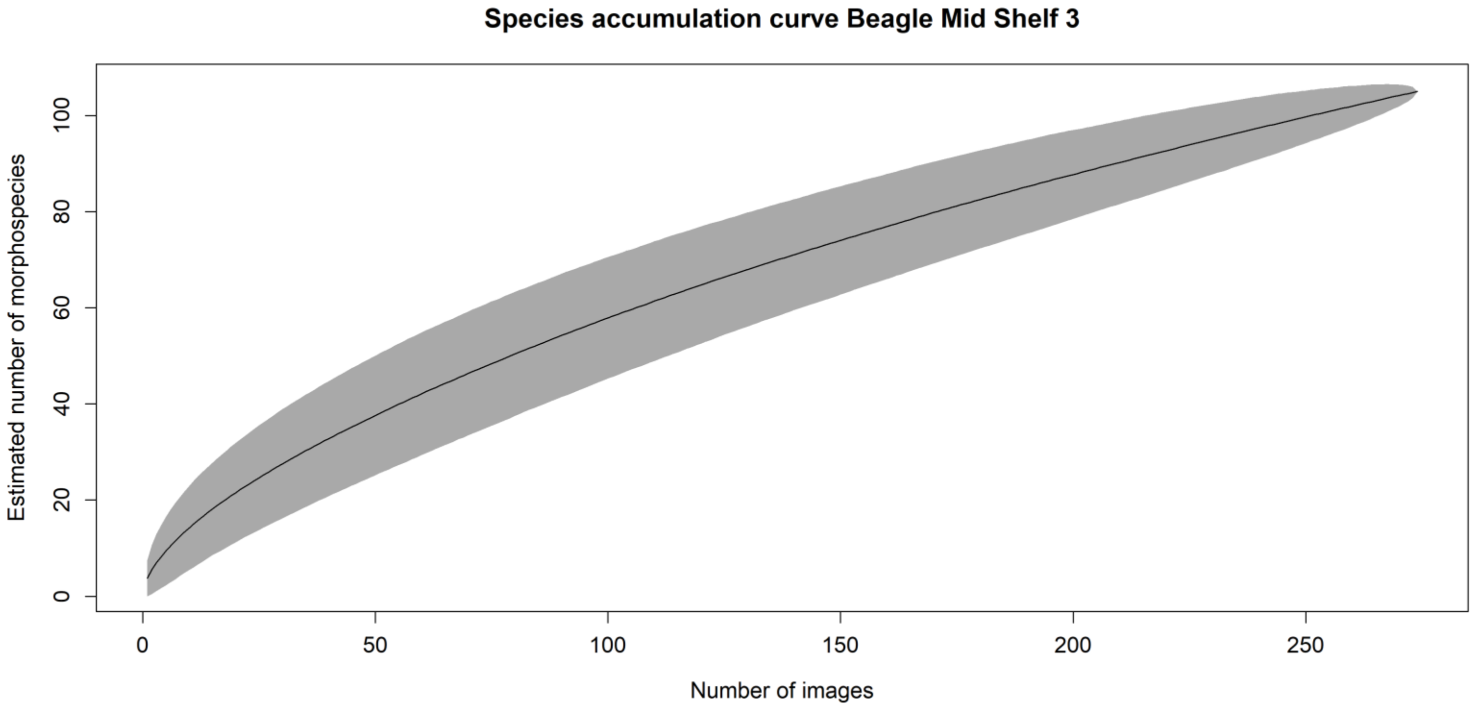


Figure 2.1.34 *Species accumulation curve for Beagle Mid-Shelf 3.*

The species accumulation curve reveals that the almost 300 images scored across time have not yet captured all the species richness at this site with the curve still not reaching an asymptote at 100 morphospecies (Figure 3.1.34).

2.2 Variability in cover across the time series: Population variability

Table 2.2.1 *Results of the population variability (PV) analysis. PV values were calculated from model-based estimates of cover each year within each marine park. The overall PV value (All AMPs) is the average of the PV value across each marine park it occurs. Morphospecies have been ordered from lowest to highest variability based on the overall PV value.*

Morphospecies	Huon	Freycinet	Flinders	Beagle	All AMPs
Non-Calcareous Encrusting Red Algae	0.084	-	-	-	0.084
Calcareous Encrusting Red Algae	0.151	-	-	-	0.151
Cup Red Smooth (sponge)	0.168	0.266	0.08	-	0.171
Cup Yellow (sponge)	0.188	0.175	0.219	-	0.194
Encrusting Light Orange (sponge)	0.209	0.252	0.125	-	0.195
Arborescent Grey (sponge)	0.331	0.203	0.086	-	0.206
Massive Purple (sponge)	0.149	0.2	0.308	-	0.219
Repent Orange (sponge)	0.355	0.222	0.12	-	0.232
Coral Orange Solitary (Caryophyllia like)	-	0.176	0.317	-	0.247
Encrusting Yellow Smooth (sponge)	0.17	0.475	0.136	-	0.26
Arborescent Orange (sponge)	0.531	0.154	0.161	-	0.282
Encrusting Orange (sponge)	0.126	0.182	0.417	0.428	0.289
Bryozoa Stumpy Hard	-	0.436	0.171	-	0.304
Massive Blue Shapeless (sponge)	0.233	0.451	0.249	-	0.311
Encrusting White (sponge)	0.246	0.608	0.109	-	0.321
Palmate Grey (sponge)	0.19	0.449	0.324	-	0.321
Encrusting Beige Smooth (sponge)	0.217	0.515	0.182	0.42	0.333
Unstalked Crinoids	0.444	0.192	0.404	-	0.347
Arborescent Orange Thin (sponge)	0.292	0.2	0.559	-	0.35
Encrusting Purple Lumpy (sponge)	0.371	0.28	0.159	0.59	0.35
Bryozoa Soft (merged)	0.473	0.533	0.2	0.236	0.361
Lumpy White (sponge)	0.341	0.43	0.318	-	0.363
Fan Pink (sponge)	0.247	0.344	0.212	0.679	0.37
Hydroid White	0.508	0.253	0.319	0.462	0.385
Encrusting Beige Oscula (sponge)	0.388	0.579	0.262	0.319	0.387
Simple Beige Lumpy (sponge)	0.4	0.468	0.289	0.466	0.406
Simple Beige Lumpy Shapeless (sponge)	0.47	0.626	0.14	0.466	0.425
Bramble Coral	-	0.44	0.418	-	0.429
Encrusting Blue (sponge)	0.207	0.873	0.263	-	0.448
Encrusting Black (sponge)	0.584	0.578	0.173	0.591	0.482
Purple Massive (sponge)	0.796	0.438	0.249	-	0.494
Branching Gray Fine Repent Like (sponge)	0.484	0.577	0.435	-	0.499
Repent Yellow (sponge)	0.566	0.451	0.324	0.678	0.505
Encrusting White Lumpy (sponge)	0.491	0.703	0.351	-	0.515
Gorgonian Red	0.203	0.692	0.784	-	0.56
Epizoanthus sp	0.575	0.729	0.637	-	0.647
Ascidian Colonial Purple	-	0.656	-	-	0.656

The PV analysis allowed a direct comparison of the variability in cover of each morphospecies in the time-series to date (Table 3). There were sometimes considerable differences in PV values for a single morphospecies between different marine parks, for example the Cup Red Smooth morphospecies had a low PV value for Flinders Marine Park, and a much higher value for Freycinet Marine Park. These differences are likely in part to be due to sampling error, as despite using model-based estimates, where abundances are low there will be considerable variability in estimates.

The lowest variability morphospecies were the encrusting red algal morphospecies at Huon Marine Park. However, as these morphospecies only occurred in one marine park, overall PV values are not influenced by PV values elsewhere as they are for most other morphospecies. Both cup sponge morphospecies (Cup Red Smooth and Cup Yellow) had low overall variability over the time series. Arborescent Grey, Massive Purple and Encrusting Light Orange sponges also had relatively low PV values.

Higher variability morphospecies included Ascidian Colonial Purple, Epizoanthus sp. and Gorgonian Red. Ascidian Colonial Purple is an encrusting ascidian that occurred only at Joe's Reef. While it may have variable cover through time, the PV value may also reflect sampling variability as it was noted to have high cover across a small number of images and therefore whether those images were sampled in a given year would affect within year estimates. For Epizoanthus sp. and Gorgonian Red, higher PV values were related to significant trends detected in their cover (see "Analysis of temporal trends for dominant morphospecies" section below).

2.3 Multivariate analysis of trend

Multivariate multi-dimensional scaling (MDS) showed that sites within marine parks and across time were relatively similar (Figure 3.3.1). The Beagle Mid-Shelf 3 site and Freycinet site 2 were distinctly different to all other sites. Freycinet site 2 is low relief and sand dominated, with a relatively low diversity of invertebrates. The Beagle Mid-Shelf 3 site is also sand dominated but contained several morphospecies not located in any of the other sites. The Huon Marine Park sites 1 and 2 were quite similar in terms of morphospecies composition and grouped distinctly from other sites due to characteristic morphospecies not found at other sites. In particular, the presence of significant cover of encrusting coralline and other encrusting red algae distinguished Huon Marine Park from the other marine parks. There was an overlap between the Flinders Marine Park sites and Joe's Reef, with many sessile invertebrate morphospecies shared across these sites. In particular, red smooth and yellow cup sponges, arborescent orange and grey sponges and many different encrusting sponge morphospecies were found across these sites.

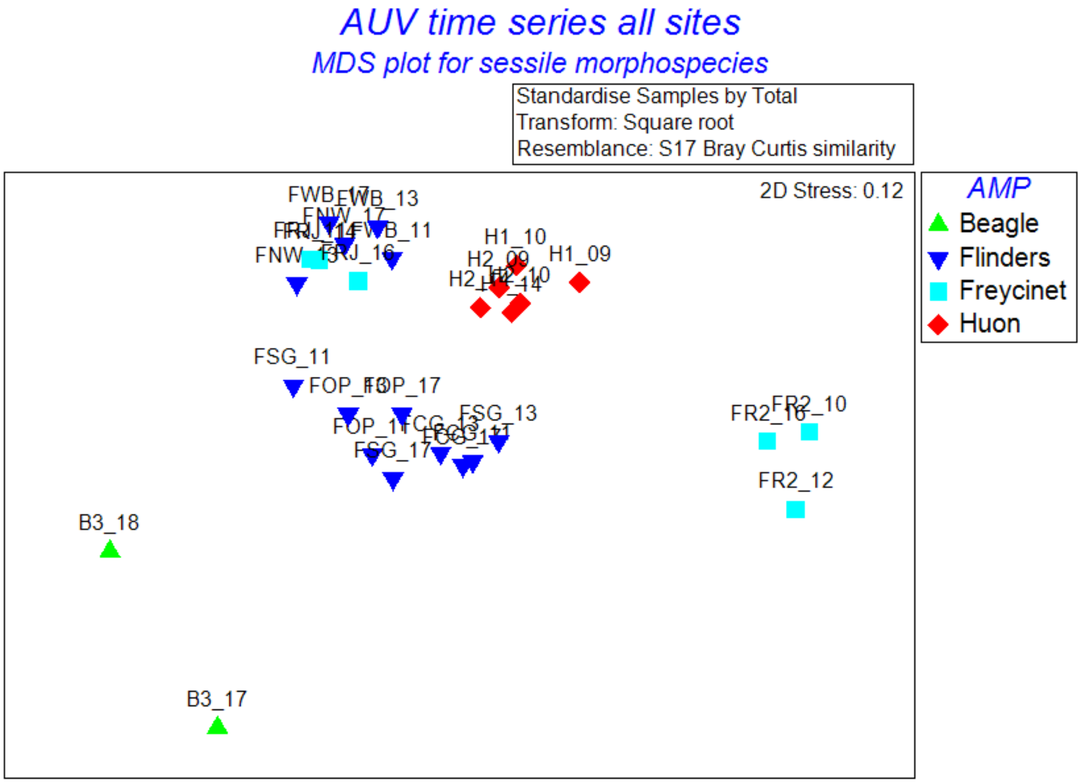


__Figure 2.3.1__ Multi-dimensional scaling (MDS) plot for all sites across all years surveyed. Only sessile morphospecies were included.

PERMANOVA analysis found that there were no significant shifts in community structure across the survey years within each marine ark. PERMANOVA could not be conducted for Beagle Marine Park as there were only 2 survey years and thus insufficient degrees of freedom for the test.

2.3.1.1 PERMANOVA results: Huon Marine Park

Factors

Name	Abbrev.	Type	Levels
Year	Ye	Fixed	3

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ye	2	1580.5	790.24	1.8569	0.116	15
Res	3	1276.7	425.56			
Total	5	2857.2				

2.3.1.2 PERMANOVA results: Freycinet Marine Park

Factors

Name	Abbrev.	Type	Levels
Year	Ye	Fixed	5

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ye	4	7803.9	1951	0.73904	0.477	15
Res	1	2639.9	2639.9			
Total	5	10444				

2.3.1.3 PERMANOVA results: Flinders Marine Park

Factors

Name	Abbrev.	Type	Levels
Year	Ye	Fixed	3

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ye	2	2249	1124.5	0.69987	0.86	995
Res	11	17674	1606.7			
Total	13	19923				

2.4 Analysis of temporal trends for dominant morphospecies

2.4.1 Arborescent Grey

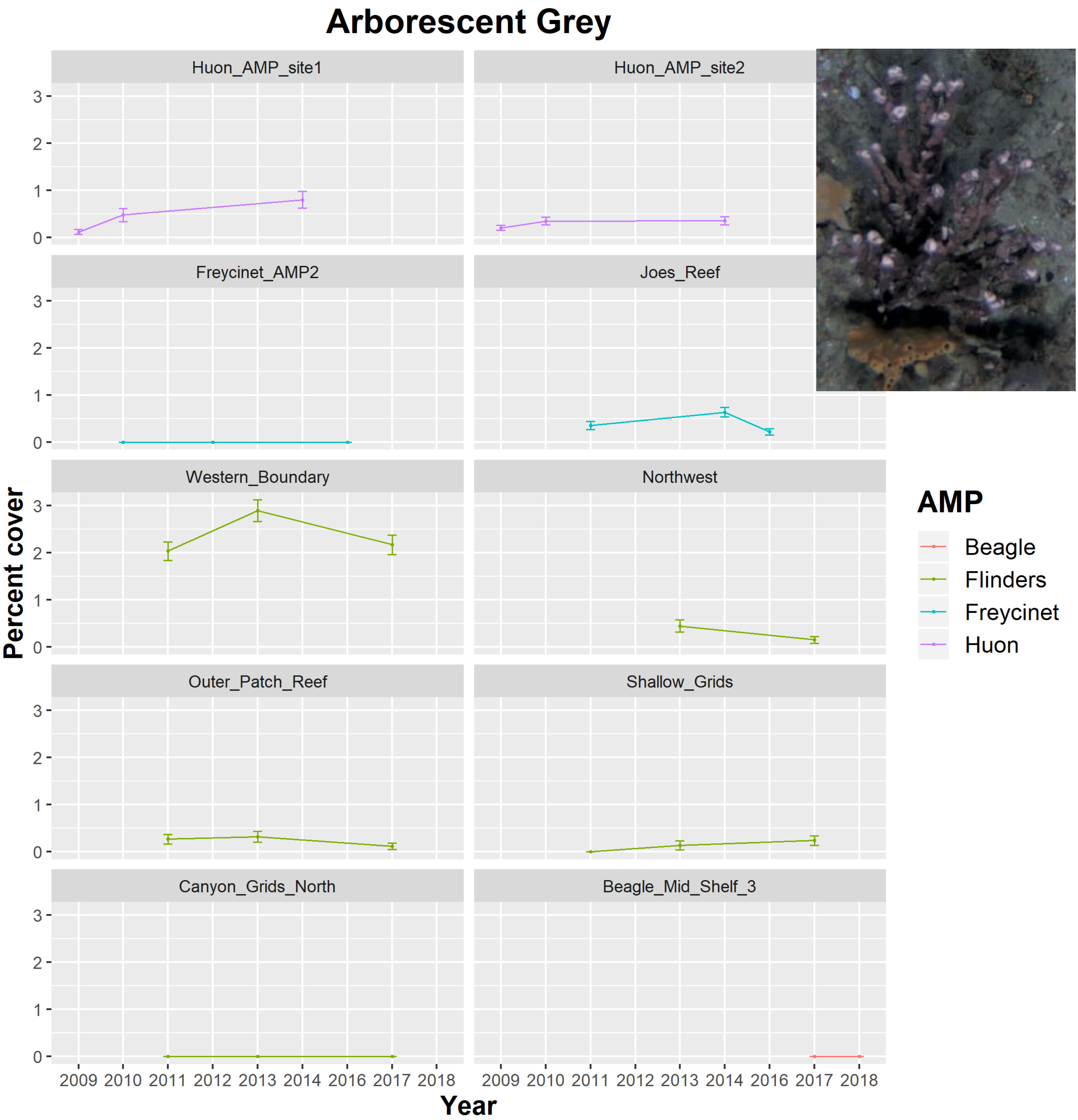


__Figure 2.4.1__ Site level trends in the raw data for Arborescent Grey sponges.

2.4.1.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.317 0.250     -7.811   -7.317     -6.829 -7.315   0
year      -0.138 0.083     -0.301   -0.138      0.024 -0.137   0
depth     -2.015 0.185     -2.387   -2.012     -1.662 -2.006   0

Random effects:
  Name     Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                     mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP   6.393 3.424      2.101    5.635      15.14  4.382
Range for i        18.606 5.216     10.726   17.797      31.02 16.280
Stdev for i         1.450 0.125      1.207    1.450       1.70  1.457
GroupRho for i      0.714 0.084      0.534    0.718       0.86  0.728
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.236 0.170     -6.577   -6.234     -5.909 -6.229   0
year       0.350 0.131      0.092    0.350      0.606  0.351   0
depth     -0.372 0.176     -0.729   -0.368     -0.037 -0.360   0

Random effects:
  Name     Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18887.906 19072.222   1316.075 13234.053  69827.997 362
1.128
Range for i           47.351    21.970     18.376    42.820    102.581    3
5.208
Stdev for i            0.972     0.197      0.622     0.961      1.393
0.944
GroupRho for i         0.846     0.064      0.689     0.857      0.938
0.879
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.348 0.793     -7.910   -6.347     -4.795 -6.345   0
year      -0.031 0.077     -0.183   -0.031      0.121 -0.030   0

Random effects:
  Name     Model
    site IID model
   i SPDE2 model

Model hyperparameters:
```

```
                      mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  0.401 0.344      0.065    0.305      1.309  0.169
Range for i        12.042 2.693      7.562   11.774     18.096 11.265
Stdev for i         1.268 0.150      0.998    1.260      1.586  1.244
GroupRho for i      0.700 0.120      0.415    0.719      0.878  0.757
```

Flinders Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.670 0.430     -7.541   -6.661     -5.852 -6.643   0
year      -0.039 0.078     -0.192   -0.038      0.114 -0.038   0
depth     -1.981 0.600     -3.263   -1.944     -0.903 -1.868   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                      mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  1.750 1.304      0.314    1.421      5.148  0.837
Range for i        12.080 2.682      7.621   11.810     18.109 11.295
Stdev for i         1.268 0.151      0.995    1.260      1.586  1.246
GroupRho for i      0.696 0.119      0.422    0.711      0.881  0.744
```

No overall trend was found for arborescent grey sponges across all marine parks. A positive trend was detected in arborescent grey sponge cover in Huon Marine Park, while for all other parks no significant linear trend was detected. The mean estimated trend at Huon Marine Park equates to a 42% increase in the odds of presence per year over the survey period. Also, an overall negative coefficient estimate for depth indicates that arborescent grey sponges tend to occupy shallower depths across those that were surveyed.

2.4.2 Arborescent Orange

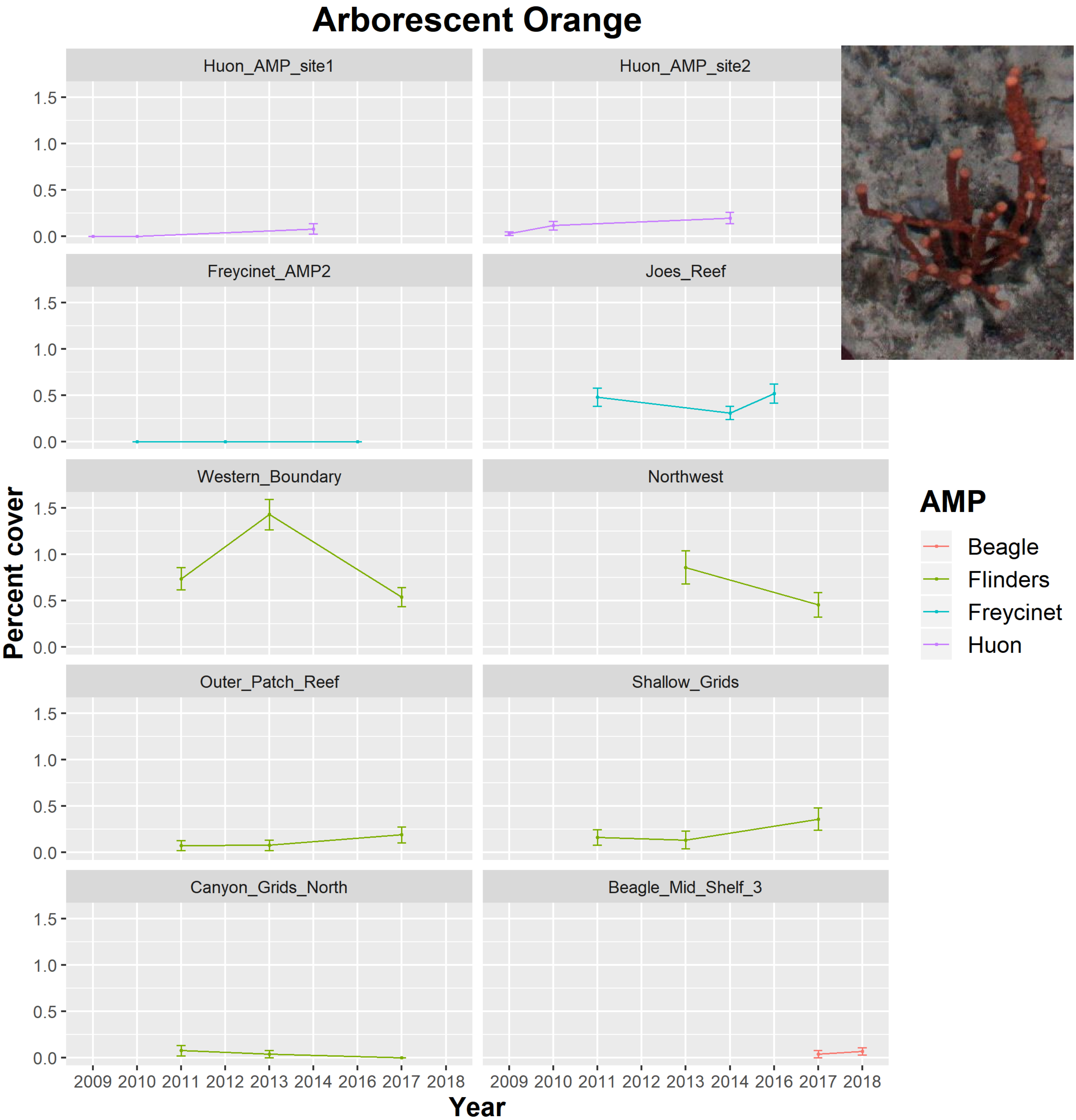


Figure 2.4.2 *Site level trends in the raw data for Arborescent Orange sponges.*

2.4.2.1 *Model-based estimates of trend*

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.415 0.312     -8.028   -7.414     -6.805 -7.413   0
year       0.010 0.092     -0.171    0.010      0.190  0.010   0
depth     -1.308 0.171     -1.659   -1.303     -0.986 -1.293   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  3.245 1.812      0.913    2.871      7.781  2.146
Range for i       13.356 2.759      8.649   13.126     19.438 12.697
Stdev for i        1.623 0.190      1.279    1.614      2.023  1.597
GroupRho for i     0.801 0.058      0.660    0.812      0.885  0.833
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.513 0.261     -8.060   -7.501     -7.032 -7.477   0
year       0.714 0.227      0.281    0.710      1.171  0.701   0
depth      0.161 0.241     -0.323    0.165      0.625  0.171   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18470.886 18078.065   1253.984 13148.802  66466.723 342
7.080
Range for i           50.917    48.855     13.790    35.953    177.252   2
1.860
Stdev for i            0.275     0.209      0.013     0.223      0.735
0.028
GroupRho for i         0.865     0.047      0.760     0.870      0.941
0.881
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.558 0.284     -8.154   -7.545     -7.036 -7.518   0
year      -0.035 0.165     -0.357   -0.035      0.289 -0.036   0
depth     -1.591 0.272     -2.156   -1.580     -1.087 -1.559   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
```

```
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19605.717 20191.821   1406.712 13601.274  73347.406 385
1.076
Range for i           22.377     9.997      9.172    20.305     47.484   1
6.868
Stdev for i            1.182     0.237      0.769     1.165      1.696
1.136
GroupRho for i         0.843     0.066      0.682     0.854      0.938
0.876
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.683 0.161     -7.017   -6.677     -6.383 -6.664   0
year      -0.131 0.099     -0.326   -0.131      0.061 -0.130   0
depth     -1.507 0.234     -1.994   -1.497     -1.076 -1.477   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18881.743 18451.774    1290.21 13455.965  67702.540 353
3.997
Range for i           12.850     2.769       8.38    12.512     19.217   1
1.842
Stdev for i            1.591     0.198       1.23     1.580      2.011
1.562
GroupRho for i         0.808     0.082       0.61     0.821      0.928
0.848
```

No overall trend was found for arborescent orange sponges across all marine parks. A positive trend was detected in arborescent orange sponge cover in Huon Marine Park, while for all other parks no significant linear trend was detected. The mean estimated trend at Huon Marine Park equates to a 104% increase in the odds of presence per year over the survey period. Also, an overall negative coefficient estimate for depth indicates that arborescent orange sponges tend to occupy shallower depths across those that were surveyed.

2.4.3 Arborescent Orange Thin

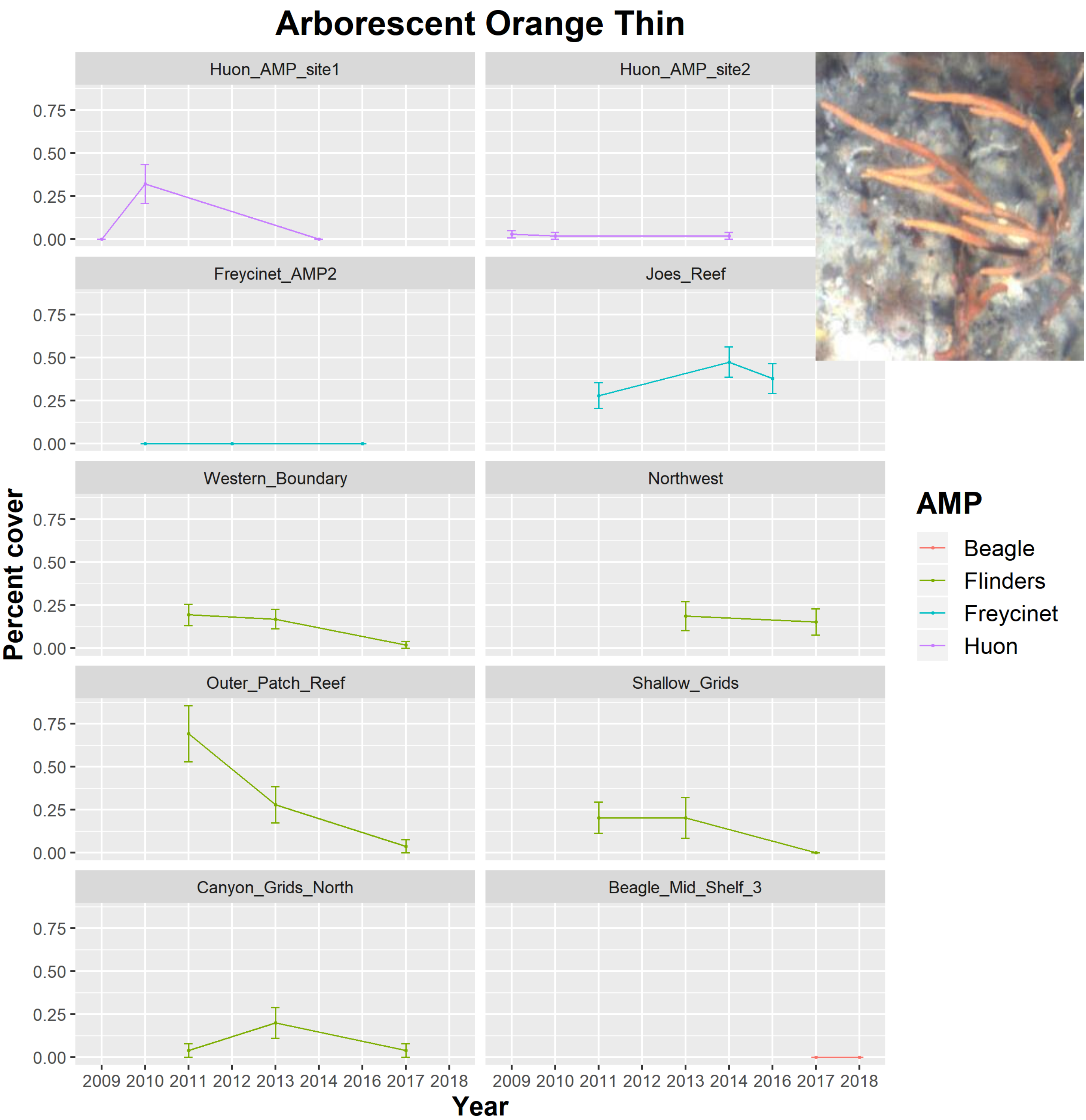


Figure 2.4.3 *Site level trends in the raw data for Arborescent Orange Thin sponges.*

2.4.3.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.975 0.315     -8.600   -7.973     -7.364 -7.968   0
year      -0.543 0.239     -1.019   -0.540     -0.079 -0.536   0
depth     -0.297 0.299     -0.892   -0.293      0.282 -0.287   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                      mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 16615.07 16593.546   1165.866 11719.316  61097.433 3206.181
Range for i         508.17   186.800    240.055   475.894    961.384  418.298
Stdev for i           1.59     0.235      1.182     1.568      2.103    1.527
GroupRho for i        0.82     0.062      0.678     0.828      0.919    0.843
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.211 0.418    -10.090   -9.190     -8.448 -9.149   0
year      -0.162 0.401     -1.010   -0.140      0.567 -0.097   0
depth      0.226 0.339     -0.459    0.233      0.874  0.246   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19401.255 19468.742   1352.189 13636.396  71184.667 369
9.004
Range for i           48.592    24.126     19.549    42.751    111.087    3
4.020
Stdev for i            1.828     0.401      1.145     1.795      2.712
1.733
GroupRho for i         0.845     0.066      0.682     0.856      0.939
0.879
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.045 0.228     -7.521   -7.036     -6.623 -7.017   0
year       0.151 0.161     -0.162    0.150      0.471  0.147   0
depth     -1.117 0.226     -1.584   -1.109     -0.695 -1.094   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
```

```
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19028.968 19116.433   1314.885 13365.410  70060.750 360
3.837
Range for i           70.135   104.931     10.030    39.728    315.902    1
9.561
Stdev for i            0.842     0.257      0.412     0.821      1.403
0.776
GroupRho for i         0.839     0.068      0.676     0.851      0.937
0.873
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.151 0.173     -7.505   -7.147     -6.824 -7.138   0
year      -0.690 0.168     -1.033   -0.685     -0.375 -0.675   0
depth     -0.184 0.176     -0.543   -0.180      0.149 -0.171   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19472.154 19371.979   1321.501 13741.164  71085.597 361
4.246
Range for i           38.724    22.939     11.911    33.134     98.306    2
4.727
Stdev for i            1.049     0.215      0.671     1.036      1.513
1.013
GroupRho for i         0.835     0.071      0.661     0.848      0.936
0.872
```

An overall linear decline was found for arborescent orange thin sponges across all marine parks, equating to an overall 42% decline per year. A negative trend was also found for Flinders Marine Park, equating to a 50% decrease in the odds of presence per year over the survey period. No significant overall depth relationship was found.

2.4.4 Ascidian Colonial Purple

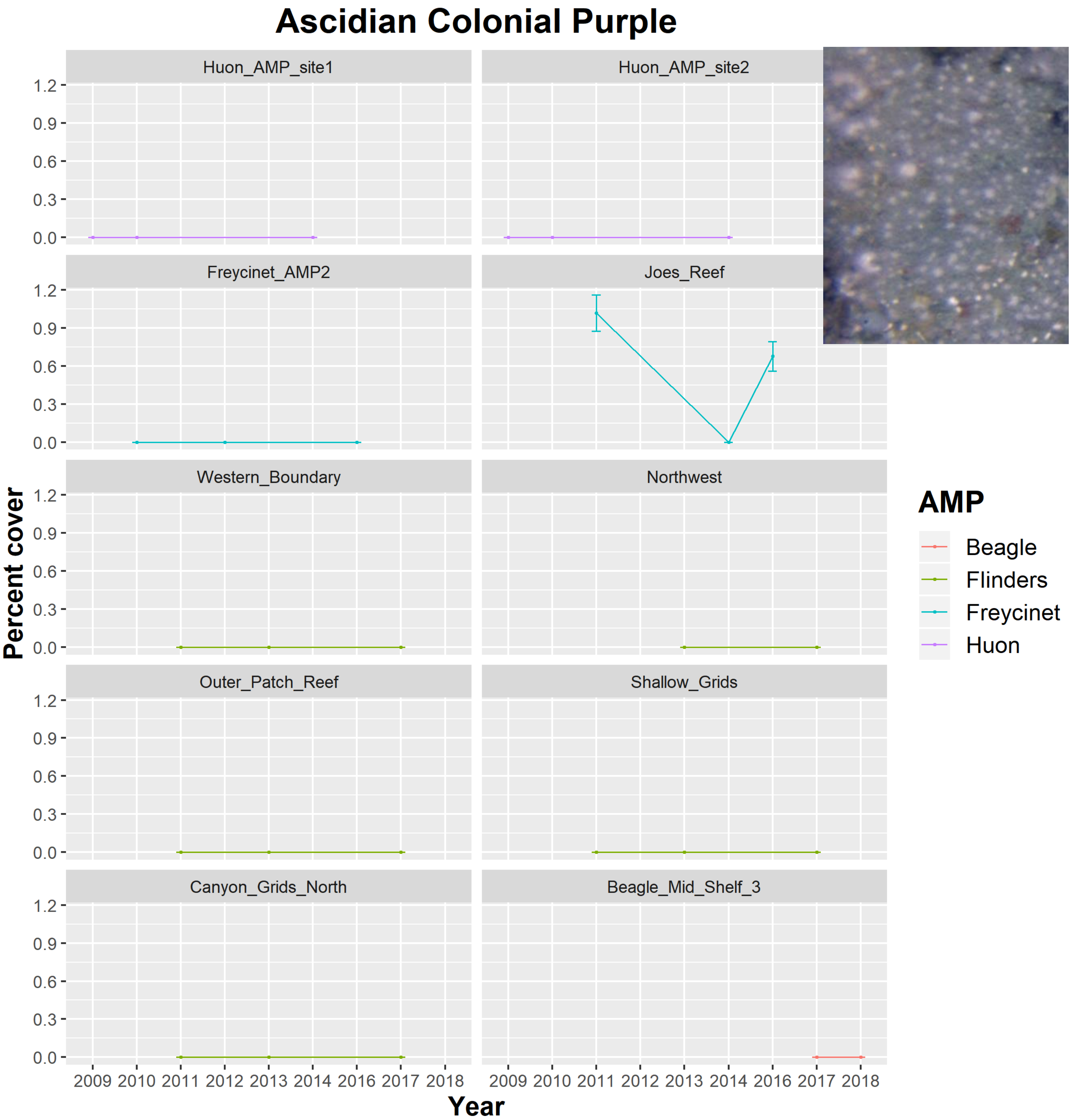


Figure 2.4.4 *Site level trends in the raw data for Ascidian Colonial Purple.*

2.4.4.1 Model-based estimates of trend

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -14.812 1.071    -17.154  -14.723    -12.957 -14.534   0
year       -1.030 0.572     -2.192   -1.017      0.055  -0.990   0
depth      -3.466 0.958     -5.532   -3.397     -1.772  -3.256   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19870.720 20418.043   1419.075 13800.853  74263.771 391
0.583
Range for i           27.522     6.180     17.410    26.837     41.559   2
5.518
Stdev for i            3.853     0.464      3.015     3.828      4.840
3.781
GroupRho for i         0.836     0.064      0.681     0.847      0.931
0.867
```

No trend was found for ascidian colonial purple. As this morphospecies only occurred at Joe's Reef in Freycinet Marine Park, a global model was not run. The negative coefficient for depth indicates that this morphospecies occupied shallower depths at the Joe's Reef site.

2.4.5 Bramble Coral

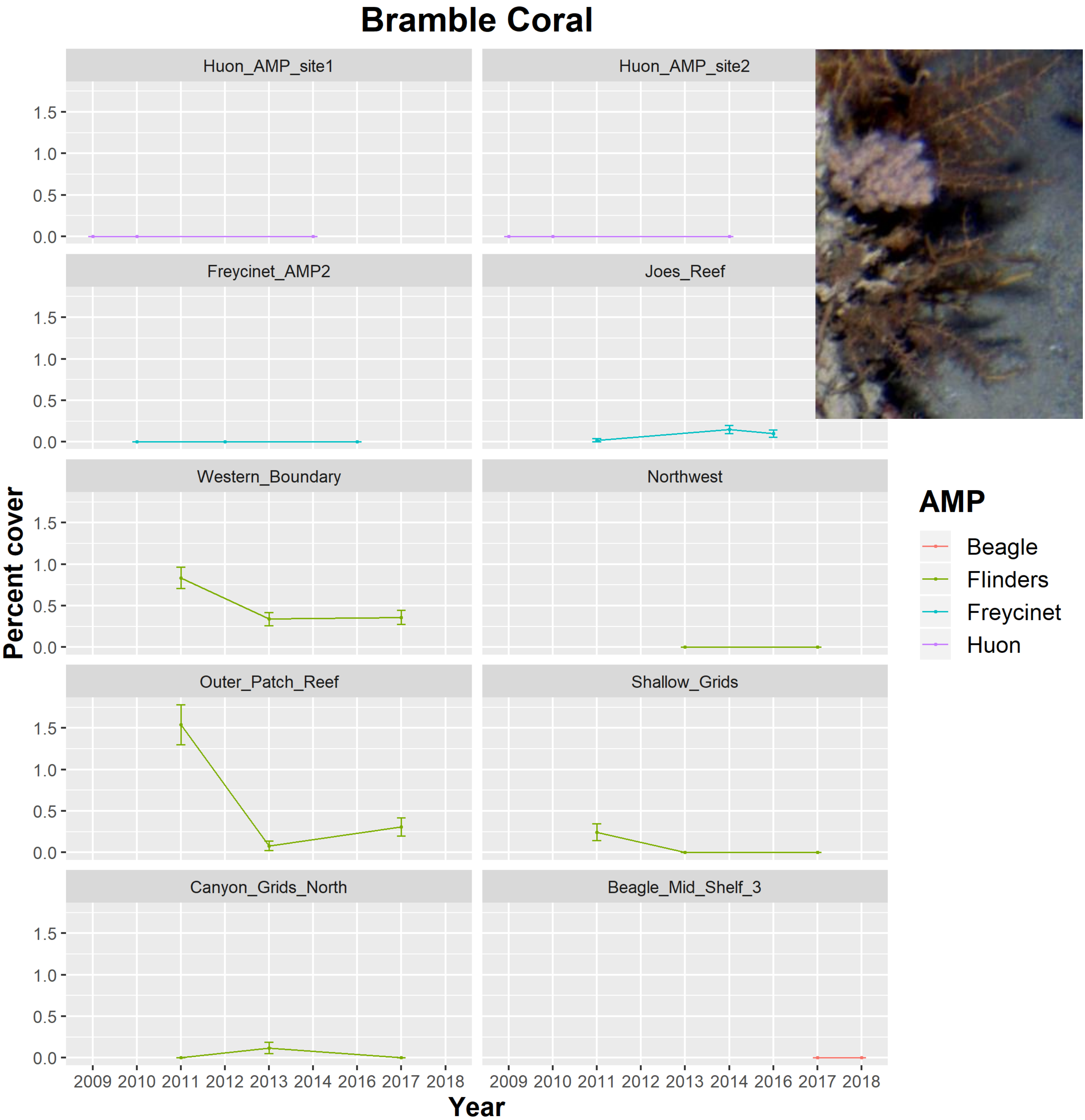


Figure 2.4.5 *Site level trends in the raw data for Bramble Coral (A. kareni like).*

2.4.5.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.936 0.378    -10.698   -9.930     -9.211 -9.917   0
year      -0.248 0.294     -0.833   -0.246      0.323 -0.241   0
depth     -0.428 0.385     -1.203   -0.421      0.311 -0.408   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant 0.5quant 0.975quant     mode
Precision for AMP 22885.357 64250.760    638.762 7993.494 137523.634 1499.409
Range for i         240.600    65.129    137.922  232.127    391.796  216.148
Stdev for i           2.369     0.322      1.845    2.329      3.104    2.234
GroupRho for i        0.838     0.064      0.703    0.843      0.944    0.859
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.814 0.476     -9.844   -8.779     -7.977 -8.705   0
year       0.479 0.335     -0.143    0.466      1.173  0.440   0
depth     -1.231 0.407     -2.100   -1.206     -0.498 -1.155   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18851.868 18542.742   1360.596 13409.937  67719.320 374
3.807
Range for i           21.015    12.895      7.158    17.545     55.037   1
2.952
Stdev for i            0.896     0.511      0.185     0.810      2.103
0.536
GroupRho for i         0.845     0.066      0.684     0.857      0.939
0.879
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.033 0.325     -8.683   -8.029     -7.407 -8.021   0
year      -0.459 0.217     -0.891   -0.457     -0.040 -0.452   0
depth     -0.420 0.371     -1.168   -0.413      0.290 -0.399   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model
```

```
Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18884.219 18499.385   1258.392 13428.894  67794.933 343
0.342
Range for i          116.736    42.099     54.426   110.169    217.705   9
7.920
Stdev for i            1.841     0.254      1.387     1.826      2.385
1.799
GroupRho for i         0.744     0.086      0.544     0.755      0.878
0.777
```

No overall trend was found for bramble coral across all marine parks. A negative trend was detected in cover of bramble coral in Flinders Marine Park equating to a 37% decrease per year over the survey period. In particular, there was a notable decline between the first survey (2011) and second survey (2013). This trend is evident at all sites except the Canyon Grids North site, where there was low overall cover and little change and the Northwest site where the morphospecies was absent. The small apparent increase visible in the plots at Joe's Reef in Freycinet Marine Park was found to be non-significant. No significant effect was found for depth.

2.4.6 Branching Gray Fine Repent Like

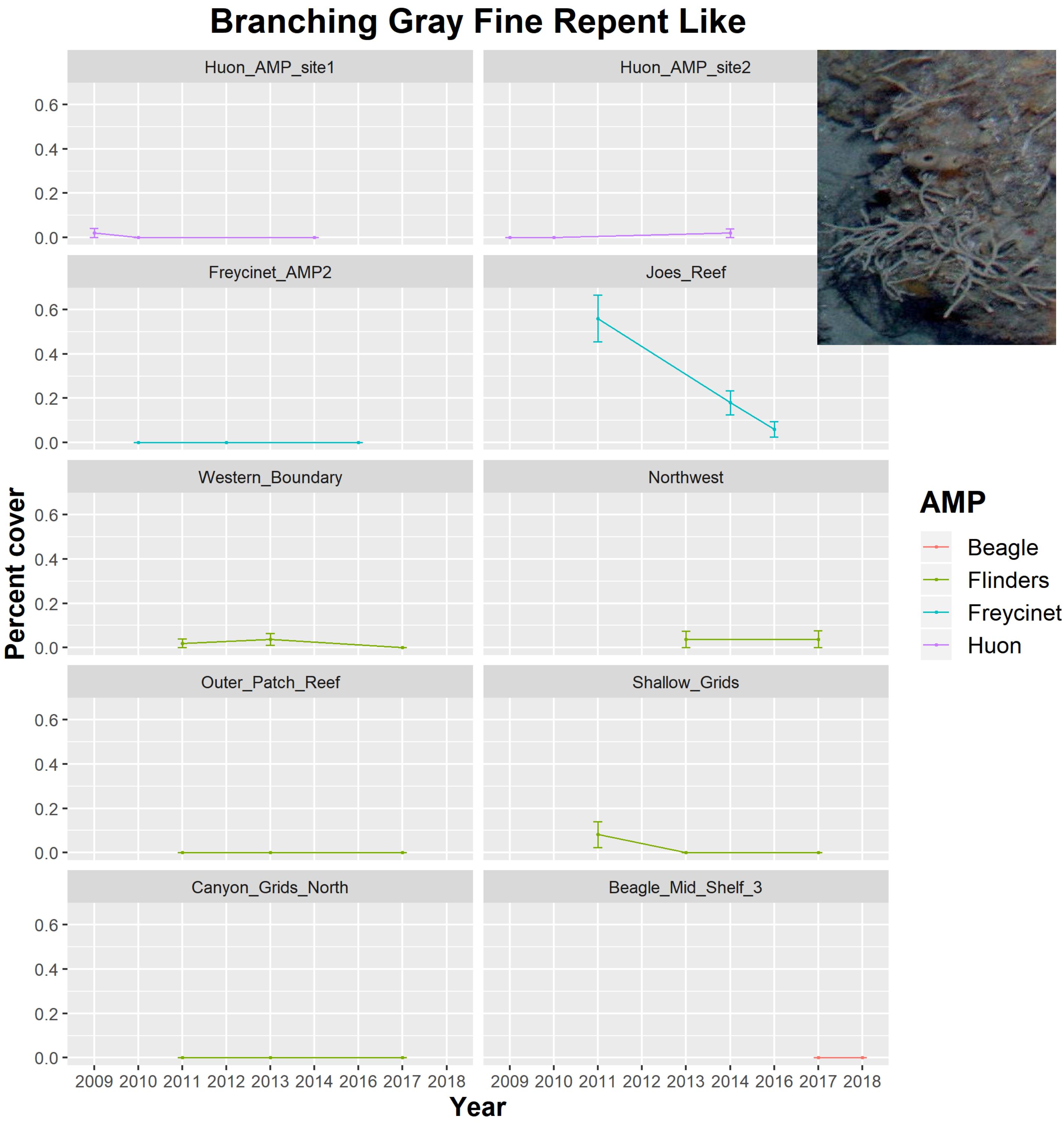


Figure 2.4.6 *Site level trends in the raw data for Branching Gray Fine Repent like sponges.*

2.4.6.1 *Model-based estimates of trend*

All Marine Parks

Fixed effects:

	mean	sd	0.025quant	0.5quant	0.975quant	mode	kld
intercept	-10.092	0.404	-10.923	-10.079	-9.335	-10.053	0
year	-0.513	0.312	-1.148	-0.505	0.078	-0.490	0
depth	-0.419	0.479	-1.436	-0.392	0.449	-0.337	0

Random effects:

Name	Model
AMP	IID model
i	SPDE2 model

Model hyperparameters:

	mean	sd	0.025quant	0.5quant	0.975quant	mode
Precision for AMP	19798.961	19840.812	1447.138	13948.91	72211.471	3999.35
Range for i	324.724	166.775	130.499	282.68	760.330	221.53
Stdev for i	1.799	0.324	1.244	1.77	2.516	1.72
GroupRho for i	0.858	0.057	0.715	0.87	0.936	0.89

Huon Marine Park

Fixed effects:

	mean	sd	0.025quant	0.5quant	0.975quant	mode	kld
intercept	-9.786	0.809	-11.582	-9.705	-8.417	-9.530	0
year	0.646	0.582	-0.513	0.652	1.775	0.662	0
depth	0.868	0.578	-0.184	0.839	2.085	0.779	0

Random effects:

Name	Model
site	IID model
i	SPDE2 model

Model hyperparameters:

	mean	sd	0.025quant	0.5quant	0.975quant	mode
Precision for site	18649.260	18399.967	1266.924	13218.557	67274.78	3463.351
Range for i	40.882	50.818	4.664	25.678	169.69	11.636
Stdev for i	0.316	0.329	0.031	0.219	1.19	0.086
GroupRho for i	0.848	0.064	0.691	0.860	0.94	0.881

Freycinet Marine Park

Fixed effects:

	mean	sd	0.025quant	0.5quant	0.975quant	mode	kld
intercept	-8.230	0.341	-8.948	-8.213	-7.607	-8.179	0
year	-0.730	0.237	-1.208	-0.726	-0.278	-0.717	0
depth	-1.345	0.328	-2.029	-1.331	-0.741	-1.302	0

Random effects:

