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Prediction of species distributions across the offshore Kimberley region.

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WAMSI Kimberley Marine Research Program

Final Report

Subproject 1.1.1.6

September 2018

WESTERN AUSTRALIAN MARINE SCIENCE INSTITUTION

CSIRO

WAMSI Kimberley Marine Research Program

Initiated with the support of the State Government as part of the Kimberley Science and Conservation Strategy, the Kimberley Marine Research Program is co-invested by the WAMSI partners to provide regional understanding and baseline knowledge about the Kimberley marine environment. The program has been created in response to the extraordinary, unspoilt wilderness value of the Kimberley and increasing pressure for development in this region. The purpose is to provide science based information to support decision making in relation to the Kimberley marine park network, other conservation activities and future development proposals.

Front cover images (L-R)

Image 1: Satellite image of the Kimberley coastline (Image: Landgate)

Image 2: A very narrow band of more abundant and diverse corals was found at the very edge of the fringing reef system (AIMS)

Image 3: Humpback whale breaching (Image: Pam Osborn)

Image 4: Figure 10. Predicted distribution of sponges throughout the study region. (Extracted from subproject report 1.1.1.6)

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Contents

Executive Summary

Analysis of species data from epibenthic sled samples and habitat morphotypes from tow video, against a suite of environmental variables, at three locations in the Kimberley provided broader regional distribution maps for 160 species and 21 habitat components. Individual species exhibited a wide variety of distribution patterns: e.g. inshore, offshore, northern, southern, widespread or localised and patchy. These data provide a synopsis of the current ecological condition of the region, and also strengthen understanding of linkages between ecological attributes and the environmental processes that affect them.

Management implications

The outputs from this study can be used to support a range of spatial planning, monitoring, assessment and management applications across the region, including for conservation, assessments of current uses, and provide a foundation for evaluating future proposed activities or developments — or the potential consequences of global drivers such as climate change — thus providing lasting benefits. The outputs will also enable spatial analyses of the overlap of human uses with multiple levels of biodiversity, permitting ecological risk assessments and, for some types of uses, fully quantitative assessments of their sustainability.

1 Introduction

Planning, assessment and management of the marine environment requires an essential base level of understanding about the distribution of species and habitats. Habitat is a key determinant of population structures and properly identifying drivers of biological response. Previous reports have dealt with the taxonomic biodiversity found within the three survey areas; Camden Sound, the Maret Islands and the Eclipse Archipelago (1.1.1.4) and the distribution of habitats and habitat/species assemblages at the regional scale. The objectives of this component of the study were to analyse the distribution patterns of multiple species and habitat forming biota across the broader region, in relation to environmental gradients, and to predict and map their spatial distribution and extent.

2 Methods

2.1 Collection of epibenthic sled and tow video data

Epibenthic sleds deployed from RV Solander (AIMS) and RV Linnaeus (CSIRO) were used to quantitatively sample epibenthic biota at 104 sites in the Camden Sound, Eclipse Archipelago and Maret Island areas during 2015 and 2016. Seabed habitat data were acquired more broadly in the same areas during voyages of the same vessels in 2014, 2015 and 2016, using towed video and scoring cover of components of habitat in real time using the "tappity" method. These field methods are described in detail in 1.1.1.1 Chapter 3. Sampling design methods are described in 1.1.1.1 Chapter 2.

2.2 Environmental data

For the purpose of species distribution modelling, up to 41 environmental variables mapped on a 0.01 degree grid for the entire Australian EEZ were available from a series of previous projects (see 1.1.1.5 for details). The most recent updated version was provided by Pitcher et al. (2018) and used herein.

2.3 Ecological modelling

The methods follow closely those used in Pitcher et al. (2017) to provide regional predicted distribution maps of >180 species across the Pilbara shelf region. After species sorting and identification of the new sled samples was completed, the distributions of species occurring sufficiently frequently for analysis were modelled. Predicted distributions of selected individual species (those with successful prediction models) were also mapped. Similarly, selected biological habitat morphotypes and observed benthos taxa recorded in the tow-video 'tappity' data were also modelled and mapped.