Name	Model
site	IID model
i	SPDE2 model

```
Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
mode
Precision for site 19336.70 19364.112   1351.821 13607.536  70923.916 370
1.089
Range for i           33.69    14.937     13.863    30.623     71.227   2
5.508
Stdev for i            1.32     0.247      0.884     1.302      1.849
1.274
GroupRho for i         0.84     0.068      0.673     0.852      0.937
0.875
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.203 0.535    -10.385   -9.152     -8.290 -9.044   0
year      -0.490 0.410     -1.362   -0.466      0.250 -0.418   0
depth     -1.006 0.719     -2.606   -0.933      0.208 -0.774   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18608.856 18378.128   1265.311 13183.084   67177.78 345
8.619
Range for i           44.095    56.199      5.213    27.309     186.55   1
2.635
Stdev for i            0.284     0.281      0.023     0.201       1.03
0.066
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

No overall trend was found for branching grey fine repent like grey sponges across all marine parks. A positive trend was detected in Huon Marine Park, with the mean estimated trend at Huon Marine Park equating to a 91% increase in the odds of presence per year over the survey period. A negative trend was detected in Freycinet Marine Park, with the mean estimated trend equating to a 52% decrease in the odds of presence per year over the survey period. No overall significant effect was found for depth.

2.4.7 Bryozoa Soft (merged)

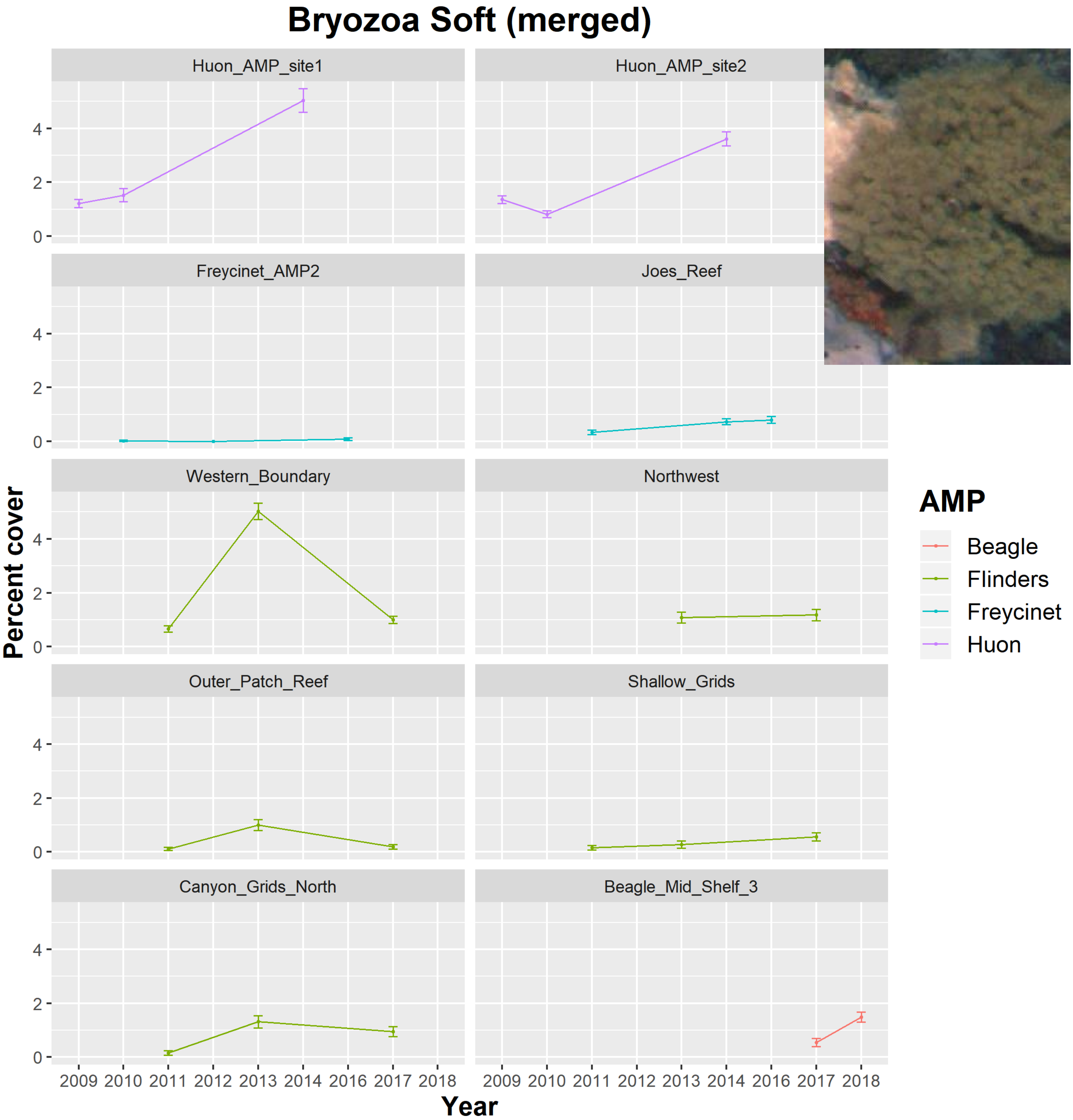


Figure 2.4.7 *Site level trends in the raw data for Bryozoa Soft (merged).*

2.4.7.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.875 0.360     -6.583   -5.875     -5.168 -5.875   0
year       0.430 0.103      0.228    0.430      0.632  0.430   0
depth     -0.393 0.108     -0.606   -0.393     -0.183 -0.392   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  2.391  0.639      1.500    2.266      3.963  2.018
Range for i       72.509 11.655     53.091   71.273     98.671 68.621
Stdev for i        1.448  0.075      1.310    1.444      1.606  1.434
GroupRho for i     0.587  0.074      0.427    0.592      0.718  0.603
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -4.248 0.112     -4.470   -4.248     -4.029 -4.247   0
year       0.577 0.085      0.409    0.577      0.744  0.577   0
depth     -0.179 0.095     -0.366   -0.179      0.005 -0.178   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 22278.123 24985.365   1702.146 14761.248   87706.825 465
2.621
Range for i             31.298     6.010     21.137    30.745      44.666   2
9.677
Stdev for i              1.337     0.126      1.105     1.332       1.599
1.323
GroupRho for i           0.796     0.081      0.604     0.809       0.916
0.834
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.178 0.217     -7.620   -7.171     -6.770 -7.159   0
year       0.627 0.172      0.296    0.625      0.972  0.620   0
depth     -0.991 0.212     -1.423   -0.986     -0.591 -0.975   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
```

```
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 21932.464 22476.234   1666.483 15280.673  81528.980 461
5.987
Range for i           19.281     5.195     11.150    18.584     31.394   1
7.268
Stdev for i            1.659     0.213      1.278     1.645      2.115
1.619
GroupRho for i         0.831     0.068      0.669     0.841      0.933
0.862
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.751 0.226     -6.197   -5.750     -5.309 -5.749   0
year       0.146 0.173     -0.194    0.146      0.485  0.146   0
depth     -0.226 0.235     -0.690   -0.225      0.232 -0.224   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18814.802 18121.964   1361.687 13535.789  66978.009 376
3.665
Range for i          170.064    35.152    112.693   165.994    250.313  15
7.895
Stdev for i            1.398     0.142      1.141     1.391      1.698
1.375
GroupRho for i         0.485     0.109      0.253     0.491      0.679
0.503
0.522
```

2.4.7.2

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.945 0.254     -6.454   -5.941     -5.455 -5.934   0
year       0.079 0.238     -0.378    0.076      0.557  0.069   0
depth     -0.721 0.212     -1.138   -0.720     -0.305 -0.720   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19557.549 19402.622   1330.611 13823.862  71232.061 364
3.642
Range for i           65.064    20.315     34.883    61.800    113.817   5
5.824
Stdev for i            1.707     0.265      1.241     1.688      2.284
1.652
GroupRho for i         0.848     0.065      0.688     0.859      0.939
0.881
0.878
```

An overall trend was found for soft bryozoans across all marine parks equating to a 54% increase in the odds of presence per year. Positive trends were also detected in Huon Marine Park (78% increase in odds of presence per year) and Freycinet Marine Park (87% increase in odds of presence per year). An overall negative effect was found for depth, suggesting that soft bryozoans tend to prefer the shallower depth across those that were surveyed.

2.4.8 Bryozoa Stumpy Hard

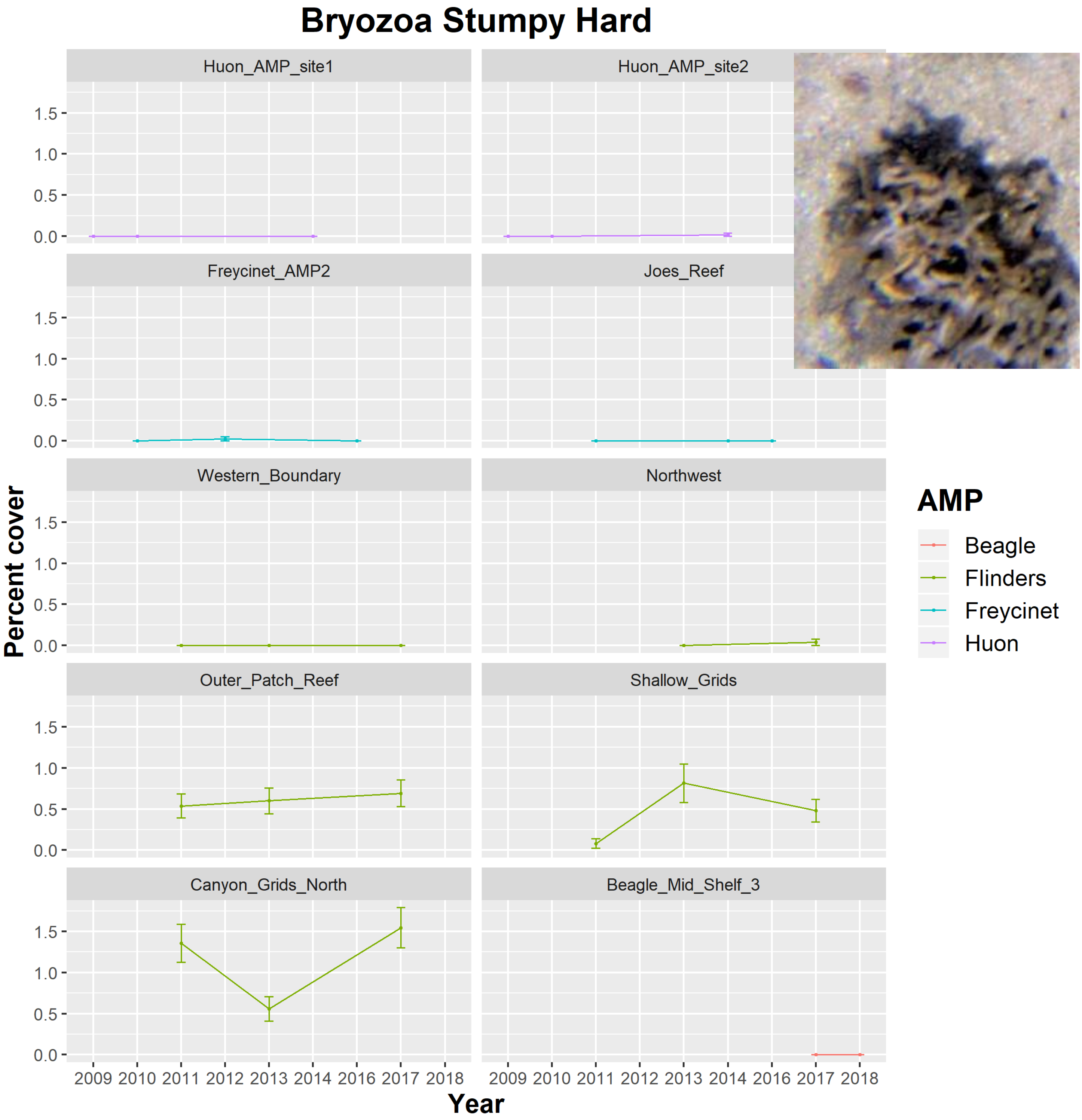


__Figure 2.4.8__ Site level trends in the raw data for Bryozoa Stumpy Hard.

2.4.8.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.777 0.459    -10.703   -9.769     -8.900 -9.752   0
year       0.173 0.271     -0.358    0.172      0.706  0.171   0
depth      1.245 0.391      0.479    1.244      2.015  1.242   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant 0.5quant 0.975quant     mode
Precision for AMP 19394.710 18695.164   1251.442 13904.62  68918.874 3377.382
Range for i         345.328   100.547    194.722   329.37    585.940  299.731
Stdev for i           2.385     0.304      1.856     2.36      3.052    2.305
GroupRho for i        0.925     0.027      0.859     0.93      0.964    0.939
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.241 0.853    -12.146  -10.150     -8.811 -9.952   0
year       -0.165 0.672     -1.577   -0.133      1.064 -0.068   0
depth       0.592 0.827     -0.839    0.521      2.405  0.371   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18768.786 18495.104   1301.536 13319.997  67602.530 356
5.662
Range for i           71.627   136.571      6.784    34.820    365.168   1
4.615
Stdev for i            0.215     0.200      0.016     0.158      0.746
0.045
GroupRho for i         0.848     0.064      0.692     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.169 0.328     -7.824   -7.165     -6.536 -7.157   0
year       0.113 0.160     -0.202    0.113      0.427  0.114   0
depth      1.559 0.324      0.926    1.558      2.197  1.556   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
```

```
                         mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 18320.634 18197.834   1251.835 12940.53  66494.153 341
8.925
Range for i          158.092    45.358     91.963   150.18    268.149  13
5.347
Stdev for i            1.715     0.204      1.356     1.70      2.155
1.668
GroupRho for i         0.893     0.041      0.792     0.90      0.952
0.914
```

No significant linear trends were found for the Bryozoa Hard Stumpy morphospecies. This morphospecies is a dominant morphospecies at the Flinders Shallow Grids and Canyon Grids North sites. An overall positive effect for depth was found, suggesting this morphospecies is found in greater depths across those surveyed. This is likely to be driven by the occurrence of this morphospecies at the Canyon Grids North site in Flinders, the deepest site surveyed.

2.4.9 Calcareous Encrusting Red Algae

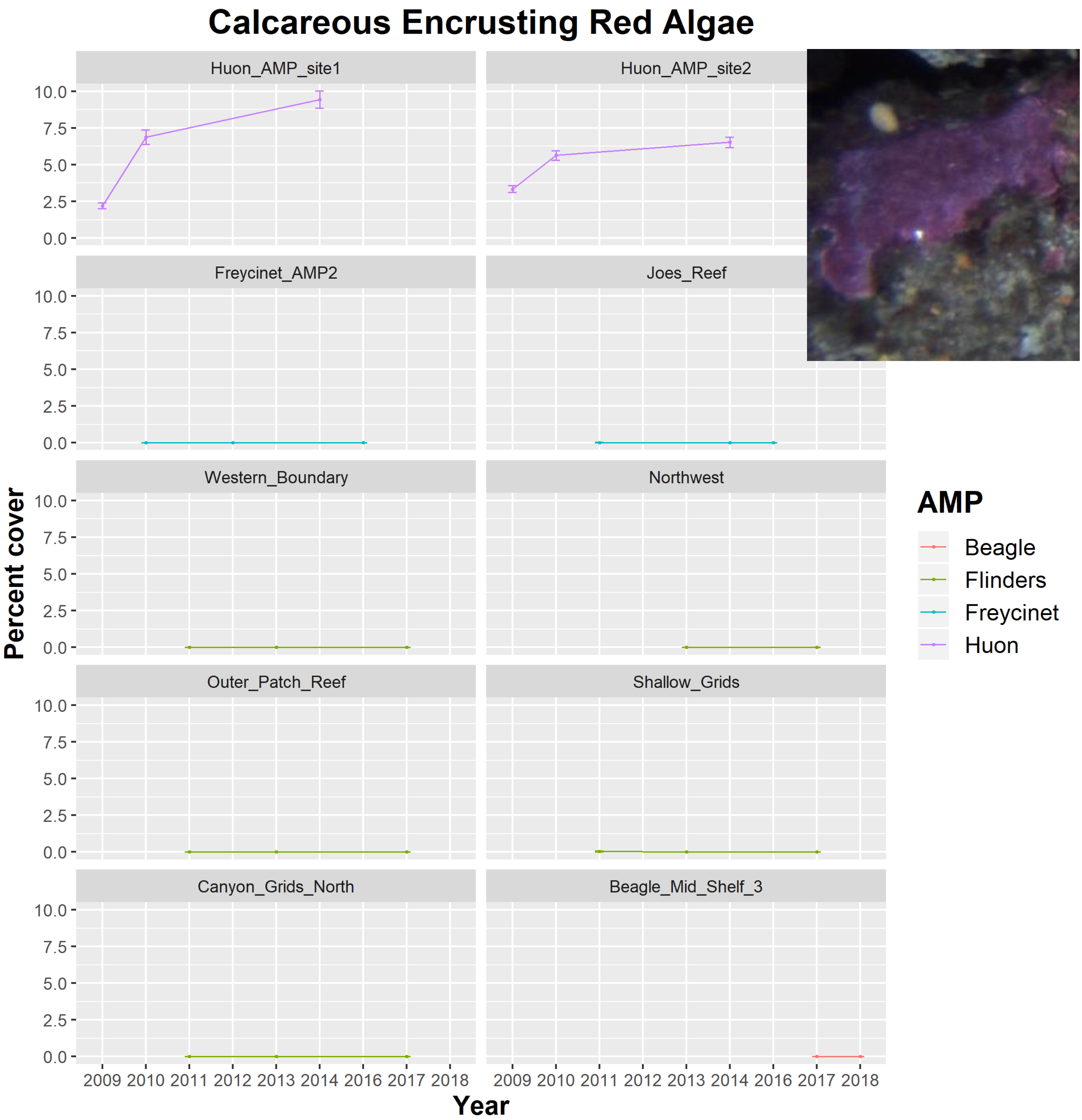


Figure 2.4.9 *Site level trends in the raw data for Calcareous Encrusting Red Algae.*

2.4.9.1 Model-based estimates of trend

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -3.523 0.096     -3.713   -3.523     -3.335 -3.522   0
year       0.136 0.064      0.010    0.136      0.261  0.136   0
depth     -0.982 0.095     -1.171   -0.980     -0.798 -0.978   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18693.643 18473.255   1175.038 13204.446  67624.080 314
2.291
Range for i           38.203     7.398     26.408    37.241     55.314   3
5.229
Stdev for i            1.035     0.082      0.884     1.031      1.205
1.023
GroupRho for i         0.855     0.054      0.725     0.863      0.935
0.879
```

Calcareous encrusting red algae is a dominant morphospecies within Huon Marine Park, which includes depths that have sufficient light penetration to support algal communities. An overall positive trend equating to a 15% increase in the odds of presence per year over the survey period. This is a relatively small increase and is less than is suggested by the plots of the raw data above. This is likely due to the wider spatial coverage of the survey in 2009 which also encompassed greater depths where algae are less likely to be present.

2.4.10 *Coral Orange Solitary (Caryophyllia like)*

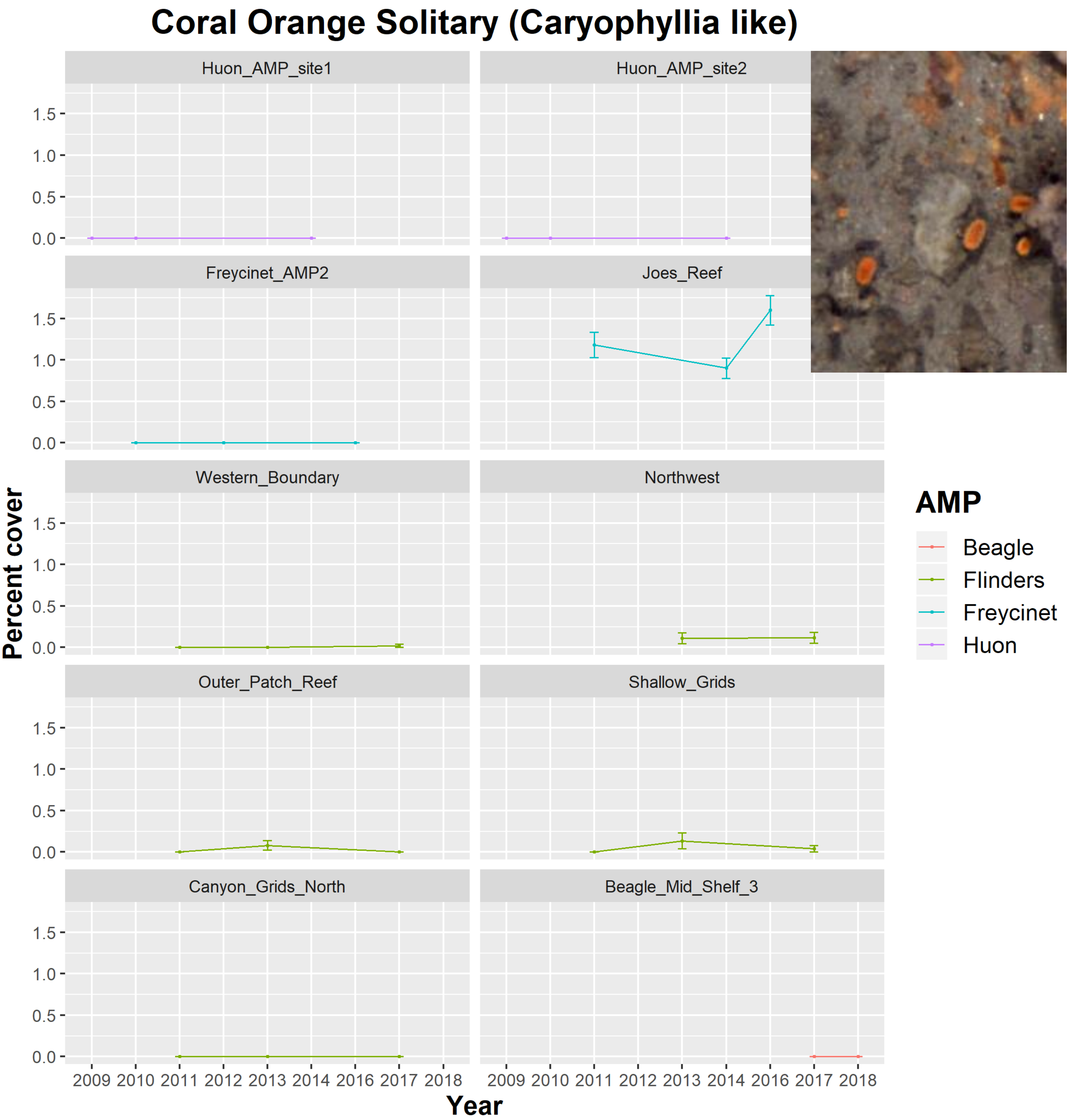


__Figure 2.4.10__ Site level trends in the raw data for Coral Orange Solitary (Caryophyllia like).

2.4.10.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -10.430 1.295    -13.022  -10.414     -7.934 -10.380   0
year        0.217 0.286     -0.342    0.216      0.778   0.215   0
depth      -1.741 0.502     -2.726   -1.741     -0.755  -1.742   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                     mean      sd 0.025quant 0.5quant 0.975quant    mode
Precision for AMP   0.294   0.349      0.028    0.189      1.197   0.074
Range for i       556.930 281.365    203.637  493.975   1272.667 393.713
Stdev for i         1.372   0.298      0.873    1.344      2.039   1.289
GroupRho for i      0.896   0.039      0.801    0.902      0.953   0.914
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.344 0.236     -6.824   -6.338     -5.896 -6.326   0
year       0.135 0.126     -0.112    0.135      0.383  0.135   0
depth     -1.636 0.221     -2.084   -1.631     -1.214 -1.622   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18831.491 17900.548   1436.080 13666.395  66575.592 402
8.396
Range for i          118.771    90.421     30.564    93.165    357.119   6
2.360
Stdev for i            0.776     0.151      0.512     0.766      1.101
0.749
GroupRho for i         0.849     0.058      0.710     0.858      0.935
0.876
0.915
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.430 0.348     -9.181   -8.405     -7.817 -8.352   0
year       0.283 0.280     -0.257    0.279      0.841  0.273   0
depth     -0.665 0.458     -1.671   -0.625      0.123 -0.539   0

Random effects:
  Name    Model
    site IID model
```

```
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18600.605 18379.205   1254.381 13170.468   67176.94 342
1.578
Range for i          104.762   280.818      7.044    40.527     599.61   1
4.677
Stdev for i            0.216     0.191      0.020     0.164       0.72
0.058
GroupRho for i         0.848     0.064      0.692     0.860       0.94
0.881
```

No significant trends were observed in the cover of orange solitary corals. This is an extremely small morphospecies, with point scoring often missing individuals. Thus, there is likely to be larger sampling variation, making any trends harder to detect. No overall trend for depth was found for this morphospecies.

2.4.11 Cup Red Smooth

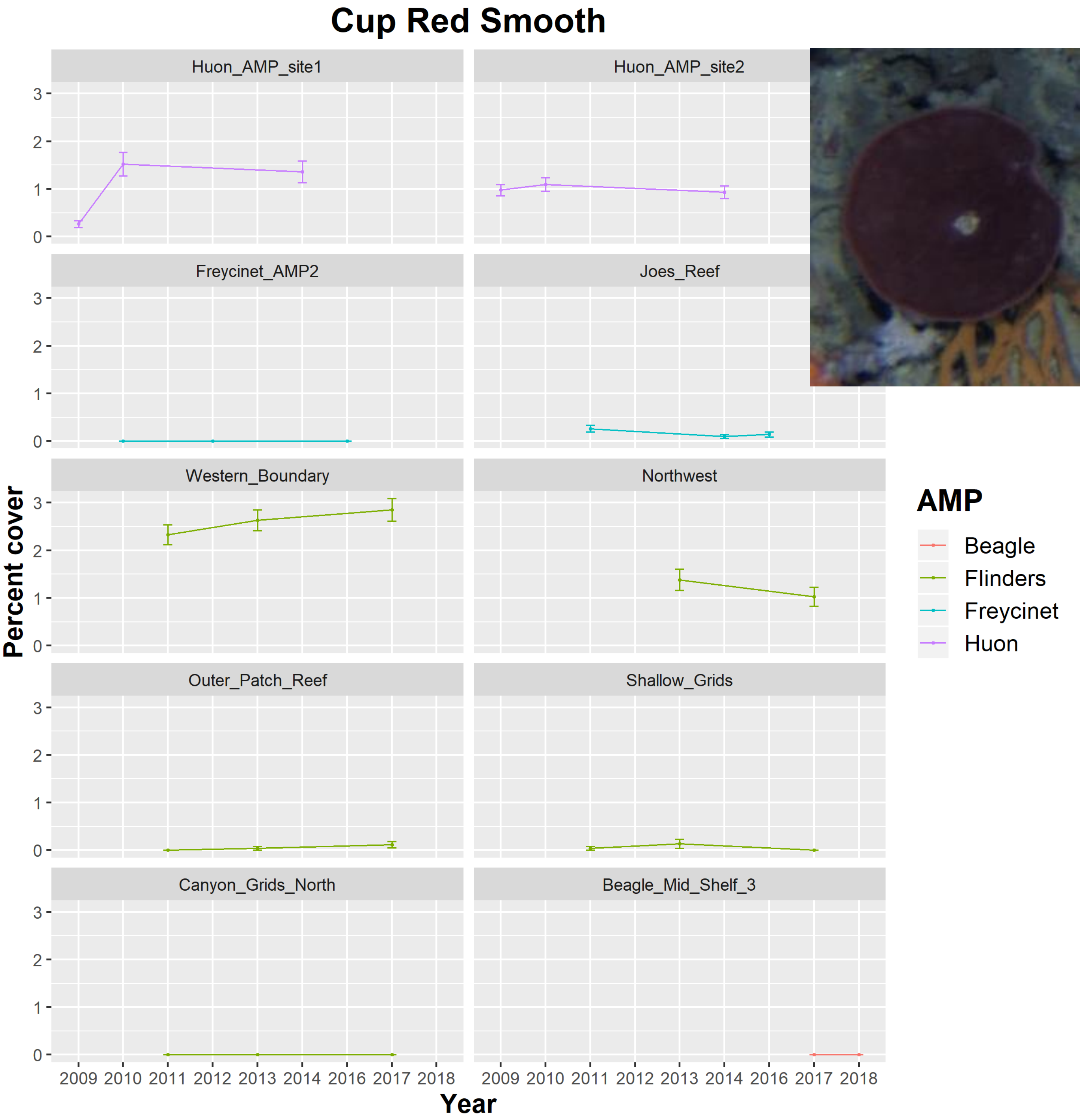


Figure 2.4.11 *Site level trends in the raw data for Cup Red Smooth sponges.*

2.4.11.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.170 0.747     -9.642   -8.168     -6.711 -8.164   0
year       0.047 0.101     -0.151    0.047      0.243  0.047   0
depth     -3.259 0.324     -3.913   -3.253     -2.639 -3.241   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  0.792  1.007      0.064    0.489      3.389  0.170
Range for i       98.618 24.947     59.430   95.262    156.897 88.852
Stdev for i        1.051  0.095      0.883    1.045      1.255  1.029
GroupRho for i     0.882  0.039      0.791    0.887      0.943  0.896
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.208 0.203     -5.610   -5.207     -4.813 -5.205   0
year       0.146 0.106     -0.062    0.146      0.353  0.147   0
depth     -0.994 0.173     -1.340   -0.992     -0.662 -0.987   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19145.426 18930.717   1303.927 13554.494  69392.190 355
3.768
Range for i          140.000    67.339     51.630   126.086    309.315  10
2.451
Stdev for i            0.809     0.141      0.561     0.800      1.112
0.784
GroupRho for i         0.843     0.064      0.686     0.854      0.935
0.875
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.463 0.501     -9.525   -8.434     -7.556 -8.377   0
year      -0.163 0.299     -0.753   -0.162      0.422 -0.160   0
depth     -1.467 0.471     -2.452   -1.445     -0.600 -1.403   0

Random effects:
  Name    Model
    site IID model
```

```
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
mode
Precision for site 18695.837 18513.802   1278.623 13228.579  67337.848 350
2.75
Range for i          106.670   104.093      6.659    75.897    379.870   1
7.71
Stdev for i            1.124     0.302      0.629     1.092      1.806
1.03
GroupRho for i         0.849     0.063      0.697     0.859      0.939
0.88
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.701 0.486     -8.686   -7.690     -6.778 -7.668   0
year       0.021 0.080     -0.137    0.021      0.178  0.021   0
depth     -4.192 0.764     -5.729   -4.179     -2.728 -4.153   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                     mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  4.187 4.162      0.481    2.978      15.14  1.312
Range for i        34.029 7.996     21.060   33.104      52.26 31.332
Stdev for i         0.995 0.100      0.810    0.991       1.20  0.985
GroupRho for i      0.784 0.084      0.584    0.797       0.91  0.823
```

No significant linear trends in the cover of the cup red smooth morphospecies were detected in any of the marine parks over the survey period, indicating this is a relatively stable morphospecies. Also, no significant relationship with depth was found.

2.4.12 Cup Yellow

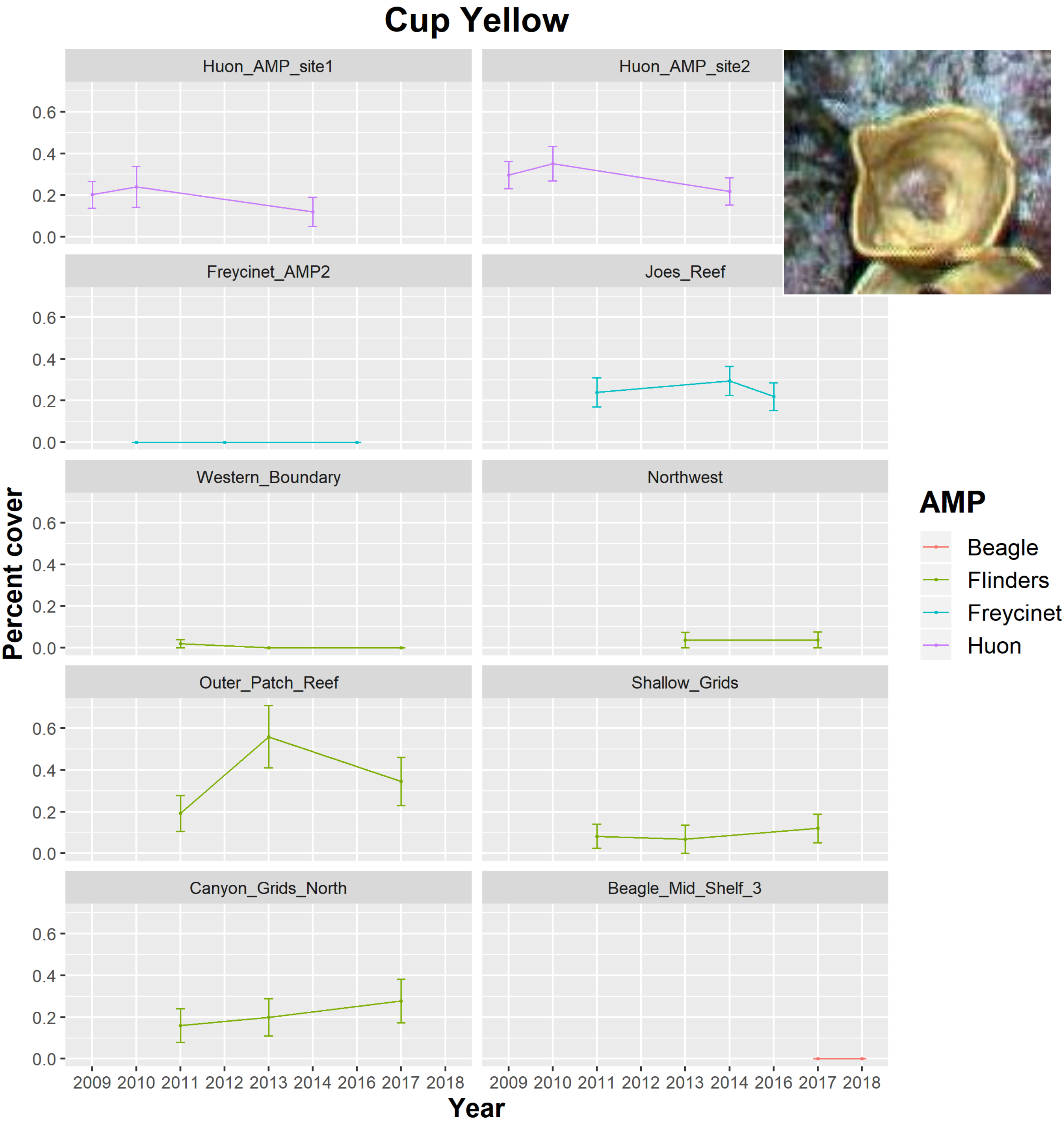


***Figure 2.4.12** Site level trends in the raw data for Cup Yellow sponges.*

2.4.12.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.572 0.324     -8.214   -7.570     -6.941 -7.566   0
year      -0.220 0.190     -0.594   -0.219      0.150 -0.218   0
depth     -0.226 0.248     -0.718   -0.224      0.255 -0.220   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                      mean                   sd 0.025quant 0.5quant 0.975quant
    mode
Precision for AMP 8456.966 1781607418062804.000    392.307 6801.809  24778.918
 993.606
Range for i        770.980              226.658    326.045  779.789   1178.992
 812.759
Stdev for i          1.343                0.142      1.153    1.311      1.697
   1.212
GroupRho for i       0.935                0.013      0.914    0.933      0.962
   0.927
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.479 0.180     -6.843   -6.475     -6.135 -6.468   0
year      -0.167 0.164     -0.499   -0.164      0.144 -0.156   0
depth      0.016 0.147     -0.279    0.018      0.299  0.022   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19299.589 18977.217   1297.220 13701.011  69547.151 353
2.309
Range for i           67.766    71.632      9.967    46.460    254.848   2
4.154
Stdev for i            0.821     0.213      0.462     0.804      1.291
0.770
GroupRho for i         0.856     0.060      0.710     0.866      0.942
0.886
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.537 0.323     -8.223   -7.519     -6.954 -7.481   0
year      -0.036 0.180     -0.385   -0.037      0.320 -0.040   0
depth     -1.581 0.278     -2.161   -1.569     -1.069 -1.545   0
```

```
Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 20311.627 19097.103   1881.446 14871.793  70810.844 536
5.266
Range for i           42.605    46.886      6.402    28.577    163.910   1
5.004
Stdev for i            0.242     0.173      0.023     0.203      0.656
0.070
GroupRho for i         0.849     0.064      0.692     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.277 0.656     -8.571   -7.275     -5.996 -7.271   0
year       0.040 0.271     -0.494    0.040      0.569  0.042   0
depth      0.003 0.280     -0.557    0.007      0.543  0.015   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18668.343 18488.687   1269.519 13205.871  67303.178 347
2.419
Range for i         3074.277  5715.064      0.341   452.304  19864.812
0.052
Stdev for i            0.937     0.276      0.514     0.898      1.586
0.824
GroupRho for i         0.861     0.056      0.726     0.870      0.942
0.888
```

No significant linear trends in the cover of the cup yellow morphospecies were detected in any of the marine parks over the survey period. Also, no significant relationship with depth was found.

2.4.13 *Encrusting Beige Oscula*

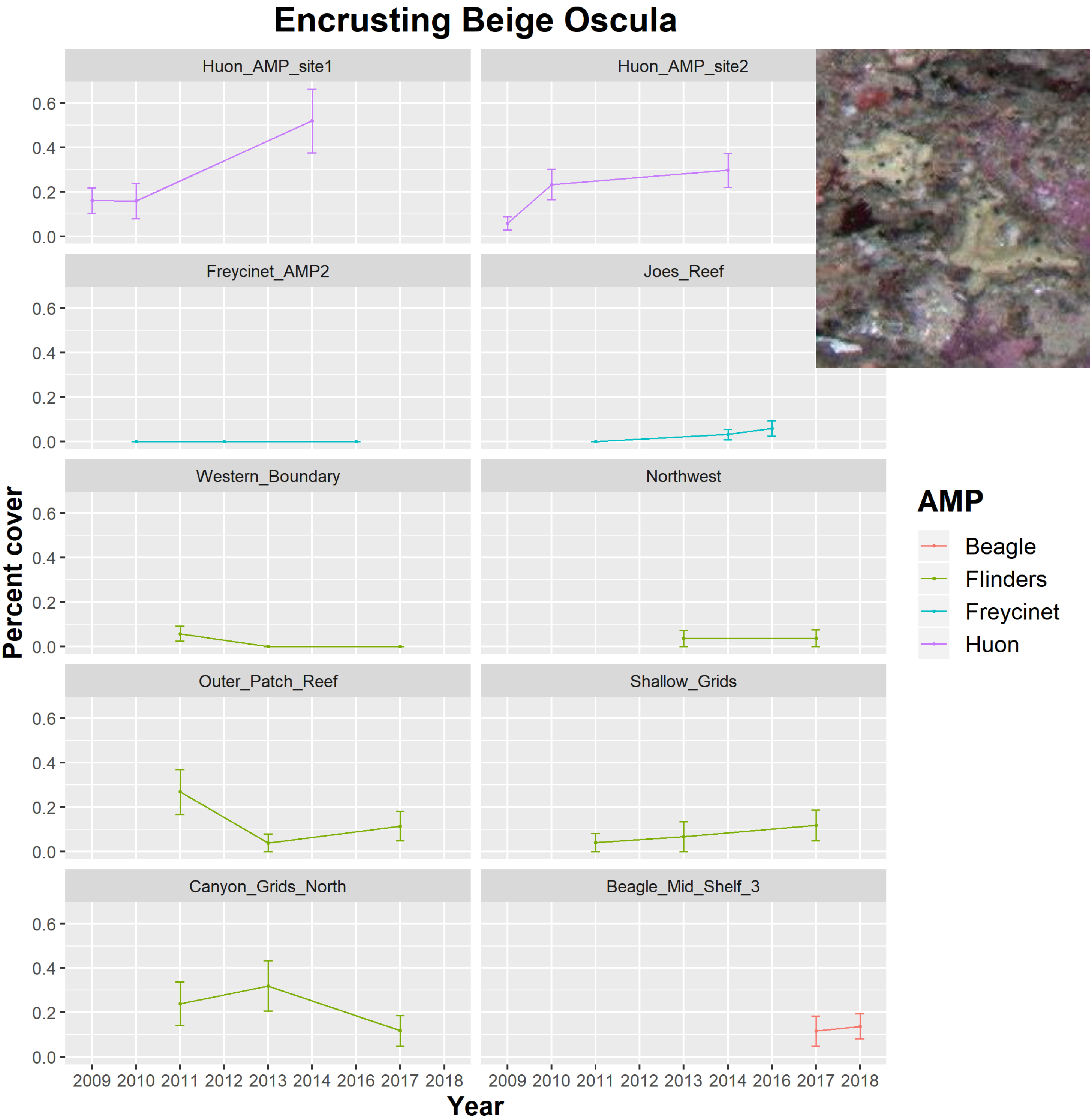


Figure 2.4.13 *Site level trends in the raw data for Encrusting Beige Oscula sponges.*

2.4.13.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.449 0.412      -8.26   -7.448     -6.643 -7.446   0
year       0.063 0.195      -0.32    0.063      0.445  0.064   0
depth      0.302 0.198      -0.09    0.303      0.687  0.305   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                      mean          sd 0.025quant 0.5quant 0.975quant    mode
Precision for AMP  820.930 4712480.285      0.314    9.815   2777.112   0.628
Range for i       3608.943    5791.033    489.686 1965.814  16959.607 948.586
Stdev for i          1.123       0.430      0.599    1.018      2.235   0.836
GroupRho for i       0.855       0.053      0.734    0.861      0.937   0.875
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.208 0.140     -6.494   -6.204     -5.943 -6.196   0
year       0.434 0.130      0.181    0.434      0.689  0.434   0
depth     -0.165 0.146     -0.461   -0.162      0.113 -0.156   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18607.595 18360.587   1259.417 13186.713  67173.100 343
8.962
Range for i           36.537    41.755      4.780    24.051    144.400   1
1.790
Stdev for i            0.198     0.172      0.022     0.152      0.651
0.063
GroupRho for i         0.849     0.064      0.692     0.860      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.680 0.793    -11.429   -9.607     -8.321 -9.452   0
year       0.824 0.585     -0.208    0.782      2.089  0.694   0
depth     -1.249 0.611     -2.574   -1.202     -0.176 -1.105   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model
```

```
Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19374.876 18956.658   1444.871 13839.947  69231.161 403
9.080
Range for i           63.048   107.901      6.488    32.809    305.422   1
4.252
Stdev for i            0.217     0.196      0.017     0.162      0.731
0.048
GroupRho for i         0.849     0.064      0.692     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.329 0.199     -7.743   -7.321     -6.961 -7.306   0
year      -0.242 0.172     -0.590   -0.238      0.084 -0.230   0
depth      0.624 0.128      0.372    0.624      0.874  0.624   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18590.452 18355.378   1254.280 13168.691   67148.89 342
1.649
Range for i           40.122    50.801      5.110    24.943     167.96   1
2.050
Stdev for i            0.287     0.281      0.027     0.205       1.04
0.076
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.779 0.346     -7.516   -6.758     -6.157 -6.716   0
year      -0.113 0.362     -0.797   -0.122      0.624 -0.141   0
depth     -0.435 0.300     -1.007   -0.442      0.173 -0.454   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18522.482 18241.197   1262.064 13142.652   66817.97 345
1.044
Range for i           82.820   119.880     19.823    48.417     360.55   2
3.399
Stdev for i            0.166     0.094      0.022     0.154       0.35
0.078
GroupRho for i         0.848     0.064      0.692     0.860       0.94
0.881
```

No overall significant trend was found for encrusting beige oscula sponges over the survey period. A positive trend equating to a 54% increase in the odds of presence over the survey period was found in Huon Marine Park. No significant association was found with depth.

2.4.14 Encrusting Beige Smooth

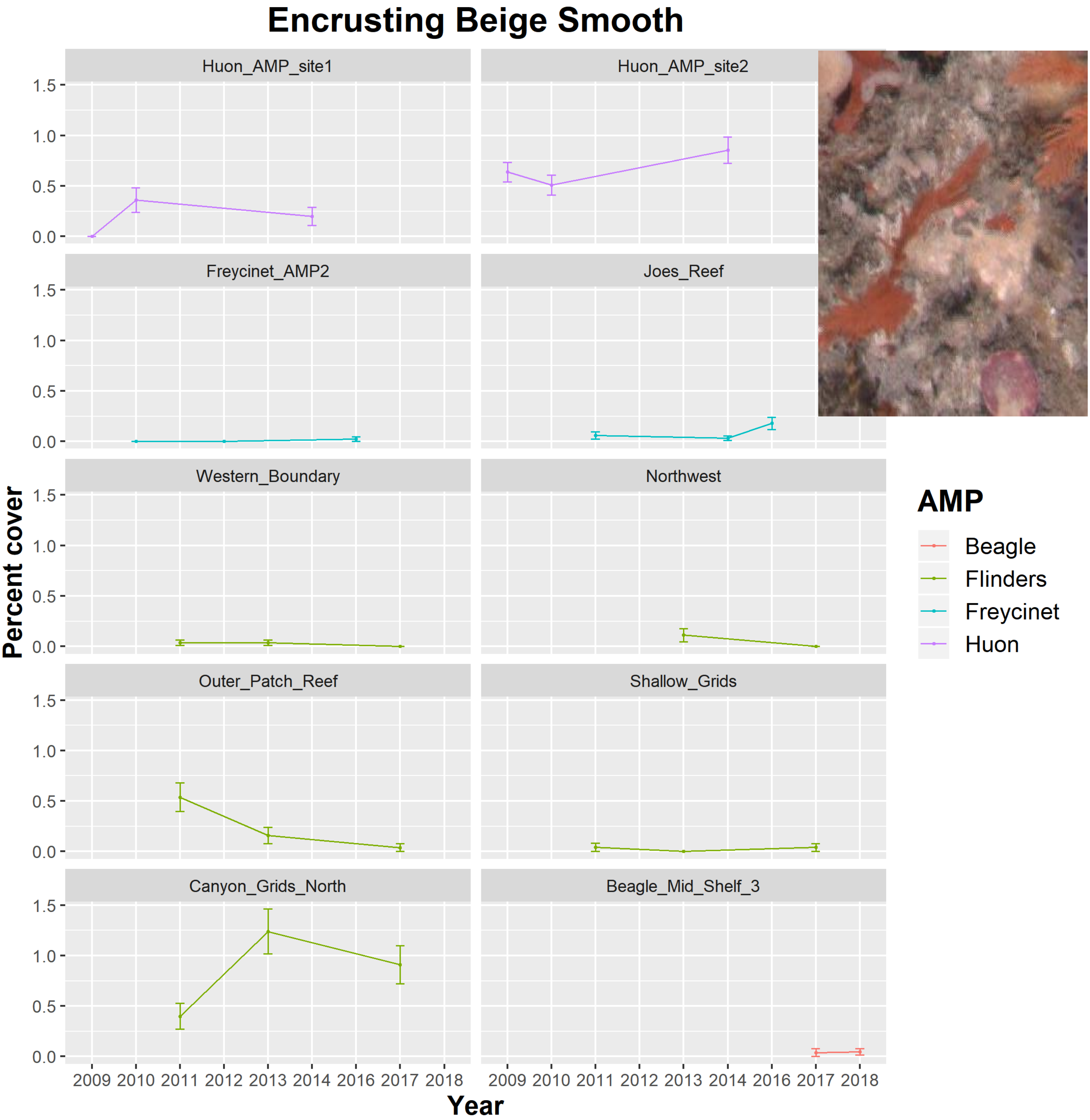


***Figure 2.4.14** Site level trends in the raw data for Encrusting Beige Smooth sponges.*

2.4.14.1 *Model-based estimates of trend*

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.170 0.304     -8.774   -8.167     -7.580 -8.162   0
year      -0.137 0.210     -0.553   -0.136      0.273 -0.134   0
depth      0.387 0.253     -0.110    0.387      0.883  0.387   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                          mean       sd 0.025quant  0.5quant 0.975quant      mode
Precision for AMP 13164.523 3531.285   7488.110 12741.657   21255.92 11959.169
Range for i         350.237   74.806    227.576   341.561     522.57   324.645
Stdev for i           1.685    0.256      1.235     1.668       2.24     1.634
GroupRho for i        0.861    0.044      0.758     0.867       0.93     0.878
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.099 0.383     -6.853   -6.099     -5.350 -6.097   0
year       0.201 0.113     -0.022    0.201      0.420  0.203   0
depth     -0.583 0.157     -0.903   -0.579     -0.285 -0.571   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                       mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for site 10.518 22.499      0.421    4.527     58.027  1.031
Range for i        27.288 12.378     10.319   24.960     57.869 20.742
Stdev for i         0.934  0.201      0.600    0.913      1.388  0.873
GroupRho for i      0.854  0.061      0.707    0.863      0.944  0.883
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.499 0.391     -9.337   -8.473     -7.801 -8.421   0
year       0.630 0.329      0.024    0.615      1.318  0.585   0
depth     -0.769 0.338     -1.480   -0.752     -0.150 -0.718   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
```

```
Precision for site 18581.245 18545.090   1279.799 13094.355  67556.268 350
1.171
Range for i           39.585    35.070      9.053    29.203    131.601   1
8.292
Stdev for i            0.861     0.425      0.230     0.802      1.840
0.616
GroupRho for i         0.852     0.062      0.702     0.862      0.941
0.883
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.701 0.207     -8.125   -7.695     -7.311 -7.684   0
year      -0.139 0.146     -0.429   -0.137      0.145 -0.135   0
depth      1.142 0.149      0.853    1.141      1.438  1.139   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
mode
Precision for site 18007.770 18103.961   1228.942 12641.207  65863.692 337
4.26
Range for i           69.620    97.170     12.158    41.097    302.323   2
1.34
Stdev for i            1.298     0.212      0.898     1.295      1.726
1.30
GroupRho for i         0.738     0.117      0.440     0.764      0.892
0.81
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.880 0.568     -9.121   -7.833     -6.894 -7.733   0
year      -0.165 0.574     -1.232   -0.187      1.026 -0.232   0
depth     -0.539 0.468     -1.429   -0.548      0.409 -0.568   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18534.065 18326.635   1263.055 13121.760   67002.97 344
9.435
Range for i           65.146   112.998      6.582    33.596     319.59   1
4.442
Stdev for i            0.277     0.285      0.017     0.191       1.04
0.044
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

No overall significant trend was found for encrusting beige smooth sponges over the survey period. A positive trend equating to an 88% increase in the odds of presence over the survey period was found in Huon Marine Park. No significant association was found with depth.

2.4.15 Encrusting Black

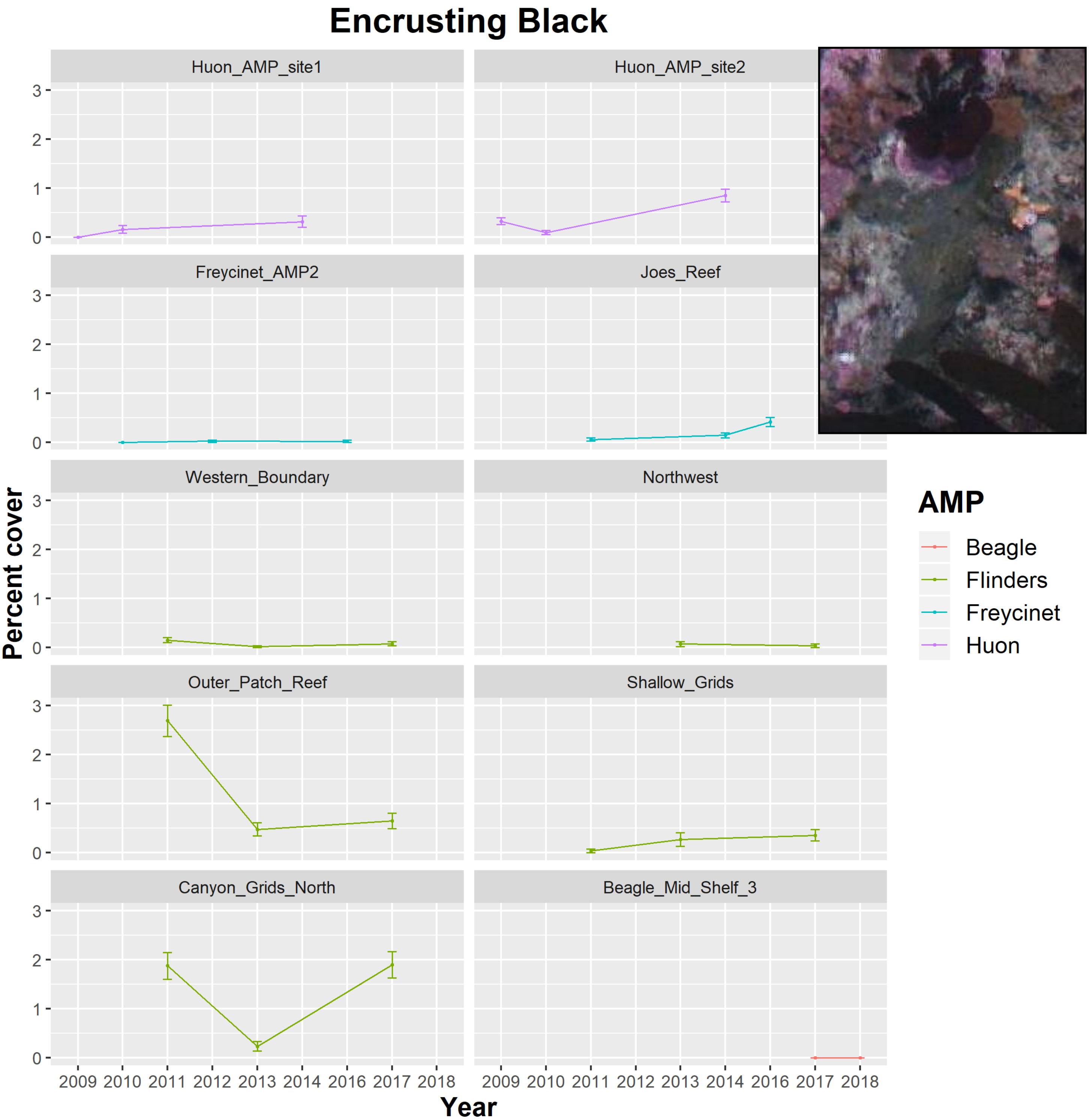


__Figure 2.4.15__ Site level trends in the raw data for Encrusting Black sponges.

2.4.15.1 *Model-based estimates of trend*

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.945 0.327     -8.594   -7.943     -7.308 -7.939   0
year       0.043 0.221     -0.391    0.043      0.475  0.044   0
depth      0.197 0.273     -0.339    0.197      0.732  0.198   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 18642.296 18361.189   1223.257 13211.222   67238.060 3321.335
Range for i         371.406    90.531    223.310   361.472     577.520  342.644
Stdev for i           1.845     0.237      1.395     1.843       2.320    1.852
GroupRho for i        0.834     0.058      0.691     0.845       0.915    0.866
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.466 0.164     -6.797   -6.463     -6.154 -6.456   0
year       0.824 0.135      0.562    0.823      1.091  0.820   0
depth     -0.035 0.165     -0.368   -0.033      0.282 -0.027   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19345.676 19801.633   1349.358 13451.837   71445.256 368
0.749
Range for i           19.865     8.868      8.636    17.864      42.488    1
4.697
Stdev for i            1.314     0.268      0.846     1.296       1.894
1.265
GroupRho for i         0.843     0.067      0.680     0.855       0.938
0.878
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.874 0.345     -8.602   -7.856     -7.244 -7.820   0
year       0.736 0.254      0.263    0.727      1.260  0.708   0
depth     -1.133 0.294     -1.745   -1.121     -0.589 -1.096   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model
```

```
Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18736.677 18702.943   1319.381 13212.831  68452.395 362
0.448
Range for i           69.906    49.149     16.110    57.283    198.502   3
8.124
Stdev for i            0.699     0.241      0.303     0.677      1.234
0.623
GroupRho for i         0.846     0.065      0.688     0.857      0.938
0.878
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.910 0.297     -7.500   -6.908     -6.333 -6.904   0
year      -0.029 0.189     -0.402   -0.029      0.341 -0.028   0
depth      0.845 0.287      0.281    0.846      1.409  0.846   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 16817.695 15774.138   1184.237 12263.062  59037.192 325
5.717
Range for i          179.225    55.698     93.619   171.386    310.312  15
6.723
Stdev for i            1.510     0.201      1.152     1.497      1.941
1.473
GroupRho for i         0.706     0.091      0.497     0.717      0.852
0.739
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.858 1.001    -12.087   -9.755     -8.171 -9.532   0
year       0.112 1.071     -1.823    0.051      2.385 -0.072   0
depth     -0.010 1.072     -1.814   -0.120      2.373 -0.357   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18772.756 18502.634   1293.452 13319.105   67630.36 354
4.146
Range for i           41.540    52.774      4.771    25.770     174.91   1
1.749
Stdev for i            0.282     0.282      0.026     0.199       1.02
0.074
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.882
```

A significant positive overall trend was found for encrusting black sponges, equating to a 4% increase in odds of presence over the survey period. Positive linear trends were also detected in Huon (128% increase in odds) and Freycinet Marine Parks (109% increase in odds). No significant trend was found for depth.

2.4.16 Encrusting Blue

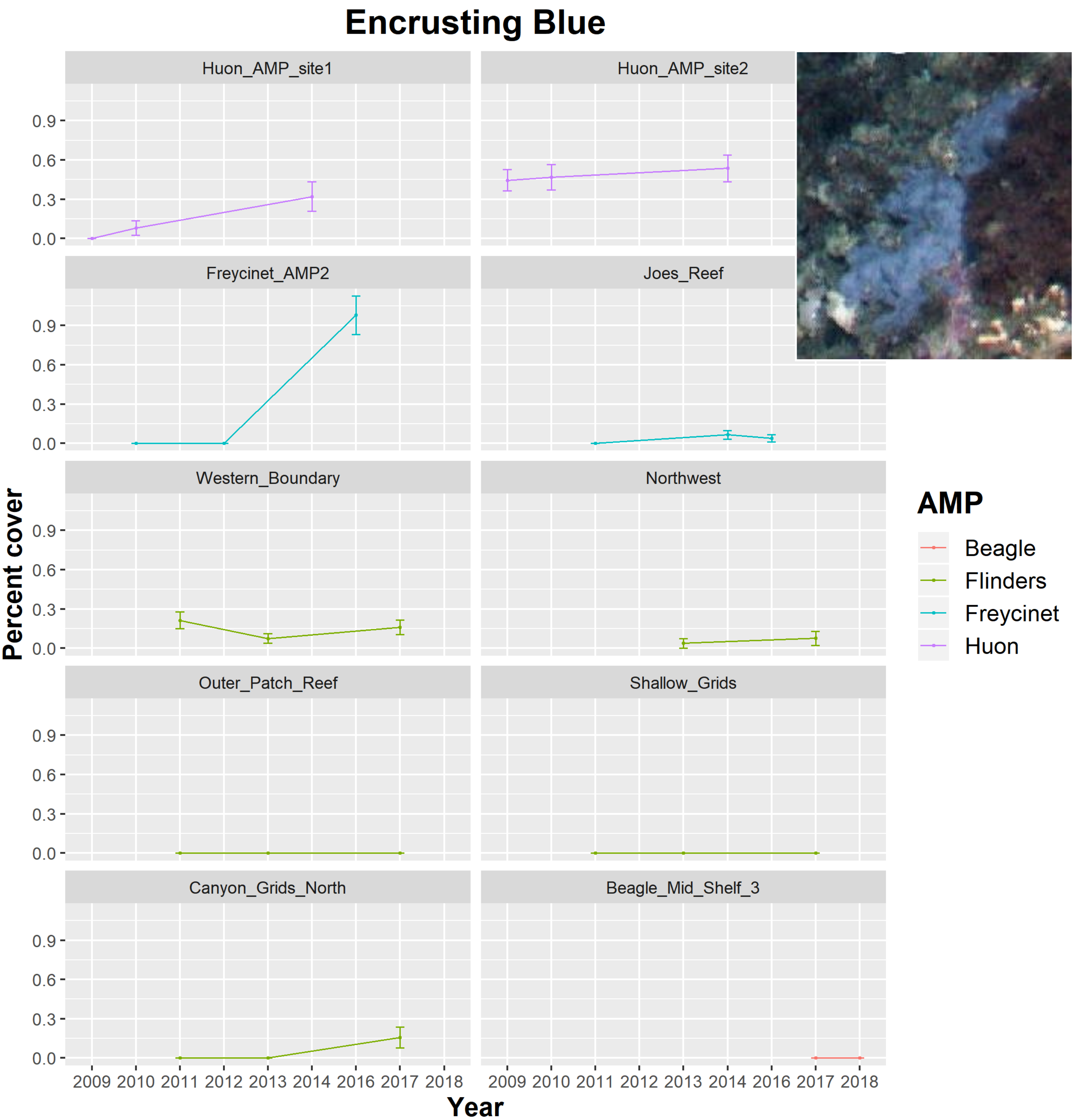


Figure 2.4.16 *Site level trends in the raw data for Encrusting Blue sponges.*

2.4.16.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.101 0.470    -10.038   -9.097     -8.191 -9.087   0
year       0.581 0.314     -0.031    0.579      1.201  0.576   0
depth     -0.081 0.371     -0.819   -0.078      0.636 -0.071   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 21658.768 20283.049   2171.999 15908.668   75399.48 6158.451
Range for i         722.387   260.923    341.223   679.394    1351.52  601.100
Stdev for i           1.978     0.323      1.417     1.952       2.69    1.903
GroupRho for i        0.856     0.050      0.738     0.863       0.93    0.878
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.242 0.482     -7.190   -6.241     -5.298 -6.239   0
year       0.192 0.116     -0.037    0.193      0.416  0.194   0
depth     -0.622 0.159     -0.947   -0.618     -0.322 -0.610   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  3.459  4.699      0.190    2.024     15.614  0.497
Range for i        28.476 22.461      7.604   21.939     87.842 14.577
Stdev for i         0.697  0.256      0.281    0.673      1.263  0.610
GroupRho for i      0.848  0.065      0.690    0.860      0.939  0.881
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.169 0.466    -10.179   -9.134     -8.350 -9.062   0
year       1.913 0.407      1.201    1.881      2.799  1.813   0
depth      0.892 0.247      0.426    0.885      1.397  0.872   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
```

```
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 21063.876 22101.957   1540.546 14469.913  79397.924 422
2.714
Range for i           14.464     4.726      7.480    13.697     25.799   1
2.303
Stdev for i            1.818     0.343      1.224     1.792      2.569
1.744
GroupRho for i         0.842     0.067      0.678     0.854      0.938
0.876
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.081 0.274     -9.641   -9.073     -8.567 -9.057   0
year       0.236 0.220     -0.195    0.235      0.669  0.235   0
depth     -0.383 0.293     -0.988   -0.372      0.163 -0.352   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 19863.224 19621.103   1447.705 14100.98  71835.664 400
9.295
Range for i           33.969    13.856     15.909    30.95     69.100   2
6.023
Stdev for i            1.931     0.335      1.346     1.91      2.658
1.863
GroupRho for i         0.827     0.073      0.651     0.84      0.932
0.864
```

No significant overall linear trend was detected for encrusting blue sponges. A significant positive linear trend was found in Freycinet Marine Park equating to a 577% increase in odds per year over the survey period. This appears to have been largely driven by a large increase seen at Freycinet Marine Park site 2 in the last year surveyed.

2.4.17 Encrusting Light Orange

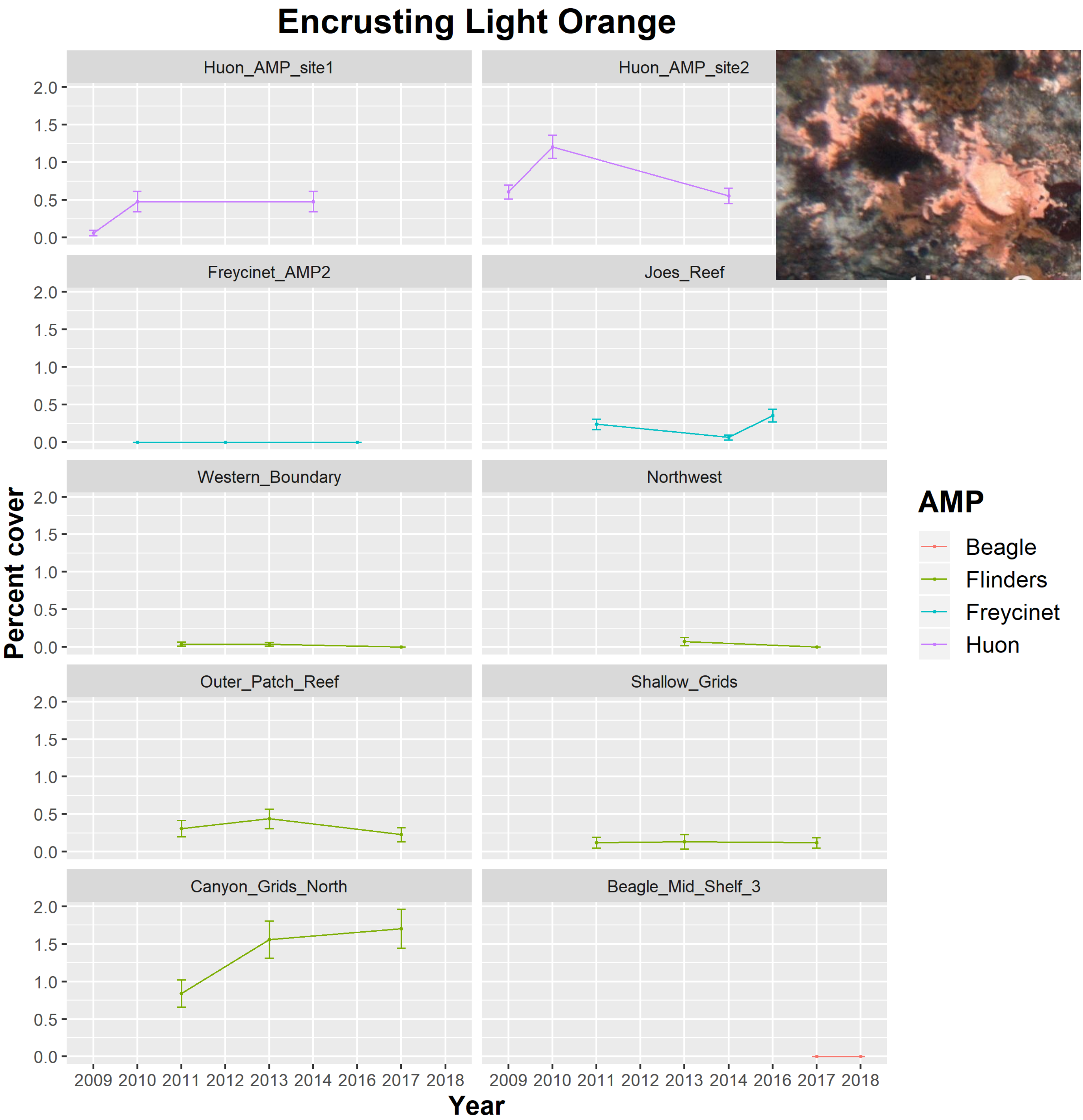


Figure 2.4.17 *Site level trends in the raw data for Encrusting Light Orange sponges.*

2.4.17.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.716 0.297     -8.306   -7.713     -7.138 -7.709   0
year      -0.253 0.187     -0.624   -0.252      0.112 -0.250   0
depth      0.169 0.240     -0.302    0.169      0.639  0.170   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant      mod
e
Precision for AMP 21611.877 13780.879   4724.634 18544.050  57383.687 12421.45
5
Range for i         434.176   127.759    232.346   418.001    729.360   387.39
3
Stdev for i           1.473     0.186      1.126     1.467      1.857     1.46
1
GroupRho for i        0.904     0.028      0.841     0.906      0.951     0.91
1
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.938 0.342     -6.611   -5.938     -5.271 -5.936   0
year      -0.193 0.135     -0.461   -0.192      0.070 -0.190   0
depth     -0.645 0.181     -1.007   -0.643     -0.298 -0.637   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                       mean      sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  31.681 103.439      0.566    9.569    199.927  1.214
Range for i        133.636 127.600      9.217   96.535    469.019 25.206
Stdev for i          0.801   0.208      0.453    0.783      1.264  0.748
GroupRho for i       0.846   0.065      0.688    0.857      0.938  0.878
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.327 0.365     -9.106   -8.305     -7.672 -8.259   0
year       0.192 0.227     -0.247    0.190      0.644  0.185   0
depth     -1.444 0.341     -2.164   -1.426     -0.822 -1.390   0

Random effects:
```

```
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
mode
Precision for site 19171.26 19687.108   1352.609 13317.079  71097.196 372
6.673
Range for i           16.54     6.299      7.600    15.411     31.954   1
3.418
Stdev for i            1.38     0.297      0.871     1.364      2.030
1.326
GroupRho for i         0.84     0.068      0.674     0.852      0.937
0.875
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.081 0.239     -7.562   -7.077     -6.624 -7.068   0
year      -0.009 0.138     -0.281   -0.008      0.261 -0.007   0
depth      1.068 0.208      0.660    1.067      1.478  1.066   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                            mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18709.422 18397.168   1265.696 13284.055   67368.94 345
6.332
Range for i          148.330    60.446     63.749   137.287     297.25  11
7.739
Stdev for i            0.966     0.180      0.651     0.953       1.36
0.931
GroupRho for i         0.841     0.061      0.694     0.850       0.93
0.869
```

No overall or marine park level significant linear trends were detected for the encrusting light orange sponge morphotype. Also, no significant depth trend was detected.

2.4.18 Encrusting Orange

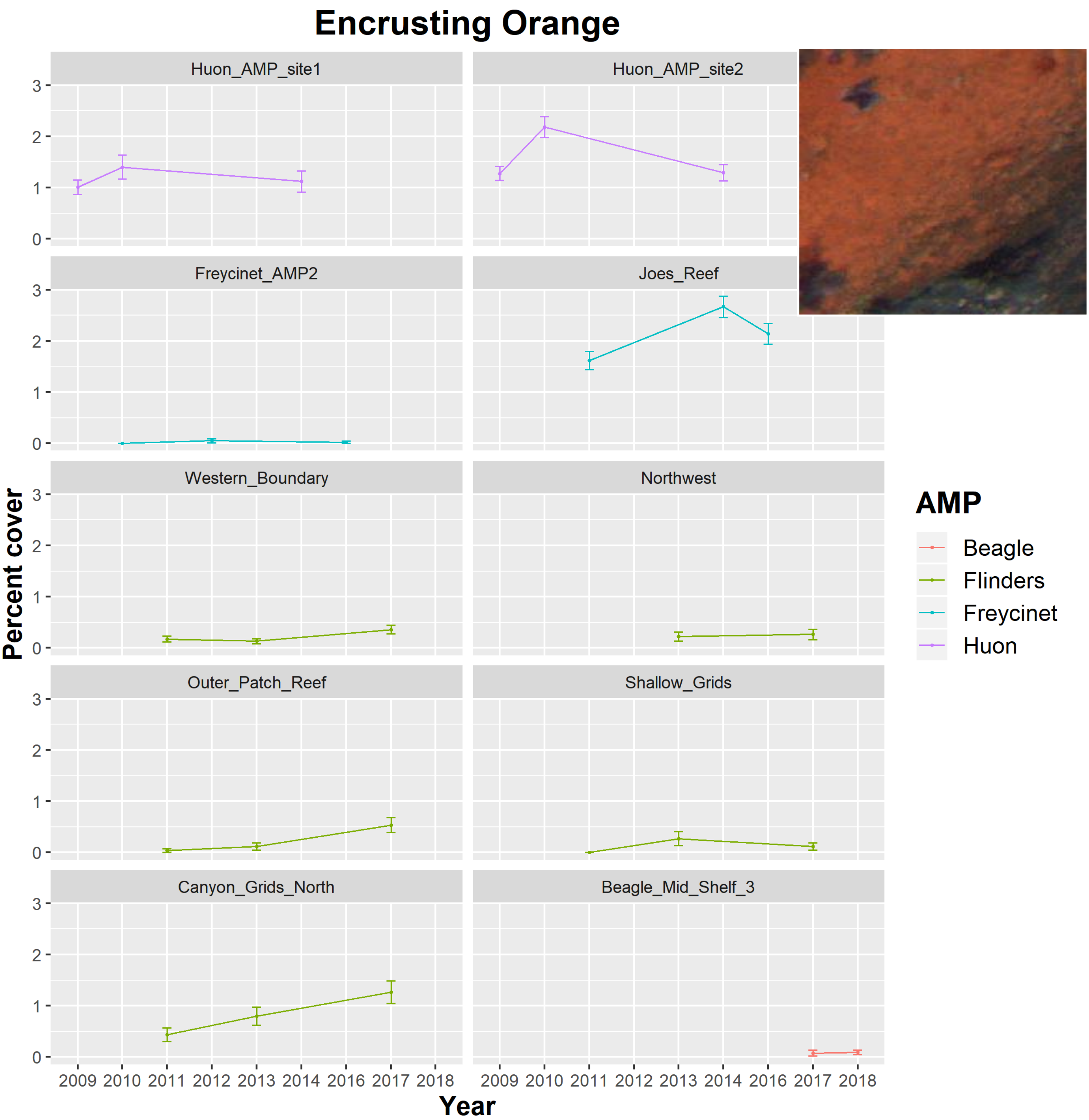


***Figure 2.4.18** Site level trends in the raw data for Encrusting Orange sponges.*

2.4.18.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.483 0.231     -6.938   -6.482     -6.033 -6.481   0
year      -0.163 0.144     -0.447   -0.163      0.120 -0.162   0
depth     -0.368 0.201     -0.764   -0.368      0.026 -0.367   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 16911.397 17687.528    1152.83 11615.279  63611.415 3157.880
Range for i         389.745    83.484     258.64   378.289    584.452  355.017
Stdev for i           1.468     0.180       1.19     1.440      1.888    1.367
GroupRho for i        0.878     0.037       0.79     0.884      0.935    0.895
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -4.632 0.148     -4.924   -4.631     -4.342 -4.630   0
year      -0.099 0.093     -0.283   -0.099      0.082 -0.098   0
depth     -0.171 0.108     -0.384   -0.171      0.039 -0.170   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19189.530 19151.534   1326.559 13524.894  70280.676 363
4.812
Range for i          104.995    52.210     36.979    94.132    236.281   7
5.524
Stdev for i            0.737     0.126      0.509     0.731      1.004
0.723
GroupRho for i         0.829     0.076      0.644     0.842      0.936
0.868
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.042 0.209     -6.467   -6.037     -5.645 -6.028   0
year       0.141 0.128     -0.110    0.141      0.393  0.141   0
depth     -1.916 0.207     -2.335   -1.912     -1.524 -1.903   0
```

```
Random effects:
  Name     Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                             mean        sd 0.025quant 0.5quant 0.975quant     m
ode
Precision for site 18889.64 18637.257   1337.310 13407.23  68186.505 3690.
228
Range for i           53.85    22.716     21.922    49.80    109.374   42.
403
Stdev for i            1.01     0.124      0.783     1.00      1.270    0.
994
GroupRho for i         0.75     0.084      0.560     0.76      0.884    0.
780
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.398 0.130     -6.660   -6.396     -6.148 -6.392   0
year       0.446 0.099      0.253    0.445      0.642  0.444   0
depth      0.454 0.112      0.233    0.454      0.673  0.454   0

Random effects:
  Name     Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                              mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19432.447 18376.092   1521.888 14146.344  67665.138 426
6.044
Range for i           39.859    18.274     15.582    36.153     85.634    2
9.865
Stdev for i            0.848     0.169      0.549     0.838      1.209
0.823
GroupRho for i         0.861     0.056      0.727     0.870      0.942
0.888
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.342 0.489     -8.415   -7.299     -6.499 -7.209   0
year       0.369 0.420     -0.413    0.354      1.237  0.324   0
depth      0.859 0.653     -0.266    0.801      2.293  0.679   0

Random effects:
  Name     Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                              mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18638.256 18381.789   1266.239 13213.525  67244.382 346
1.192
Range for i           49.080    69.494      5.693    28.594    218.737    1
3.188
Stdev for i            0.225     0.206      0.020     0.167      0.765
0.057
```

```
GroupRho for i          0.848      0.064       0.691      0.860       0.940
0.881
```

No significant overall trend was found for encrusting orange sponges, but a significant positive trend was found in Flinders Marine Park equating to a 56% increase in odds per year. No significant overall depth association was found.

2.4.19 Encrusting Purple Lumpy

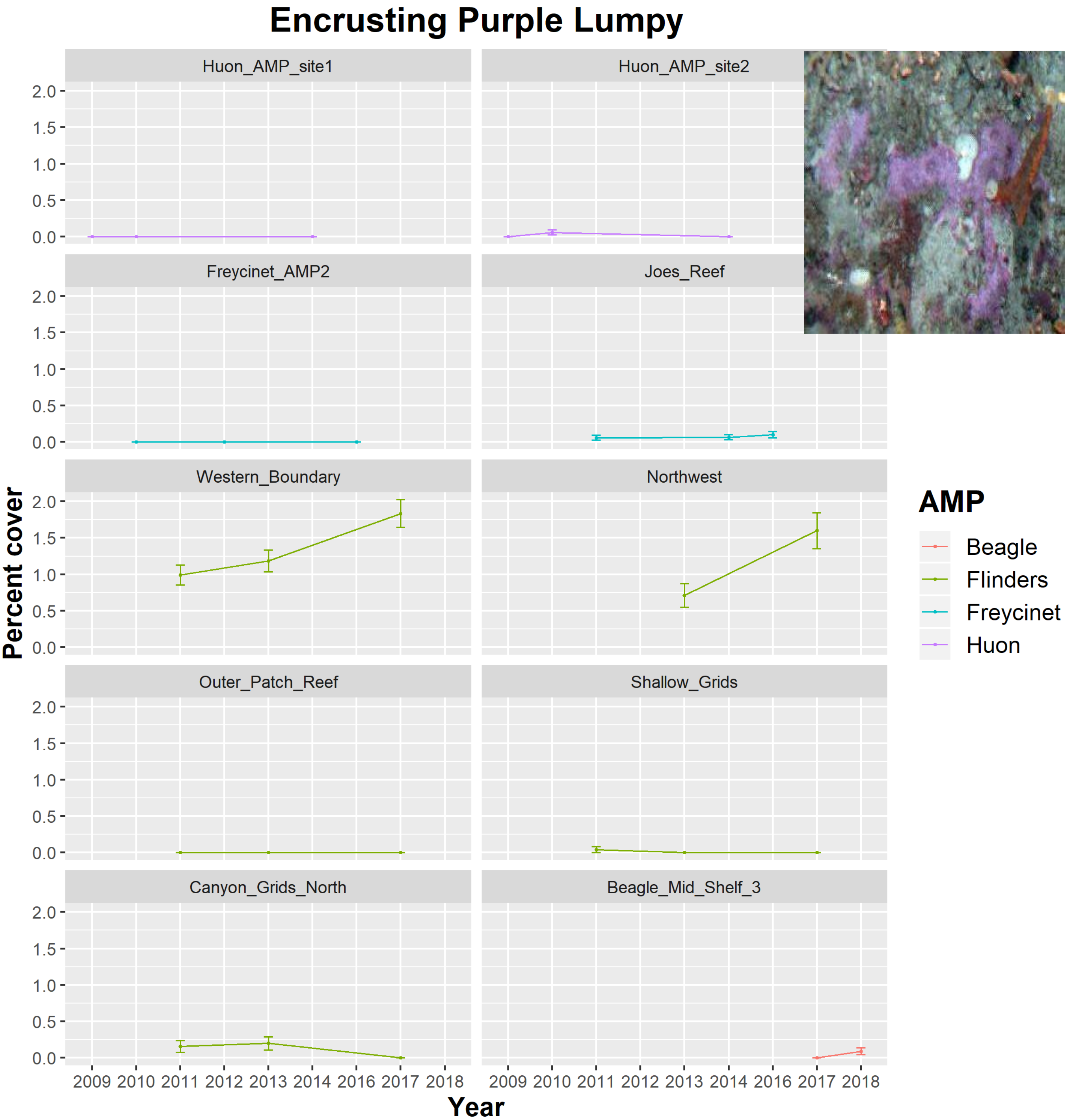


***Figure 2.4.19** Site level trends in the raw data for Encrusting Purple Lumpy sponges.*

2.4.19.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.504 0.496    -10.483   -9.503     -8.537 -9.499   0
year       0.128 0.157     -0.181    0.128      0.436  0.128   0
depth     -1.268 0.223     -1.721   -1.263     -0.843 -1.253   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  1.257  0.730      0.289    1.117      3.061  0.774
Range for i       62.014 20.856     35.583   57.185    115.007 48.347
Stdev for i        1.891  0.179      1.530    1.898      2.225  1.933
GroupRho for i     0.849  0.062      0.693    0.861      0.933  0.883
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.209 0.566    -10.448   -9.161     -8.231 -9.059   0
year      -0.135 0.581     -1.402   -0.087      0.876  0.012   0
depth      0.234 0.452     -0.683    0.245      1.093  0.265   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18628.348 18367.123   1262.112 13207.338  67211.725 344
7.535
Range for i           68.636   127.356      6.643    33.946    345.279   1
4.371
Stdev for i            0.244     0.238      0.017     0.174      0.876
0.048
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.882
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.040 0.859    -11.912   -9.971     -8.545 -9.826   0
year        0.093 0.347     -0.565    0.085      0.797  0.070   0
depth      -2.301 0.676     -3.748   -2.258     -1.091 -2.169   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19024.719 18688.951   1340.969 13533.309  68361.543 370
4.716
Range for i           28.595    22.362      7.256    22.184     87.674   1
4.703
Stdev for i            0.868     0.400      0.265     0.815      1.788
0.663
GroupRho for i         0.843     0.067      0.679     0.855      0.938
0.878
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.407 0.238     -7.885   -7.403     -6.952 -7.396   0
year       0.107 0.140     -0.170    0.107      0.382  0.108   0
depth     -1.473 0.301     -2.083   -1.466     -0.901 -1.453   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18055.724 18175.244   1220.629 12660.368  66018.416 333
1.592
Range for i           68.717    23.941     38.760    63.068    129.932   5
2.885
Stdev for i            1.872     0.177      1.561     1.859      2.256
1.826
GroupRho for i         0.808     0.065      0.657     0.816      0.911
0.833
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.333 0.774    -10.058   -8.252     -7.033 -8.075   0
year       0.590 0.871     -0.848    0.489      2.549  0.266   0
depth     -0.860 0.408     -1.702   -0.846     -0.098 -0.819   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18628.823 18370.424   1262.401 13206.659  67214.859 344
8.534
Range for i           60.213   100.776      6.278    31.754    289.509   1
3.838
Stdev for i            0.261     0.254      0.021     0.187      0.937
0.060
```

```
GroupRho for i          0.848     0.064      0.691     0.860      0.940
0.882
```

No overall or marine park level significant linear trends were detected for the encrusting light orange sponge morphotype. Also, no significant depth trend was detected.

2.4.20 Encrusting White

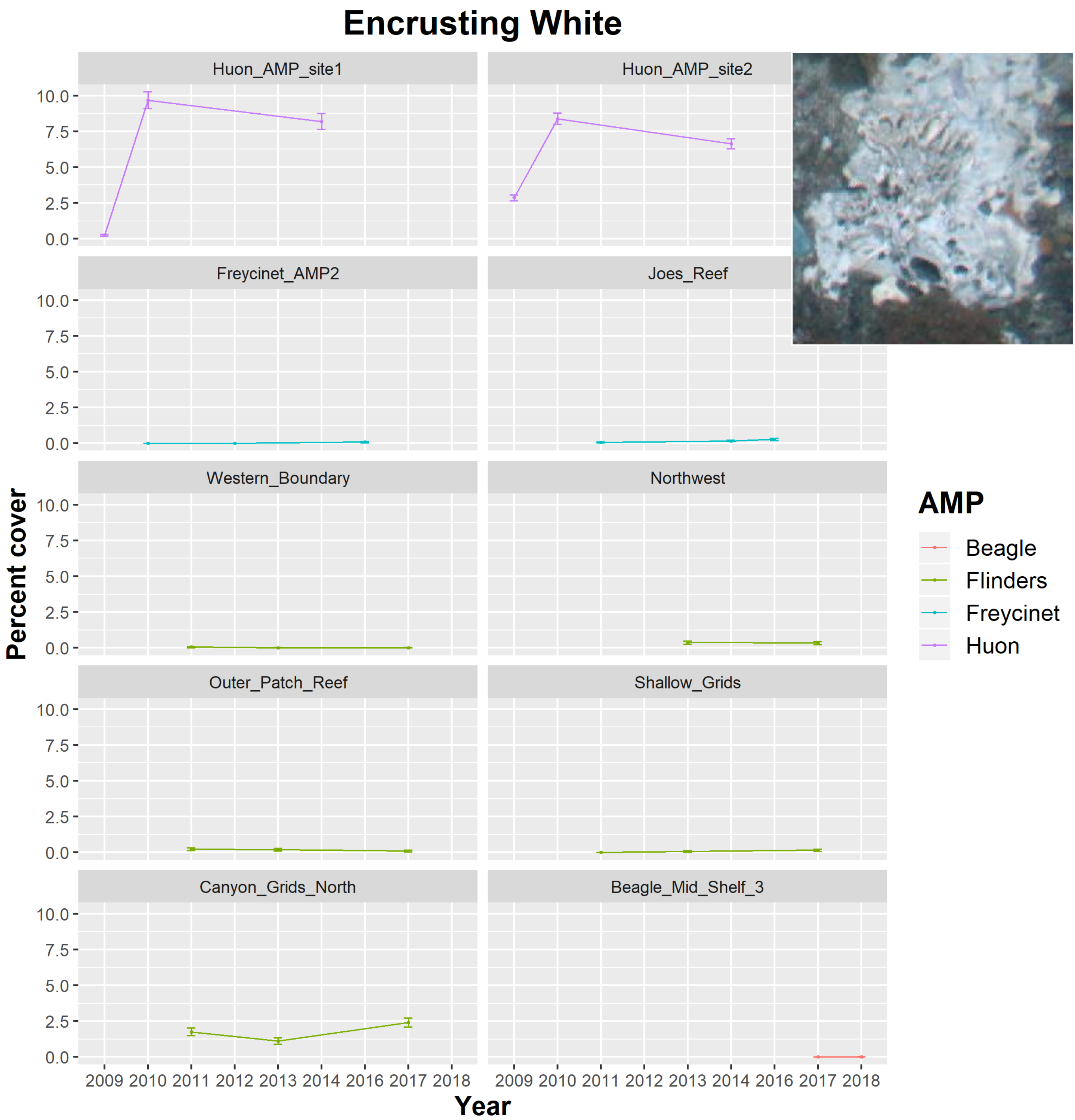


Figure 2.4.20 *Site level trends in the raw data for Encrusting White sponges.*

2.4.20.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.034 0.519     -9.059   -8.032     -7.022 -8.028   0
year      -0.172 0.293     -0.747   -0.172      0.402 -0.172   0
depth     -1.440 0.303     -2.035   -1.440     -0.846 -1.439   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                      mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 19056.611 19231.091   1381.077 13374.328  70290.403 3812.545
Range for i         644.901   125.302    438.727   630.838    929.912  602.461
Stdev for i           2.569     0.322      1.998     2.547      3.259    2.504
GroupRho for i        0.905     0.030      0.836     0.909      0.951    0.916
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -4.014 0.427     -4.855   -4.014     -3.178 -4.012   0
year       0.243 0.199     -0.148    0.243      0.633  0.243   0
depth     -1.465 0.187     -1.833   -1.464     -1.100 -1.463   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18210.686 18191.457   1236.044 12821.914  66333.649 337
5.739
Range for i          228.314    54.800    141.146   221.323    355.216  20
7.853
Stdev for i            1.558     0.218      1.172     1.544      2.027
1.516
GroupRho for i         0.801     0.070      0.635     0.811      0.908
0.831
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.922 0.369     -8.707   -7.901     -7.256 -7.857   0
year       0.793 0.257      0.317    0.782      1.326  0.762   0
depth     -1.324 0.287     -1.926   -1.311     -0.798 -1.284   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 21233.398 21816.282   1638.740 14775.863  79358.504 454
3.809
Range for i           56.536    85.812      6.565    31.672    260.030   1
4.612
Stdev for i            0.278     0.222      0.027     0.221      0.844
0.080
GroupRho for i         0.848     0.065      0.690     0.859      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.689 0.384     -7.445   -6.688     -5.936 -6.687   0
year       0.053 0.104     -0.152    0.053      0.257  0.053   0
depth      0.835 0.269      0.307    0.834      1.363  0.834   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                     mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  1.974  1.665      0.328    1.515      6.366  0.847
Range for i        30.939 14.526     12.706   27.631     67.951 22.457
Stdev for i         0.962  0.156      0.681    0.955      1.290  0.945
GroupRho for i      0.845  0.065      0.687    0.856      0.938  0.877
```

No overall linear trend in the cover of the encrusting white sponge morphotype was found. A positive trend was found for Freycinet Marine Park equating to a 121% increase in the odds per year. Also, a significant negative association was found with depth, indicating a preference for shallower depths for this morphospecies.

2.4.21 Encrusting White Lumpy

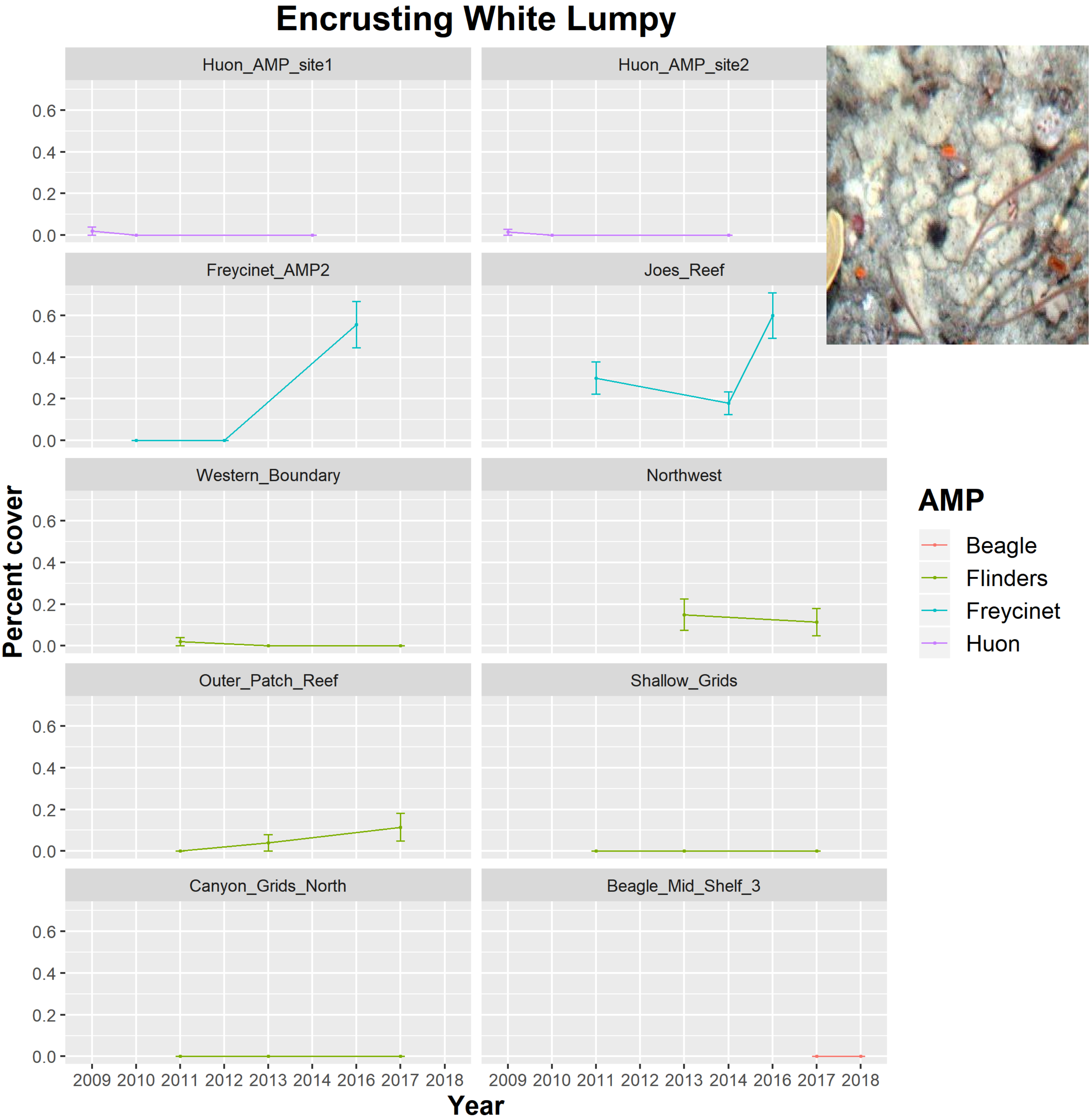


***Figure 2.4.21** Site level trends in the raw data for Encrusting White Lumpy sponges.*

2.4.21.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.989 1.181    -12.324   -9.984     -7.687 -9.973   0
year       0.905 0.198      0.528    0.901      1.304  0.893   0
depth     -0.638 0.294     -1.254   -0.624     -0.099 -0.596   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  0.232  0.128      0.073    0.203      0.562  0.156
Range for i       34.600 11.870     17.582   32.509     63.549 28.786
Stdev for i        1.535  0.213      1.154    1.522      1.992  1.498
GroupRho for i     0.796  0.072      0.626    0.807      0.907  0.827
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.837 0.800    -11.625   -9.751     -8.498 -9.563   0
year      -0.477 0.849     -2.380   -0.383      0.934 -0.174   0
depth      0.347 0.499     -0.641    0.350      1.319  0.356   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18625.630 18374.967   1264.288 13202.033  67210.517 345
5.072
Range for i           71.055   135.245      6.734    34.580    362.202    1
4.518
Stdev for i            0.222     0.205      0.018     0.163      0.765
0.050
GroupRho for i         0.848     0.064      0.692     0.860      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.441 0.240     -7.932   -7.434     -6.988 -7.420   0
year       1.031 0.206      0.643    1.025      1.452  1.014   0
depth     -0.389 0.196     -0.778   -0.387     -0.010 -0.383   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 20405.331 20467.350   1489.051 14366.855  74834.559 411
1.518
Range for i           29.919    12.974     13.238    27.057     62.810   2
2.462
Stdev for i            1.560     0.229      1.152     1.547      2.051
1.523
GroupRho for i         0.807     0.078      0.619     0.819      0.922
0.844
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.469 0.354     -9.234   -8.443     -7.845 -8.390   0
year       0.346 0.282     -0.193    0.341      0.915  0.331   0
depth     -0.671 0.461     -1.683   -0.631      0.123 -0.546   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18598.624 18375.900   1258.283 13170.670   67193.24 343
4.971
Range for i           40.353    45.744      4.592    26.689     159.35   1
2.015
Stdev for i            0.358     0.374      0.033     0.248       1.36
0.093
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

No overall linear trend in the cover of the encrusting white sponge morphotype was found. A positive trend was found for Freycinet Marine Park equating to a 180% increase in the odds per year. No significant association was found with depth.

2.4.22 Encrusting Yellow Smooth

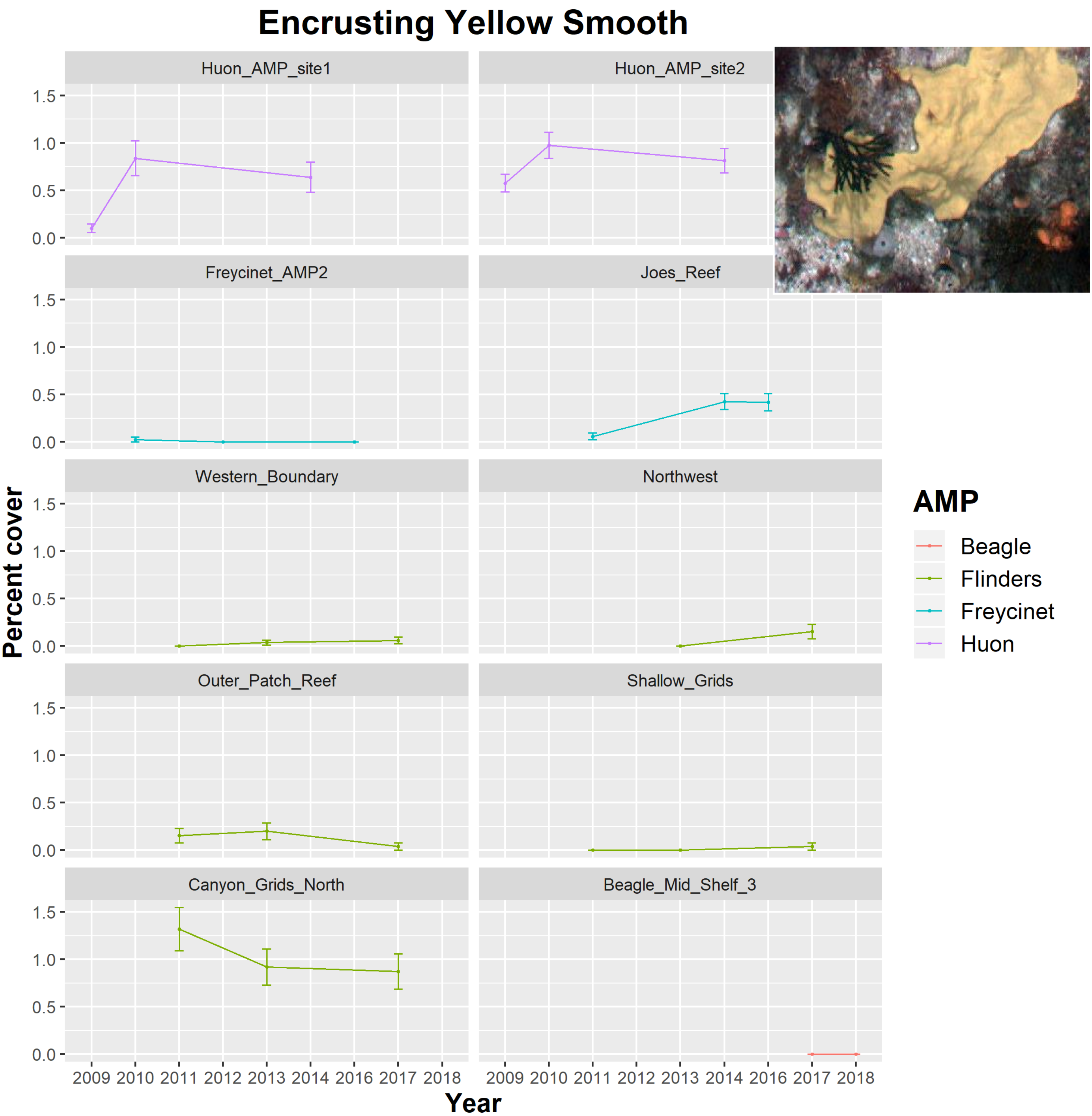


__Figure 2.4.22__ Site level trends in the raw data for Encrusting Yellow Smooth sponges.

2.4.22.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.947 0.365     -8.671   -7.945     -7.237 -7.940   0
year      -0.201 0.236     -0.666   -0.200      0.260 -0.198   0
depth     -0.044 0.259     -0.552   -0.043      0.463 -0.043   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 21598.638 21620.253   1409.698 15176.788  78769.505 3794.253
Range for i         630.668   190.650    342.081   601.940   1083.622  548.755
Stdev for i           1.671     0.246      1.231     1.658      2.197    1.634
GroupRho for i        0.866     0.047      0.754     0.873      0.936    0.887
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.262 0.444     -6.136   -5.261     -4.393 -5.259   0
year       0.072 0.183     -0.287    0.072      0.430  0.073   0
depth     -0.521 0.184     -0.883   -0.521     -0.160 -0.521   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18419.025 17858.818   1274.949 13186.637  66118.658 350
5.799
Range for i          621.276   428.801    141.311   513.853   1739.001  34
1.592
Stdev for i            0.835     0.252      0.436     0.804      1.416
0.744
GroupRho for i         0.833     0.070      0.663     0.845      0.933
0.868
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.248 0.274     -7.823   -7.236     -6.745 -7.211   0
year       0.532 0.190      0.171    0.528      0.918  0.519   0
depth     -1.196 0.241     -1.693   -1.187     -0.749 -1.170   0

Random effects:
  Name    Model
```

```
    site IID model
       i SPDE2 model

Model hyperparameters:
                            mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19122.941 18980.042   1333.567 13523.074  69404.907 366
9.871
Range for i          172.206   333.484      9.540    80.783    907.558   2
4.122
Stdev for i            0.511     0.235      0.182     0.470      1.083
0.388
GroupRho for i         0.842     0.066      0.681     0.854      0.937
0.876
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.848 0.225     -8.309   -7.841     -7.424 -7.828   0
year       0.013 0.149     -0.281    0.013      0.303  0.015   0
depth      1.147 0.166      0.824    1.146      1.477  1.143   0

Random effects:
  Name    Model
    site IID model
       i SPDE2 model

Model hyperparameters:
                            mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18429.201 18232.857   1270.968 13049.394  66705.843 347
8.542
Range for i           41.045    21.398     14.637    36.136     95.886   2
8.461
Stdev for i            1.283     0.211      0.903     1.273      1.729
1.257
GroupRho for i         0.827     0.071      0.656     0.839      0.931
0.861
```

No overall linear trend in the cover of the encrusting yellow smooth morphotype was found. A positive trend was found for Freycinet Marine Park equating to a 70% increase in the odds per year. A significant negative association was found with depth, indicating a preference for shallower depths in those that were surveyed.

2.4.23 *Epizoanthus sp*

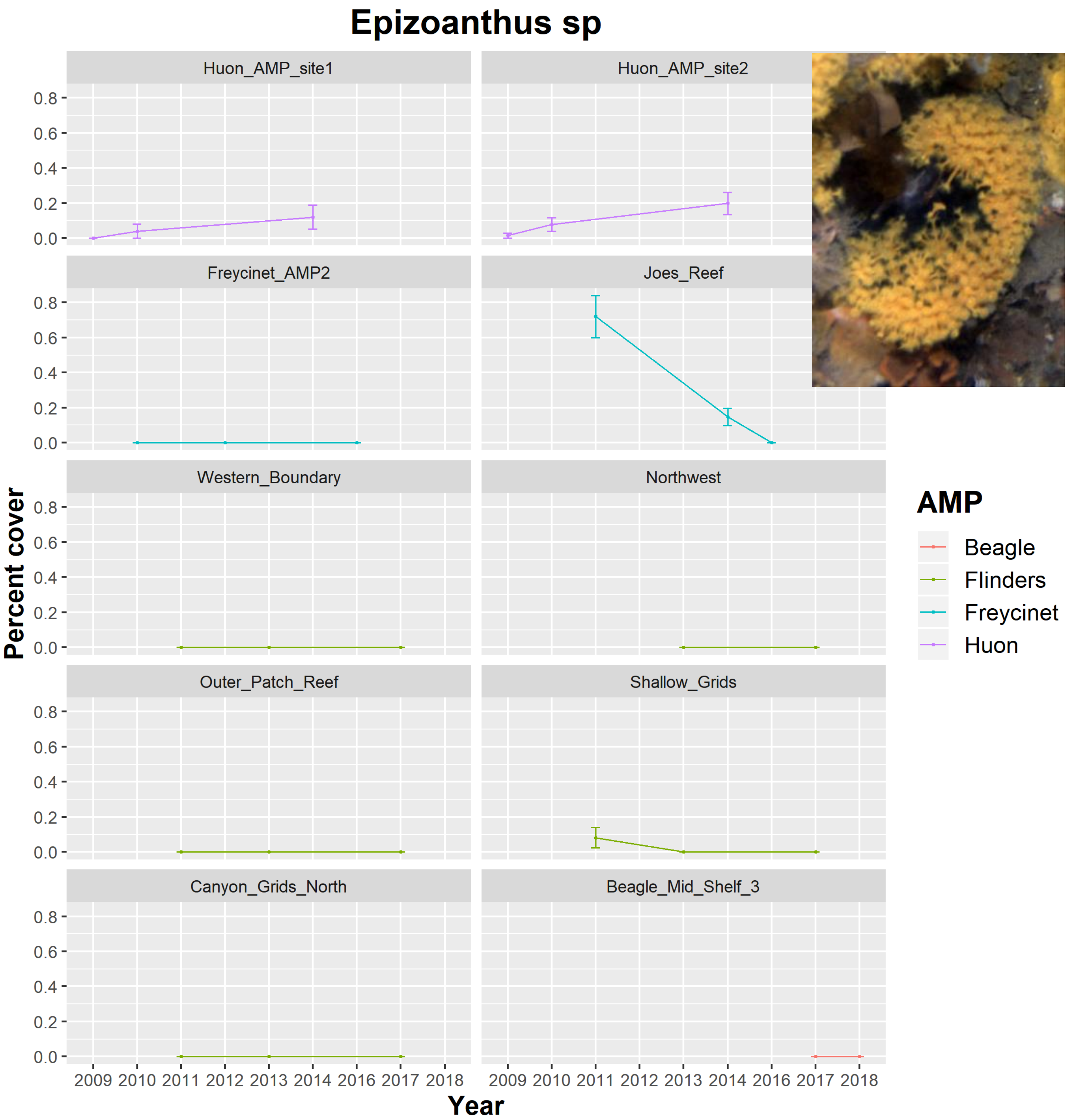


Figure 2.4.23 *Site level trends in the raw data for Epizoanthus sp.*

2.4.23.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -13.249 0.778    -14.803  -13.240    -11.747 -13.222   0
year       -0.198 0.382     -0.968   -0.192      0.533  -0.178   0
depth      -1.557 0.881     -3.096   -1.628      0.363  -1.777   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  1.878  3.326      0.101    0.930      9.566  0.259
Range for i       53.772 21.500     22.790   50.173    106.218 43.501
Stdev for i        2.972  0.442      2.150    2.961      3.880  2.957
GroupRho for i     0.829  0.057      0.698    0.836      0.921  0.849
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.120 0.494     -9.135   -8.104     -7.194 -8.073   0
year       0.844 0.287      0.297    0.838      1.424  0.827   0
depth     -1.148 0.450     -2.078   -1.132     -0.310 -1.100   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18726.867 18573.100   1282.879 13240.472  67623.921 351
6.583
Range for i          211.816   160.911     47.047   168.060    634.825   10
8.720
Stdev for i            1.178     0.318      0.652     1.148      1.892
1.089
GroupRho for i         0.828     0.074      0.647     0.841      0.933
0.866
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -12.927 1.160    -15.476  -12.823    -10.932 -12.604   0
year       -1.271 0.574     -2.463   -1.248     -0.208  -1.203   0
depth      -2.749 0.940     -4.794   -2.675     -1.108  -2.519   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18356.069 18284.967   1260.088 12948.507  66613.020 344
5.815
Range for i           34.929    11.198     18.346    33.110     61.757   2
9.803
Stdev for i            2.409     0.363      1.775     2.381      3.199
2.328
GroupRho for i         0.837     0.059      0.697     0.846      0.927
0.864
```

Flinders Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -10.311 0.826    -12.159  -10.220     -8.934 -10.022   0
year       -1.012 0.848     -2.895   -0.927      0.422  -0.743   0
depth      -0.143 0.614     -1.505   -0.082      0.897   0.050   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18616.242 18368.277   1261.733 13193.719  67196.488 344
6.559
Range for i           74.177   144.649      6.816    35.525    381.410   1
4.716
Stdev for i            0.215     0.197      0.017     0.159      0.736
0.047
GroupRho for i         0.849     0.064      0.691     0.860      0.940
0.882
```

No overall trend was detected for epizoanthus sp. However, a positive linear trend equating to a 133% increase in odds per year was found for Huon Marine Park between 2009 and 2014, while a negative trend equating to a 72% decrease in odds was found for Freycinet Marine Park between 2011 and 2016. No significant overall association was found for depth.