Univariate modelling was conducted using Random Forests (Breiman 2001), a bootstrapped tree-based method recognised for its prediction modelling power. Analyses were implemented in the R computing environment (R Core Team, 2015) using package 'randomForest' (Liaw & Wiener, 2002). Importance of each predictor was calculated as the increase in Out-of-Bag (OOB) mean squared error (%IncMSE) when the values of the predictor were randomly permuted. Model performance (measured by OOB R^2) was improved in all analyses by iteratively excluding predictors with low importance until OOB R^2 stopped improving. Model complexity, in terms of the number of terminal nodes of trees ('maxnodes') was optimized by iteratively fitting RFs with maxnodes increasing from 1 up to N/5, then selecting the number of terminal nodes associated with the highest OOB R^2 for the final model. Successful models (positive cross-validated OOB R^2) were used to predict and map the distribution of species on the regional-scale grid of environmental variables.

3 Results and Discussion

3.1 Results of species distribution modeling

Successful species distribution models and maps were generated for 160 sled species/taxa of 314 genera that met the minimum occurrence criterion of being sampled at ≥5 sites. Note that the majority of species (1010 of 1324) were too rare for analyses; most occurred only once. A successful model is defined as being able to predict held-out data better than random in cross-validation tests. This is not the same as model fit to the data or "explained variation", which was generally around 50–85% for most successful models (even for some models with unsuccessful prediction performance). Nevertheless, a substantive number of unsuccessful models could not fit the data better than the overall mean. Most models of video biological morphotype distributions were successful (21 of 24). Explained variation was generally around 75–90%. The prediction performance of the species distribution models is summarized in Figure 1. While many successful models (R sqd > 0) were relatively weak, prediction performance typically ranged up to 10–50% (max: 67%) for sleds and up to 30–55% (max: 56%) for videos.

Sled: Video:

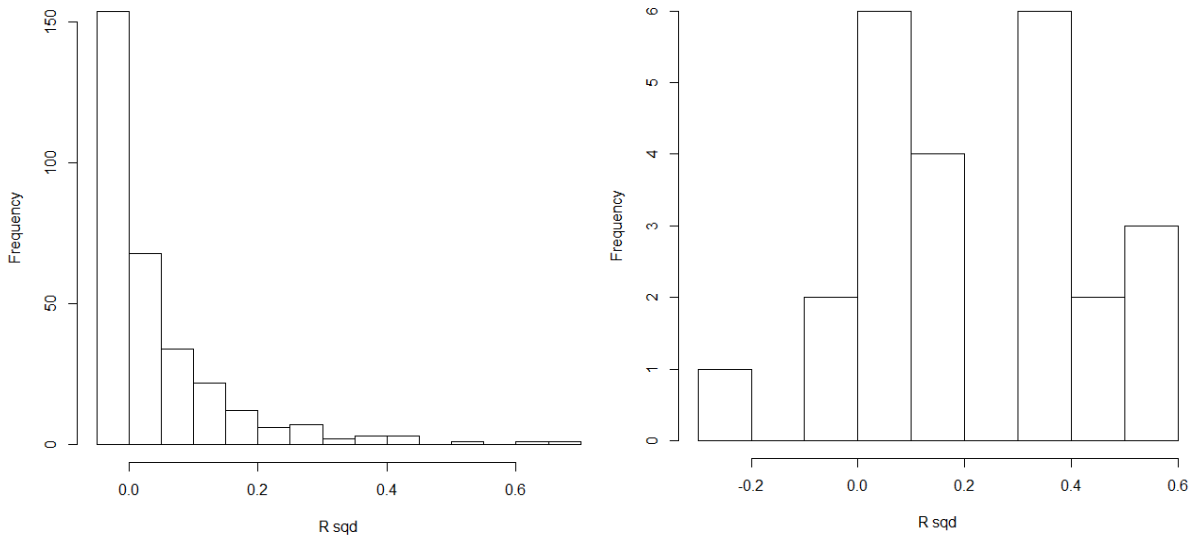


Figure 1. Histograms of sled species & video morphotype distribution models prediction performance (R squared) on held out samples.