2.4.24 Fan Pink

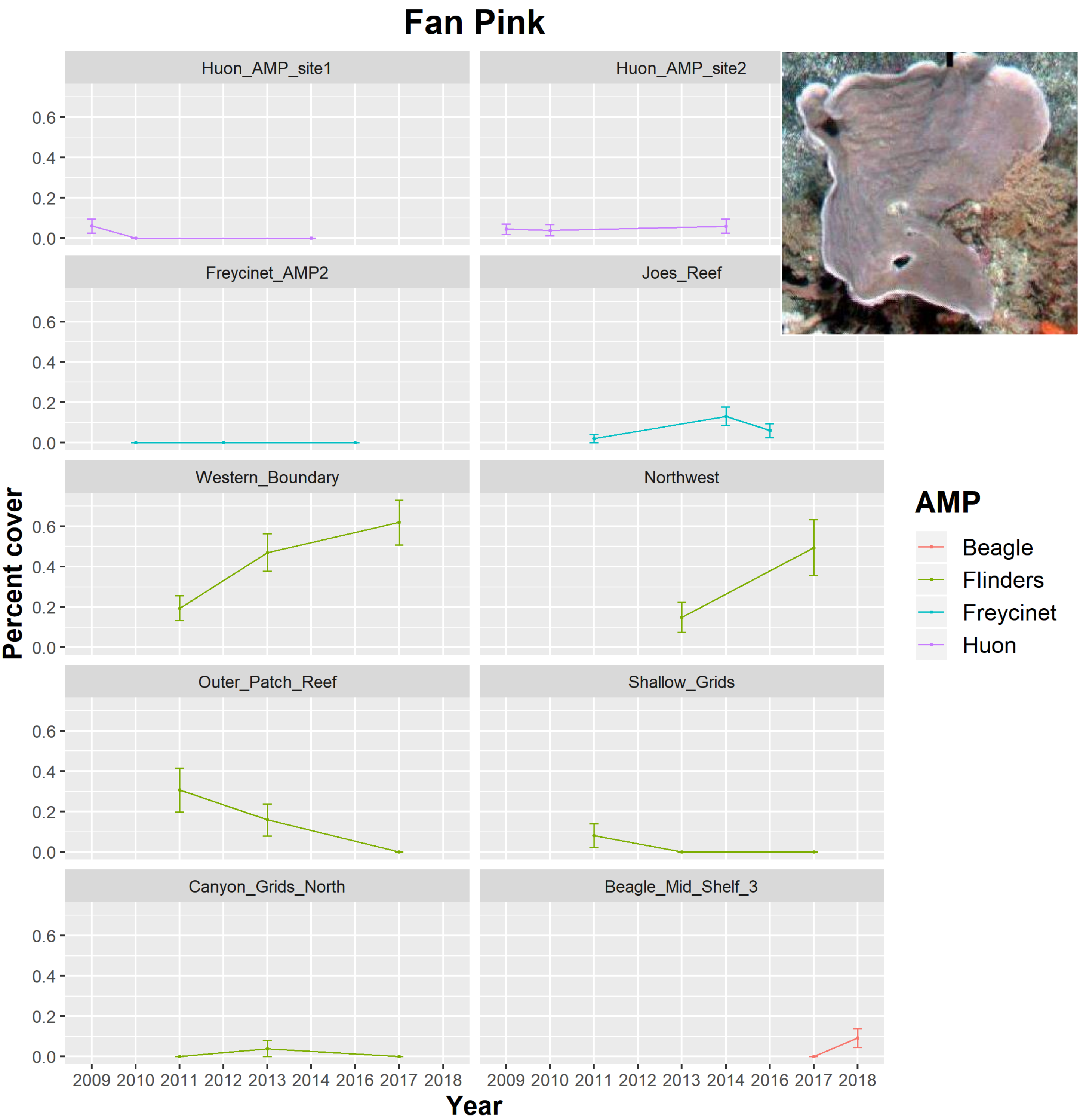


Figure 2.4.24 *Site level trends in the raw data for Fan Pink sponges.*

2.4.24.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.697 0.188     -9.085   -8.690     -8.348 -8.677   0
year       0.255 0.117      0.027    0.255      0.485  0.254   0
depth     -1.482 0.236     -1.962   -1.476     -1.036 -1.463   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                      mean        sd 0.025quant  0.5quant 0.975quant    mode
Precision for AMP 15971.851 18145.745   1029.322 10443.061  64455.264 2779.11
Range for i          10.435     2.195      6.821    10.198     15.398    9.73
Stdev for i           2.256     0.254      1.790     2.245      2.787    2.23
GroupRho for i        0.797     0.081      0.611     0.807      0.924    0.83
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.850 0.302     -8.489   -7.833     -7.302 -7.800   0
year      -0.063 0.314     -0.721   -0.048      0.512 -0.018   0
depth     -0.046 0.286     -0.636   -0.036      0.485 -0.016   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18633.301 18369.793   1263.323 13212.009  67220.030 345
1.570
Range for i           42.971    55.106      5.191    26.524    182.068    1
2.461
Stdev for i            0.235     0.213      0.022     0.175      0.793
0.064
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.480 0.480     -9.524   -8.442     -7.643 -8.363   0
year       0.312 0.334     -0.312    0.301      1.000  0.279   0
depth     -1.207 0.415     -2.094   -1.182     -0.461 -1.130   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18619.728 18361.217   1261.769 13200.244   67191.66 344
6.654
Range for i           43.403    57.708      5.247    26.236     186.91   1
2.337
Stdev for i            0.324     0.344      0.026     0.221       1.24
0.071
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.999 0.243     -8.513   -7.986     -7.558 -7.960   0
year       0.179 0.141     -0.098    0.179      0.455  0.180   0
depth     -1.484 0.353     -2.234   -1.464     -0.846 -1.422   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 28158.108 37690.944   2234.867 16839.359 123240.234 587
5.926
Range for i           11.103     2.469      6.971    10.865     16.612   1
0.415
Stdev for i            2.150     0.283      1.646     2.131      2.756
2.096
GroupRho for i         0.803     0.085      0.599     0.816      0.927
0.845
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.893 0.676     -9.411   -7.817     -6.773 -7.648   0
year       1.001 0.848     -0.394    0.902      2.912  0.679   0
depth     -0.069 0.439     -0.860   -0.095      0.864 -0.147   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18609.169 18359.645   1262.037 13189.581   67168.77 344
7.886
Range for i           49.090    73.689      4.964    27.575     226.75   1
1.841
Stdev for i            0.383     0.460      0.030     0.244       1.58
0.081
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

An overall positive linear trend for fan pink sponges was detected, equating to a 29% increase in the odds of presence over the survey period. Interestingly, no significant marine park level changes were detected. A negative association for depth was detected indicating that this morphospecies tends to be found in the shallower depths across those which were surveyed.

2.4.25 Gorgonian Red

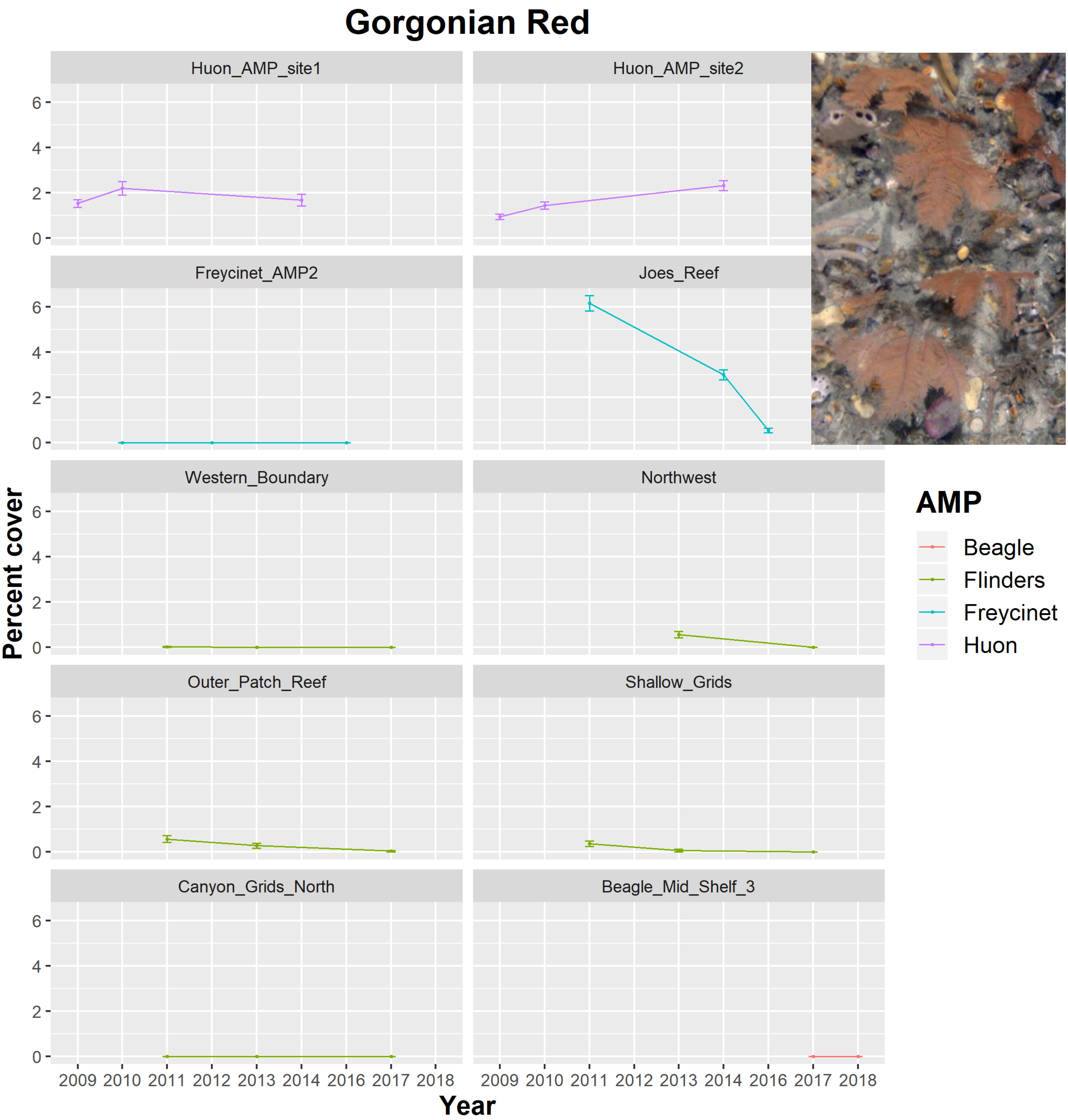


__Figure 2.4.25__ Site level trends in the raw data for Gorgonian Red.

2.4.25.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.858 0.436     -9.734   -8.851     -8.020 -8.837   0
year      -1.515 0.277     -2.072   -1.510     -0.985 -1.500   0
depth     -3.085 0.441     -3.957   -3.083     -2.227 -3.078   0

Random effects:
  Name    Model
    AMP  IID model
   i  SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 23348.815 23172.276   2454.465 16628.436  84333.283 6796.341
Range for i         330.397    74.557    213.995   319.841    504.870  298.709
Stdev for i           2.389     0.244      1.947     2.375      2.907    2.346
GroupRho for i        0.905     0.027      0.842     0.908      0.949    0.914
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -3.432 0.644     -4.697   -3.432     -2.171 -3.431   0
year       0.067 0.254     -0.432    0.067      0.564  0.067   0
depth     -1.457 0.190     -1.830   -1.457     -1.086 -1.456   0

Random effects:
  Name    Model
    site IID model
   i  SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant 0.5quant 0.975quant     
mode
Precision for site 18581.975 18346.140   1272.073 13168.47   67090.738 347
8.141
Range for i           487.794   162.172    240.707   464.63     870.480   42
0.851
Stdev for i             1.462     0.251      1.025     1.44       2.007    
1.410
GroupRho for i          0.852     0.053      0.726     0.86       0.932    
0.875
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.813 0.266     -7.357   -6.806     -6.310 -6.791   0
year      -0.981 0.157     -1.291   -0.981     -0.676 -0.979   0
depth     -2.513 0.263     -3.049   -2.506     -2.017 -2.492   0

Random effects:
```

```
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18428.810 17958.063    1320.17 13174.826  66190.907 366
9.455
Range for i           36.742     7.689      24.00    35.931     54.125   3
4.355
Stdev for i            1.539     0.149       1.26     1.533      1.849
1.523
GroupRho for i         0.779     0.064       0.63     0.786      0.881
0.802
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.066 0.829     -9.728   -8.054     -6.471 -8.030   0
year      -1.413 0.344     -2.143   -1.394     -0.792 -1.354   0
depth     -1.657 0.972     -3.745   -1.591      0.071 -1.455   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                      mean      sd 0.025quant 0.5quant 0.975quant    mode
Precision for site   2.623  11.928      0.060    0.652     16.919   0.137
Range for i        495.749 445.221     72.817  370.251   1670.125 192.370
Stdev for i          0.772   0.329      0.293    0.720      1.561   0.613
GroupRho for i       0.842   0.068      0.676    0.854      0.938   0.877
```

An overall linear decrease in the cover of gorgonian red fans was detected over the survey period equating to a 78% decrease in the odds of presence. Linear decreases were also detected for Freycinet and Flinders Marine Parks equating to decreases in the odds of presence of 63% and 76% respectively. A negative association with depth indicates that this morphospecies tends to be found in shallower depths across those surveyed.

2.4.26 Hydroid White

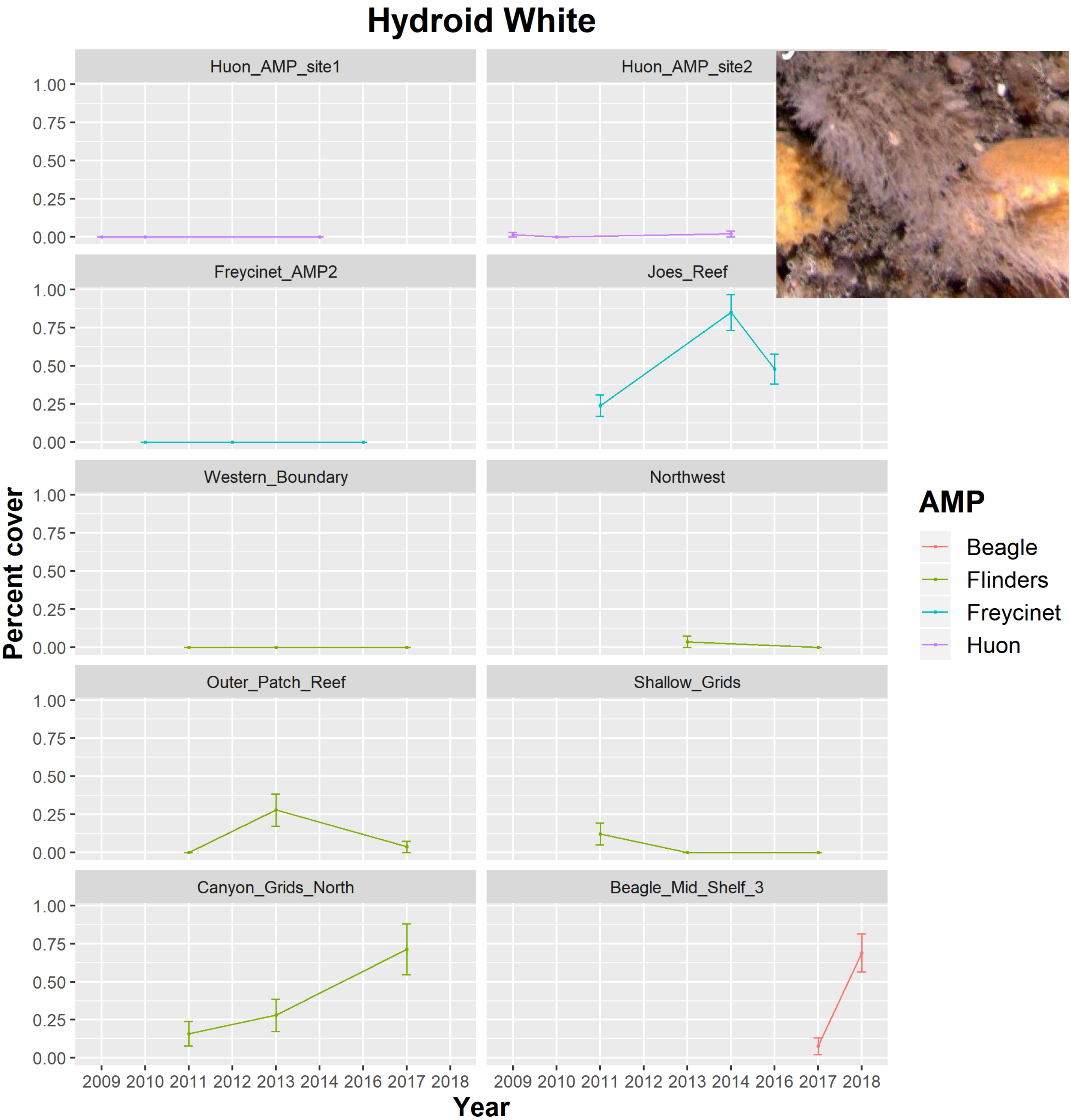


Figure 2.4.26 *Site level trends in the raw data for Hydroid White.*

2.4.26.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.179 0.379     -9.937   -9.174     -8.448 -9.165   0
year       0.666 0.262      0.160    0.663      1.187  0.658   0
depth     -0.050 0.334     -0.707   -0.050      0.604 -0.049   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant 0.5quant 0.975quant     mode
Precision for AMP 18401.626 18241.315   1221.943 13000.64  66412.021 3332.545
Range for i         293.712   112.067    130.209   275.50    565.047  241.698
Stdev for i           2.280     0.301      1.739     2.26      2.922    2.230
GroupRho for i        0.862     0.049      0.744     0.87      0.934    0.884
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.923 0.883    -11.887   -9.833     -8.432 -9.637   0
year       0.717 0.592     -0.452    0.719      1.873  0.723   0
depth      1.011 0.602     -0.070    0.975      2.296  0.900   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                             mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19279.251 19117.906   1370.697 13649.661  69697.520 377
0.934
Range for i            45.783    61.428      5.357    27.529    198.616   1
2.741
Stdev for i             0.234     0.219      0.020     0.172      0.807
0.058
GroupRho for i          0.848     0.064      0.692     0.860      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.499 0.427     -9.394   -8.479     -7.716 -8.439   0
year       0.212 0.201     -0.179    0.210      0.610  0.208   0
depth     -2.461 0.380     -3.247   -2.447     -1.755 -2.419   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18876.604 18724.474   1313.477 13352.532  68551.584 361
6.080
Range for i           35.780    15.989     14.736    32.449     76.022   2
6.942
Stdev for i            1.229     0.230      0.825     1.214      1.725
1.187
GroupRho for i         0.792     0.078      0.608     0.804      0.911
0.827
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.762 0.245     -8.273   -7.751     -7.312 -7.729   0
year       0.322 0.159      0.012    0.321      0.637  0.319   0
depth      0.977 0.139      0.710    0.974      1.258  0.969   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 22630.774 22161.500   2224.909 16218.917   81000.26 627
7.226
Range for i           72.861   158.778      7.039    32.754     386.98   1
3.652
Stdev for i            0.458     0.315      0.057     0.391       1.22
0.175
GroupRho for i         0.847     0.064      0.692     0.857       0.94
0.878
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.878 0.439     -7.778   -6.865     -6.055 -6.838   0
year       0.457 0.396     -0.258    0.435      1.296  0.391   0
depth     -0.909 0.260     -1.422   -0.908     -0.400 -0.906   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 18879.533 18583.847   1273.997 13396.49  67764.809 348
7.095
Range for i          221.306   114.568     75.041   196.67    512.440  15
5.216
Stdev for i            1.477     0.311      0.947     1.45      2.164
1.402
GroupRho for i         0.846     0.071      0.672     0.86      0.944
0.885
```

An overall positive trend was found for the hydroid white morphospecies, with estimates indicating an increase in the odds of 95% per year over the survey period. A significant positive trend was also found for Flinders Marine Park equating to a 38% increase in the odds of presence per year. No overall association with depth was discovered.

2.4.27 Lumpy White

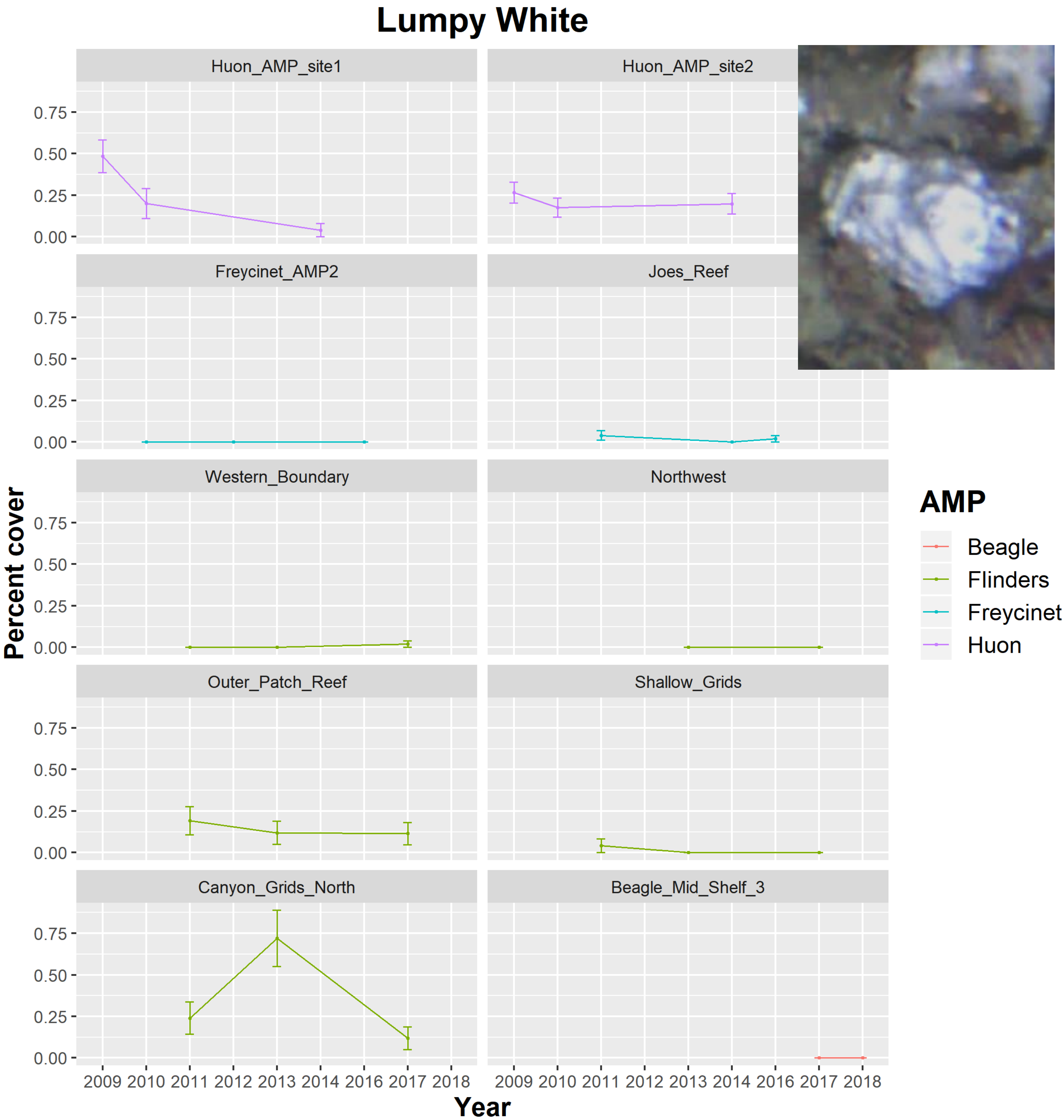


***Figure 2.4.27** Site level trends in the raw data for Lumpy White sponges.*

2.4.27.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.329 0.637     -9.594   -8.324     -7.092 -8.315   0
year      -0.419 0.179     -0.777   -0.417     -0.074 -0.413   0
depth      0.486 0.171      0.152    0.486      0.822  0.486   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean      sd 0.025quant 0.5quant 0.975quant    mode
Precision for AMP  1.006   0.882      0.154    0.759      3.345   0.405
Range for i      283.991 235.313     52.595  218.708    904.998 129.557
Stdev for i        0.795   0.182      0.481    0.781      1.193   0.756
GroupRho for i     0.852   0.063      0.699    0.863      0.942   0.883
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.159 0.149     -6.467   -6.154     -5.881 -6.144   0
year      -0.369 0.160     -0.700   -0.363     -0.071 -0.351   0
depth      0.023 0.116     -0.209    0.024      0.246  0.027   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18763.770 18489.025   1303.743 13317.585  67577.710 357
1.287
Range for i           25.762    17.947      4.780    21.519     72.827    1
3.064
Stdev for i            0.272     0.202      0.038     0.223      0.799
0.112
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.452 0.648    -10.881   -9.392     -8.345 -9.263   0
year      -0.377 0.552     -1.510   -0.360      0.659 -0.327   0
depth     -0.846 0.593     -2.119   -0.807      0.211 -0.725   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18606.373 18358.315   1262.190 13187.135   67162.01 344
8.457
Range for i           47.044    66.546      4.638    27.366     211.52   1
1.477
Stdev for i            0.365     0.414      0.033     0.241       1.45
0.091
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.381 0.360     -9.122   -8.369     -7.707 -8.345   0
year      -0.305 0.228     -0.765   -0.301      0.130 -0.292   0
depth      0.856 0.293      0.283    0.855      1.434  0.852   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 18297.252 18234.189   1256.533 12905.30  66474.407 343
9.471
Range for i          203.194   202.514     21.198   144.33    737.727   5
8.722
Stdev for i            1.033     0.274      0.574     1.01      1.644
0.961
GroupRho for i         0.829     0.069      0.664     0.84      0.931
0.862
```

An overall negative linear trend for lumpy white sponges was detected, equating to a 34% reduction in the odds of presence over the survey period. Also, a decrease equating to a 31% decrease in odds was detected at Huon Marine Park. A positive association for depth was detected indicating that this morphospecies tends to be found in the deeper depths across those which were surveyed.

2.4.28 *Massive Blue Shapeless*

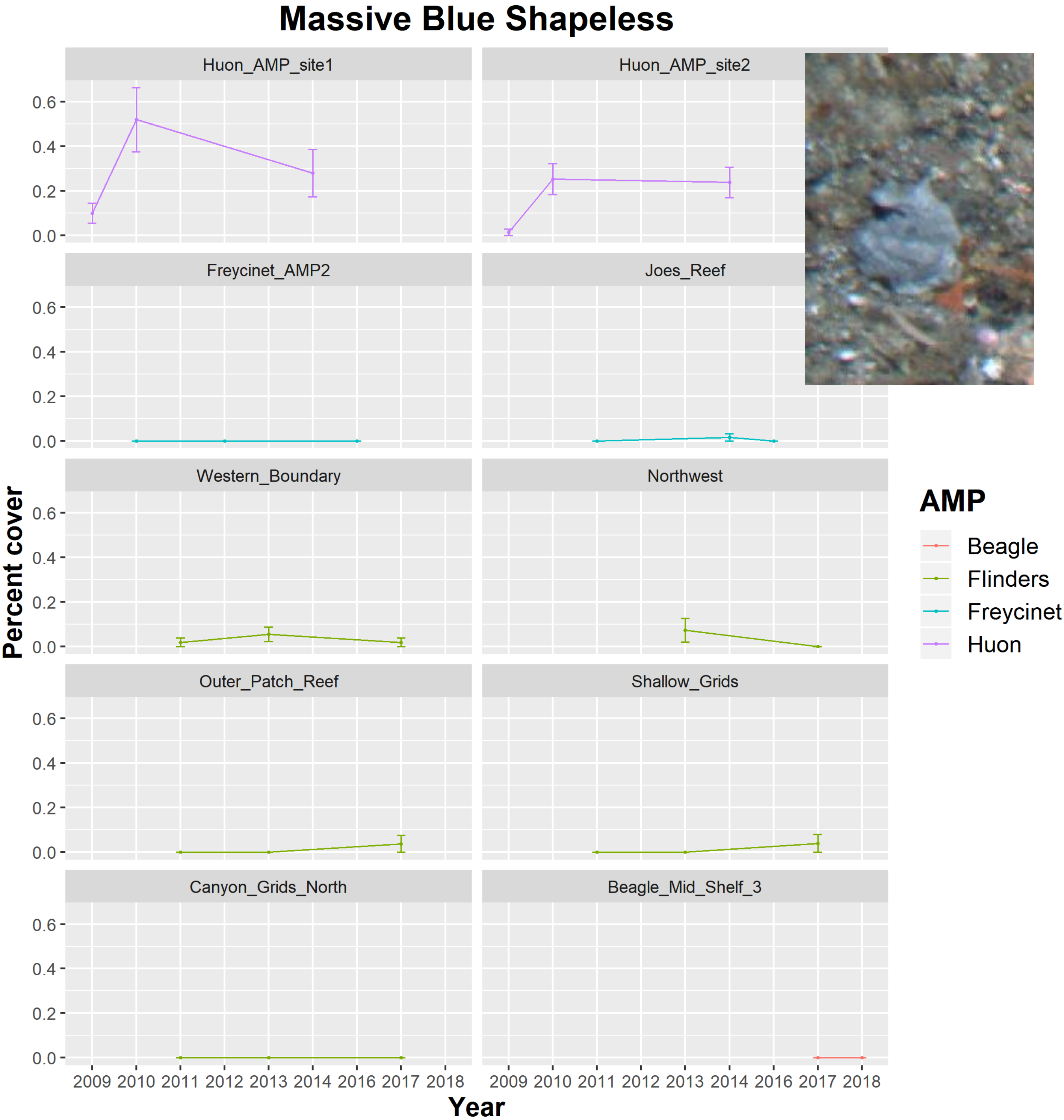


***Figure 2.4.28** Site level trends in the raw data for Massive Blue Shapeless sponges.*

2.4.28.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.266 0.797    -10.851   -9.259     -7.722 -9.245   0
year       0.210 0.171     -0.129    0.211      0.542  0.212   0
depth     -1.022 0.402     -1.867   -1.002     -0.285 -0.963   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                   mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  0.737  0.554      0.188    0.582      2.219  0.393
Range for i       34.877 25.612      9.195   27.737    103.594 18.967
Stdev for i        0.808  0.202      0.457    0.795      1.246  0.770
GroupRho for i     0.827  0.068      0.658    0.840      0.924  0.863
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.500 0.165     -6.833   -6.496     -6.187 -6.489   0
year       0.229 0.147     -0.062    0.230      0.515  0.233   0
depth     -0.334 0.175     -0.690   -0.330     -0.002 -0.322   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 20352.872 19851.591   1711.478 14597.095  73271.427 484
9.002
Range for i           54.694    69.391      7.902    33.972    227.882   1
7.307
Stdev for i            0.634     0.284      0.198     0.599      1.277
0.495
GroupRho for i         0.838     0.070      0.667     0.851      0.936
0.875
```

Freycinet Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.085 0.708    -11.643  -10.021     -8.868 -9.885   0
year        0.129 0.721     -1.234    0.110      1.601  0.072   0
depth      -0.205 0.709     -1.649   -0.186      1.135 -0.148   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18629.481 18377.348   1263.788 13205.117  67218.025 345
3.329
Range for i           66.004   118.315      6.589    33.378    327.683   1
4.342
Stdev for i            0.212     0.194      0.016     0.157      0.727
0.046
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.787 0.437     -9.749   -8.748     -8.036 -8.665   0
year       0.068 0.318     -0.565    0.070      0.685  0.075   0
depth     -0.906 0.613     -2.264   -0.846      0.135 -0.718   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 18725.791 18465.994   1276.691 13278.06  67497.291 349
3.653
Range for i           51.801    76.278      5.932    29.51    234.264   1
3.518
Stdev for i            0.264     0.254      0.024     0.19      0.941
0.068
GroupRho for i         0.848     0.064      0.691     0.86      0.940
0.882
```

No overall or marine park level trends were detected for repent orange sponges. A negative association for depth was detected indicating that this morphospecies tends to be found in the shallower depths across those which were surveyed.

2.4.29 Massive Purple

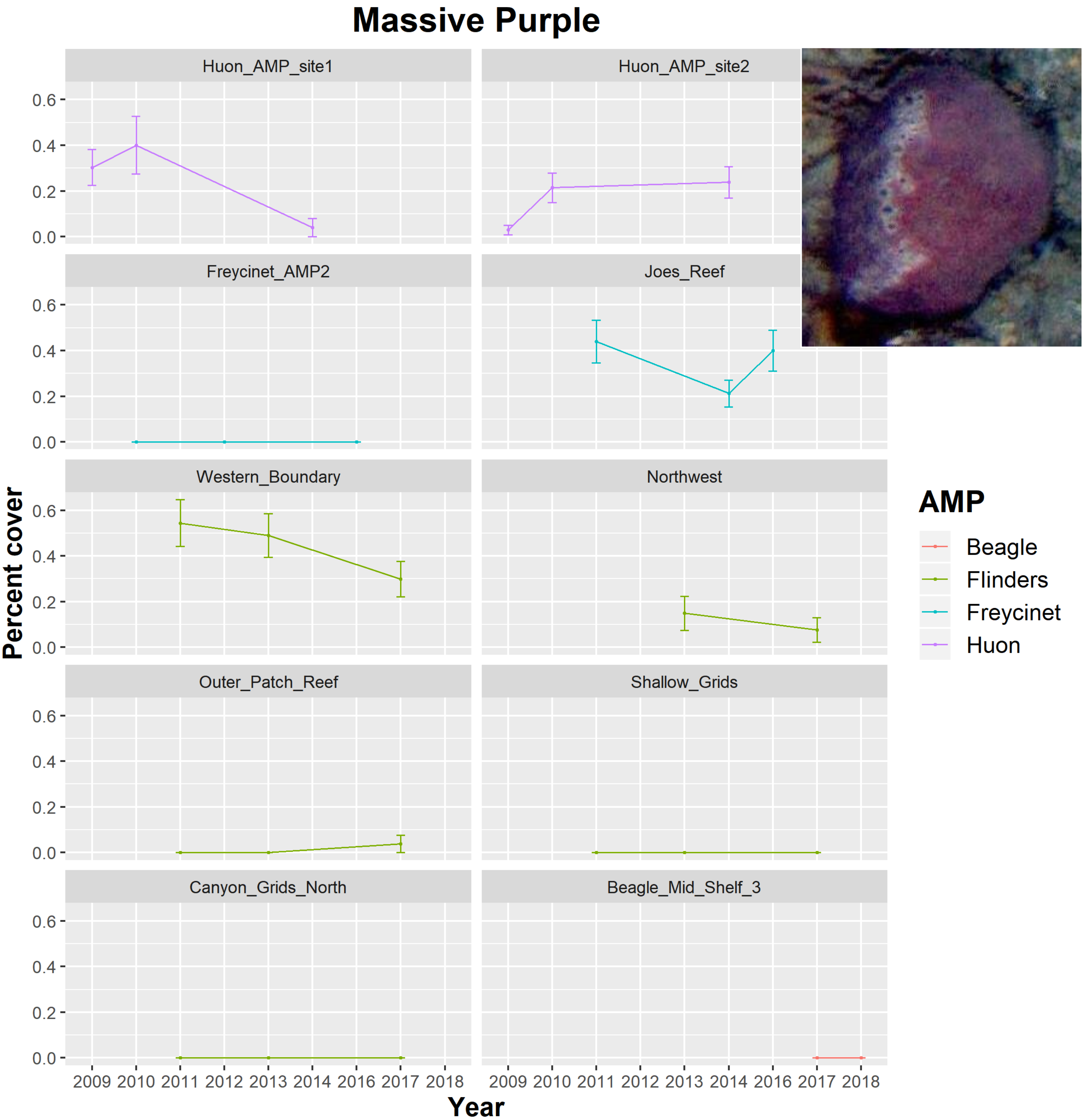


Figure 2.4.29 *Site level trends in the raw data for Massive Purple sponges.*

2.4.29.1 *Model-based estimates of trend*

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.533 0.534     -9.588   -8.531     -7.492 -8.526   0
year      -0.313 0.129     -0.570   -0.313     -0.062 -0.311   0
depth     -2.226 0.321     -2.883   -2.217     -1.623 -2.198   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                   mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  1.341  0.800      0.412    1.145      3.411  0.852
Range for i       30.488 15.689     10.955   26.939     70.559 21.318
Stdev for i        1.554  0.162      1.252    1.550      1.888  1.545
GroupRho for i     0.774  0.077      0.600    0.782      0.899  0.799
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.780 0.187     -7.158   -6.776     -6.424 -6.768   0
year       0.047 0.175     -0.304    0.050      0.381  0.056   0
depth      0.116 0.159     -0.201    0.117      0.424  0.120   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                         mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18218.178 18181.987   1238.542 12834.324  66324.660 338
3.648
Range for i           25.813    10.825     10.758    23.815     52.401   2
0.266
Stdev for i            1.317     0.293      0.805     1.299      1.950
1.267
GroupRho for i         0.836     0.071      0.660     0.849      0.935
0.873
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.509 0.417     -9.393   -8.486     -7.754 -8.439   0
year      -0.117 0.190     -0.489   -0.117      0.256 -0.118   0
depth     -2.213 0.365     -2.977   -2.196     -1.541 -2.164   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 20014.953 20367.670   1433.667 13975.371  74250.791 394
9.221
Range for i           15.112     6.154      6.762    13.893     30.437   1
1.824
Stdev for i            1.387     0.321      0.842     1.360      2.098
1.310
GroupRho for i         0.798     0.084      0.597     0.811      0.921
0.838
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.184 0.655    -10.597   -9.137     -8.024 -9.040   0
year      -0.304 0.189     -0.680   -0.302      0.063 -0.299   0
depth     -3.439 0.942     -5.448   -3.381     -1.744 -3.264   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 16929.557 17775.452   1150.997 11601.669   63779.82 315
3.763
Range for i          159.506   101.106     43.784   134.440     423.43   9
6.395
Stdev for i            1.085     0.242      0.655     1.073       1.60
1.055
GroupRho for i         0.825     0.076      0.649     0.835       0.94
0.859
```

An overall negative linear trend for massive purple sponges was detected, equating to a 27% reduction in the odds of presence over the survey period. Interestingly, no significant marine park level changes were detected. A negative association for depth was detected indicating that this morphospecies tends to be found in the shallower depths across those which were surveyed.

2.4.30 *Non-Calcareous Encrusting Red Algae*

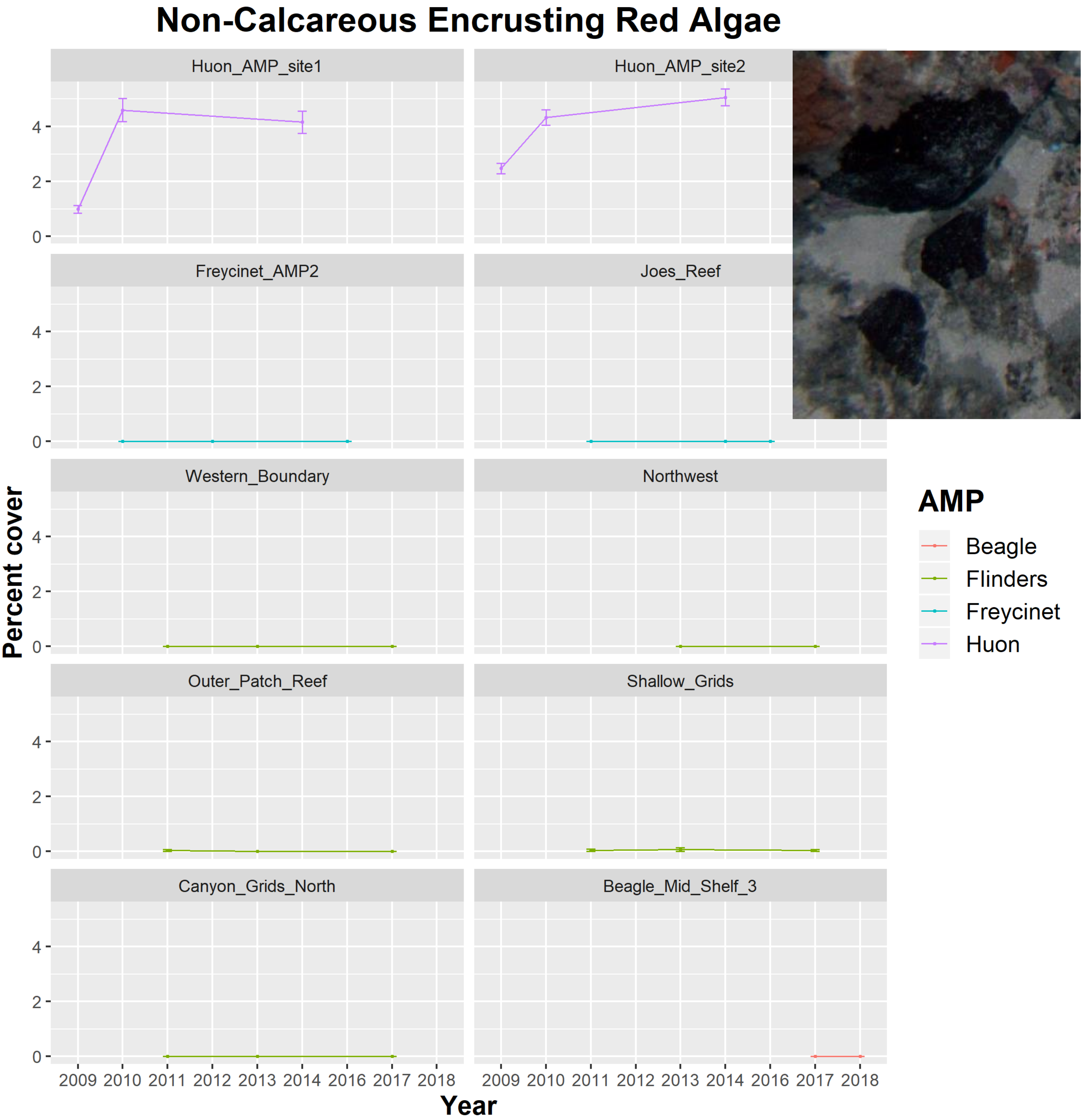


Figure 2.4.30 *Site level trends in the raw data for Non-Calcareous Encrusting Red Algae.*

2.4.30.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -11.125 1.746    -14.656  -11.088     -7.799 -11.015   0
year        0.112 0.095     -0.075    0.112      0.297   0.112   0
depth      -2.702 0.297     -3.298   -2.698     -2.130  -2.689   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  0.100 0.072      0.016    0.082      0.285  0.046
Range for i       33.683 5.266     24.328   33.364     44.985 32.802
Stdev for i        0.997 0.085      0.836    0.995      1.169  0.993
GroupRho for i     0.898 0.042      0.793    0.906      0.956  0.921
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -4.106 0.184     -4.468   -4.106     -3.745 -4.106   0
year       0.057 0.065     -0.070    0.057      0.184  0.058   0
depth     -1.023 0.101     -1.226   -1.021     -0.828 -1.018   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                     mean      sd 0.025quant 0.5quant 0.975quant   mode
Precision for site 59.274 151.678      1.534   21.865     350.52  3.488
Range for i        32.980   5.368     24.188   32.358      45.19 30.995
Stdev for i         0.989   0.084      0.837    0.985       1.16  0.975
GroupRho for i      0.884   0.049      0.761    0.894       0.95  0.911
```

No overall or marine park level trends were detected for non-calcareous encrusting red algae. A significant negative depth association was found indicating this morphospecies tends to be found in shallower depths across those which were surveyed.

2.4.31 Palmate Grey

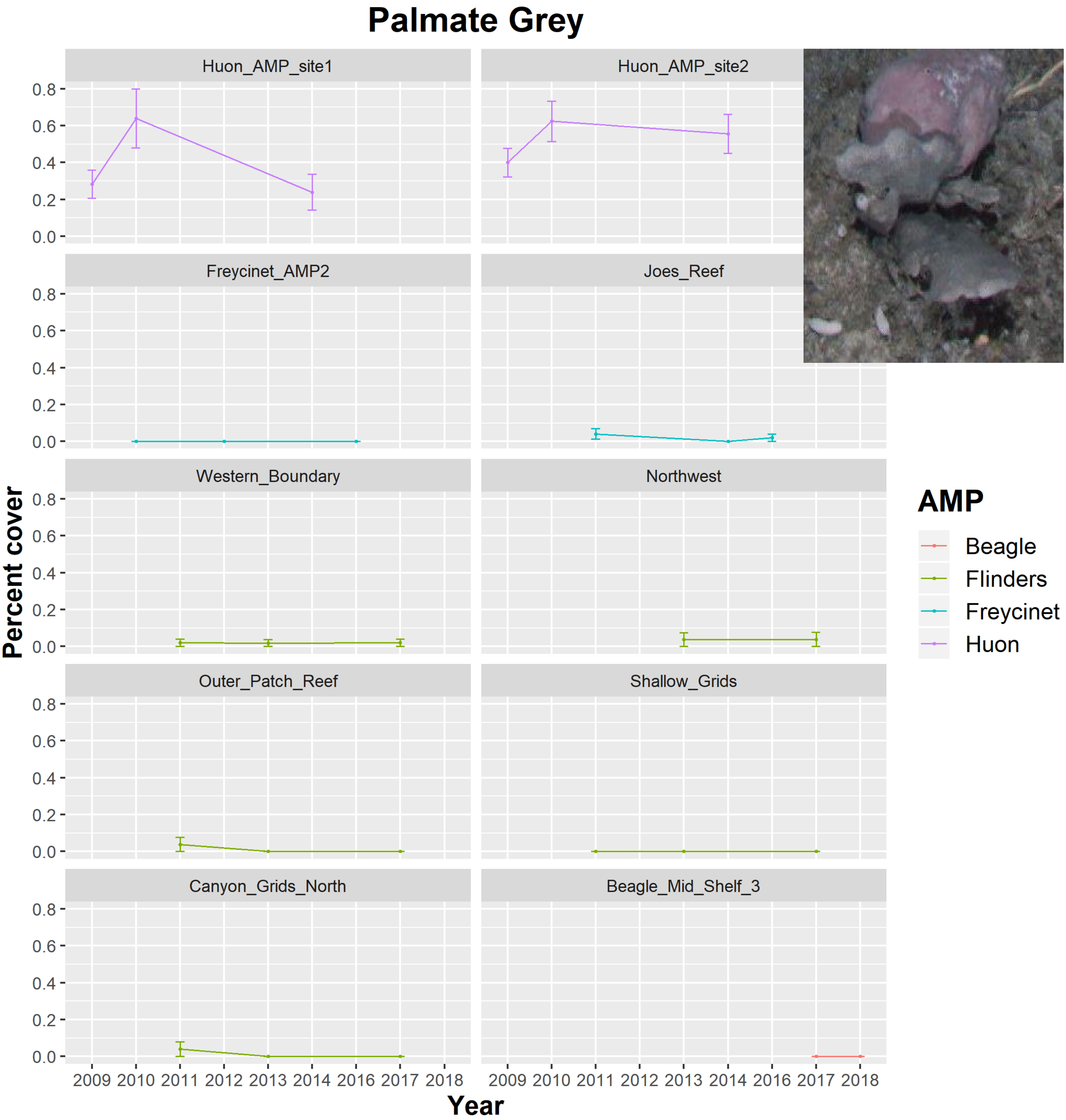


***Figure 2.4.31** Site level trends in the raw data for Palmate Grey sponges.*

2.4.31.1 *Model-based estimates of trend*

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.982 0.771    -10.510   -8.977     -7.483 -8.967   0
year      -0.099 0.155     -0.407   -0.098      0.200 -0.095   0
depth     -1.195 0.370     -1.944   -1.187     -0.492 -1.171   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                   mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP  0.568  0.436      0.094    0.456      1.714  0.257
Range for i       57.312 29.357     20.790   50.645    132.185 40.156
Stdev for i        0.916  0.168      0.615    0.908      1.271  0.896
GroupRho for i     0.863  0.059      0.720    0.874      0.946  0.893
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.725 0.502     -6.715   -5.723     -4.744 -5.720   0
year      -0.119 0.200     -0.513   -0.118      0.272 -0.117   0
depth     -1.082 0.224     -1.524   -1.081     -0.646 -1.080   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18285.200 17834.470   1227.892 13034.465  65938.874 334
4.822
Range for i          147.386   254.799      0.017    29.308    890.403
0.000
Stdev for i            0.978     0.267      0.543     0.949      1.586
0.894
GroupRho for i         0.858     0.058      0.718     0.868      0.941
0.886
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.512 0.680    -11.016   -9.447     -8.352 -9.308   0
year      -0.392 0.555     -1.531   -0.376      0.650 -0.342   0
depth     -0.943 0.615     -2.268   -0.900      0.144 -0.810   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18638.439 18384.929   1263.258 13211.689  67235.226 345
1.246
Range for i           49.987    71.725      5.767    28.894    224.756   1
3.288
Stdev for i            0.228     0.211      0.019     0.169      0.783
0.056
GroupRho for i         0.848     0.064      0.692     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.839 0.381     -9.657   -8.813     -8.161 -8.760   0
year      -0.221 0.372     -0.993   -0.206      0.469 -0.176   0
depth     -0.345 0.452     -1.338   -0.305      0.431 -0.219   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18670.743 18429.180   1272.355 13231.900  67348.209 348
0.506
Range for i           67.409   121.959      6.676    33.885    336.663   1
4.497
Stdev for i            0.210     0.191      0.016     0.156      0.714
0.044
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.881
```

No overall or marine park level trends were detected for palmate grey sponges. A significant negative depth association was found indicating this morphospecies tends to be found in shallower depths across those which were surveyed.