3.2 Maps of species distribution model predictions

Distribution maps were predicted for 160 species (or taxa) (Table 1) and these are presented in Figures 3 to 21. A key to interpreting the maps is given in Figure 2. The maps indicate species or taxa names, frequency of occurrence in sled or video data, names of useful predictors in order of importance, cross-validated model performance, and model complexity (as indicated by the number of predictors and number of terminal nodes [tree branches]). The maps demonstrate that different species are associated with different environmental variables and so have different distributions — even similar, congeneric species, thus emphasizing the importance of species level identifications where possible

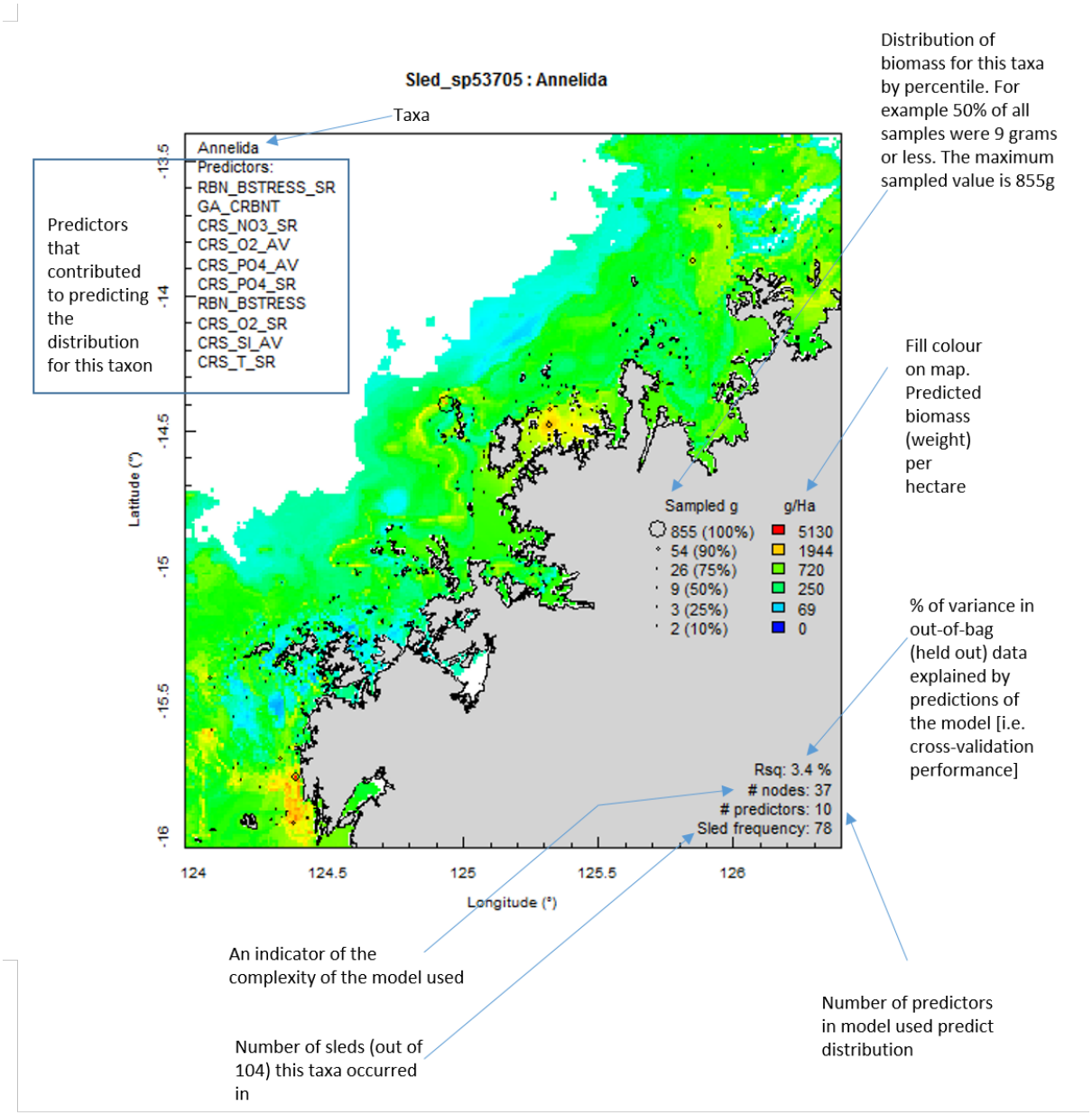


Figure 2. Example of species prediction map with explanation of the annotations.