2.4.32 Purple Massive

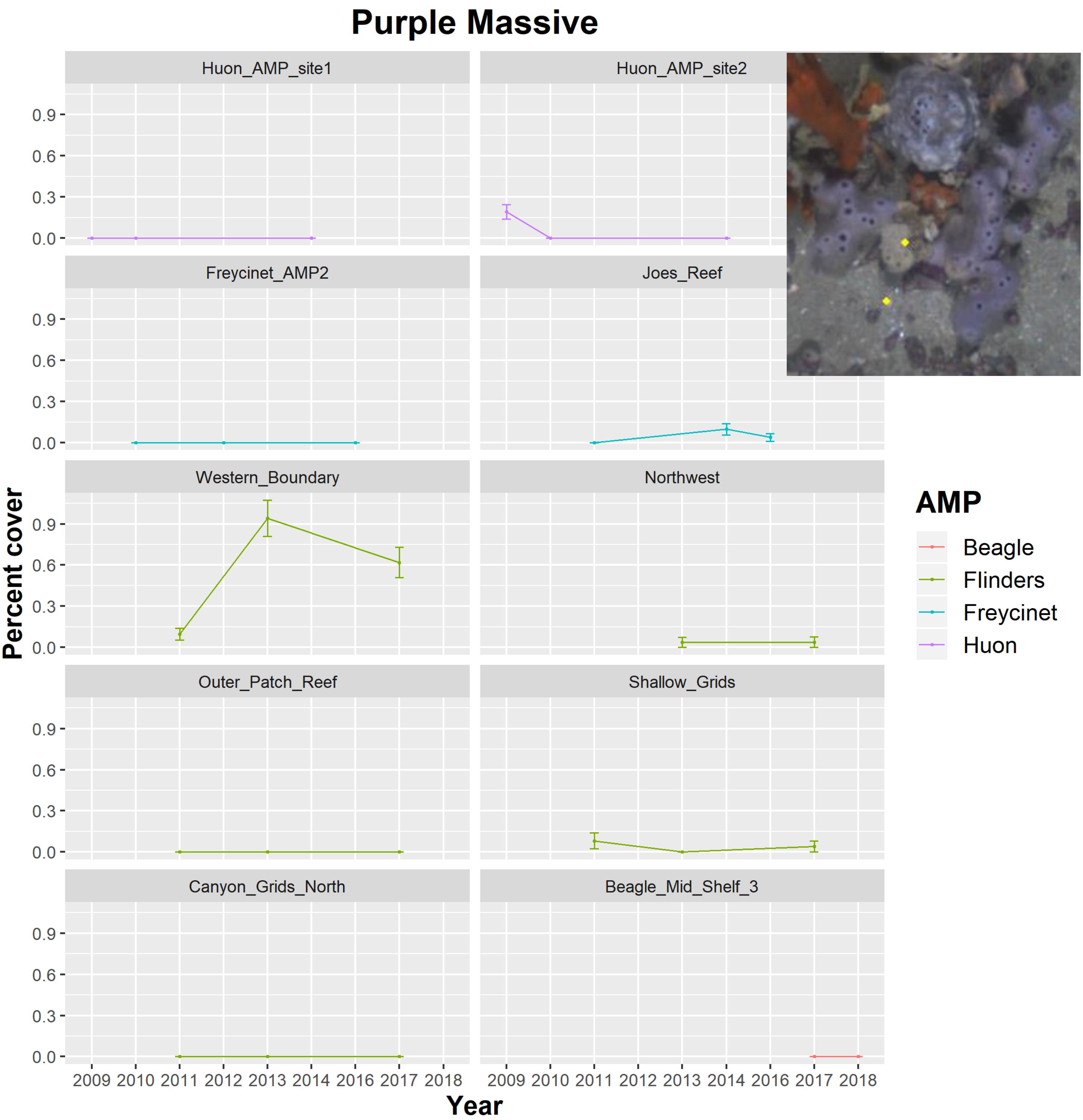


Figure 2.4.32 *Site level trends in the raw data for Purple Massive sponges.*

2.4.32.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.046 0.535    -11.174  -10.019     -9.069 -9.964   0
year       -0.150 0.341     -0.826   -0.147      0.511 -0.142   0
depth      -2.299 0.710     -3.812   -2.257     -1.021 -2.170   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                      mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 20963.638 20750.649   1472.170 14856.502   75752.63 4024.749
Range for i         660.049   252.570    307.278   613.119    1280.39  531.527
Stdev for i           1.708     0.328      1.148     1.680       2.43    1.626
GroupRho for i        0.809     0.066      0.654     0.819       0.91    0.837
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -10.617 1.112    -13.094  -10.503     -8.743 -10.254   0
year       -2.361 1.174     -4.973   -2.241     -0.382  -1.980   0
depth      -0.959 0.550     -2.164   -0.912     -0.009  -0.813   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
mode
Precision for site 19236.905 19186.548   1325.394 13560.287   70412.21 361
7.43
Range for i           22.553    12.827      8.201    19.211      56.21    1
4.58
Stdev for i            1.534     0.424      0.839     1.491       2.49
1.41
GroupRho for i         0.848     0.064      0.691     0.859       0.94
0.88
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.440 0.414     -9.336   -8.409     -7.712 -8.345   0
year       0.468 0.394     -0.255    0.449      1.294  0.411   0
depth     -0.504 0.370     -1.277   -0.488      0.178 -0.456   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18709.087 18412.963   1271.478 13279.225  67401.588 347
6.668
Range for i           63.311   109.346      6.565    32.782    309.982   1
4.333
Stdev for i            0.216     0.194      0.017     0.162      0.722
0.048
GroupRho for i         0.849     0.064      0.691     0.860      0.940
0.882
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.615 0.743    -10.186   -8.575     -7.266 -8.495   0
year       0.234 0.120     -0.002    0.234      0.470  0.234   0
depth     -2.582 1.128     -4.997   -2.508     -0.566 -2.359   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                     mean    sd 0.025quant 0.5quant 0.975quant   mode
Precision for site  1.328 1.430      0.134    0.904       5.07  0.364
Range for i        14.958 6.526      6.513   13.537      31.51 11.246
Stdev for i         1.033 0.294      0.540    1.008       1.68  0.958
GroupRho for i      0.849 0.064      0.693    0.860       0.94  0.881
```

No overall trend was found for purple massive sponges. A negative linear trend equating to a decrease of 91% per year in the odds of presence was found for Huon Marine Park. A negative trend for depth was found indicating this morphospecies was found in shallower depths across those that were surveyed.

2.4.33 Repent Orange

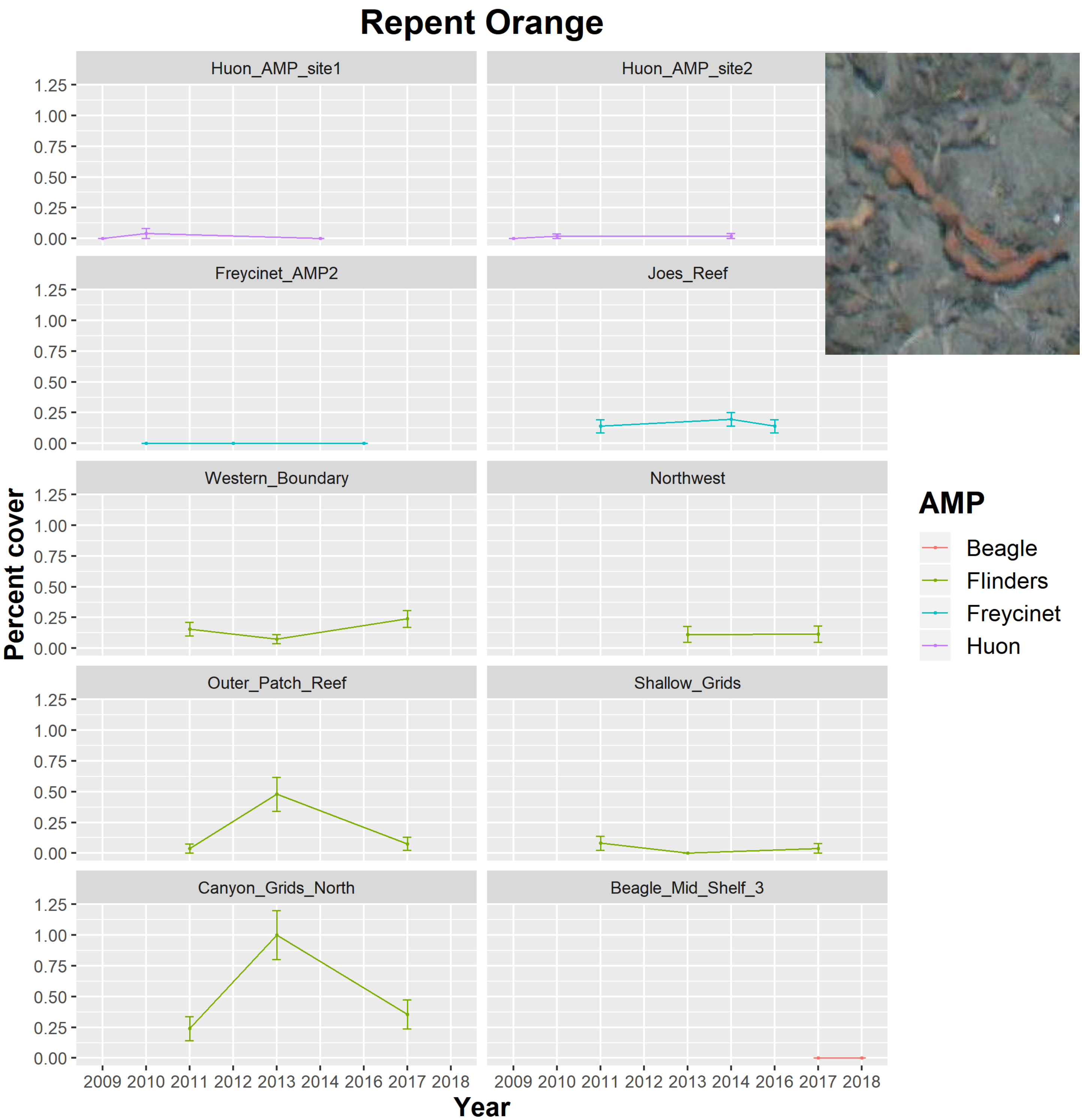


Figure 2.4.33 *Site level trends in the raw data for Repent Orange sponges.*

2.4.33.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.463 0.448     -9.349   -8.460     -7.589 -8.456   0
year       0.085 0.159     -0.228    0.085      0.396  0.085   0
depth      0.111 0.152     -0.190    0.112      0.406  0.113   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                    mean     sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP   1.681  0.744      0.606    1.562      3.507  1.314
Range for i       123.467 56.868     51.459  110.549    271.347 90.343
Stdev for i         1.293  0.144      1.048    1.280      1.615  1.246
GroupRho for i      0.798  0.041      0.710    0.799      0.872  0.801
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.109 0.508    -10.210   -9.071     -8.216 -8.992   0
year       0.213 0.492     -0.794    0.228      1.136  0.258   0
depth     -0.239 0.544     -1.410   -0.202      0.727 -0.125   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18647.584 18373.936   1262.273 13225.444   67252.35 344
7.118
Range for i           39.067    47.868      4.531    24.740     161.16   1
1.315
Stdev for i            0.291     0.293      0.029     0.206       1.07
0.080
GroupRho for i         0.848     0.064      0.691     0.860       0.94
0.882
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.645 0.366     -9.421   -8.626     -7.980 -8.585   0
year      -0.009 0.271     -0.539   -0.010      0.524 -0.012   0
depth     -1.098 0.378     -1.890   -1.080     -0.406 -1.044   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant 
 mode
Precision for site 19628.203 20032.212   1471.941 13708.276  72872.932 408
5.137
Range for i           41.601    29.155     11.163    33.703    118.165   2
3.321
Stdev for i            1.617     0.380      0.974     1.584      2.458  
1.524
GroupRho for i         0.816     0.077      0.632     0.828      0.928  
0.853
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.866 0.153     -7.173   -6.863     -6.573 -6.858   0
year       0.038 0.125     -0.209    0.038      0.281  0.039   0
depth      0.368 0.139      0.093    0.368      0.638  0.369   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant 
mode
Precision for site 19126.81 18265.653   1530.234 13866.390  66995.564 433
1.972
Range for i           45.04    25.450     13.300    39.431    109.870   2
9.721
Stdev for i            0.94     0.181      0.615     0.932      1.322  
0.919
GroupRho for i         0.79     0.106      0.524     0.811      0.933  
0.852
```

No overall or marine park level trends were detected for repent orange sponges. Also, no significant depth trends were detected for this morphospecies.

2.4.34 Repent Yellow

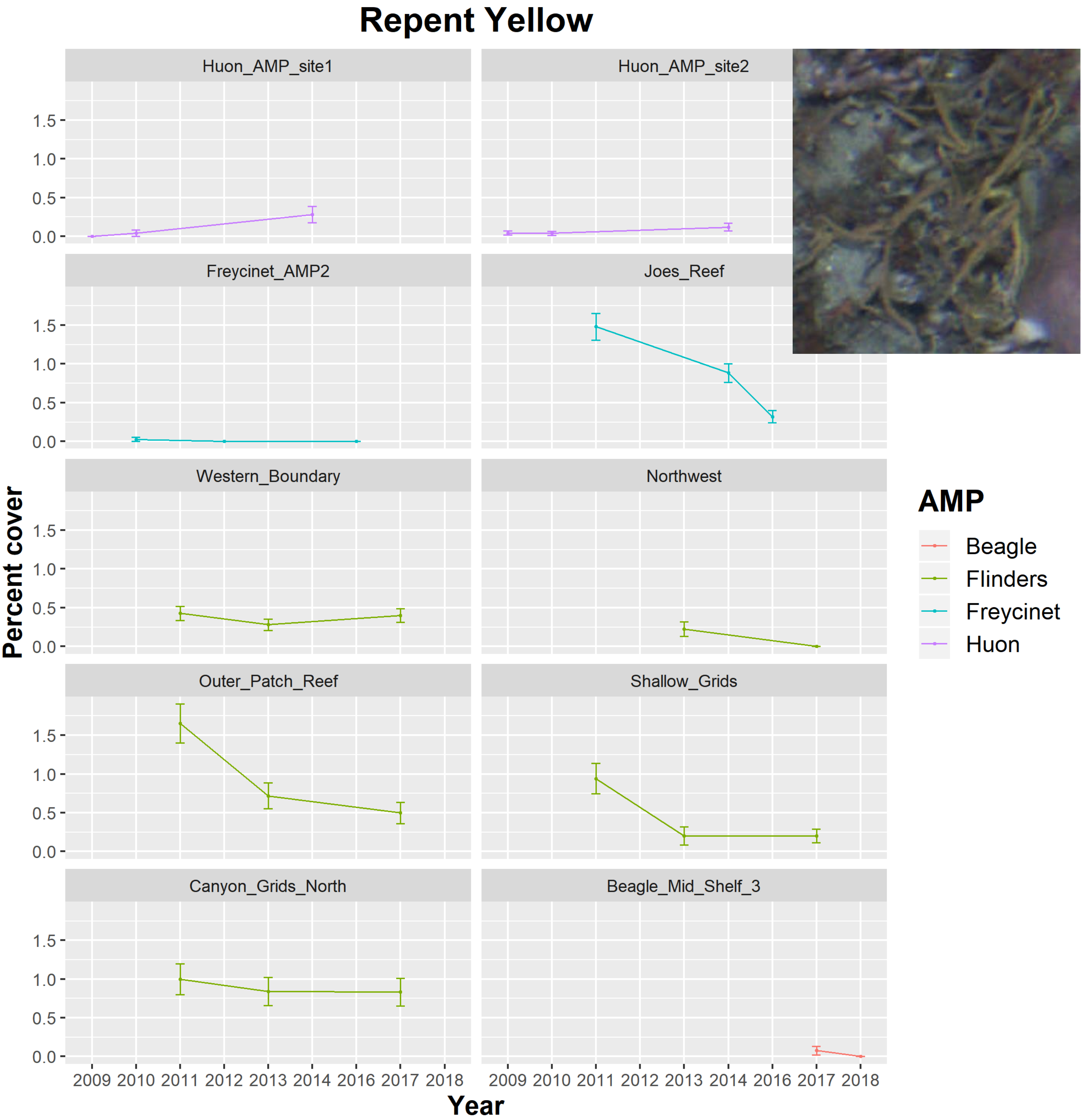


Figure 2.4.34 *Site level trends in the raw data for Repent Yellow sponges.*

2.4.34.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.682 0.628     -8.922   -7.680     -6.458 -7.674   0
year      -0.279 0.153     -0.581   -0.279      0.021 -0.279   0
depth      0.102 0.190     -0.273    0.102      0.474  0.103   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                     mean     sd 0.025quant 0.5quant 0.975quant    mode
Precision for AMP   1.116  1.331      0.091    0.715      4.602   0.247
Range for i       254.505 94.412    121.534  237.237    485.753 206.954
Stdev for i         1.318  0.146      1.051    1.310      1.627   1.297
GroupRho for i      0.871  0.041      0.775    0.876      0.935   0.886
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.466 0.270     -8.037   -7.452     -6.977 -7.423   0
year       0.806 0.233      0.367    0.799      1.284  0.785   0
depth      0.060 0.242     -0.427    0.064      0.522  0.073   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                            mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18610.176 18356.073   1263.693 13192.553  67164.094 345
3.407
Range for i           28.467    19.188      5.168    24.126     78.598    1
4.637
Stdev for i            0.287     0.201      0.045     0.240      0.817
0.134
GroupRho for i         0.848     0.064      0.691     0.859      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.690 0.190     -7.078   -6.684     -6.331 -6.674   0
year      -0.487 0.134     -0.752   -0.486     -0.226 -0.484   0
depth     -1.249 0.196     -1.648   -1.244     -0.878 -1.234   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                           mean        sd 0.025quant  0.5quant 0.975quant
mode
Precision for site 21052.21 21260.651   1452.914 14749.359  77409.770 396
9.717
Range for i           20.43     7.161      9.945    19.244     37.727   1
7.103
Stdev for i            1.30     0.163      1.001     1.287      1.643
1.271
GroupRho for i         0.86     0.056      0.727     0.869      0.942
0.886
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.922 0.126     -6.173   -5.921     -5.676 -5.919   0
year      -0.313 0.094     -0.500   -0.313     -0.131 -0.312   0
depth      0.370 0.129      0.117    0.371      0.622  0.372   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                            mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 19742.369 19522.072   1370.201 13988.08  71640.791 376
6.708
Range for i           53.099    21.474     21.983    49.59    104.690   4
2.895
Stdev for i            1.009     0.121      0.788     1.00      1.263
0.995
GroupRho for i         0.809     0.075      0.630     0.82      0.922
0.843
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.566 0.836    -10.436   -8.477     -7.168 -8.280   0
year      -0.982 0.739     -2.593   -0.922      0.304 -0.796   0
depth     -0.166 0.683     -1.351   -0.223      1.328 -0.343   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                            mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18627.136 18374.324   1264.137 13203.786  67225.495 345
4.261
Range for i           46.432    62.888      5.375    27.764    202.251   1
2.777
Stdev for i            0.250     0.239      0.022     0.181      0.885
0.061
```

```
GroupRho for i          0.848      0.064       0.691      0.860       0.940
0.881
```

No overall linear trend was found for repent yellow sponges. A linear increase was detected for the repent yellow morphospecies in Huon Marine Park equating to a 124% increase in the odds of presence each year. Linear decreases were detected in Freycinet and Flinders Marine Parks, equating to 39% and 27% decreases in the odds of presence per year respectively. No significant effect for depth was detected.

2.4.35 Simple Beige Lumpy

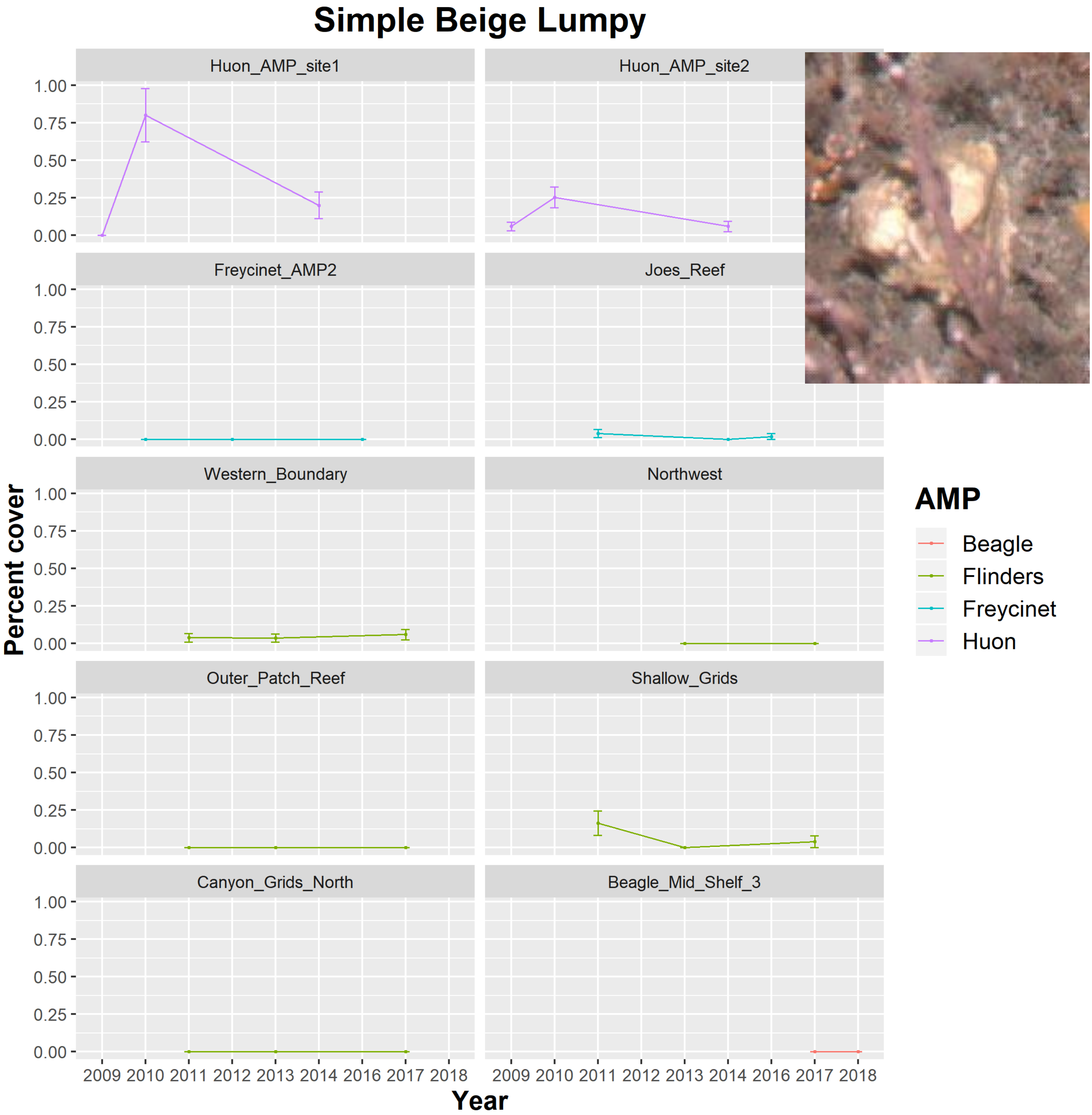


__Figure 2.4.35__ Site level trends in the raw data for Simple Beige Lumpy sponges.

2.4.35.1 *Model-based estimates of trend*

All Marine Parks

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.573 0.523    -10.637   -9.559     -8.582 -9.533   0
year      -0.495 0.349     -1.199   -0.489      0.173 -0.476   0
depth     -1.885 0.657     -3.187   -1.881     -0.607 -1.873   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 19567.356 18651.103   1698.271 14219.730  69276.617 4818.588
Range for i        1245.293   632.482    436.918  1108.648   2849.391  882.156
Stdev for i           1.488     0.327      0.940     1.457      2.221    1.398
GroupRho for i        0.843     0.062      0.692     0.853      0.933    0.872
```

Huon Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -5.025 1.730     -8.422   -5.025     -1.632 -5.024   0
year      -0.297 0.668     -1.611   -0.296      1.012 -0.295   0
depth     -0.596 0.323     -1.230   -0.596      0.039 -0.597   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18854.678 18539.395   1269.936 13385.839  67716.695 347
5.083
Range for i         2578.155  1894.509    695.645  2045.827   7578.438 139
6.266
Stdev for i            1.499     0.467      0.775     1.435      2.594
1.315
GroupRho for i         0.829     0.068      0.664     0.841      0.928
0.863
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.726 0.787    -11.472   -9.647     -8.394 -9.478   0
year      -0.427 0.561     -1.576   -0.411      0.628 -0.378   0
depth     -1.215 0.685     -2.706   -1.160     -0.020 -1.046   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18606.012 18359.614   1262.339 13186.293  67161.405 344
8.976
Range for i           49.379    68.632      5.644    29.080    217.968   1
3.308
Stdev for i            0.271     0.270      0.021     0.192      0.984
0.057
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.469 0.367     -9.267    -8.44     -7.830 -8.379   0
year      -0.230 0.294     -0.833    -0.22      0.321 -0.201   0
depth     -0.806 0.502     -1.911    -0.76      0.056 -0.663   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18653.879 18379.276   1258.824 13229.061  67274.472 343
3.760
Range for i           54.842    84.464      6.128    30.429    253.119   1
3.723
Stdev for i            0.207     0.182      0.018     0.157      0.683
0.051
GroupRho for i         0.848     0.064      0.691     0.860      0.940
0.882
```

No overall or marine park level trends were detected for simple beige lumpy sponges. A significant negative depth association was found indicating this morphospecies tends to be found in shallower depths across those which were surveyed.

2.4.36 Simple Beige Lumpy Shapeless

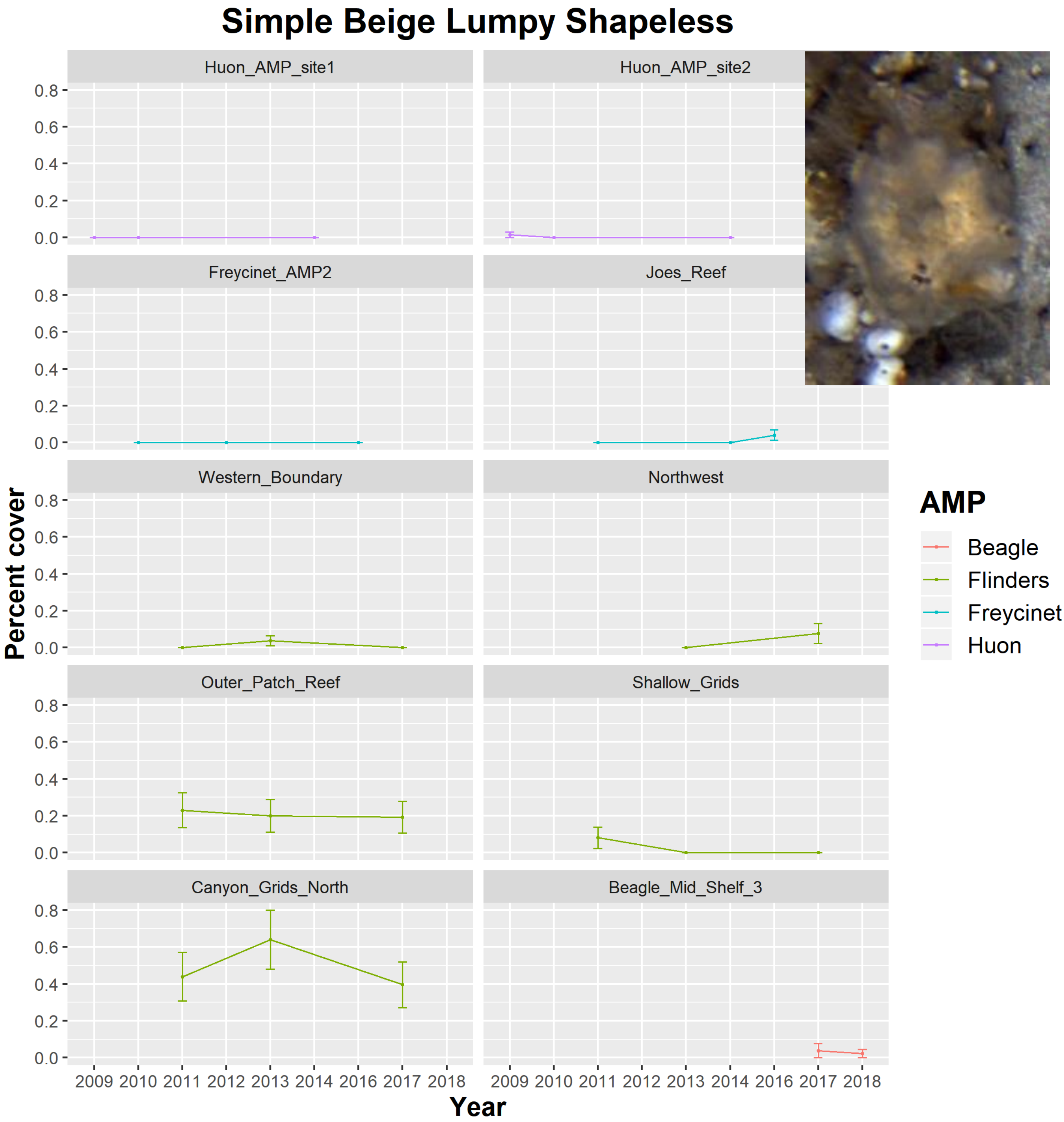


Figure 2.4.36 *Site level trends in the raw data for Simple Beige Lumpy Shapeless sponges.*

2.4.36.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -9.232 0.575    -10.380   -9.225     -8.122 -9.212   0
year       0.033 0.187     -0.336    0.034      0.398  0.035   0
depth      0.764 0.146      0.479    0.763      1.054  0.762   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                     mean      sd 0.025quant 0.5quant 0.975quant   mode
Precision for AMP   1.264   1.004      0.203    1.001      3.911  0.549
Range for i       150.029 126.211     21.499  115.893    483.191 59.215
Stdev for i         0.879   0.221      0.502    0.862      1.360  0.831
GroupRho for i      0.833   0.080      0.636    0.848      0.943  0.878
```

Huon Marine Park

```
Fixed effects:
              mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.187 0.809    -11.990  -10.102     -8.828 -9.918   0
year       -0.400 0.868     -2.336   -0.309      1.058 -0.111   0
depth      -0.279 0.723     -1.863   -0.218      0.972 -0.088   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                          mean        sd 0.025quant 0.5quant 0.975quant
mode
Precision for site 18679.481 18437.909   1272.749 13237.89  67398.340 348
0.909
Range for i           42.255    53.882      4.981    26.16    178.536   1
2.089
Stdev for i            0.263     0.255      0.025     0.19      0.942
0.069
GroupRho for i         0.848     0.064      0.691     0.86      0.940
0.881
```

Freycinet Marine Park

```
Fixed effects:
              mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.112 0.912    -12.148  -10.015     -8.585 -9.802   0
year        0.968 0.831     -0.455    0.890      2.801  0.726   0
depth      -0.638 0.650     -2.037   -0.593      0.516 -0.500   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18896.612 18606.643   1323.258 13420.365  67946.466 362
8.438
Range for i           51.992    77.075      5.930    29.493    237.488   1
3.425
Stdev for i            0.227     0.211      0.019     0.167      0.786
0.054
GroupRho for i         0.848     0.064      0.692     0.860      0.940
0.881
```

Flinders Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.467 0.202     -7.883   -7.460     -7.090 -7.446   0
year      -0.046 0.145     -0.334   -0.044      0.234 -0.042   0
depth      0.950 0.134      0.691    0.949      1.217  0.946   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 20635.236 20004.252   1787.336 14855.722  73974.206 504
7.307
Range for i           79.579   136.621      9.381    41.487    384.530   1
8.907
Stdev for i            0.795     0.238      0.387     0.780      1.305
0.745
GroupRho for i         0.835     0.072      0.657     0.848      0.936
0.873
```

Beagle Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.183 0.632     -9.570   -8.128     -7.093 -8.011   0
year      -0.323 0.634     -1.556   -0.327      0.931 -0.335   0
depth     -0.385 0.570     -1.424   -0.414      0.815 -0.473   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18647.378 18382.204   1263.123 13222.251   67262.84 345
0.205
Range for i           41.916    54.684      4.694    25.606     179.93   1
1.528
Stdev for i            0.311     0.327      0.030     0.214       1.18
0.083
```

```
GroupRho for i          0.848     0.064      0.692     0.860       0.94
0.881
```

No overall or marine park level trends were detected for simple beige lumpy shapeless sponges. A significant positive depth association was found indicating this morphospecies tends to be found in shallower depths across those which were surveyed.

2.4.37 Unstalked Crinoids

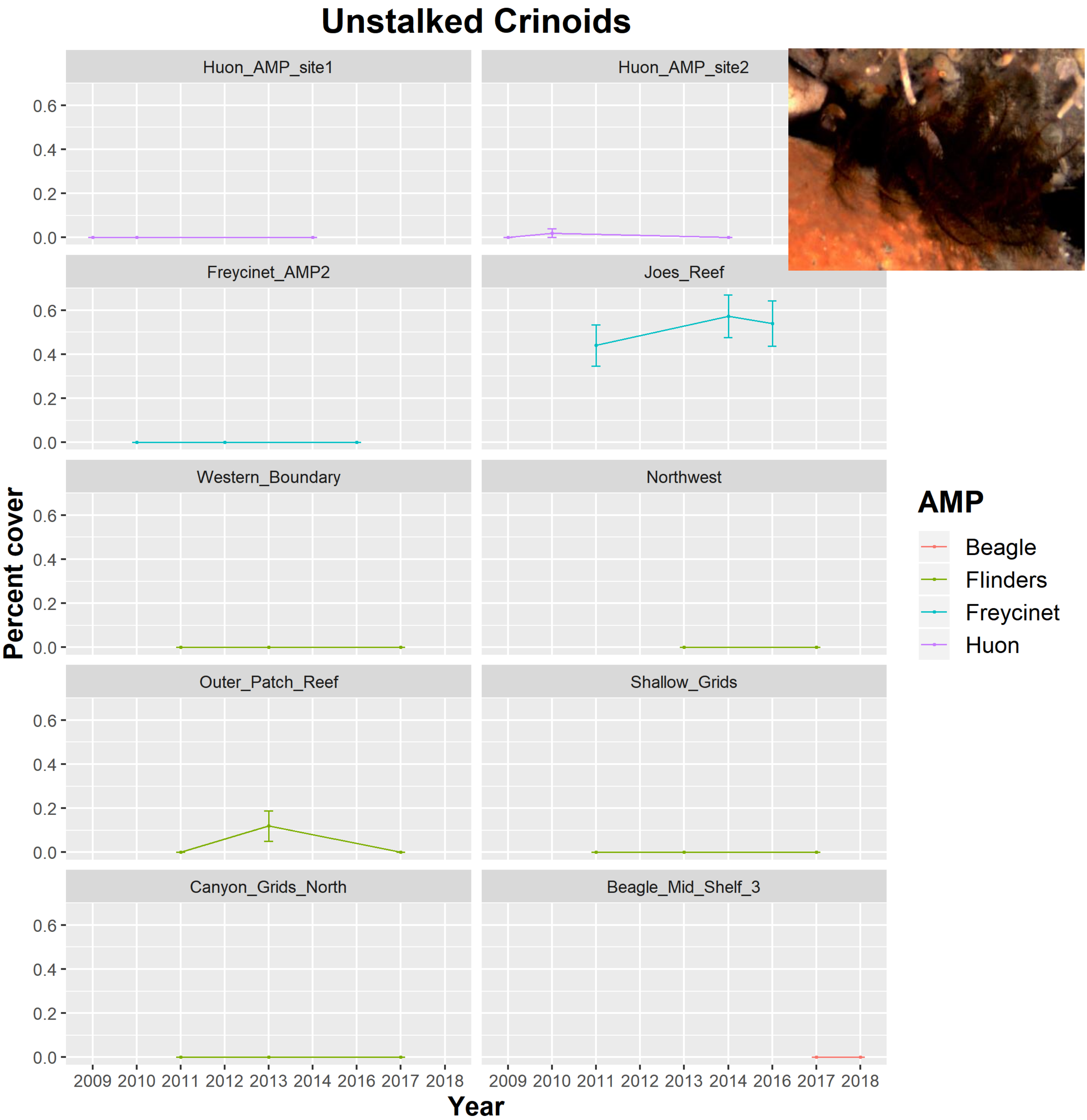


Figure 2.4.37 Site level trends in the raw data for Unstalked Crinoids.

2.4.37.1 Model-based estimates of trend

All Marine Parks

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -12.025 0.633    -13.336  -12.001    -10.851 -11.952   0
year       -0.343 0.444     -1.241   -0.334      0.505  -0.316   0
depth      -0.528 0.740     -2.078   -0.494      0.831  -0.426   0

Random effects:
  Name    Model
    AMP IID model
   i SPDE2 model

Model hyperparameters:
                       mean        sd 0.025quant  0.5quant 0.975quant     mode
Precision for AMP 20446.799 20359.183   1589.985 14477.387  74269.842 4414.778
Range for i         310.425   113.884    148.139   290.231    589.320  254.537
Stdev for i           2.606     0.435      1.856     2.570      3.563    2.499
GroupRho for i        0.889     0.037      0.801     0.894      0.944    0.905
```

Huon Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -10.042 0.761    -11.725   -9.969     -8.746 -9.813   0
year        0.064 0.748     -1.563    0.123      1.367  0.248   0
depth       0.288 0.634     -0.998    0.303      1.490  0.333   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18639.749 18372.545   1263.048 13217.778   67238.34 345
0.299
Range for i           46.008    63.135      5.177    27.293     201.00   1
2.355
Stdev for i            0.306     0.318      0.029     0.213       1.15
0.082
GroupRho for i         0.848     0.064      0.692     0.860       0.94
0.881
```

Freycinet Marine Park

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -8.049 0.351     -8.789   -8.031     -7.409 -7.995   0
year       0.115 0.182     -0.241    0.114      0.475  0.113   0
depth     -1.999 0.331     -2.691   -1.984     -1.389 -1.955   0

Random effects:
  Name    Model
```

```
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 18824.939 18406.598    1289.78 13412.414  67523.836 353
4.957
Range for i           21.081     6.510      11.15    20.134     36.487   1
8.374
Stdev for i            1.458     0.235       1.04     1.442      1.966
1.413
GroupRho for i         0.842     0.064       0.69     0.853      0.935
0.873
```

Flinders Marine Park

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant    mode kld
intercept -10.747 0.584    -12.009  -10.705     -9.717 -10.617   0
year       -0.236 0.580     -1.468   -0.202      0.812  -0.134   0
depth       0.140 0.573     -1.106    0.185      1.142   0.279   0

Random effects:
  Name    Model
    site IID model
   i SPDE2 model

Model hyperparameters:
                        mean        sd 0.025quant  0.5quant 0.975quant
 mode
Precision for site 19001.910 18930.174   1308.513 13405.243  69420.697 358
8.637
Range for i           59.696    37.888     18.588    49.654    159.451   3
6.161
Stdev for i            1.229     0.475      0.446     1.191      2.252
1.061
GroupRho for i         0.845     0.066      0.683     0.856      0.938
0.878
```

No overall or marine park level trends were detected for unstalked crinoids. Also, no significant depth association was found.

2.5 Summary of significant linear trends for dominant morphospecies

Table 2.5.1 *Summary of significant linear trends found for the dominant 37 morphospecies modelled. Green shading indicates a significant positive linear trend, red a significant negative linear trend. Unshaded cells indicate no linear trend was detected. Percentages in shaded cells are the magnitude of the linear change expressed as the change in odds of presence per year. Shading in depth cell indicates whether significant association with depth were detected i.e. red = negative, associated with shallower depths, green = positive associated with deeper depths.*

Morphospecies	**All AMPs**	**Huon**	**Freycinet**	**Flinders**	**Beagle**	**Depth**
Arborescent Grey		42%				
Arborescent Orange		104%				
Arborescent Orange Thin	42%			50%		
Ascidian Colonial Purple						
Bramble Coral				37%		
Branching Gray Fine Repent Like		91%	52%			
Bryozoa Soft (merged)	54%	78%	87%			
Bryozoa Stumpy Hard						
Calcareous Encrusting Red Algae		15%				
Coral Orange Solitary (Caryophyllia like)						
Cup Red Smooth						
Cup Yellow						
Encrusting Beige Oscula		54%				
Encrusting Beige Smooth			88%			
Encrusting Black	4%	128%	109%			
Encrusting Blue			577%			
Encrusting Light Orange						
Encrusting Orange				56%		
Encrusting Purple Lumpy						
Encrusting White			121%			
Encrusting White Lumpy			180%			
Encrusting Yellow Smooth			70%			
Epizoanthus sp		132%	72%			
Fan Pink	29%					
Gorgonian Red	78%		63%	76%		
Hydroid White	95%			38%		
Lumpy White	34%	31%				
Massive Blue Shapeless						
Massive Purple	27%					
Non-Calcareous Encrusting Red Algae						
Palmate Grey						
Purple Massive		91%				

Repent Orange						
Repent Yellow		124%	39%	27%		
Simple Beige Lumpy						
Simple Beige Lumpy Shapeless						
Unstalked Crinoids						

For all marine parks significant linear decreases were observed for arborescent orange thin sponges, gorgonian red fans, and lumpy white and purple massive sponge morphospecies. Significant linear increases were observed for soft bryozoans, hydroid white, encrusting black sponges and fan pink sponges.

For Huon Marine Park increases were found over the survey period for erect structure forming species such as arborescent grey and orange sponges and soft bryozoa, as well as encrusting species such as encrusting beige oscula and encrusting black sponges and repent yellow, repent grey fine branching and Epizoanthus species. A small but significant increase in the cover of encrusting calcareous algae was also observed.

For Freycinet Marine Park linear increases in a number of encrusting sponge morphospecies were observed including beige smooth, black, blue (particularly at site 2), white, white lumpy and yellow smooth. Soft bryozoans were also noted to have increased in cover over the survey period. Decreases were observed in two repent sponges (yellow and branching grey fine) as well as Epizoanthus sp. Also, a strong decline in the cover of gorgonian red fans was observed.

For Flinders Marine Park linear increases were detected for encrusting orange sponges and the hydroid white morphospecies. Linear declines were observed for arborescent orange thin sponges, repent yellow sponges and two octocoral species: gorgonian red fans and bramble corals.

No evidence for significant linear trends were observed for Beagle Marine Park, although only two time points were available for a single site within this park.

Many morphospecies were associated with shallower depths (significant negative association with depth), with only stumpy bryozoa hard, lumpy white sponges and simple beige lumpy shapeless sponges being positively associated with depth.

2.6 Power analysis

2.6.1 Power to detect a 50% decline in cover

For the simulation-based power analysis for a 50% decline in the cover of the Arborescent Grey sponge morphospecies it was found that high power could be achieved with both 100 and 200 images for both Flinders and Huon Marine Parks when all sites within the marine park were used as part of the analysis, but not for Freycinet Marine Park (Figure 3.6.1). When considering individual sites, high power could only be achieved at the Western Boundary site within Flinders Marine Park (both with 100 and 200 images), and only with 200 images at the Huon Marine Park site 1.

For the Arborescent Orange sponge morphospecies high power to detect the 50% decline could only be achieved at Freycinet Marine Park and Flinders Marine Park. 200 images were required at Freycinet with all sites combined or for the Joe's Reef site alone (Figure 3.6.2). At Flinders Marine Park high power could not be achieved at any individual site but could be achieved by combining the data from all sites with either 100 or 200 images.

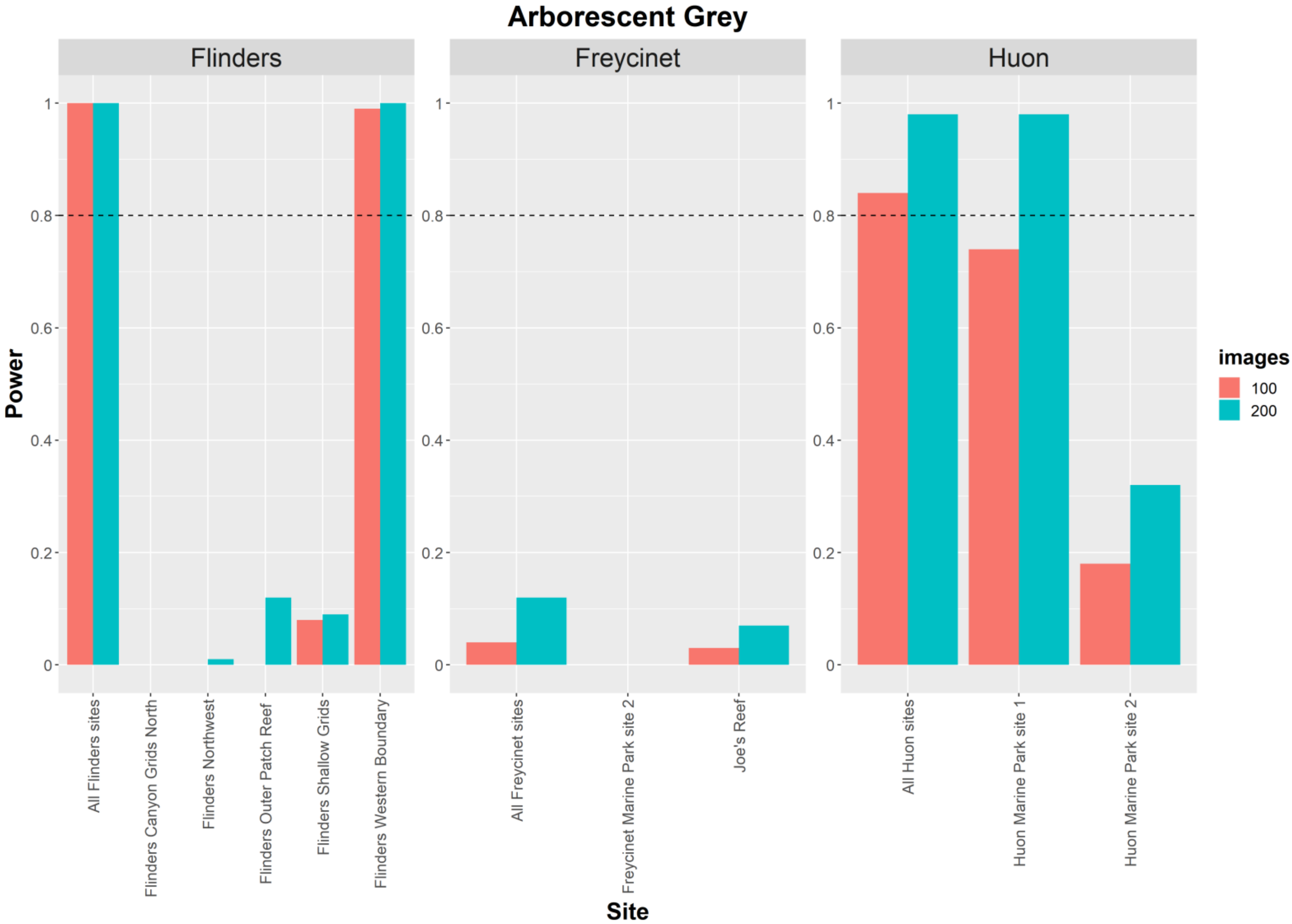


***Figure 2.6.1** Power to detect a simulated 50% decline in the Arborescent Grey sponge morphospecies. The dashed line is at 80% power.*

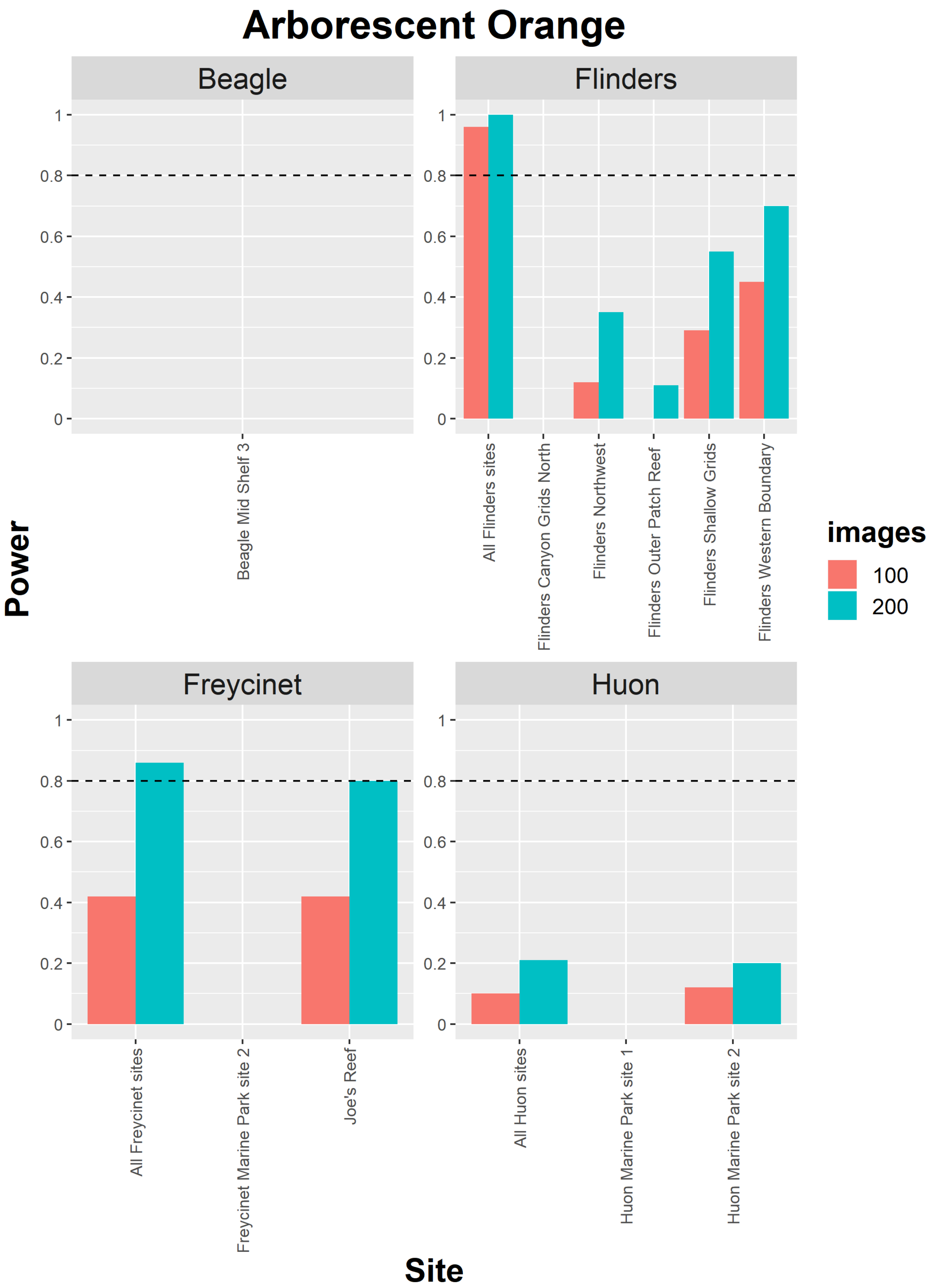


Figure 2.6.2 *Power to detect a simulated 50% decline in the Arborescent Orange sponge morphospecies. The dashed line is at 80% power.*

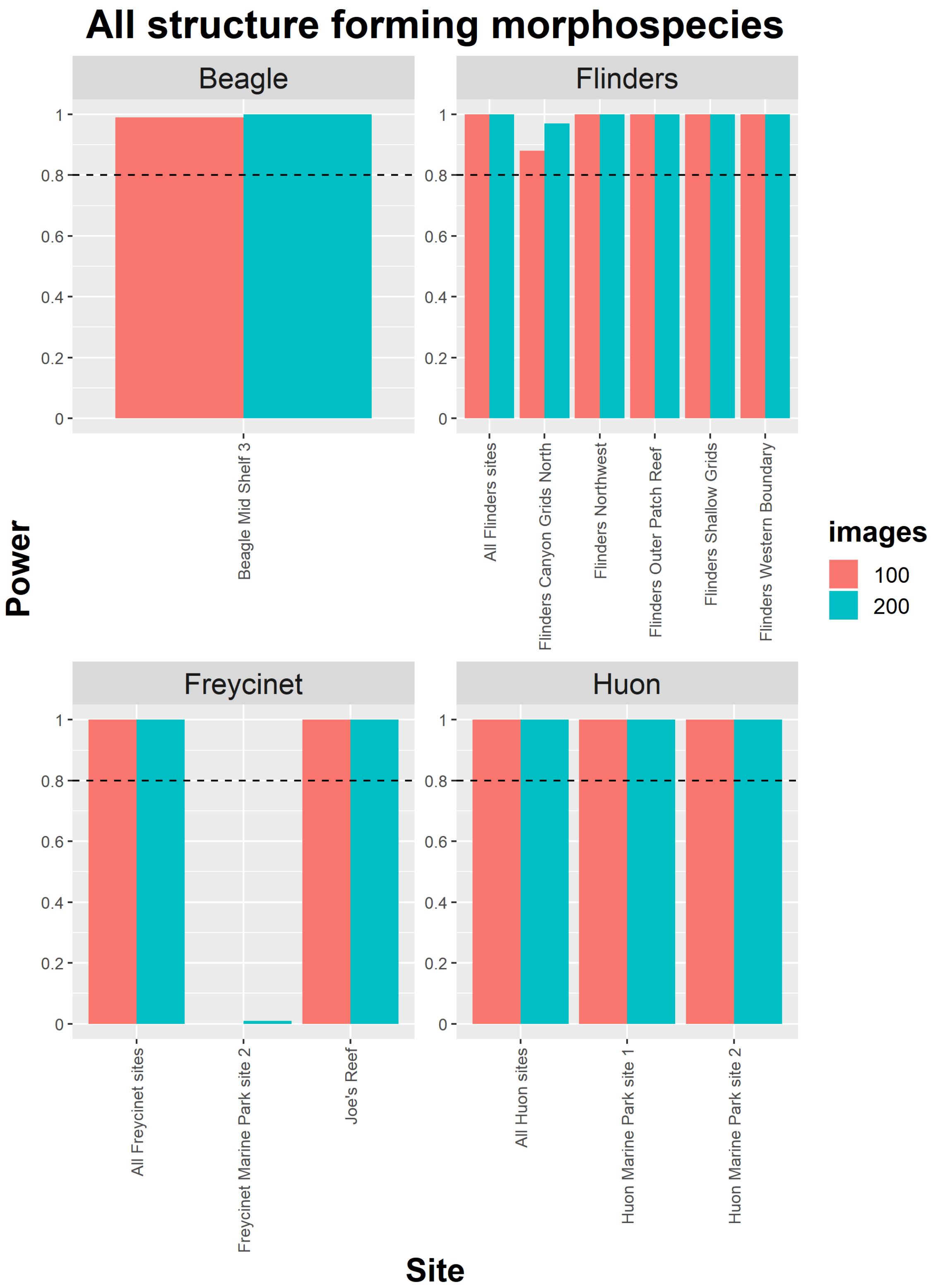


Figure 2.6.3 *Power to detect a simulated 50% decline in all structure forming morphospecies. The dashed line is at 80% power.*

High power could be achieved to detect a 50% decline in the cover of all structure forming species within all marine parks and at all sites regardless of whether 100 or 200 images were used (Figure 3.6.3).