3.3 Echinoderms

Echinoderms showed a high level of predictability with 48 species out of a total of 160 species (or 30% of all taxa) for which there were successful models (Figures 3 to 9).

3.4 Phylum Echinodermata: Class Crinoidea

Crinoids were identified in both tow videos (as a class level category) and in sleds. In general, most crinoids were identified to species. The model of crinoid distribution from the video data had an R square of 30.2% and indicates an increasing abundance with increasing distance offshore and with the highest abundance in the northern survey area around Eclipse Archipelago (Figure 3).

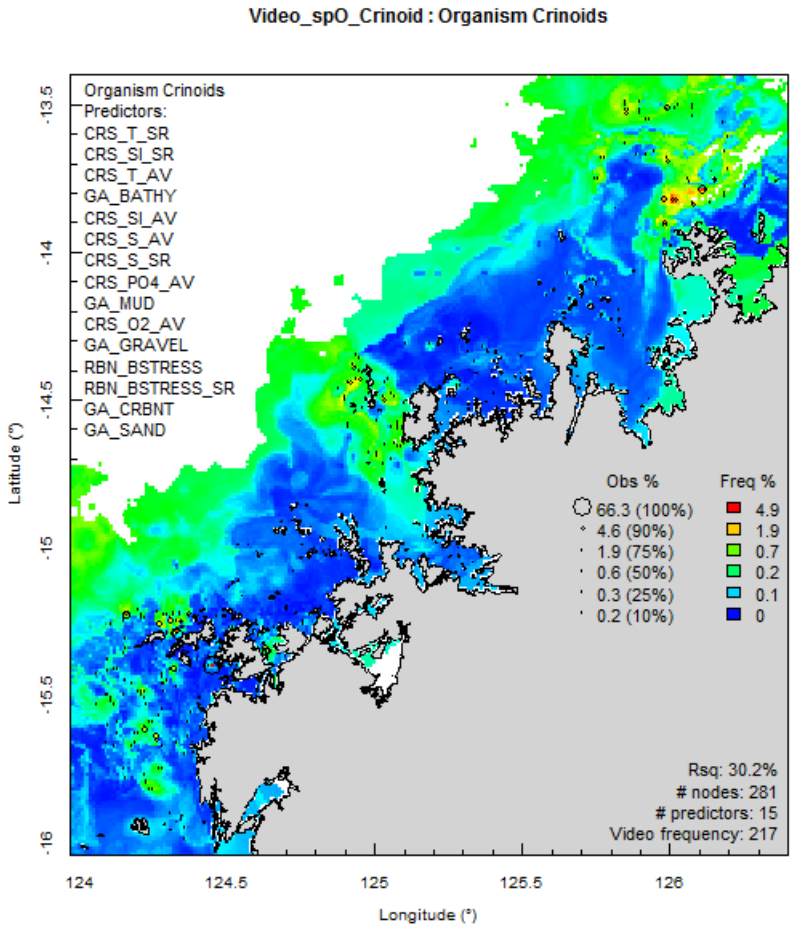


Figure 3. Predicted distribution of crinoids throughout the study region based on tow video transects.

From the sled data, 15 crinoid species had successful species distribution models with R squares ranging from 0.7 to 53 % although only *Zygometra elegans* had an R square less than 5% (Figure 4). Most species showed a similar pattern with increasing abundance with distance offshore and highest abundances in the northern study area around Eclipse Archipelago. An exception was *Heterometra crenulata* which were predicted to have higher abundances in the central and in particular the southern study area of Camden Sound. *Comanthus gisleni* had the best performing model (R square of 53%) with seasonal temperature range and bathymetry the best predictors of abundance (Figure 4).

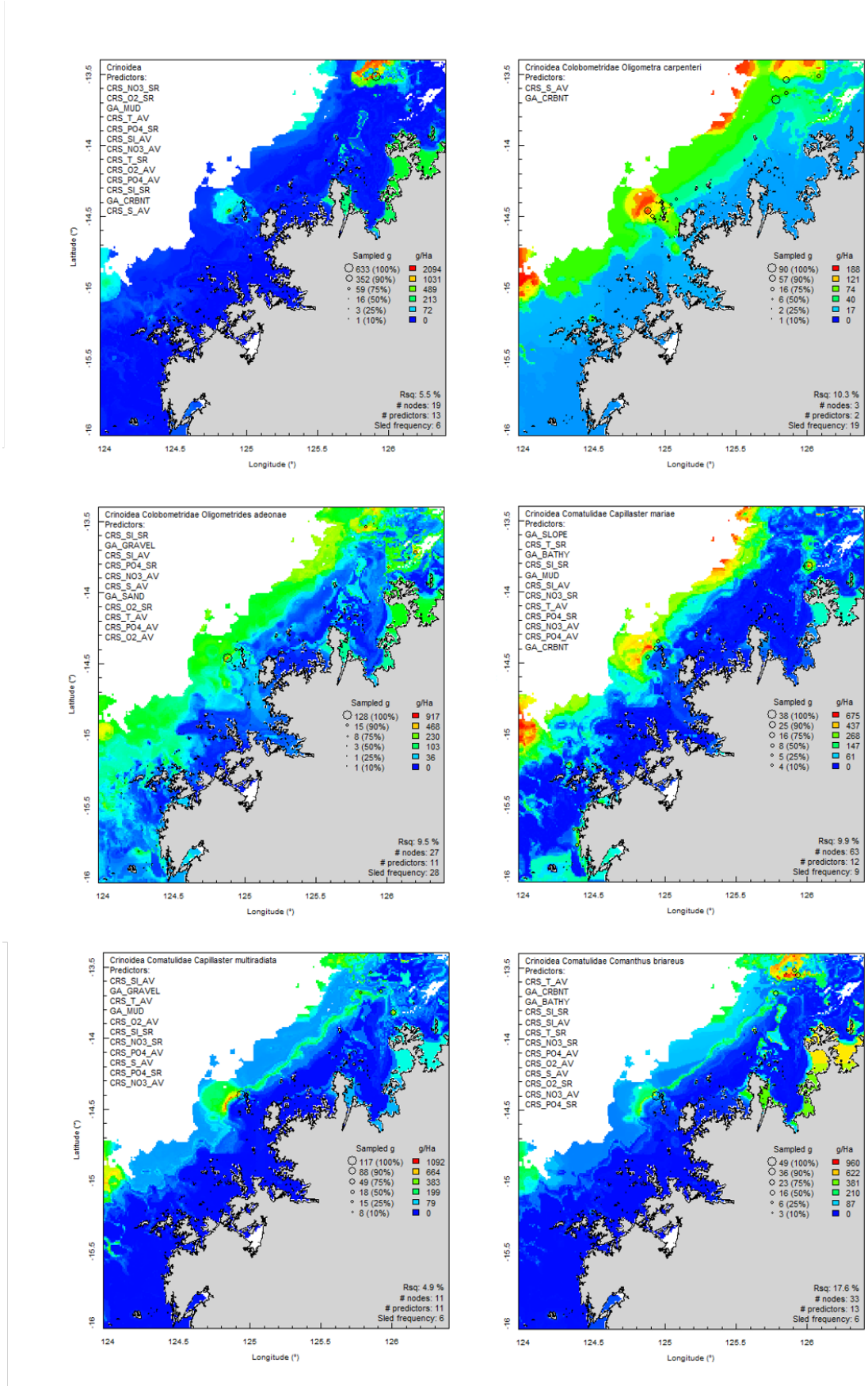


Figure 4. Predicted distribution of selected crinoid taxa throughout the study region based on sled samples. Top left figure is for all crinoids not identified beyond Class level.