2.6.2 Power to detect change over a longer time frame

2.6.2.1 Flinders: a 75% decline in Red Cup Smooth over 30 years

The linear-mixed-model estimate for temporal variance of the Red Cup Smooth morphospecies from the empirical data at Flinders Marine Park was 0, indicating high temporal stability. Detecting a 75% decline in the cover of the Red Cup Smooth morphospecies in Flinders Marine Park was achievable within the 30 year time frame when considering all sites, and also at the Western Boundary site and Northwest site (Figure 3.6.4). High power could not be achieved at the other sites. The highest power was always achieved when data from all sites was combined and was achievable in a shorter amount of time with annual revisits (8 years). Detecting the change with either 3 or 5 year revisits took 12 and 14 years respectively when using all the sites. Detecting the change at the Western Boundary site took between 10 (annual revisits) and 17 years (5 year revisit schedule). For the Northwest site achieving high power took between 15 years (annual revisits) and 22 years (5 year revisit schedule).

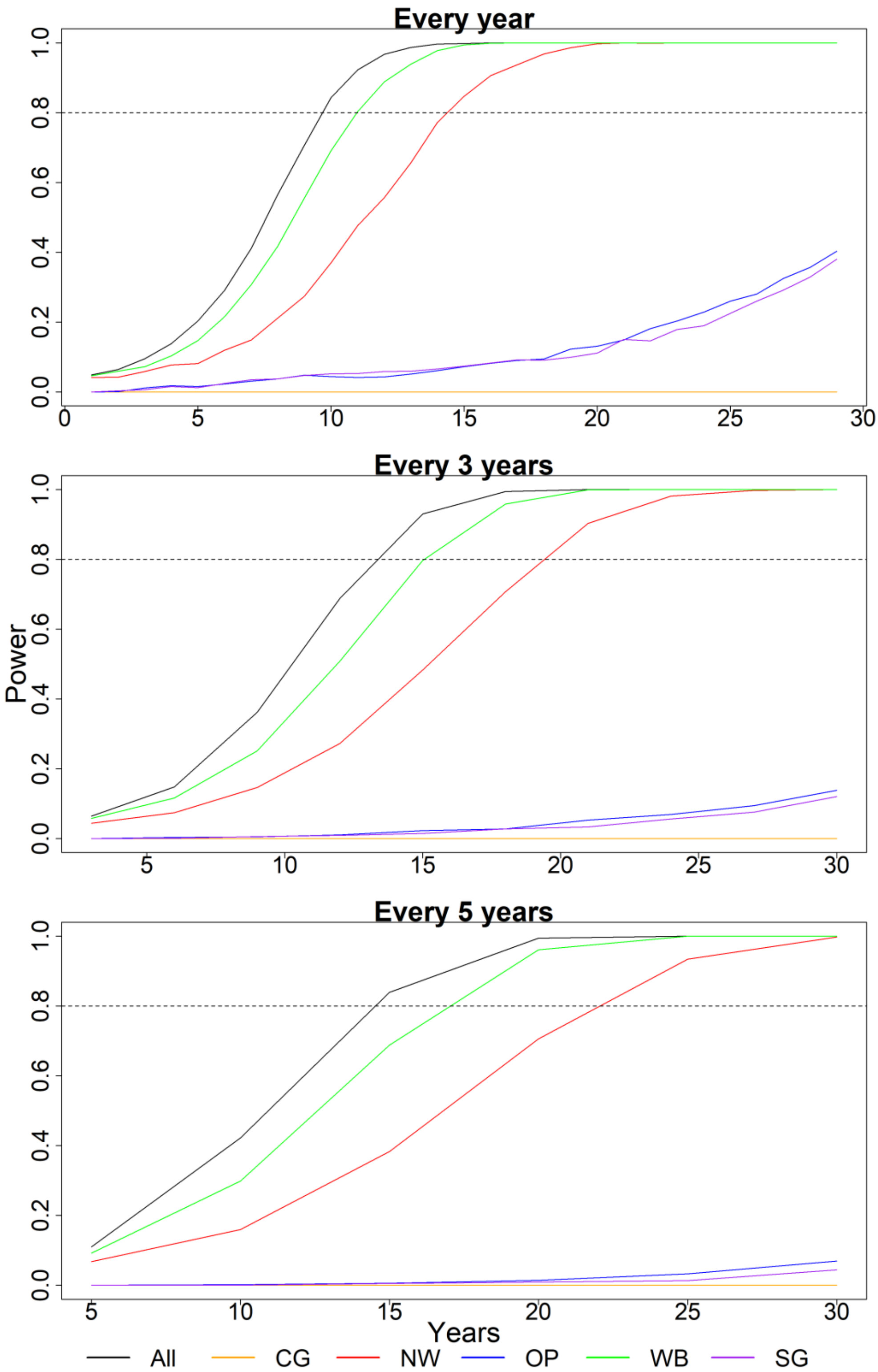


Figure 2.6.4 *Power to detect a simulated 75% decline over 30 years in the Red Cup Smooth morphospecies in Flinders Marine Park. The dashed line is at 80% power. CG = Canyon Grids North, NW = Northwest, OP = Outer Patch Reef, WB = Western Boundary, SG = Shallow Grids.*

2.6.2.2 Flinders: a 75% decline in Bramble Coral over 30 years

For Bramble Coral, the linear-mixed-model estimate for temporal variance in the empirical data was 0.37. High power could be achieved using all sites and all revisit schedules, but took much longer: 19 years, 26 years and 28 years for annual, 3 year and 5 year revisit schedules respectively (Figure 3.6.5). High power could also be achieved for the Outer Patch Reef and Western Boundary sites with annual revisits (approximately 22 years) and only for the Outer Patch Reef with revisits every 3 years at the 30 year mark. Results show that within a relatively high proportion (up to 60%) significant linear trends were often detected in the first 10 years of monitoring. These are likely to be "false positives" that are due to large fluctuations in cover that are the result of the high baseline variability that was incorporated.

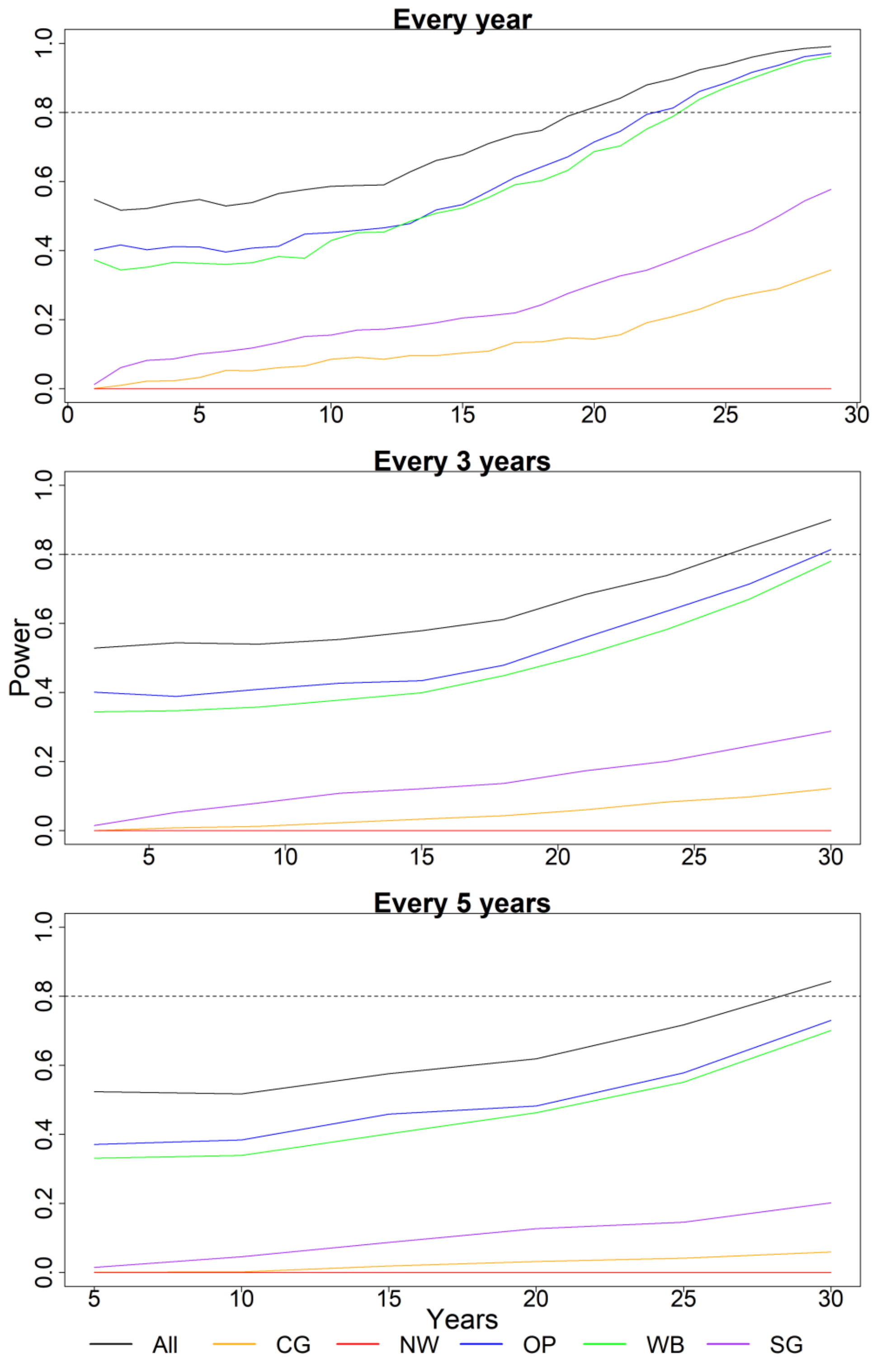


Figure 2.6.5 *Power to detect a simulated 75% decline over 30 years in the Bramble Coral morphospecies in Flinders Marine Park. The dashed line is at 80% power. CG = Canyon Grids North, NW = Northwest, OP = Outer Patch Reef, WB = Western Boundary, SG = Shallow Grids.*

2.6.3 Power to detect different levels of change

Power to detect differing levels of change in all structure forming morphospecies within Flinders Marine Park using 200 images increased as the level of change increased with distinct differences in the level of change detectable between the different sites (Figure 3.6.6). The smallest level of change (15%) was detectable with high power when including all sites. For individual sites, levels of change detectable ranged between 20% (Flinders Western Boundary site) to 45% (Flinders Canyon Grids site). Lower levels of change were generally detectable in sites with higher cover of structure forming species in the last survey year: Flinders Western Boundary 11.5% cover, Flinders Northwest 5.6% cover, Flinders Outer Patch Reef 3.5% cover, Flinders Canyon Grids North 3.3% cover, Flinders Shallow Grids 2.0% cover. The exception to this pattern was the Flinders Canyon Grids North site, where structure forming species were more patchily distributed as they were generally associated with hard substrate on canyon wall features.

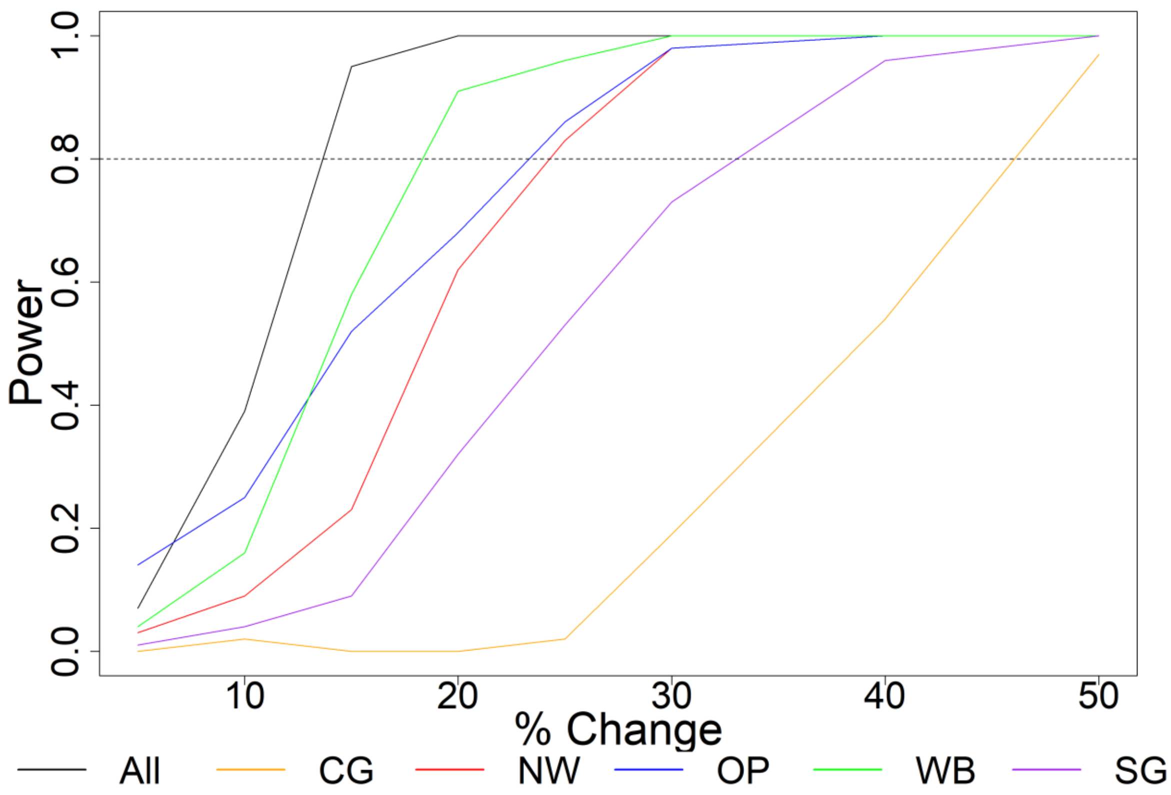


Figure 2.6.6 *Power to detect simulated declines between 5% and 50% for all structure forming morphospecies in Flinders Marine Park using 200 images. The dashed line is at 80% power. CG = Canyon Grids North, NW = Northwest, OP = Outer Patch Reef, WB = Western Boundary, SG = Shallow Grids.*

2.7 Targeted scoring

2.7.1 Flinders Western Boundary

Subsetting to every fifth image at the Flinders Western Boundary site to create a set of non-overlapping images along the entire length of the transect resulted in over 1500 images to score in each year (Table 3.7.1). Density of Cup Red Smooth sponges was found to be high and relatively stable, with on average greater than one sponge in each image in each year, and total counts in excess of 2000 when considering both unbleached and bleached sponges. Bleached sponges showed a large increase in mean numbers per image in 2017 compared to the two previous years.

Targeted scoring for the two selected morphospecies at Flinders Western Boundary took approximately 15-17 hours per year of imagery. As bramble coral colonies were often small, targeted scoring took considerably longer than scoring the Cup Red Smooth morphospecies. Scoring was done first for the bleached and unbleached cup sponges (approximately 5 hours per year) and then for the bramble corals (approximately 11 hours per year). On average, this equates to approximately 10 seconds per image for Cup Red Smooth and 23 seconds per image for Bramble Coral.

Table 2.7.1 *Summary of targeted scoring at Flinders Western Boundary.*

Year	Total images scored	Cup Red Smooth		Cup Red Smooth Bleached		Bramble Coral	
		Count	**Mean (± SD) per image**	**Count**	**Mean (± SD) per image**	**Count**	**Mean (± SD) per image**
2011	1588	1840	1.16 ± 1.79	298	0.19 ± 0.56	1620	1.03 ± 2.19
2013	1507	1955	1.29 ± 2.06	244	0.16 ± 0.59	185	0.12 ± 0.91
2017	2233	2917	1.31 ± 1.97	774	0.34 ± 0.79	1904	0.85 ± 2.11

2.7.1.1 Bramble Coral

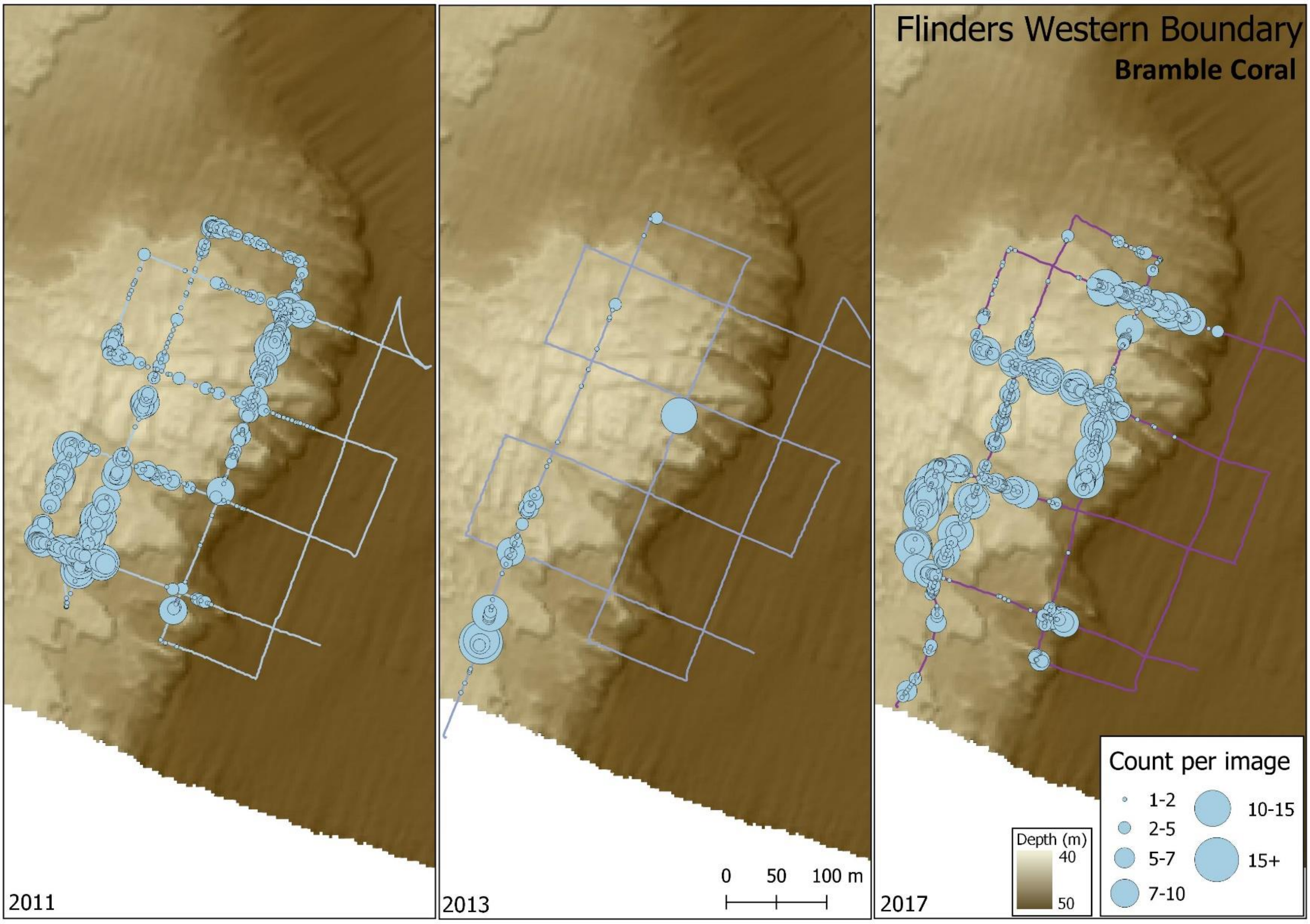


***Figure 2.7.1** Map showing changes in count of Bramble Coral at Flinders Western Boundary using targeted scoring in each year surveyed.*

Model-based estimates of trend: full data set

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -4.152 0.174     -4.499   -4.150     -3.815 -4.147   0
year      -0.097 0.168     -0.427   -0.096      0.232 -0.096   0
depth     -2.195 0.157     -2.509   -2.194     -1.892 -2.190   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i    22.55 1.946      18.94   22.484     26.568 22.367
Stdev for i     2.45 0.135       2.19    2.443      2.721  2.437
GroupRho for i -0.19 0.127      -0.44   -0.188      0.057 -0.178
```

Model-based estimates of trend: 200 images

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept 28.983 2.288     24.559   28.961     33.534 28.916   0
year      -0.098 0.165     -0.423   -0.098      0.226 -0.097   0
depth     -0.731 0.052     -0.834   -0.730     -0.630 -0.729   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                  mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i     22.414 1.942     18.914   22.298     26.549 22.030
Stdev for i      2.439 0.133      2.191    2.435      2.712  2.425
GroupRho for i -0.181 0.124     -0.411   -0.186      0.074 -0.199
```

No significant linear trend was found when using the targeted scoring data for bramble coral, whether using the full number of targeted images, or a subset of 200 images.

2.7.1.2 Cup Red Smooth

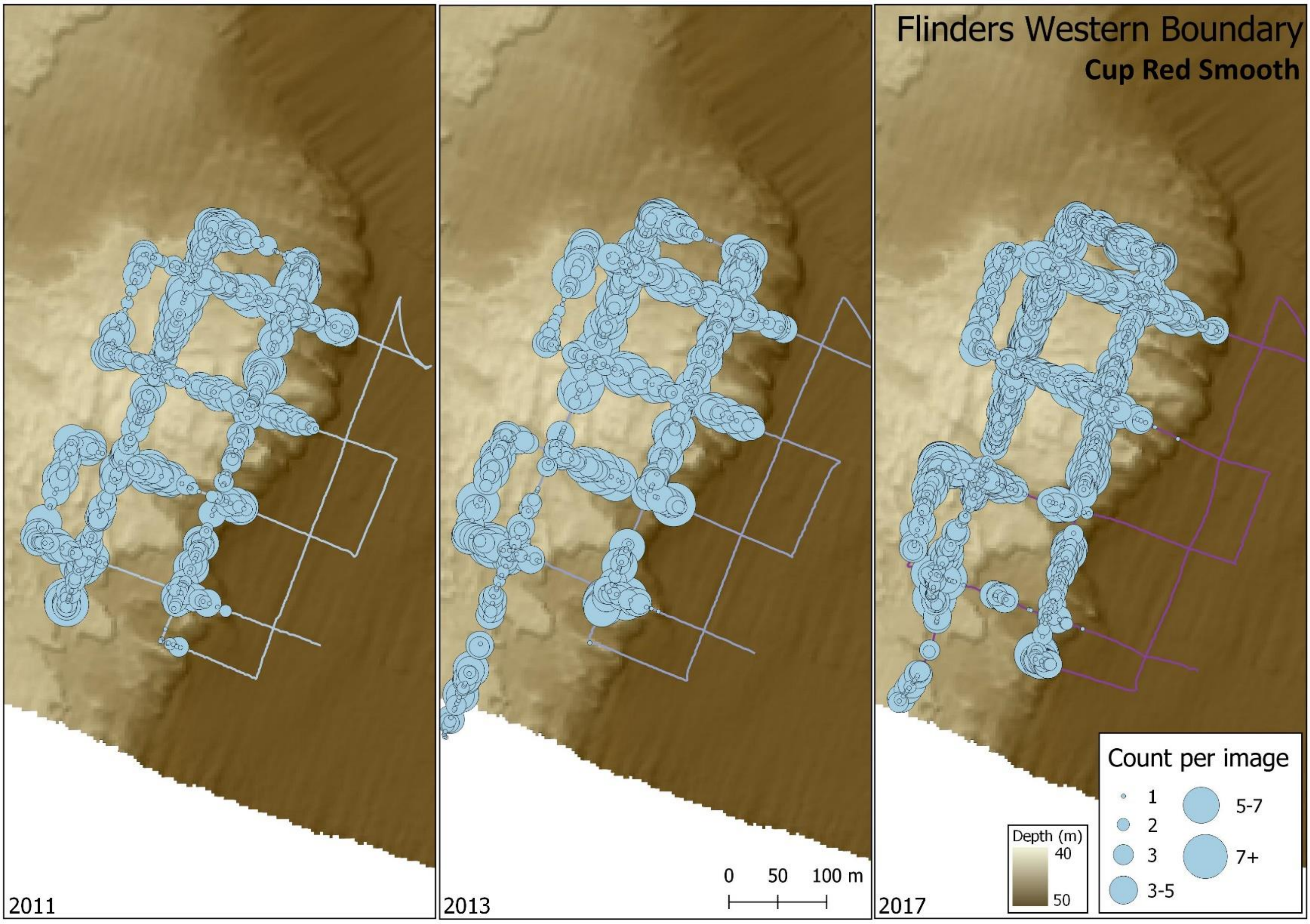


Figure 2.7.2 *Map showing changes in count of Cup Red Smooth at Flinders Western Boundary using targeted scoring in each year surveyed.*

Model-based estimates of trend: full data set

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -1.628 0.137     -1.897   -1.628     -1.361 -1.627   0
year      -0.091 0.055     -0.198   -0.091      0.016 -0.091   0
depth     -2.318 0.109     -2.534   -2.317     -2.104 -2.317   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                  mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i     27.446 2.611     22.754   27.289     33.009 26.944
Stdev for i      1.267 0.068      1.139    1.265      1.406  1.261
GroupRho for i   0.891 0.027      0.828    0.894      0.935  0.901
```

Model-based estimates of trend: 200 images

```
Fixed effects:
             mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept 33.432 1.623     30.258   33.427     36.629 33.418   0
year      -0.091 0.055     -0.199   -0.091      0.017 -0.091   0
depth     -0.773 0.037     -0.845   -0.773     -0.702 -0.773   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                  mean    sd 0.025quant 0.5quant 0.975quant  mode
Range for i     27.407 2.602     22.720   27.259     32.929 26.94
Stdev for i      1.266 0.068      1.138    1.264      1.404  1.26
GroupRho for i  0.891 0.027      0.829    0.894      0.936  0.90
```

No significant linear trend was found when using the targeted scoring data for cup red smooth, whether using the full number of targeted images, or a subset of 200 images.

2.7.1.3 Cup Red Smooth Bleached

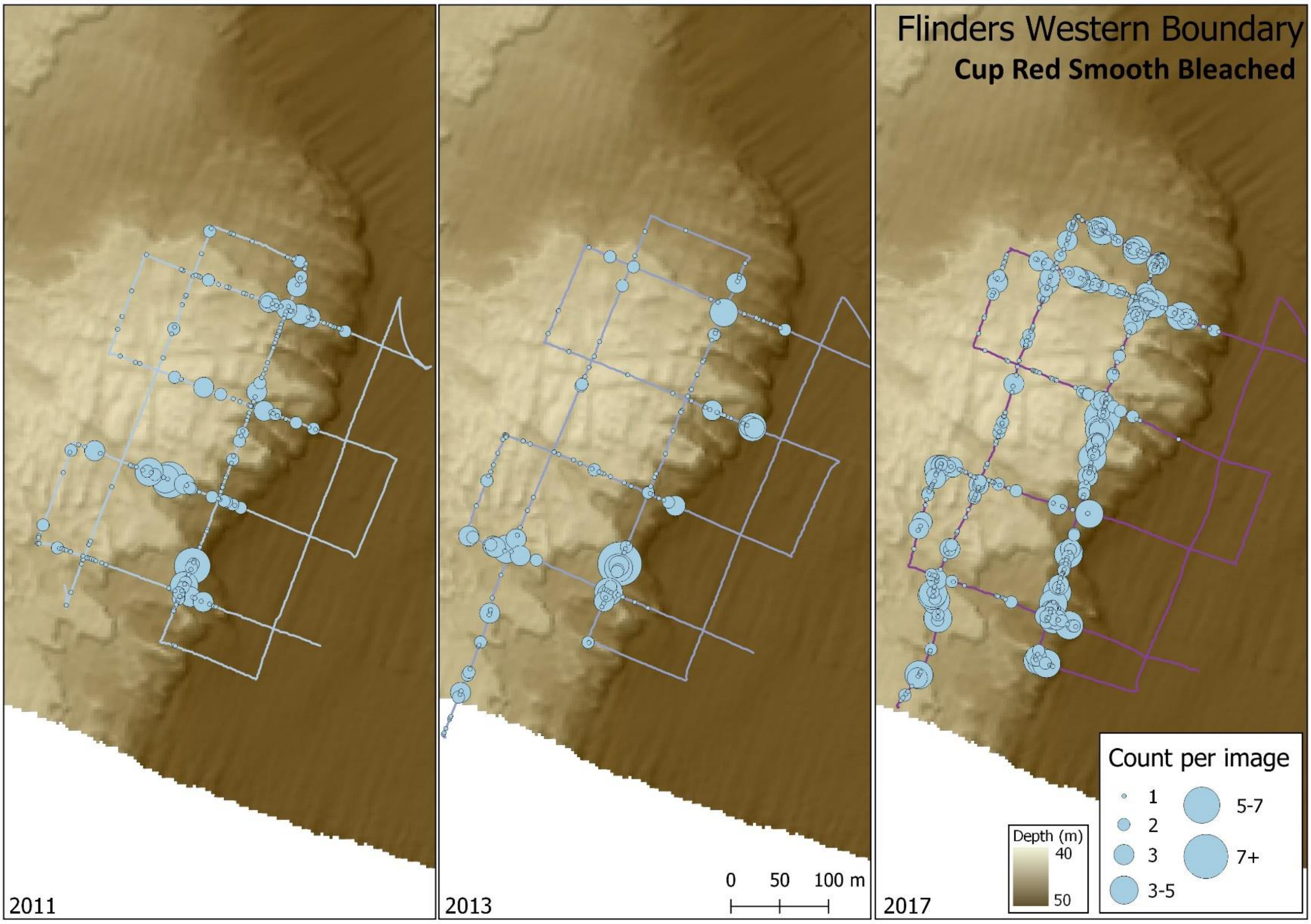


Figure 2.7.3 Map showing changes in count of Cup Red Smooth Bleached at Flinders Western Boundary using targeted scoring in each year surveyed.

Model-based estimates of trend: full data set

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -3.182 0.232     -3.640   -3.181     -2.729 -3.179   0
year       0.285 0.094      0.100    0.285      0.470  0.285   0
depth     -2.011 0.175     -2.356   -2.010     -1.671 -2.009   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                 mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i    46.291 7.884     33.089   45.484     63.967 43.811
Stdev for i     1.519 0.121      1.297    1.513      1.771  1.501
GroupRho for i  0.869 0.036      0.788    0.873      0.927  0.881
```

Model-based estimates of trend: 200 images

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept 27.249 2.614     22.140   27.241     32.397 27.226   0
year       0.286 0.095      0.100    0.286      0.472  0.286   0
depth     -0.671 0.059     -0.787   -0.671     -0.557 -0.671   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i    46.46 7.875     32.837   45.831     63.753 44.620
Stdev for i     1.52 0.123      1.297    1.520      1.781  1.510
GroupRho for i  0.87 0.036      0.785    0.875      0.926  0.884
```

A significant increase in the number of bleached cup red smooth individuals was found when using both the full number of targeted scoring images or a subset of 200 images. The plot (Figure 80) shows that there was a particularly marked increase between 2013 and 2017. The magnitude of change when using either all images or 200 images was similar (a 0.285 increase in log count versus a 0.286 increase), suggesting that 200 images has provided sufficient information.

2.7.2 Joe's Reef

Table 2.7.2 *Summary of targeted scoring at Joe's Reef.*

Year	Total images scored	Massive Purple		Black Coral	
		Count	**Mean (± SD) per image**	**Count**	**Mean (± SD) per image**
2011	1783	311	0.17 ± 0.59	12	0.01 ± 0.11
2014	1488	370	0.25 ± 0.64	28	0.02 ± 0.15
2016	2285	524	0.23 ± 0.61	54	0.02 ± 0.19

Targeted scoring for the two selected morphospecies at Joe's Reef took approximately 10-11 hours per year of imagery. As black coral colonies were quite rare, targeted scoring was relatively quick (approximately half an hour per year) and could be completed alongside scoring the massive purple sponge morphospecies. On average, this equates to approximately 21 seconds per image.

2.7.2.1 Massive Purple

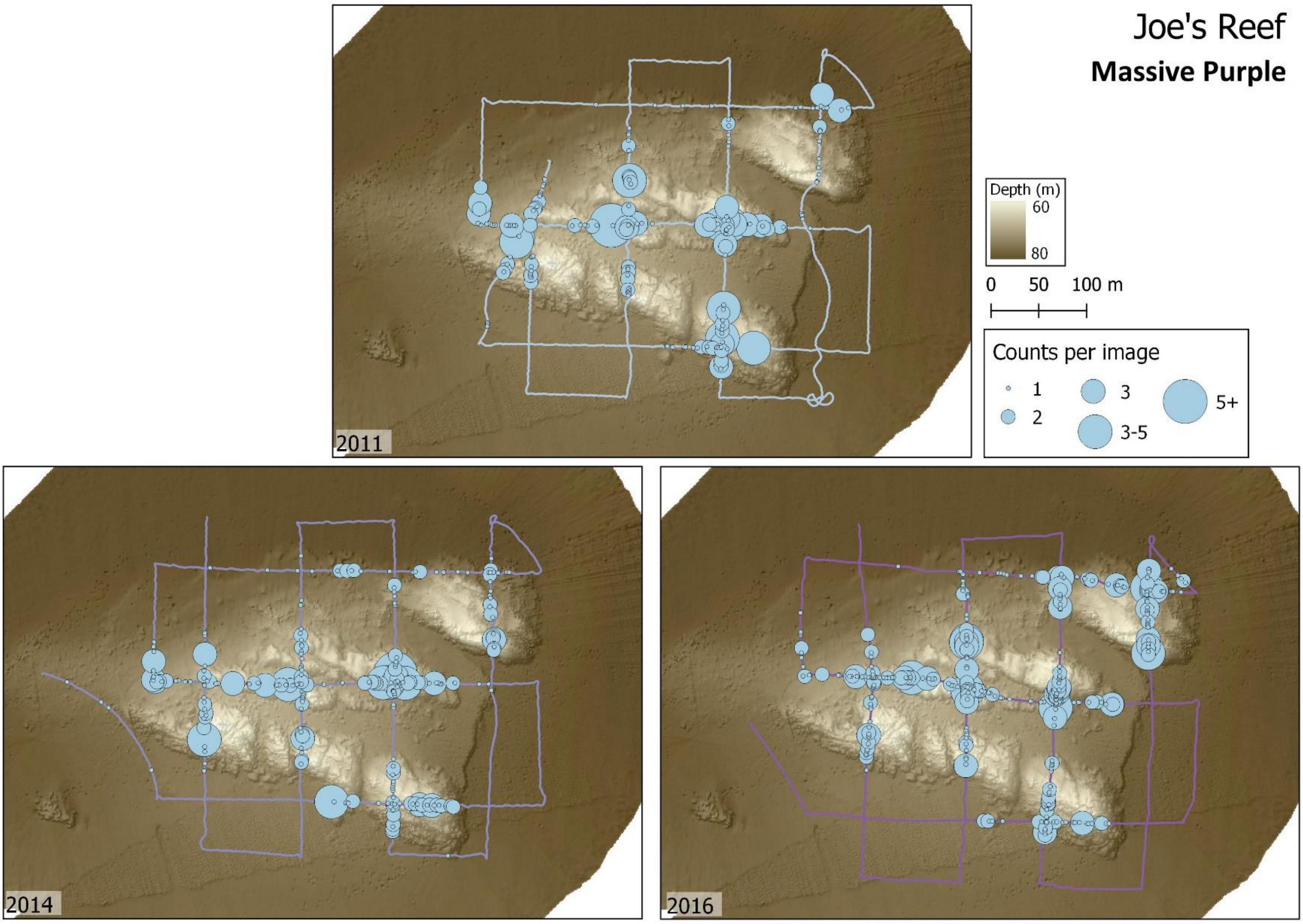


Figure 2.7.4 *Map showing changes in count of Massive Purple sponges at Joe's Reef using targeted scoring in each year surveyed.*

Model-based estimates of trend: full data set

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -3.622 0.245     -4.105   -3.622     -3.143 -3.620   0
year       0.232 0.093      0.050    0.232      0.416  0.232   0
depth     -1.492 0.129     -1.746   -1.491     -1.239 -1.491   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                 mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i    51.942 9.281     36.337   51.032     72.716 49.205
Stdev for i     1.532 0.145      1.267    1.525      1.837  1.510
GroupRho for i  0.899 0.030      0.827    0.904      0.946  0.912
```

Model-based estimates of trend: 200 images

```
Fixed effects:
            mean     sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -0.357 29.528    -58.340   -0.354     57.556 -0.345   0
year       0.005  0.015     -0.024    0.005      0.034  0.005   0
depth     -0.154  0.018     -0.190   -0.154     -0.119 -0.154   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                 mean    sd 0.025quant 0.5quant 0.975quant   mode
Range for i    26.092 0.878     24.673   26.061     27.574 24.848
Stdev for i     0.648 0.113      0.445    0.643      0.886  0.637
GroupRho for i  0.840 0.066      0.681    0.851      0.935  0.872
```

A positive linear trend was found when analysing all targeted scoring images for massive purple sponges at Joe’s Reef equating to an increase in the log count of 0.232 per year. However, analysis of the reduced data set of 200 images found no significant increase through time.

2.7.2.2 Black Coral

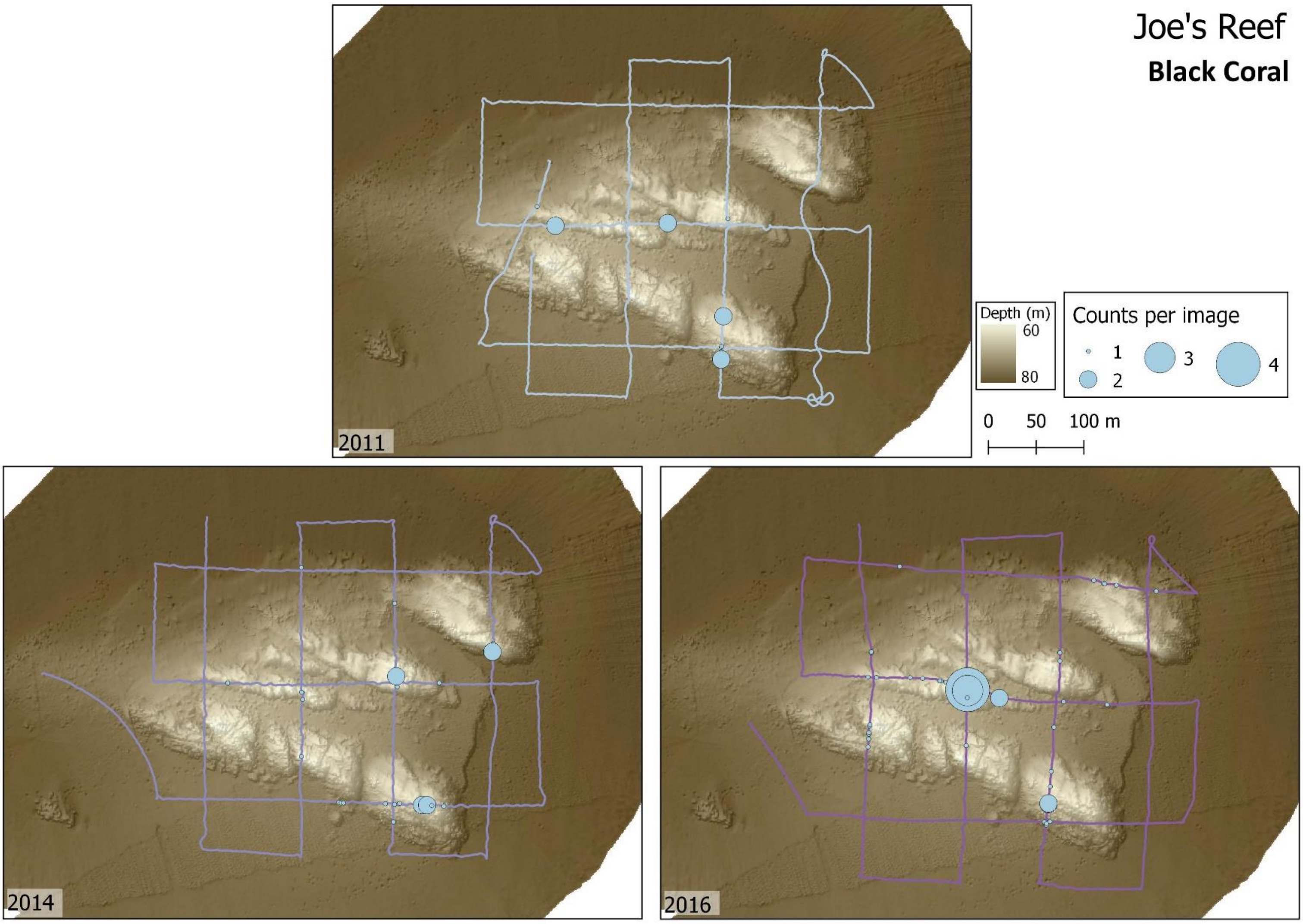


Figure 2.7.5 *Map showing changes in count of Black Coral at Joe's Reef using targeted scoring in each year surveyed.*

Model-based estimates of trend: full data set

```
Fixed effects:
            mean    sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -6.772 0.258     -7.307   -6.761     -6.295 -6.741   0
year       0.607 0.162      0.297    0.604      0.935  0.598   0
depth     -1.544 0.173     -1.896   -1.539     -1.216 -1.531   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                mean    sd 0.025quant 0.5quant 0.975quant  mode
Range for i    7.782 2.139      4.476    7.478     12.815 6.905
Stdev for i    1.723 0.225      1.320    1.710      2.201 1.687
GroupRho for i 0.847 0.062      0.696    0.857      0.937 0.877
```

Model-based estimates of trend: 200 images

```
Fixed effects:
            mean     sd 0.025quant 0.5quant 0.975quant   mode kld
intercept -7.676 31.405    -69.337   -7.676     53.926 -7.674   0
year       0.008  0.016     -0.022    0.008      0.039  0.008   0
depth     -0.182  0.051     -0.285   -0.181     -0.085 -0.178   0

Random effects:
  Name    Model
    i SPDE2 model

Model hyperparameters:
                  mean      sd 0.025quant 0.5quant 0.975quant   mode
Range for i    202.154 301.493      8.452  109.920    960.858 20.563
Stdev for i      0.680   0.271      0.265    0.645      1.308  0.565
GroupRho for i   0.844   0.066      0.685    0.856      0.938  0.877
```

A positive linear trend was found when analysing all targeted scoring images for black coral at Joe's Reef equating to a 0.607 increase in log counts per year. Analysis of the reduced data set of 200 images found a significant increase, but of a smaller magnitude of an increase of 0.008 in the expected log count per year. Black corals are generally long-lived and an increase in abundance such as this over a short time is unexpected. However, overall counts were very low (Table 3.7.2), and results based on such sparse data are likely to be unreliable.

2.8 Comparison of scoring approaches

2.8.1 Flinders Western Boundary

Power simulations using different scoring approaches at the Flinders Western Boundary site showed that high power was achievable for detecting 50% declines in Cup Red Smooth and Bramble Coral when using the full count approach with either 100 or 200 images (Figure 3.8.1). High power was achievable when using the point count approach for Cup Red Smooth with both 100 and 200 images but could not be achieved for Bramble Coral. High power was not achievable for either morphospecies when using the presence-absence approach.

Based on average image scoring times (see previous section), scoring 100 images with the full count approach would take approximately 17 minutes for Cup Red Smooth and approximately 39 minutes for Bramble Coral.

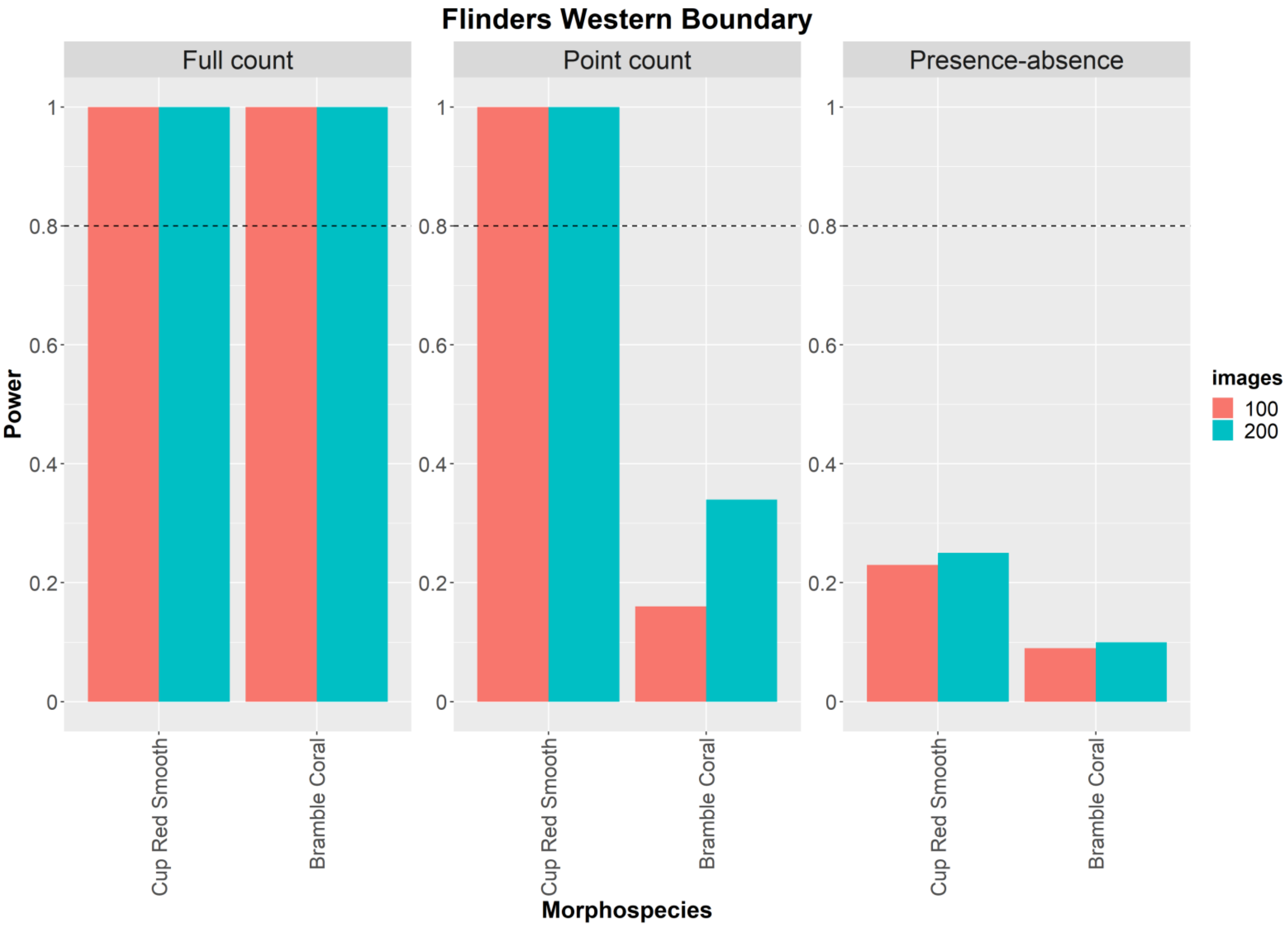


Figure 2.8.1 *Comparison of the ability of different scoring approaches to detect a simulated 50% decline in Cup Red Smooth and Bramble Coral at Flinders Western Boundary. Dashed line is at 80% power.*

2.8.2 Joe's Reef

Power simulations using different scoring approaches at Joe's Reef showed that using the full count approach yielded high power to detect a 50% decline in cover of Massive Purple sponges when using either 100 or 200 images (Figure 3.8.2). High power could not be achieved using either the point count or presence-absence approaches for Massive Purple sponges. For Black Coral, high power to detect a 50% decline was not achievable with any of the approaches tested.

Based on average image scoring times (see previous section), scoring 100 images with the full count approach would take approximately 35 minutes for Massive Purple and only a small amount of time to additionally score Black Coral.