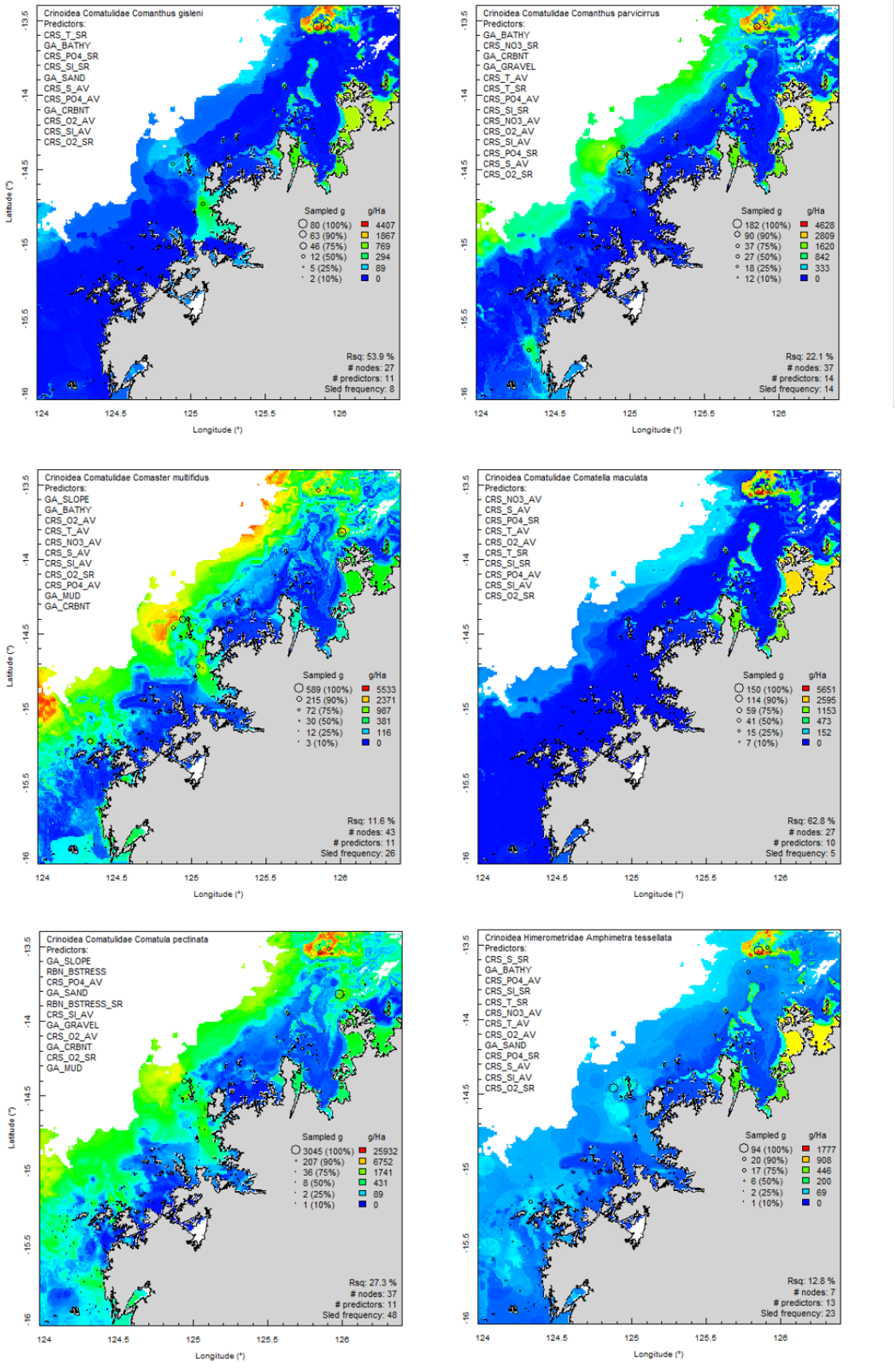


Figure 4 (continued). Predicted distribution of selected crinoid taxa throughout the study region based on sled samples.