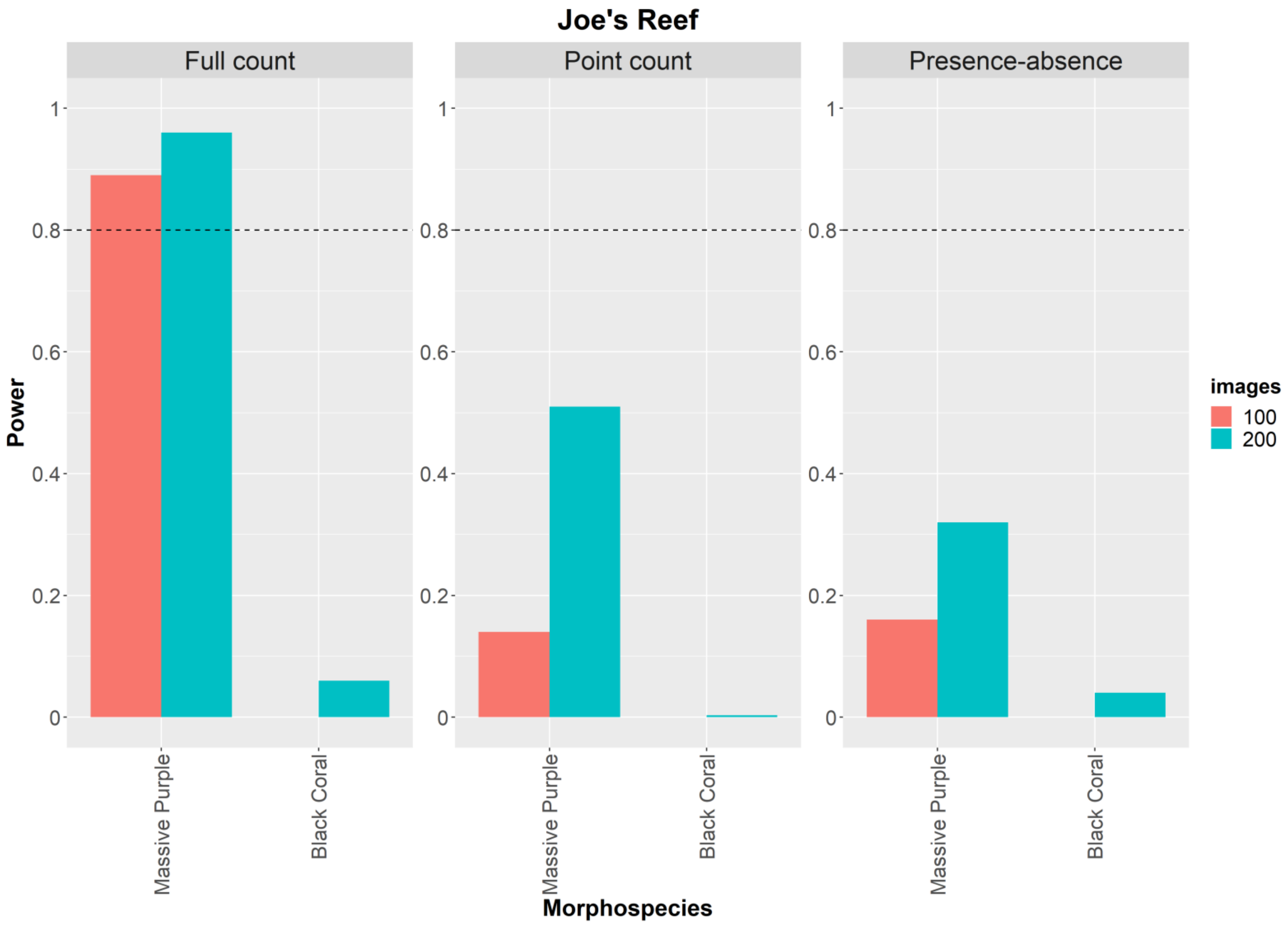


Figure 2.8.2 *Comparison of the ability of different scoring approaches to detect a simulated 50% decline in Massive Purple Sponges and Black Corals at Joe's Reef Dashed line is at 80% power.*

3 Discussion

This project provides the first insights into the spatial distribution and temporal dynamics of deeper (40-200 metre) reef sessile algal and invertebrate communities in shelf waters around Tasmania over a ten-year monitoring period. A time series of image-based benthic surveys in Australian Marine Parks utilising the Integrated Marine Observing System (IMOS) Autonomous Underwater Vehicle (AUV) facility has provided novel insights into the communities present across a large spatial extent, and how these communities and morphospecies within them change through time.

Multivariate analysis revealed that there were no significant shifts in overall community composition in each marine park over the survey period; however, several individual morphospecies underwent significant change. While the common assumption is that deeper water marine species are relatively stable compared to shallower water species, this study shows that a subset of deeper water species around Tasmania exhibit considerable fluctuations in abundance over time periods less than ten years. Understanding these dynamics has important implications for the management and ongoing monitoring of these communities. In particular, understanding "natural" or "baseline" variability is crucial to separate trends that are due to pressures of interest from natural fluctuations in abundance and in aiding the selection of indicators.

Power analyses conducted as part of this report show that given sufficient sampling, changes in the cover of more dominant morphospecies can be detected given current scoring protocols. Considerable improvements in the ability to detect change can be made by taking a targeted scoring approach where complete enumeration of individuals in a subset of imagery is completed. Through targeted scoring it was also found that a cup sponge morphospecies in Flinders Marine Park experienced a significant bleaching event between surveys in 2013 and 2017 during a period of extreme warming, suggesting that scoring of the condition of morphospecies may provide an additional or even improved indicator of change. Below, the results of the analyses conducted are discussed in more detail in relation to the ongoing monitoring and management of deeper water sessile communities across the SE Network.

3.1 Variability in cover of dominant morphospecies

Understanding the variability in the abundance of potential indicators is crucial to disentangle natural background variability from changes from anthropogenic sources such as fishing pressure or climate change. The population variability (PV) measure used to examine variability in the cover of morphospecies in the time-series to date provided a useful means of ranking morphospecies in terms of variability. PV values were often considerably different between different marine parks, leading to higher overall measures of PV when averaging across all parks. This indicates different processes operating at a local scale driving variability and could be the result of localised recruitment events or competition or localised pressures on populations. Plots of the raw percent cover data sometimes suggested between site differences within a marine park, indicating that different processes may be acting on an even more localised level. However, by considering PV across all parks, morphospecies with lower overall PV values can be considered those that are likely to be more stable at least over the decadal time scale that the monitoring program has covered to date. This information can be used in the selection of indicators (see section below) and should be updated as more data becomes available. It should be noted however that assessments of variability are being made under conditions that are likely to already be outside longer-term historical norms, with significant warming events occurring over recent decades (Oliver et al. 2018), a situation that is likely to continue (Oliver et al. 2014). Understanding what is likely to be natural variability and what is being driven by other pressures will be challenging and require the incorporation of additional environmental and monitoring data such as the data relating to warming and storm events, and a longer time-series of monitoring data.

3.2 Linear trends in the cover of important morphospecies

Several significant linear trends in the cover of individual morphospecies were found when considering broad changes across the entire SE Network. Of note was the large increase in cover of soft bryozoa and decrease in the cover of the widespread red gorgonian fan. The increase in the cover of soft bryozoa was largely driven by the positive trends observed at Huon and Freycinet Marine Parks. At Huon Marine Park the growth of individual bryozoan colonies was observable across the time series, with low "fuzzy" cover in 2009, intermediate growth in 2010 and large structured colonies in 2014. Linear trends were not found in Flinders Marine Park; however raw plots of the data and the imagery generally show a low cover in 2011, high cover in 2013 and lower cover in 2017 which is not captured by a linear trend. This points to the likelihood of soft bryozoans having a short life cycle on the order of 5-10 years, and the current time-series is only capturing a section of this natural cycling of abundance. Further clarification of this observation is required with ongoing monitoring as bryozoa form a dominant and important component of the ecology of all deeper water reefs across the SE region. The gorgonian red morphospecies (likely to be Pteronisis sp.; see Alderslade 1998) has been previously observed to have fluctuating cover on short time scales of 5-10 years at other locations (Lab 2011, Perkins et al. 2017). The overall linear decline detected was driven by large declines in Freycinet Marine Park at Joe's Reef and across sites at Flinders Marine Park. Once again, this could be due to the time-series only capturing a portion of natural cycling of abundances and recovery . A study examining the size structure of the population through time would be informative, as there appears to be a lack of information regarding growth rates of Pteronisis sp. in the literature. Current observations need confirmation with ongoing surveys as this morphospecies may also be susceptible to warming, as temperate octocorals elsewhere have been noted to have large die-offs in warming events (e.g. Garrabou et al. 2009, Pivotto et al. 2015). The large increase in hydroid white and decreases in massive purple, arborescent orange thin and lumpy white sponge morphospecies should be continued to be monitored to establish if declines are ongoing.

The extent to which marine park-level significant trends are part of natural cycling or succession in the abundance of different morphospecies or reflect longer term trends related to anthropogenic disturbance is currently unclear. For example, Huon Marine Park displayed significant increases in a number of structure forming species such as erect sponges and soft bryozoa which may be the result of recovery from prior disturbance through storm events. Generally, the height of the cover of many morphospecies at Huon Marine Park is low (see example pictures in Appendix B) and suggests frequent disturbance of these shallower sites by storm events. For Freycinet Marine Park, significant increases in a number of encrusting sponge morphospecies, particularly encrusting blue sponges at Freycinet Marine Park site 2, and the afore-mentioned increase in the cover of soft bryozoa and decrease in cover of red gorgonians may also reflect natural cycling in abundance of these morphospecies. Also, the significant declines in both gorgonian red and bramble corals at Flinders Marine Park could be natural cycling due to short life cycles for these morphospecies. However, as previously mentioned, corals may be more susceptible to warming events that may be altering the extent of natural variation. Disentangling natural variability from anthropogenic disturbance is likely to be challenging and will require incorporation of new knowledge of these morphospecies and environmental data as it is collected.

It should be re-emphasized here that only linear trends were tested for during this project, and the conclusions that can be drawn with only three time points are limited. Non-linear trends such as low-high-low or high-low-high covers over the survey period may be biologically significant and indicate short-term boom-bust life cycle histories or frequent disturbances. While non-linear trends can be modelled, doing so with three time points will lead to over-fitting. It is therefore recommended that modelling of these kind of trends be conducted once more data has been collected.

The spatio-temporal modelling approach introduced in this project provides several advantages in detecting trends through time and should continue to be used within the AUV monitoring program. The power to detect change is greatly enhanced by using images as the base level of replication rather than aggregating data up to the site level (Perkins et al. 2020a). However, images that are located closer together in space are unlikely to be independent and models must account for the inherent spatial autocorrelation when using the resultant data in this way. Also, when modelling time-series, temporal correlation is likely to exist between observations through time. The spatio-temporal models used in this project account for both these factors, and thus provide unbiased estimates of trend and the associated error. Furthermore, this modelling approach offers the advantage of being able to deal with data that has come from surveys that are not well aligned such as the change in design over time at Huon Marine Park.

3.3 Choosing indicators

Information regarding the spatial distribution and temporal variability of morphospecies gained through work conducted in this project has provided vital information to aid in the selection of indicators. This information in combination with ecological knowledge of the study system is used here to recommend some potential indicators and identify knowledge gaps to aid in selecting indicators (Appendix C). Suggested indicators are made based on a number of desirable properties: occurrence across a large number of sites, high relative abundance, low temporal variability (information gained from PV analysis conducted in this study), whether they are long-lived; and whether they are likely to respond to pressures of interest such as warming events, recovery from historical trawling/potting and storm events. It is also noted whether suggested indicators are likely to be easy to identify using artificial intelligence or machine learning algorithms that are likely to be developed soon. Finally, potential indicators are suggested as either widespread, in that they are distributed across the SE Network and potentially beyond, or whether they are more localised. For localised indicators it is also noted which marine parks they occur in and the number of sites across which they occur in each park. This list is not intended to be exhaustive, but to provide a starting point for the selection of potential indicators identified through the present work, some of the considerations that should be taken into account and where there are current knowledge gaps to provide focus for future research.

The power simulations conducted in this study highlight the importance of some of the afore-mentioned desirable properties of indicators. Simulated fifty percent declines for morphospecies with low relative abundance such as black coral at Freycinet Marine Park, arborescent orange sponges in Huon Marine Park or arborescent grey sponges at Freycinet Marine Park could not be detected with point scoring with 200 images. However, increasing scoring from 100 to 200 images resulted in high power for arborescent grey at Huon Marine Park site 1 and arborescent orange sponges at Joe's Reef. Both these site-level percent covers were approximately 0.5%, suggesting this might the minimum site-level abundance for detecting a 50% change with 200 images. When considering more abundant indicators, such as grouping all structure forming morphospecies, lower levels of change could be detected such as a 15% decline when grouping data from all sites in Flinders Marine Park. These findings should be further explored with similar analyses once indicators are chosen.

Indicators that are widespread allow the incorporation of information from multiple sites which can vastly improve the power to detect change (Andersen et al. 2019, Perkins et al. 2020b). For all power analyses conducted, modelling data from multiple sites greatly improved power, sometimes allowing for high power to detect change across a marine park where individual site-level changes could not be detected with high power (e.g. 50% declines in arborescent orange sponge at Flinders Marine Park); or allowing detection of longer-term chronic declines in a shorter amount of time such as detecting the simulated 75% decline in red cup smooth sponges at Flinders Marine Park. Indicators that are relatively abundant at a site-level and are present at many sites should therefore be preferred. There were several sites where surveys had not yet been repeated and so were not included in this project. It is important that as imagery is scored at these sites that knowledge of the spatial distribution of morphospecies is built upon as having information from more sites will improve the power to detect change. Furthermore, where it makes sense indicators can be made from grouped morphospecies, such as grouping all structure forming morphospecies to detect the impacts of trawling. The power analysis conducted in this project showed that detecting changes in such grouped indicators that provide an abundant and widespread coverage is achievable with high power and the lowest sampling effort tested. However, such grouping is not always appropriate as species are likely to have differing responses to some pressures such as warming events.

Indicators are typically evaluated through comparison to reference sites or by measuring their response along stress gradients, or a combination of both (Hayes et al. 2015). For the sites in the AUV program, there tends to be a lack of reference sites, or where possible reference sites outside marine park boundaries do exist there may be a lack of spatially explicit knowledge regarding the extent of disturbances such as trawling impacts. Ideally, appropriate outside reference sites should be developed to allow reporting on the effects of protection, as without knowledge about the rates of recovery from disturbances such as trawling it will be difficult to separate protection effects from other pressures. However, the large spatial spread of the marine parks in the SE Network provides sufficient scope to test pressure gradients. For example, it would be expected that climate change impacts through the increased influence of the East Australian Current (EAC) may first impact sites in the north such as Flinders and Beagle Marine Parks. Therefore, having sites spread over the extent of the east coast of Tasmania allows the testing of warming events over a large pressure gradient and analyses could be tied to oceanographic observations.

The finding of a large increase in bleaching of the cup red smooth morphospecies at the Flinders Western Boundary site is significant as bleaching in temperate sponge species has been rarely reported (but see Cerrano et al. 2001). This indicates bleaching or other changes in the condition of morphospecies may be an important potential indicator as an early warning of warming impacts on deeper water communities. Bleaching of sponges has been reported in tropical settings, and has been linked to warming effects on sponges that have symbiotic relationships with organisms such as cyanobacteria or photosynthetic algae (Usher 2008, Miller and Strychar 2010). The waters northeast of Tasmania were noted to have undergone a marine heatwave event in the summer of 2015/16 (Oliver et al. 2018), prior to the survey which revealed a large increase in the number of bleached individuals. While the relationship between increased bleaching in cup red smooth sponges and this heat wave event is only correlational, further investigation of the potential for bleaching in sponges is warranted. Indeed, this morphospecies is widespread, occurring in all marine parks apart from data collected at Beagle Marine Park so far. This indicates that this morphospecies or other morphospecies that may be subject to bleaching could be used to examine impacts over a gradient of warming. This should be a priority for future research.

Temperate coral species elsewhere have been noted to be particularly susceptible to warming events and other anthropogenic pressures (e.g. Garrabou et al. 2009, Pivotto et al. 2015, Cerrano et al. 2019), indicating that coral morphospecies in the SE Network may be useful indicators. The gorgonian red octocoral is widespread, occurring across the entire SE Network. However, this morphospecies displayed large fluctuations in cover including an overall decline as well as significant declines detected in Flinders and Freycinet Marine Parks, while cover remained stable in Huon Marine Park. Similarly, bramble coral which was found in Flinders and Freycinet Marine Parks showed a decline in Flinders Marine Park while remaining relatively stable at Freycinet Marine Park. Targeted scoring of bramble coral at the Flinders Western Boundary site revealed a rebounding in abundance in 2017 after a strong decline between 2011 and 2013. This implies that the extreme warming event in 2015/16 did not have a strong impact on bramble coral. It is currently unclear whether these two relatively abundant coral species are being impacted by warming or whether fluctuations seen to date are part of natural cycling of abundances with these morphospecies being relatively short-lived. A study examining the size structure of these populations over time would be informative in helping understand growth rates and population dynamics. The power analysis for bramble coral at Flinders Marine Park made the assumption that variation seen to date was natural, which resulted in the simulated “real” effect taking a long time to detect with high power and at a stage when this morphospecies may already have been in critical trouble. Therefore, ongoing monitoring of changes in abundance is warranted for these two species, with current evidence suggesting they may not have desirable properties as indicators. Other large coral species such as the black corals at Joe’s Reef, or the large gorgonian fans (Mopsella sp.) in Flinders and Beagle Marine Parks are not sufficiently abundant to track changes in cover or abundance through time. For example, power analysis at Joe’s Reef for black corals suggests that high power would be difficult to achieve due to the low number of observations. If these species are in fact suitable indicators, then it is likely that targeted scoring of all individuals and observation of condition of individual colonies may be the best path forward.

3.4 Scoring approaches and monitoring design

The different scoring approaches trialled in this project have highlighted that both the quantity and quality of data generated from the vast amount of AUV imagery available can have dramatic impacts on monitoring outcomes and ecological insights into important dynamics. The targeted scoring of all individuals across non-overlapping images at two sites provided additional insights with the conclusions drawn being different when compared to the data from a point scoring approach. For example, power analyses comparing different point scoring approaches highlighted that targeted scoring consistently outperformed point scoring approaches.

The point scoring approach used for the majority of the scoring completed in this project is useful to provide an initial quantitative description of the important morphospecies present at a site and to track changes in the more abundant morphospecies or in multivariate assemblages. However, point scoring is quite labour-intensive and a large amount of time is spent labelling non-biological categories such as sand, searching the database for rarer species or adding new species to the database or labelling points as "matrix" categories as the image resolution does not allow further classification. For example, more than half the points within Huon Marine Park scored during the project were placed into matrix categories due to low and often non-distinguishable cover of encrusting organisms. While these categories are important components of the ecosystem, it is unlikely they will be monitoring targets. Furthermore, randomly allocated points may often fail to land on species that are of high conservation value, particularly if they are small or rare. Also, as imagery is subset, the random subset of imagery may fail to capture important species. For example, no black corals were observed at Joe's Reef in 2014 with the point scoring approach.

A comparison of the power of different potential scoring approaches revealed that the targeted scoring of all individuals (a "full count" approach) consistently outperformed both a point count and presence-absence approach. While this result is intuitive, as more information is contained in a full count approach, the magnitude of this difference was surprising. The full count approach was able to detect a 50% decline for all targeted morphospecies with either 100 or 200 images, except for the rare black coral. Point scoring was only able to detect the simulated 50% decline for the most abundant morphospecies tested (cup red smooth at Flinders Western Boundary) but could be achieved with either 100 or 200 images. Presence-absence scoring, while appealing due to the speed it may be able to be conducted, was unable to detect any of the simulated changes with high power. This highlights the advantage of a targeted full count approach, which should be the preferred method for individual indicator morphospecies moving forward. Another bonus of targeted scoring is that it generates more data for individual morphospecies that can be used to train machine-learning algorithms for future automated scoring. Further simulation work could be conducted to establish the effectiveness of this approach for other morphospecies. Given the current results using just 100 images, it seems likely that this approach will be useful for a wide range of morphospecies, even those that have been previously considered rare due to low cover (< 0.5%). For extremely rare morphospecies such as black corals at Joe's Reef, current counts within imagery are insufficient to detect declines in abundance. Where morphospecies are deemed to have high conservation value, such as black corals or the large gorgonians found in Flinders and Beagle Marine Parks, additional survey work could be conducted such as more AUV imagery collected over a larger extent of the reef, or the use of other technologies such as remotely operated vehicles (ROVs). Alternatively, for rarer but potentially susceptible morphospecies, the condition of individuals seen in imagery could be used as an index of impacts.

The time taken to complete different scoring approaches can allow a cost-benefit comparison. Power analysis showed that 200 images are likely to be necessary for detecting changes of 50% in cover of morphospecies with around 0.5% cover. During the project, experienced scorers averaged 5-7 minutes per image (with 25 points), meaning that scoring 200 images at a site takes approximately 17 – 24 hours of scoring. Targeted scoring of every non-overlapping image (1500-2200 images) took between 5 hours (all cup red smooth sponges at Flinders Western Boundary) to 11 hours (bramble coral at Flinders Western Boundary. The smaller bramble coral colonies required scanning through each image, and therefore took considerably longer. This suggests that 3-5 morphospecies could be scored across all imagery in the same amount of time as point scoring of all morphospecies with 200 images. However, modelling using 200 images with targeted scoring provided similar conclusions as all targeted images for the bleaching event of cup red smooth sponges, suggesting that a reduced number of images could be scored with targeted scoring and significant changes could still be detected. Indeed, the power comparing the different scoring approaches suggests that even 100 images with targeted is likely to detect a 50% decline. Average scoring times per image suggest that 100 images could be scored in between 17 minutes per year (cup red smooth sponges at Flinders Western Boundary) to 39 minutes (bramble coral at Flinders Western Boundary). The clear advantages of targeted scoring in improving the power to detect change, and the minimal comparative time taken to score in this way suggests that this approach should be adopted for identified target indicators moving forward. Point scoring could still be continued and may be useful for detecting large scale shifts in the cover of individual morphospecies, multivariate changes in assemblages or the incursion of new morphospecies such as invasive species that may be missed otherwise. It is therefore suggested that a hybrid approach be adopted moving forward to allow a “best of both worlds” scenario. The amount of effort devoted to each approach can be assessed once indicators have been chosen.

Power analysis conducted in this project and elsewhere (see Urquhart et al. 1993, Urquhart and Kincaid 1999, Perkins et al. 2017, Andersen et al. 2019, Perkins et al. 2020b) suggests that annual revisits to sites are not necessary to detect longer-term trends in abundance. The power to detect trends depends on a complex interplay between the magnitude of change, sampling variability, the number of sites and the variability in change between sites. Generally, more sites have been found to increase the power to detect trends (e.g. Andersen et al. 2019, Perkins et al. 2020b); however, differences in the trend between sites can also play a significant role (Sims et al. 2007). The results of power analysis in this project show that where trends are consistent, having more sites provides a significant improvement in power. This is also an important consideration when selecting indicators, as those that occur across a larger number of sites will provide a better means of assessing regional trends. Ultimately, temporal and spatial revisit plans must be balanced within budgetary constraints, but the results reported here and elsewhere show that while annual revisits are likely to detect changes in a shorter amount of time, less frequent revisits will typically detect change within management relevant timeframes. Further work exploring this interplay and incorporating knowledge of variability for selected indicators across sites and marine parks would be informative in directing future resources and sampling effort.

Recommendations

- Suggested indicators for ongoing monitoring of the SE Network (widespread indicators) and individual marine parks (localised indicators) are given in Appendix C. These indicators were selected based on a number of desirable properties: occurrence across a large number of sites, high relative abundance, low temporal variability (information gained from PV analysis conducted in this study), whether they are long-lived, whether they are likely to respond to pressures of interest such as warming events, recovery from historical trawling/potting and storm events, and whether they are likely to be easily identified using artificial intelligence or machine learning algorithms. Suggestions are based on current knowledge, and this list should be updated as new data is acquired regarding the spatial extent, temporal variability and response to pressures.

- Targeted scoring of all individuals should be the preferred method of image annotation for future selected indicators as it provides a much higher probability of detecting changes. Further exploration of the necessary sampling effort using this approach should be conducted once indicators are selected, but current work suggests that 100 images of targeted scoring may be sufficient for reasonably abundant morphospecies and can be completed in a short amount of time.

- Further exploration of correlation between environmental data and patterns in the abundance of morphospecies should be conducted to allow the effects of perturbations such as warming events or storms to be separated from background variability.

- Particular attention should be given in future monitoringa efforts to morphospecies where significant linear trends have been identified in this project to establish whether trends continue or are part of longer-term natural cycling.

- Effort is made to score currently unscored sites that were not included in this project due to a lack of repeat surveys. Power analysis conducted in this project and elsewhere suggest that the ability to detect changes is greatly improved by incorporating more sites where an indicator is present in sufficient abundance, and therefore knowledge of the spatial distribution of morphospecies across currently unscored sites will help with the planning of ongoing monitoring efforts.

- Power analyses such as those conducted in this project should be done under a variety of scenarios for chosen indicators to ensure sampling designs are adequate to detect likely levels of change.

- The modelling approach used in this project should continue to be used for ongoing analysis of AUV imagery as it accounts for spatial and temporal correlation, thereby providing unbiased estimates and a higher probability of detecting change when it occurs.

- Effort should be made to establish suitable reference sites outside Marine Parks and to quantify impacts in these sites to allow a comparison of how the protection offered by marine parks differs from impacted sites.

Appendix A: Table of all AUV sites in the SE Marine Parks Network

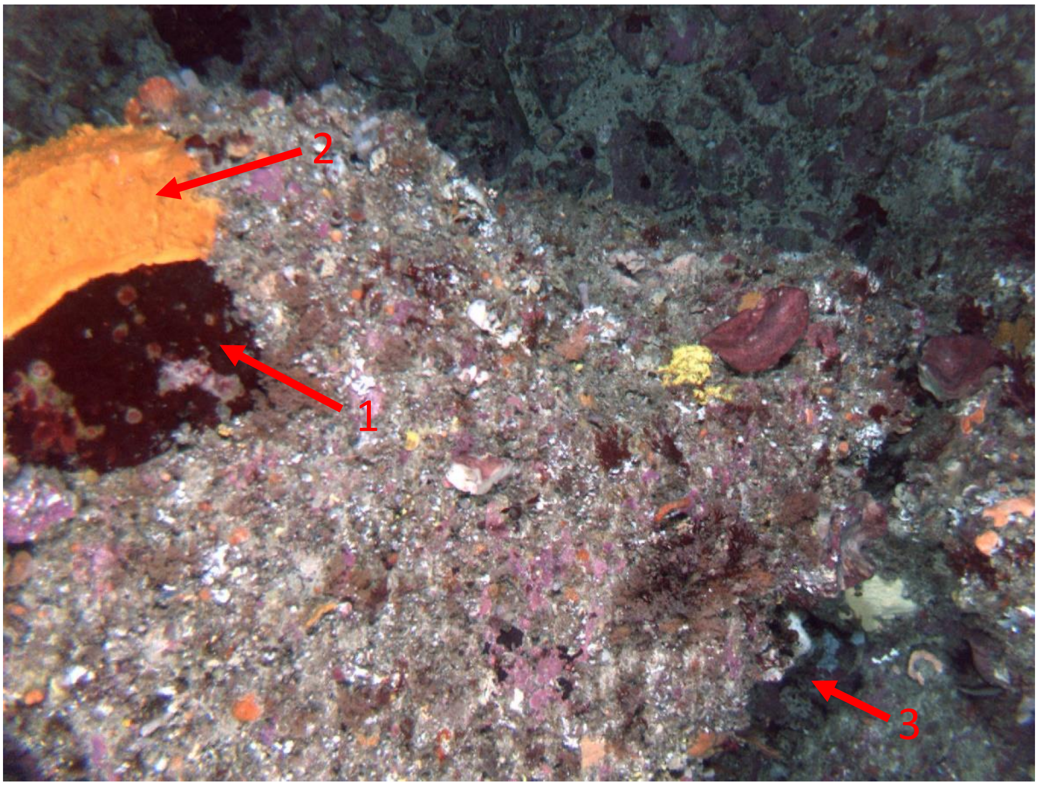
AMP	Site	Years surveyed	Depth range (m)
Huon	Huon MP site 1	2009, 2010, 2014	45-71
Huon	Huon MP site 2	2009, 2010, 2014	47-72
Huon	Huon MP outside	2009	45-71
Freycinet	Joe's Reef	2011, 2014, 2016	59-83
Freycinet	Freycinet MP site 2	2009, 2010, 2012, 2014, 2016	93-100
Freycinet	Freycinet MP site 1	2009, 2010, 2012, 2014, 2016	87-94
Freycinet	Freycinet MP Sand	2009	76-82
Freycinet	Freycinet MP Patch Reef	2009	98-118
Freycinet	Freycinet MP Offshore	2009	85-99
Flinders	Flinders Northwest	2013, 2017	41-45
Flinders	Flinders Outer Patch Reef	2011, 2013, 2017	75-94
Flinders	Flinders Canyon Grids North	2011, 2013, 2017	112-181
Flinders	Flinders Shallow Grids	2011, 2013, 2017	62-78
Flinders	Flinders Western Boundary	2011, 2013, 2017	43-52
Flinders	Flinders East Shelf	2013	64-92
Flinders	Flinders Canyon Grids South	2011	120-216
Flinders	Flinders Canyon Grids site 2	2011	123-155
Beagle	Beagle Mid Shelf 3	2017, 2018	57-65
Beagle	Beagle Mid Shelf 4	2017	57-65
Beagle	Beagle Mid Shelf 8	2017	63-67
Beagle	Beagle Mid Shelf 10	2018	58-65
Beagle	Beagle Mid Shelf 11	2018	53-62
Beagle	Beagle Mid Shelf 12	2018	56-64
Beagle	Beagle Mid Shelf 13	2018	60-66
Beagle	Beagle Mid Shelf 14	2018	61-66
Beagle	Beagle Mid Shelf 15	2018	63-66

Beagle	Beagle Mid Shelf 16	2018	60-68
Beagle	Beagle Mid Shelf 17	2018	57-62
Tasman Fracture	Southwest Mew Stone	2015	93-137

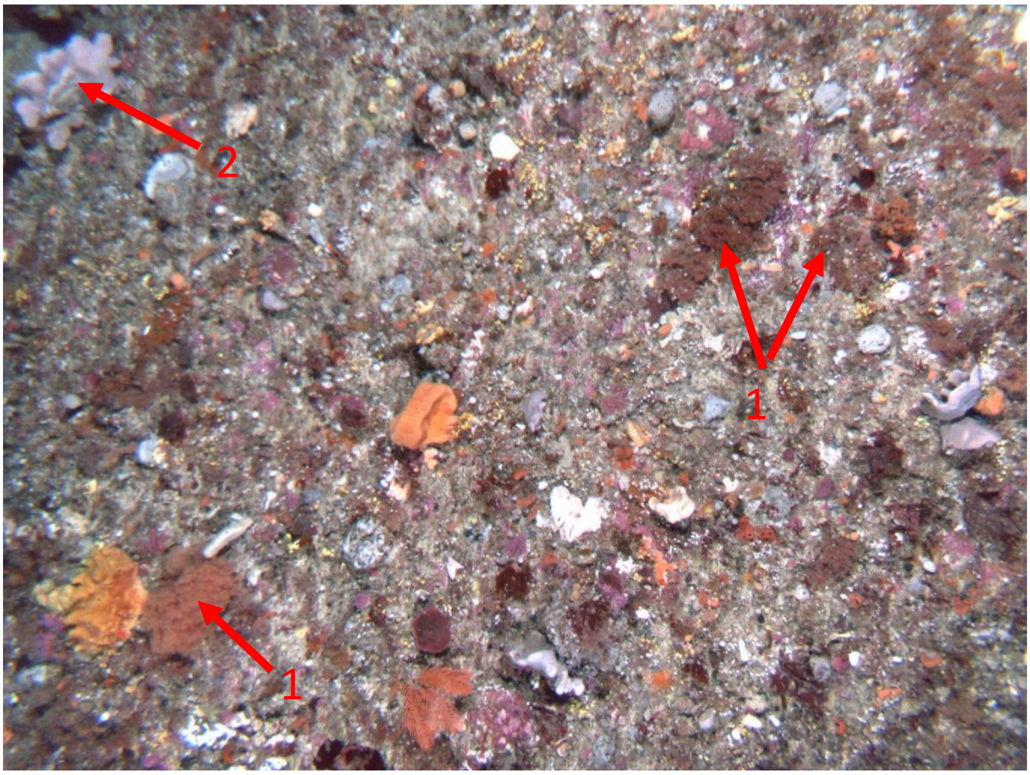
Appendix B: Example images from sites

Huon Marine Park site 1

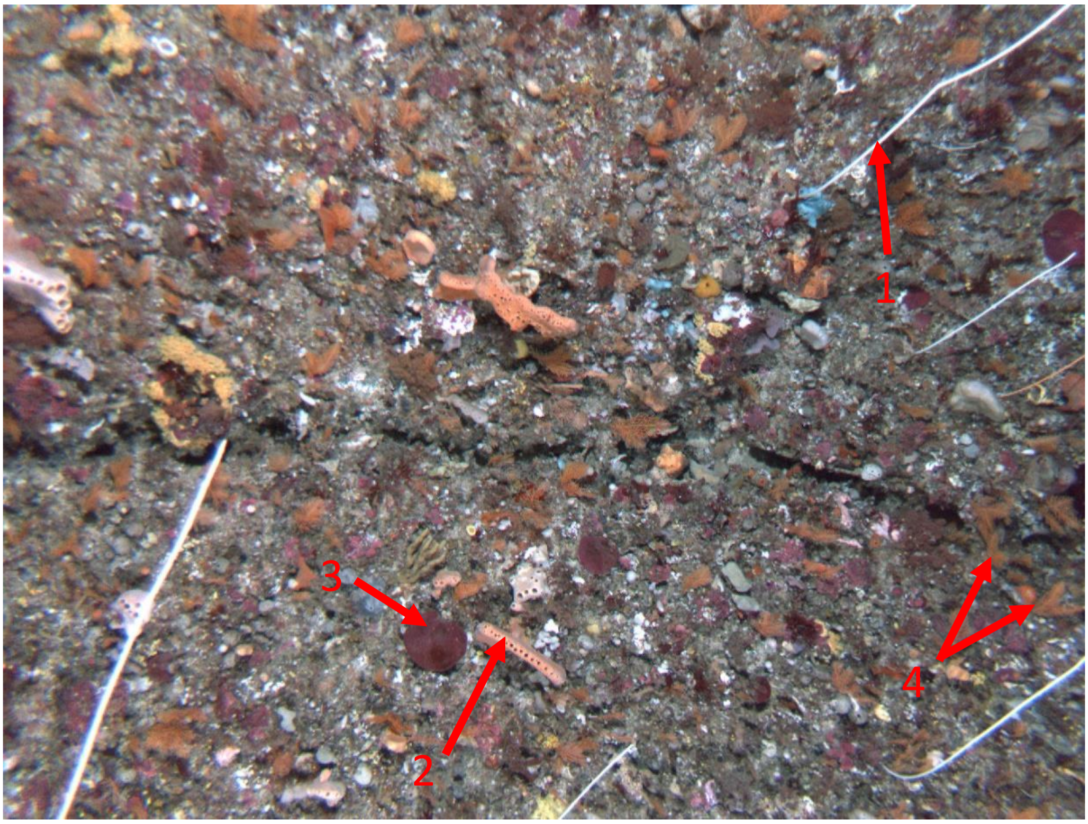
Example imagery from Huon Marine Park site 1



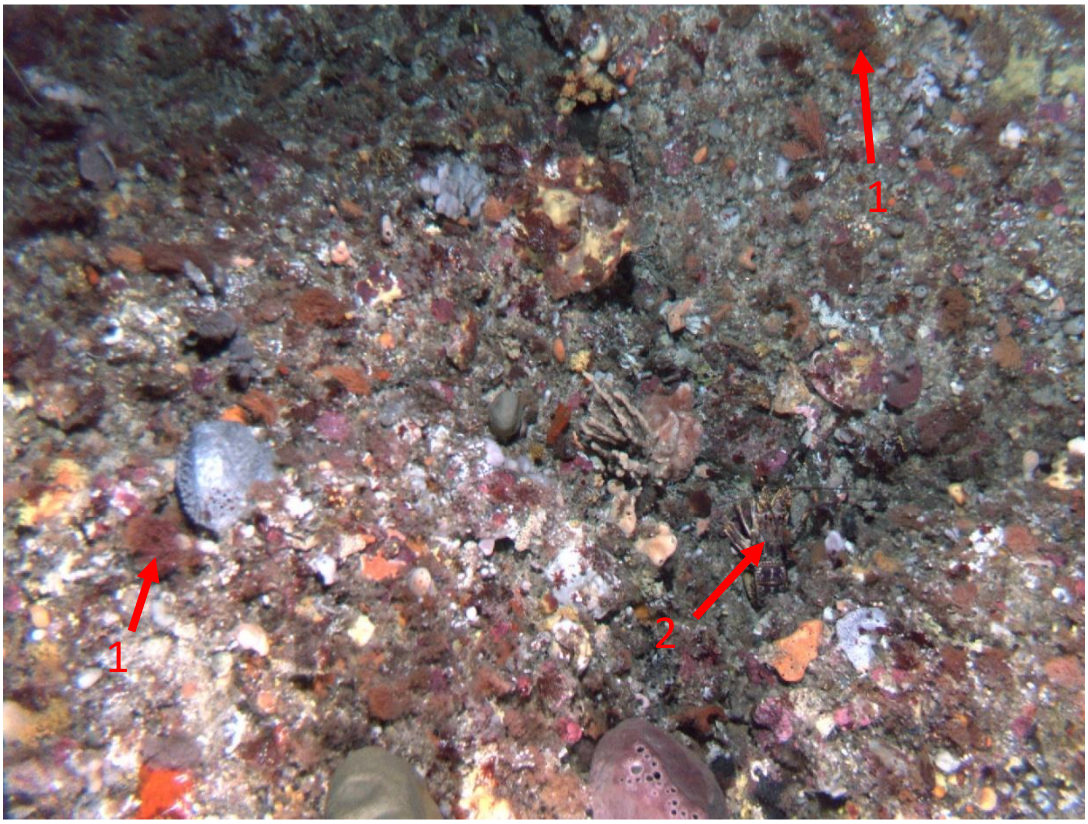
Non-calcareous encrusting red algae (1), encrusting orange sponge (2), thick blue cup sponge (3)



Soft bryozoans (1), palmate grey sponge (2) and a variety of other sponges



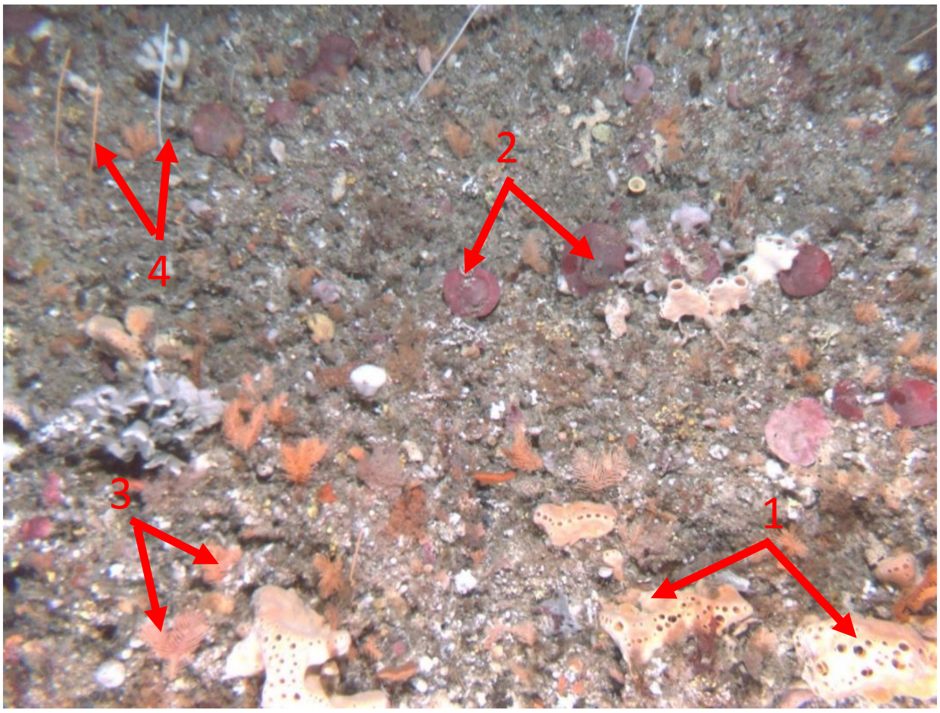
Sea whips (1), orange fan sponges (2), cup red smooth sponges (3) and red gorgonians (4)



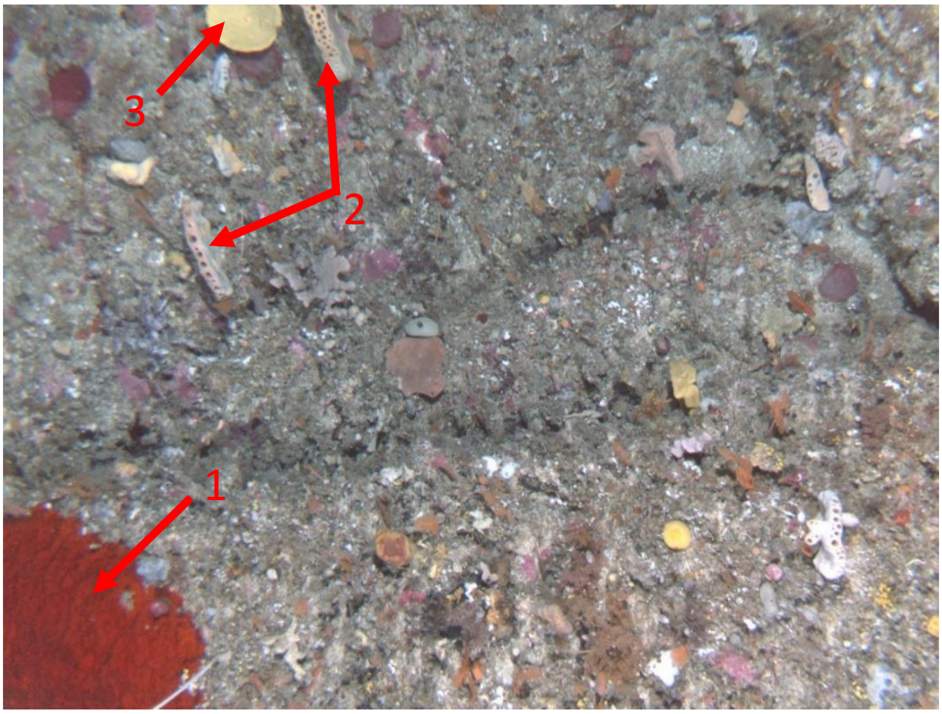
A variety of massive and encrusting sponges, soft bryozoans (1) and a rock lobster (2)

Huon Marine Park site 2

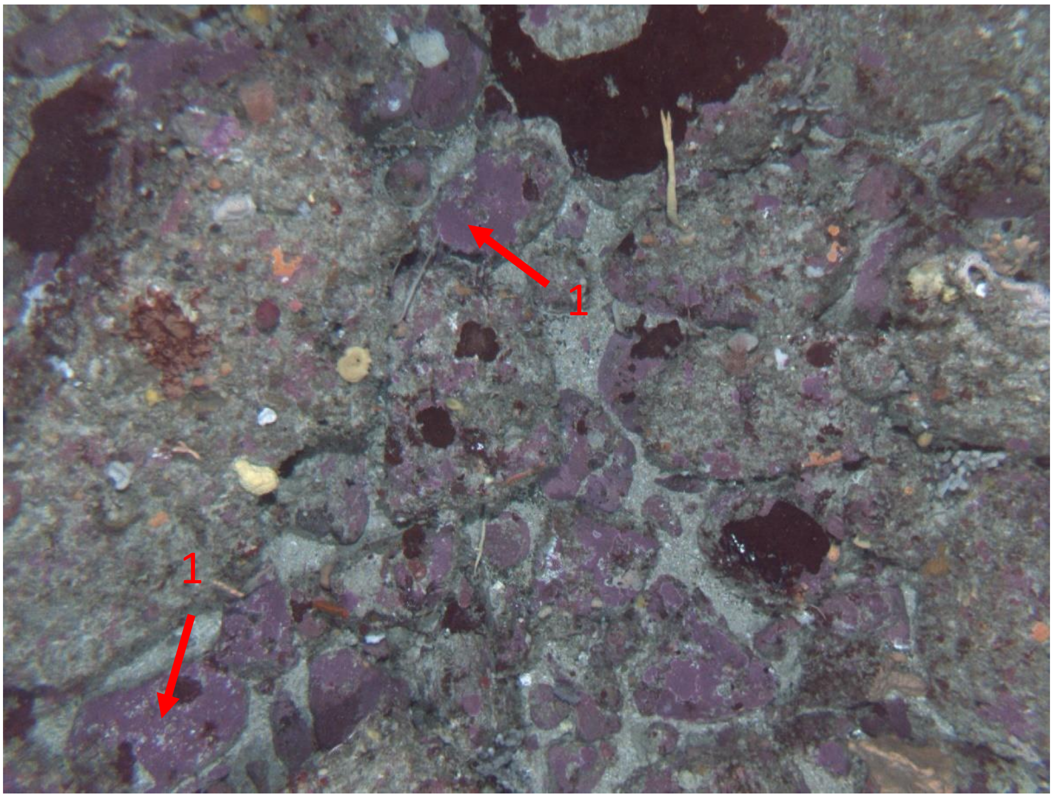
Example images from Huon Marine Park site 2



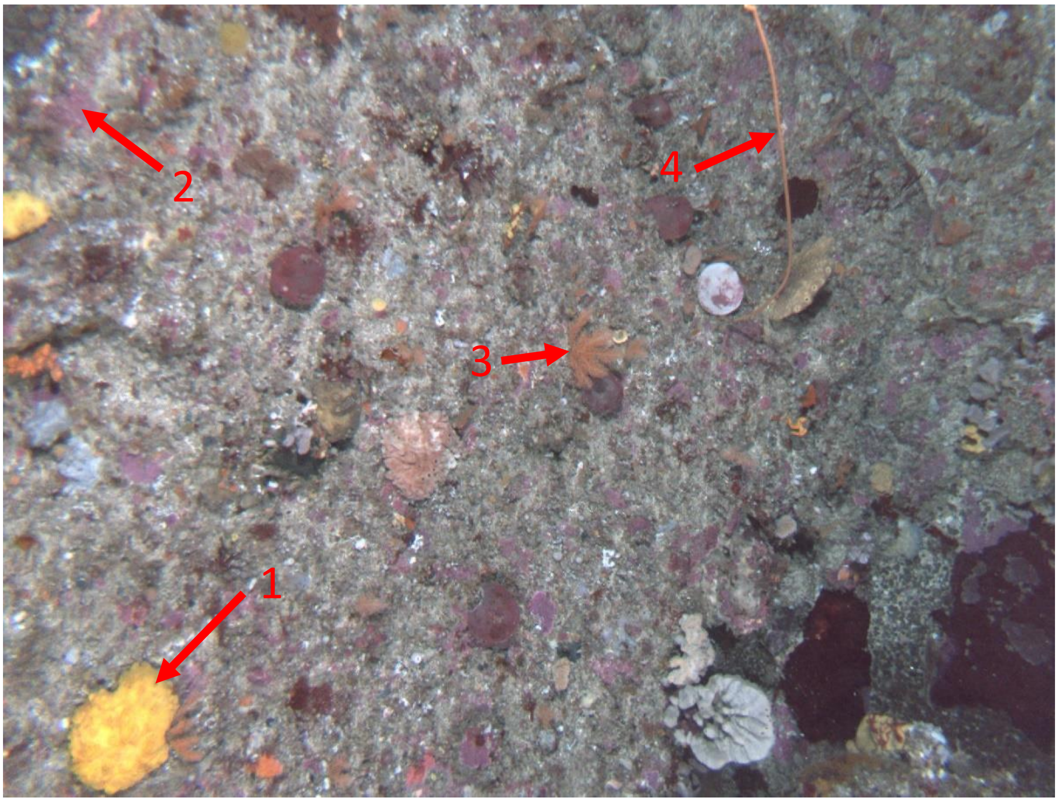
Massive orange sponges (1), cup red smooth sponges (2), red gorgonians (3) and sea whips (4)



Encrusting orange sponge (1), peach fan sponges (2), yellow cup sponges (3)



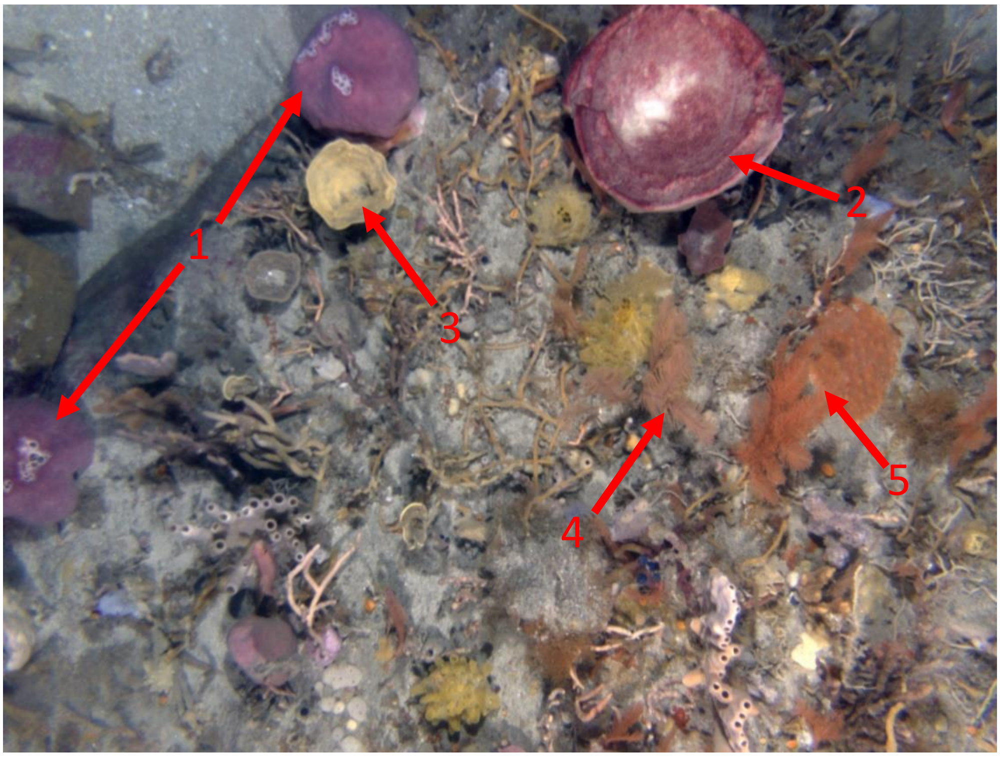
Encrusting coralline algae (1) and a variety of sponges



Massive yellow papillate sponges (1), encrusting coralline algae (2), red gorgonian (3), and sea whip (4)

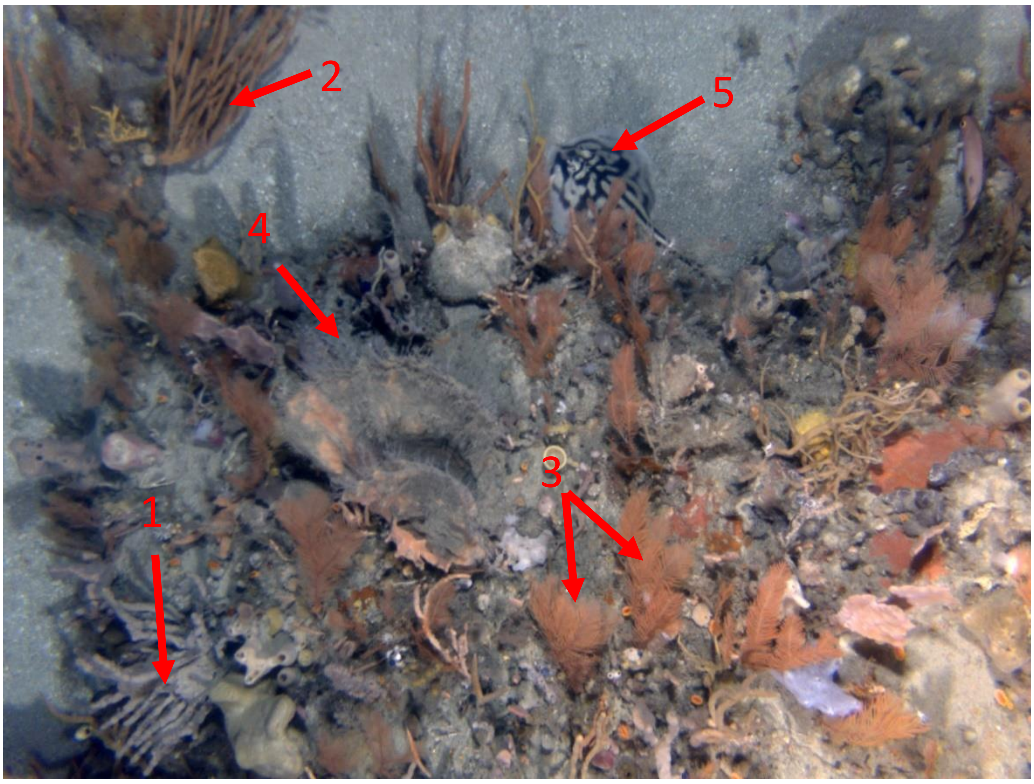
Joe's Reef

Example images from Bicheno Offshore (Joe's Reef)

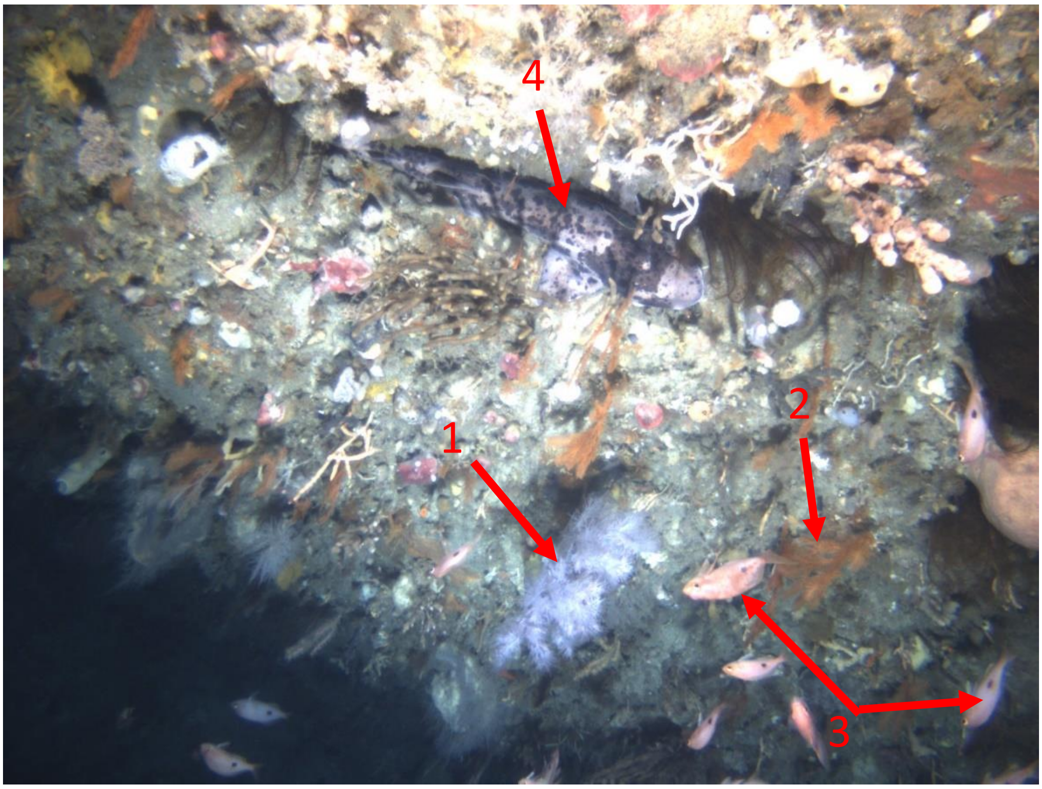


Massive purple sponges (1), red (2) and yellow (3) cup sponges, red gorgonians (4) and encrusting orange sponge (5)

Massive purple sponges (1), barrel sponges covered with yellow zoanthid colonial anemones (2) and encrusting orange sponge (3)



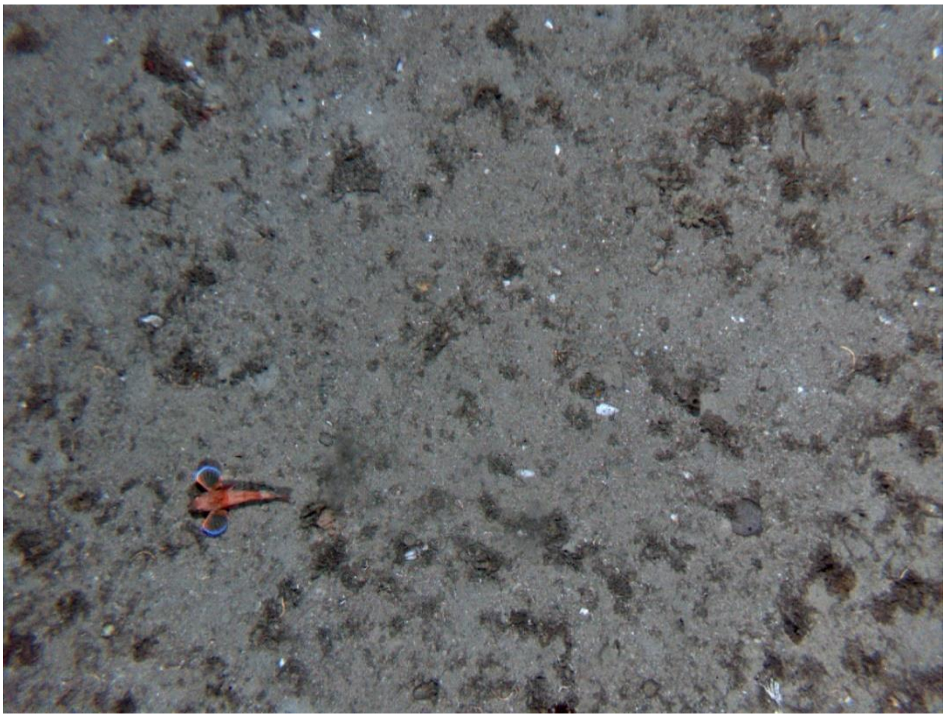
Arborescent grey (1) and orange (2) sponges, red gorgonians (3), hydroid white (4) and a banded stingaree (5)



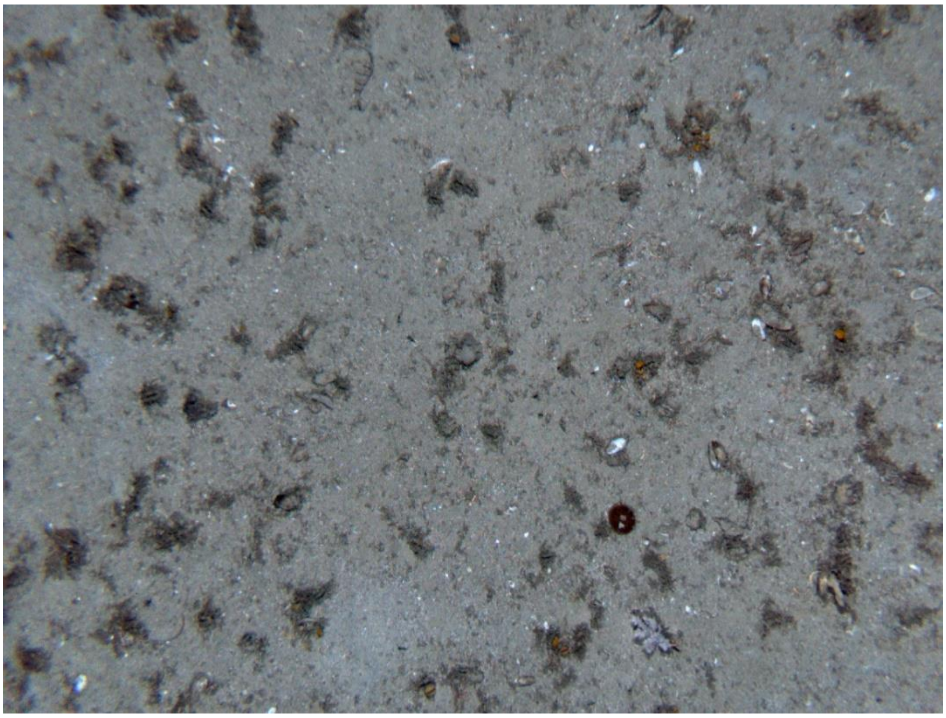
Variety of sponges, black coral (1), red gorgonians (2), butterfly perch (3) and a “sleepy joe” draughtboard shark (4)

Freycinet Marine Park site 2

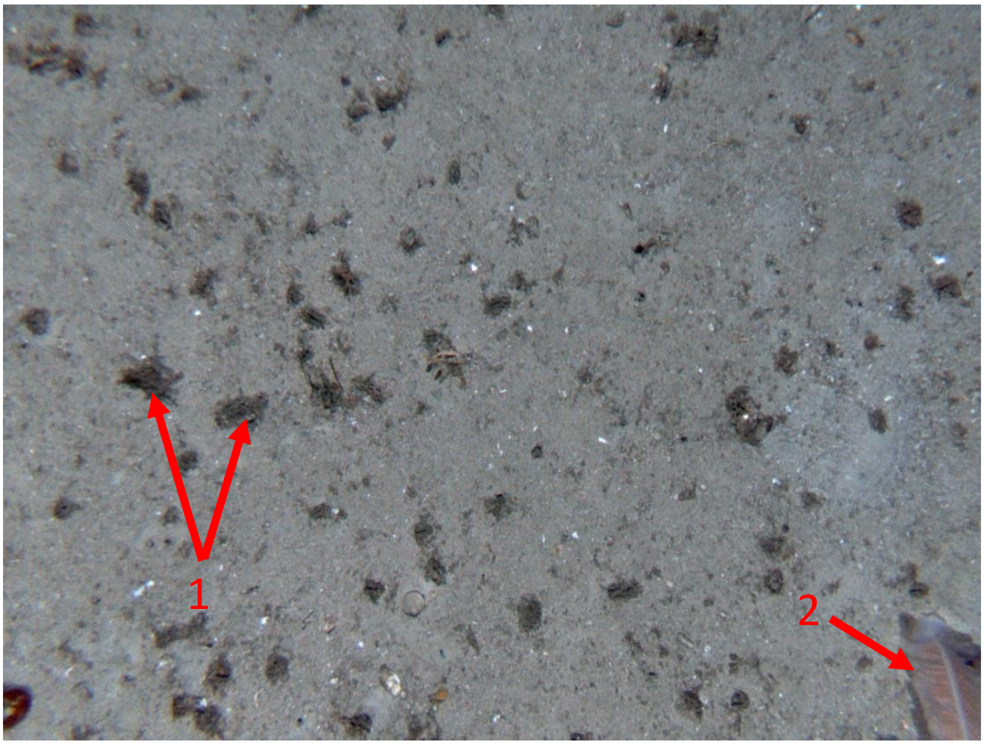
Example images from Freycinet Marine Park site 2



Soft bryozoans and “flying” red gurnard



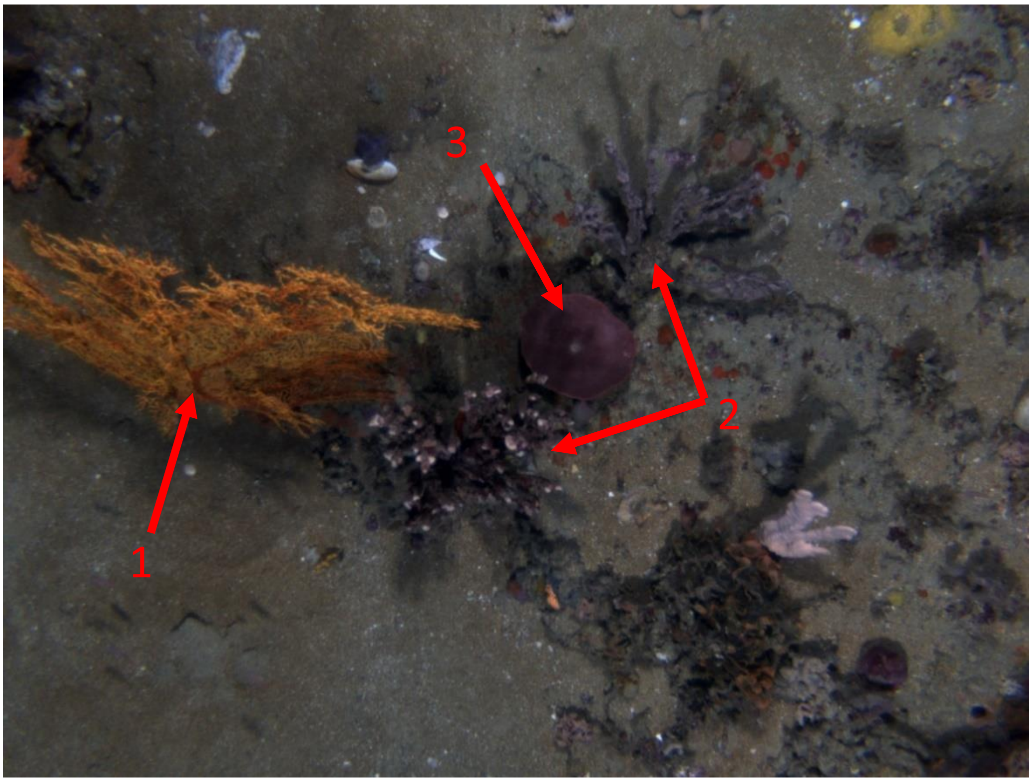
Soft bryozoans and sponges



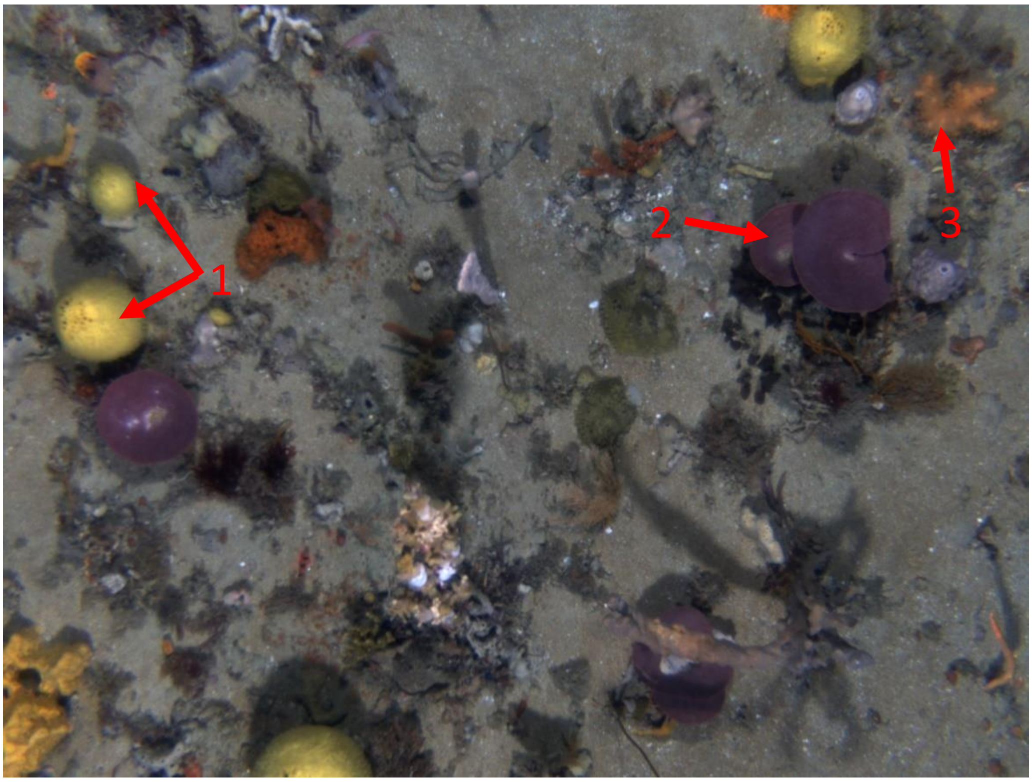
Bryozoans (1) and sea pen (2)

Flinders Northwest

Example images from Flinders Northwest



Large gorgonian fan (1), arborescentt grey sponges (2) and red cup smooth cup sponge (3)

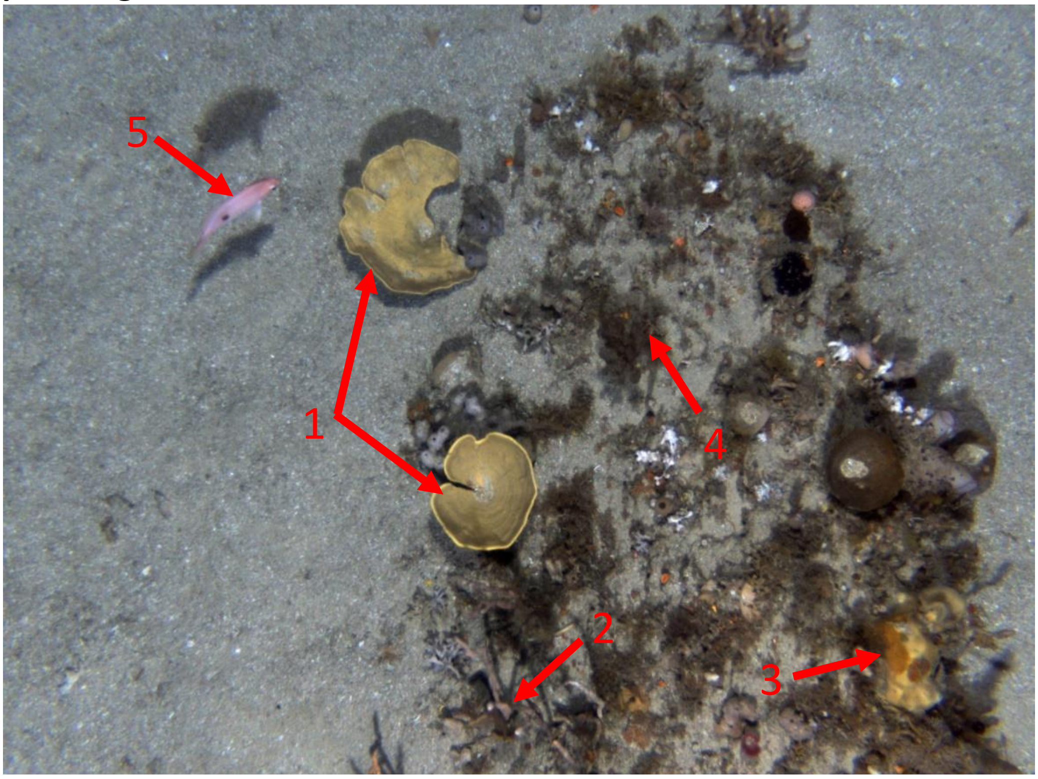


Massive yellow ball sponges (1), red cup smooth sponges (2) and soft coral (3)

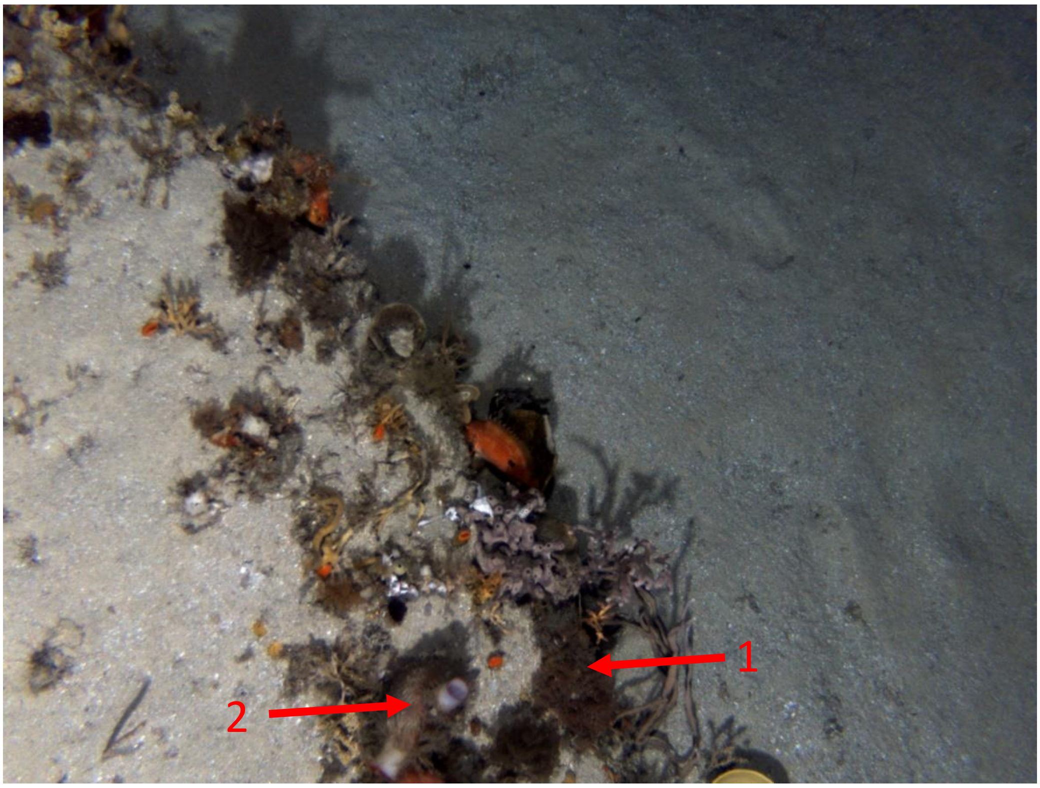
Cup red smooth sponges (1), pink cup sponges (2), soft corals (3) and gorgonians (4)

Flinders Outer Patch Reef

Example images from Flinders Outer Patch Reef



Yellow cup sponges (1), arborescent grey sponge (2), massive yellow sponge (3), soft bryozoans (4) and a butterfly perch (5)

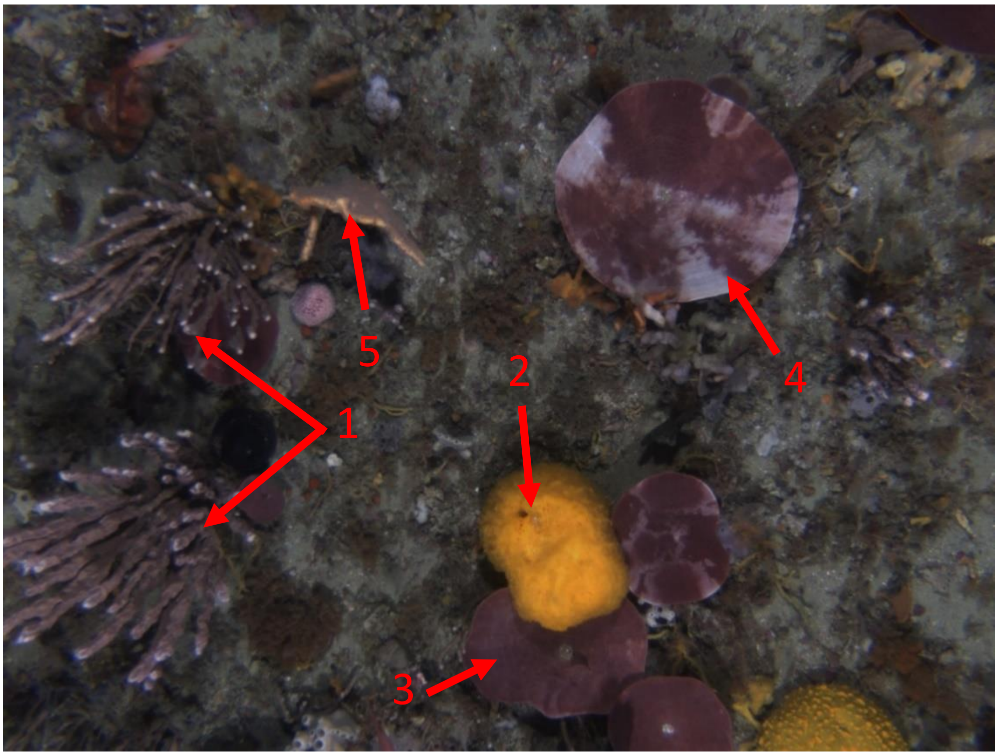


A variety of sponges, soft bryozoans (1) and ascidians (2) on the edge of a low relief ledge feature

Diverse sponge and bryozoan community on a higher relief ledge feature

Flinders Western Boundary

Example images from Flinders Western Boundary

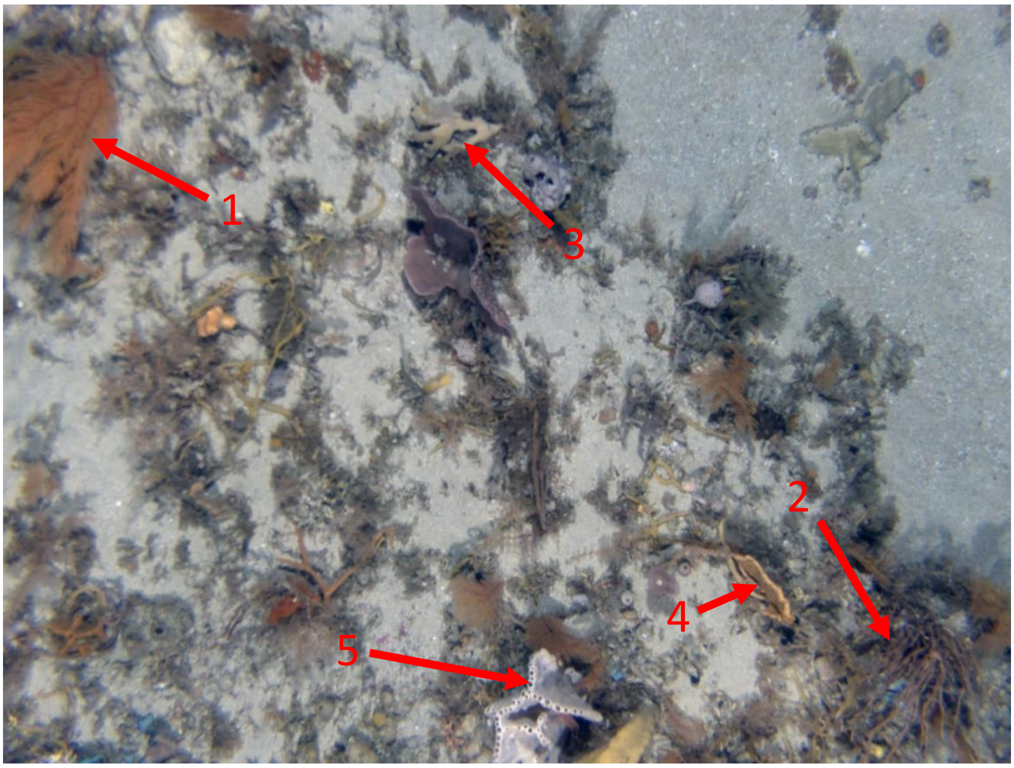


Arborescent grey sponges (1), yellow massive papillate sponges (2), cup red smoothsponges (3) including one showing bleaching (4), and orange fan sponge (5)

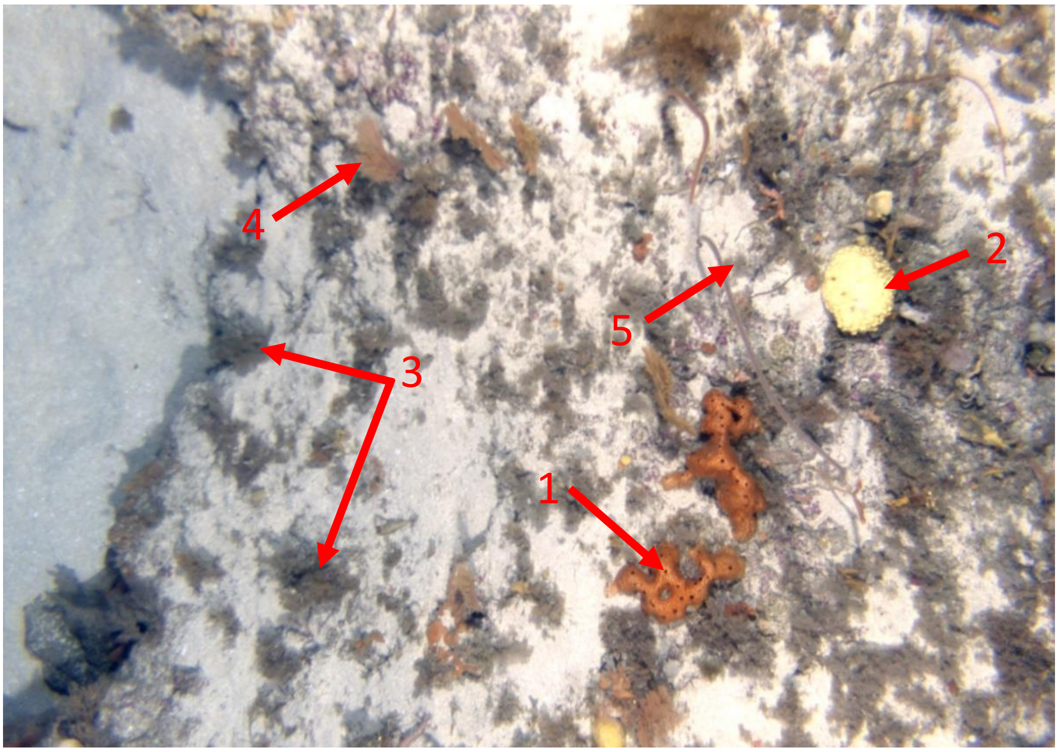
Arborescent grey sponges (1), yellow massive papillate sponges (2), cup red smooth sponges (3) and grey tubular sponges (4)

Flinders Shallow Grids

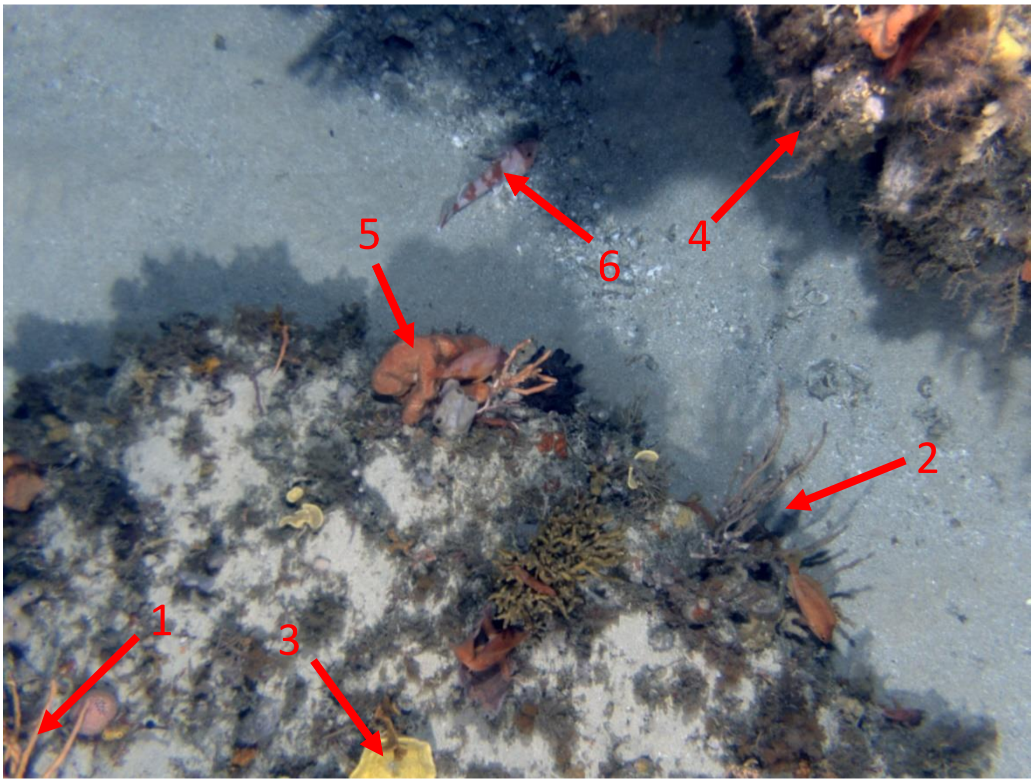
Example images from Flinders Shallow Grids



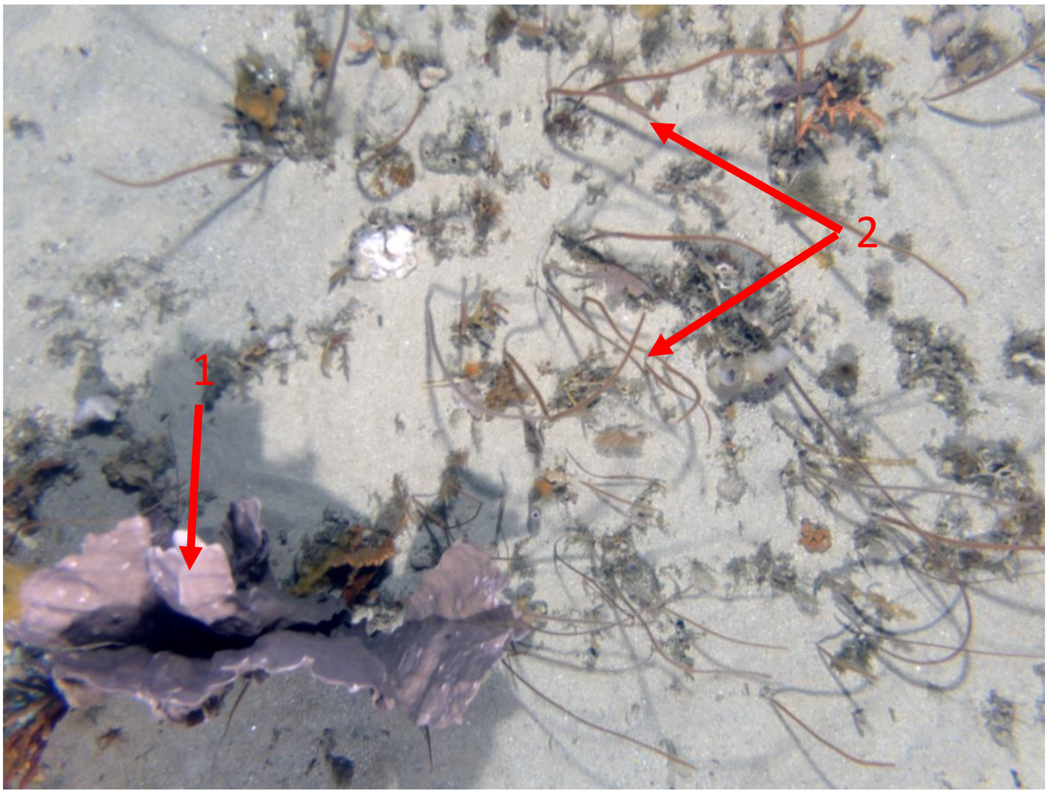
Red gorgonians (1), arborescent grey (2) and yellow sponges (3) and laminar orange (4) and white (5) sponges



Orange (1) and yellow (2) massive sponges, soft bryozoans (3), red gorgonians (4) and sea whips (5)



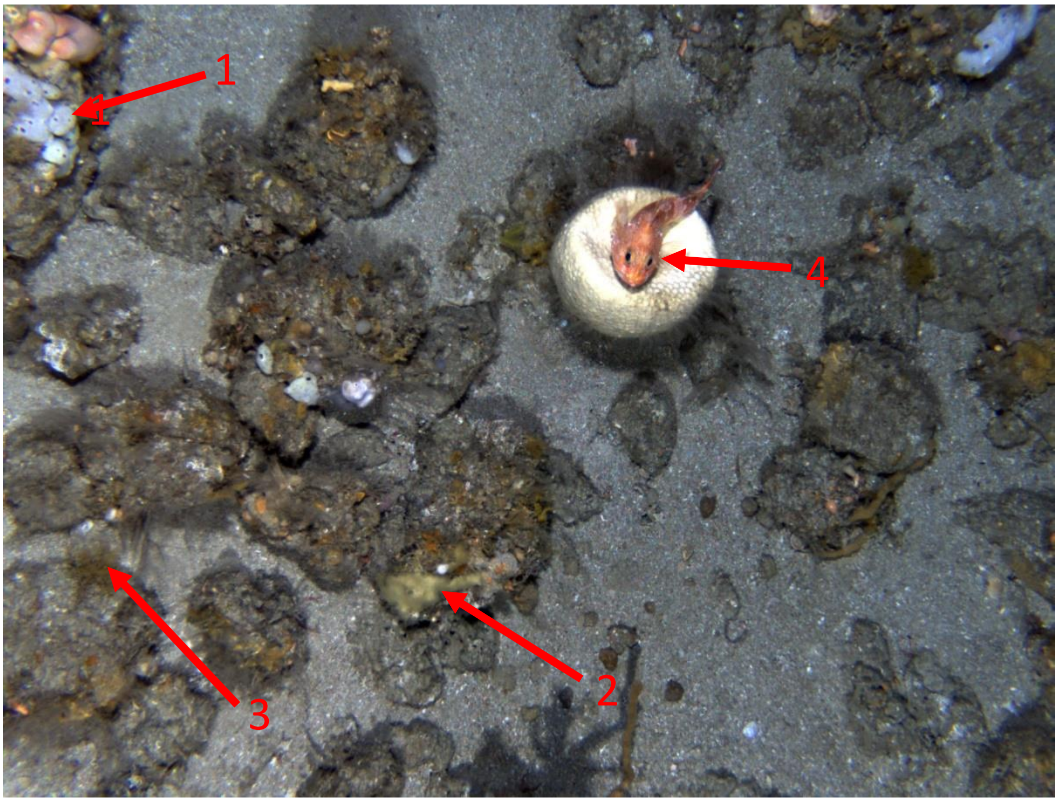
Orange (1) and grey (2) arborescent sponges (1), yellow cup sponge (3), bramble coral (4), massive orange sponge (5) and an ocean perch (6)



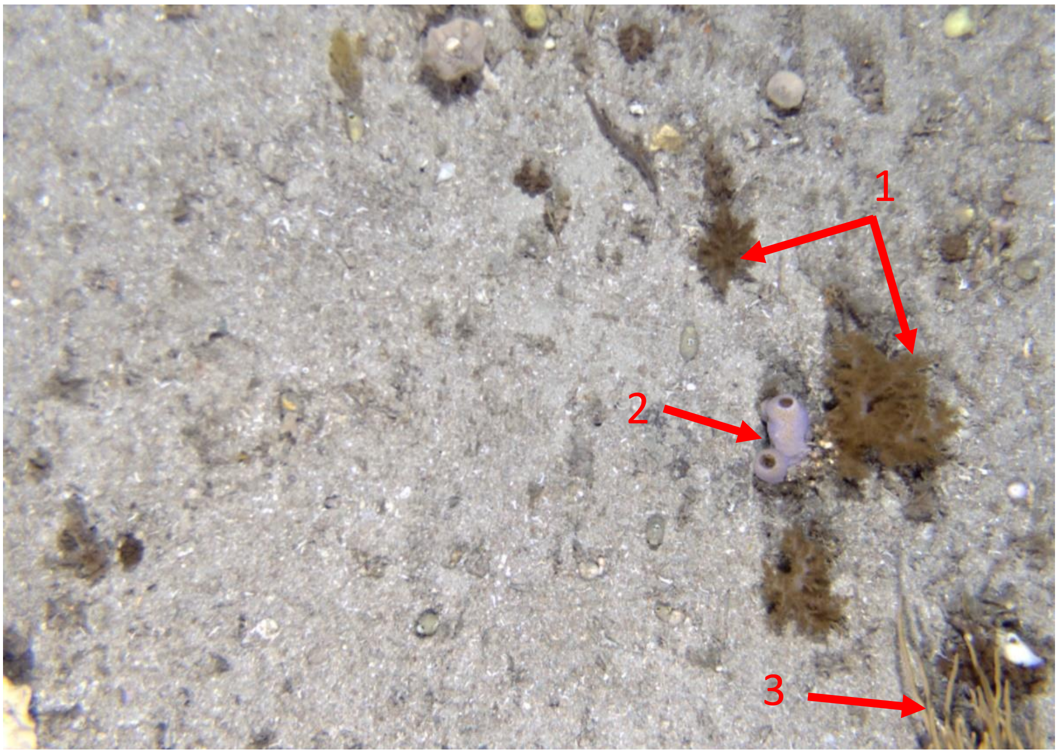
Large pink fan sponge (1) and sea whips (2)

Flinders Canyon Grids North

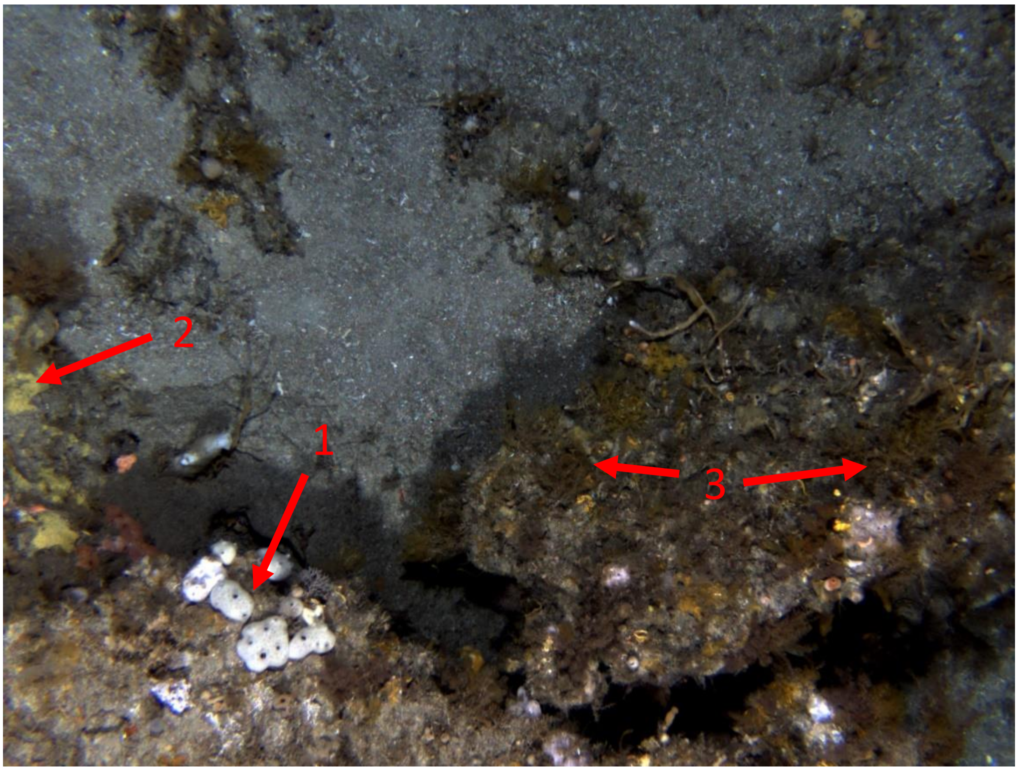
Example images from Flinders Canyon Grids North



Massive whie sponges (1), encrusting yellow sponge (2), soft bryozoans (3) and a red gurnard perch resting in a white barrel sponge (4)



Soft corals (1), tubular grey sponges (2) and arborescent yellow sponge (3)

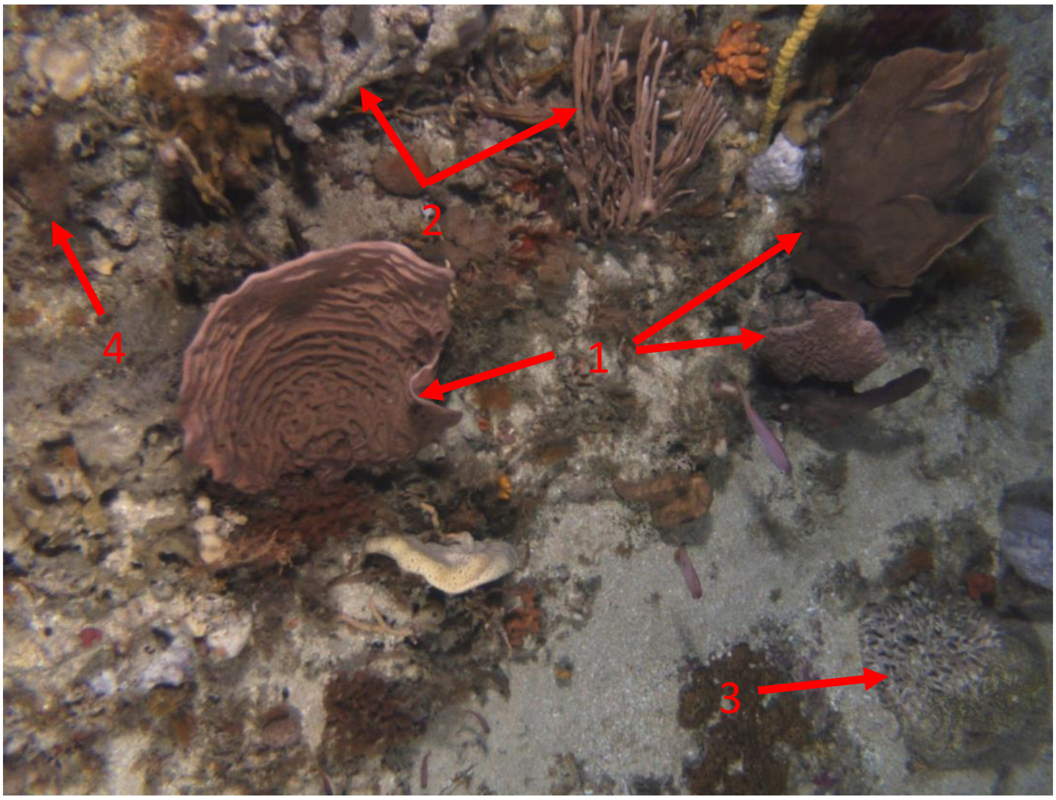


Massive white lumpy sponges (1), encrusting yellow sponge (2) and soft bryozoans (3)

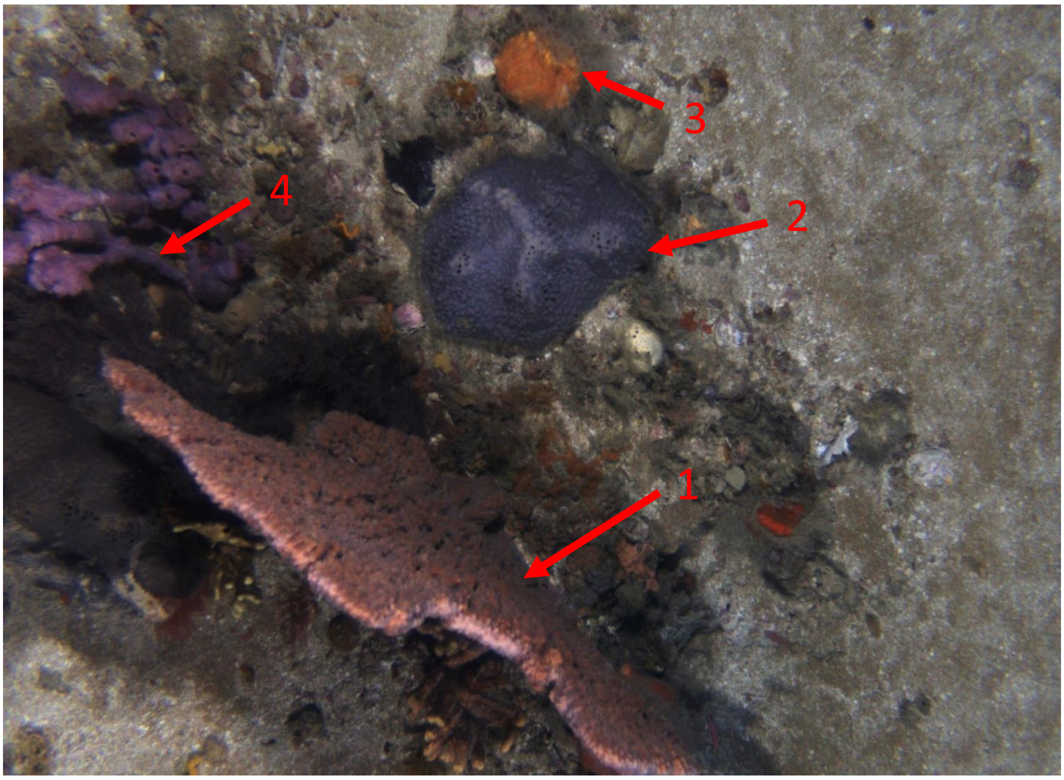
Brown cup sponge (1), massive white lumpy sponges (2) and soft bryozoans (3)

Beagle Mid Shelf 3

Example images from Beagle Mid Shelf 3



Pink fan sponges (1), arborescent sponges (2) and hard (3) and soft (4) bryozoans



Fan sponge (1), massive purple (2) and orange (3) sponges and purple stalked ascidian (4)

Large hard bryozoan (1) amongst shell and pebble

Port Jackson sharks

Appendix C: Potential indicators for the SE Marine Parks Network

Widespread indicators									
Indicator	**AMPs present**	**Has sites with relatively high cover (> 0.5%)**	**Low temporal variability**	**Long lived**	**Currently appears to be relatively stable**	**Likely to respond to warming**	**Likely to respond to trawling/potting**	**Likely to respond to storm events**	**Potential to be easily identified with AI**
Structure forming sponges (erect, massive, fan, cup) and corals	Tas Fracture, Huon, Freycinet, Flinders, Beagle	Yes	?	Yes	?	?	Yes	Yes	?
Cup Red Smooth	Tas Fracture (?), Huon, Freycinet, Flinders	Yes	Yes	Yes	Yes	Yes (bleaching)	Yes	?	Yes
Arborescent Orange	Tas Fracture, Huon, Freycinet, Flinders, Beagle	Yes	?	?	Yes	?	Yes	Yes	Yes
Arborescent Grey	Tas Fracture (?), Huon, Freycinet, Flinders	Yes	?	?	Yes	?	Yes	Yes	Yes
Cup Yellow	Tas Fracture (?), Huon, Freycinet, Flinders	No	Yes	Yes	Yes	Yes	Yes	?	Yes
Massive Purple	Tas Fracture (?), Huon, Freycinet, Flinders	Yes (?)	Yes	?	Yes	?	Yes	Yes	Yes
Gorgonian Red	Tas Fracture (?), Huon, Freycinet, Flinders	Yes	No	No (appears to have short lifespan)	No	Yes	Yes	?	Yes
Palmate grey sponge	Huon (2), Freycinet (1),	Yes (Huon only)	?	?	?	Yes	Yes	Yes	

	Flinders (4)								
Bryozoa hard stumpy	Flinders (4)	Yes (Flinders only)	?	?	Yes	Yes	?	Yes	
Bramble coral (A. kareni)	Flinders (4), Freycinet (1)	Yes (Flinders only and last survey has low cover)	No	?	Yes	Yes	?	?	
Encrusting coralline algae	Huon (2)	Yes	Yes	?	Yes	No	No	Yes	
Large gorgonian fans (e.g. Mopsella sp.)	Flinders (4), Freycinet (1), Beagle (1)	No	Yes	Yes	Yes	Yes	?	Yes	
Large black corals	Freycinet (1)	No	Yes	Yes	Yes	Yes	?	Yes	
Soft coral (Capnella like)	Flinders (2), Huon (2)	No	?	?	Yes	Yes	Yes	Yes	
Bramble coral (Acabaria sp.)	Flinders (3), Beagle (1)	No	?	?	Yes	Yes	Yes	Yes	
Laminar grey fungi sponge	Huon (2), Flinders (2), Beagle (1)	No	?	?	?	Yes	Yes	Yes	

Local indicators									
Indicator	**AMPs present (number of sites in brackets)**	**Has sites with relatively high cover (> 0.5%)**	**Low temporal variability**	**Long lived**	**Currently appears to be relatively stable**	**Likely to respond to warming**	**Likely to respond to trawling/potting**	**Likely to respond to storm events**	**Potential to be easily identified with AI**
Palmate grey sponge	Huon (2), Freycinet (1), Flinders (4)	Yes (Huon only)	?	?	Yes	?	Yes	Yes	Yes
Bryozoa hard stumpy	Flinders (4)	Yes (Flinders only)	?	?	Yes	Yes	Yes	?	Yes
Bramble coral (A. kareni)	Flinders (4), Freycinet (1)	Yes (Flinders only and last survey has low cover)	No	No (appears to have short lifespan)	No	Yes	Yes	?	?
Encrusting coralline algae	Huon (2)	Yes	Yes	?	Yes	Yes	No	No	Yes
Large gorgonian fans (e.g. Mopsella sp.)	Flinders (4), Freycinet (1), Beagle (1)	No	Yes	Yes	Yes(?)	Yes	Yes	?	Yes
Large black corals	Freycinet (1)	No	Yes	Yes	Yes(?)	Yes	Yes	?	Yes
Soft coral (Capnella like)	Flinders (2), Huon (2)	No	?	?	Yes(?)	Yes	Yes	Yes	Yes
Bramble coral (Acabaria sp.)	Flinders (3), Beagle (1)	No	?	?	No	Yes	Yes	Yes	Yes
Laminar grey fungi sponge	Huon (2), Flinders (2), Beagle (1)	No	?	?	?	?	Yes	Yes	Yes

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