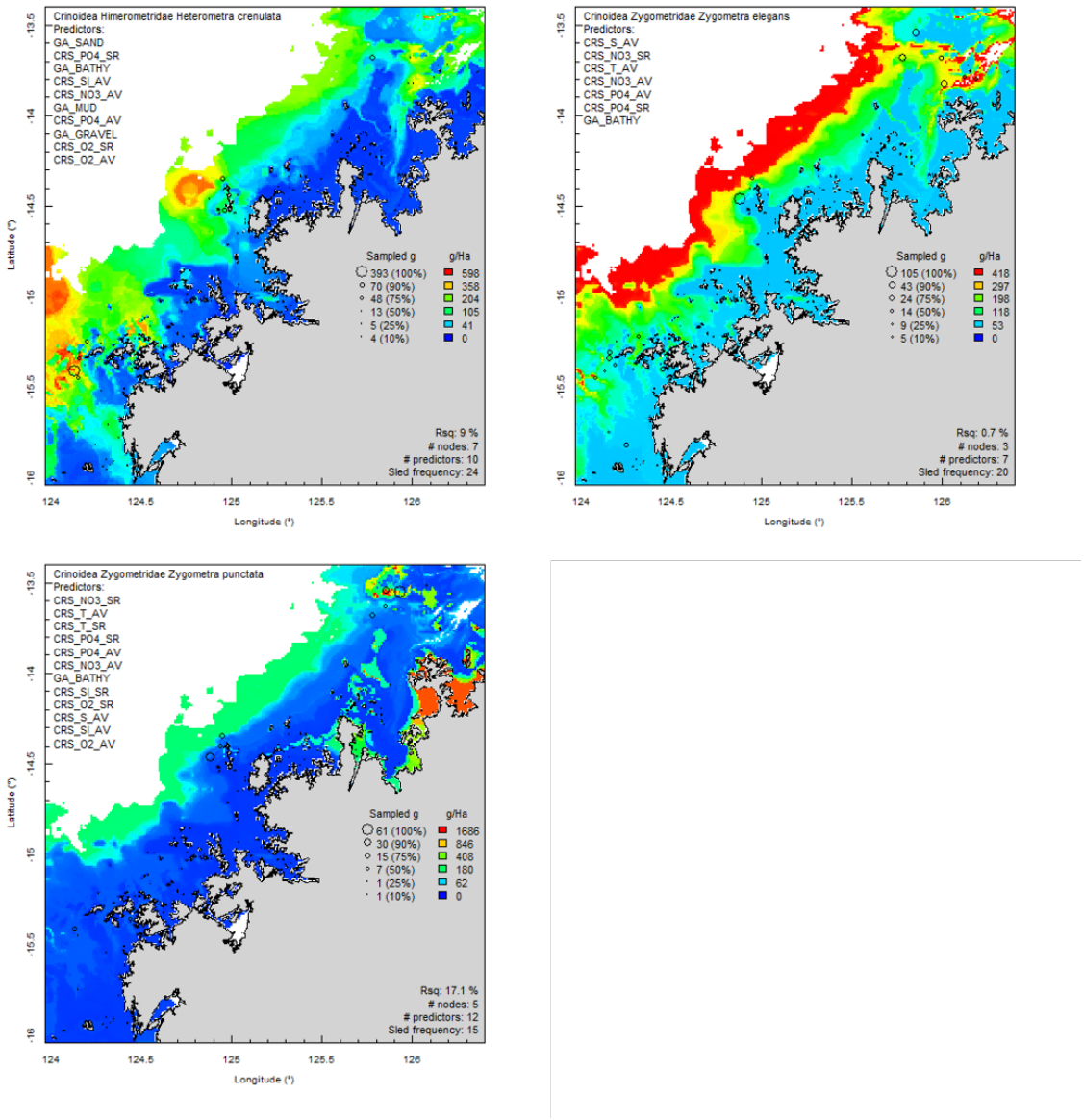


Figure 4 (continued). Predicted distribution of selected crinoid taxa throughout the study region based on sled samples

3.5 Phylum Echinodermata: Class Asteroidea

Asteroids had in general lower levels of predictability, just three species and R square values of 1.5 – 4.6 % (Figure 5). *Goniosdiscaster rugosus* was predicted mainly in the more offshore stations suggestion we sampled on the shallowest distribution of this species and *Iconaster longimanus* had a predominantly northern distribution most strongly influenced by bathymetry.

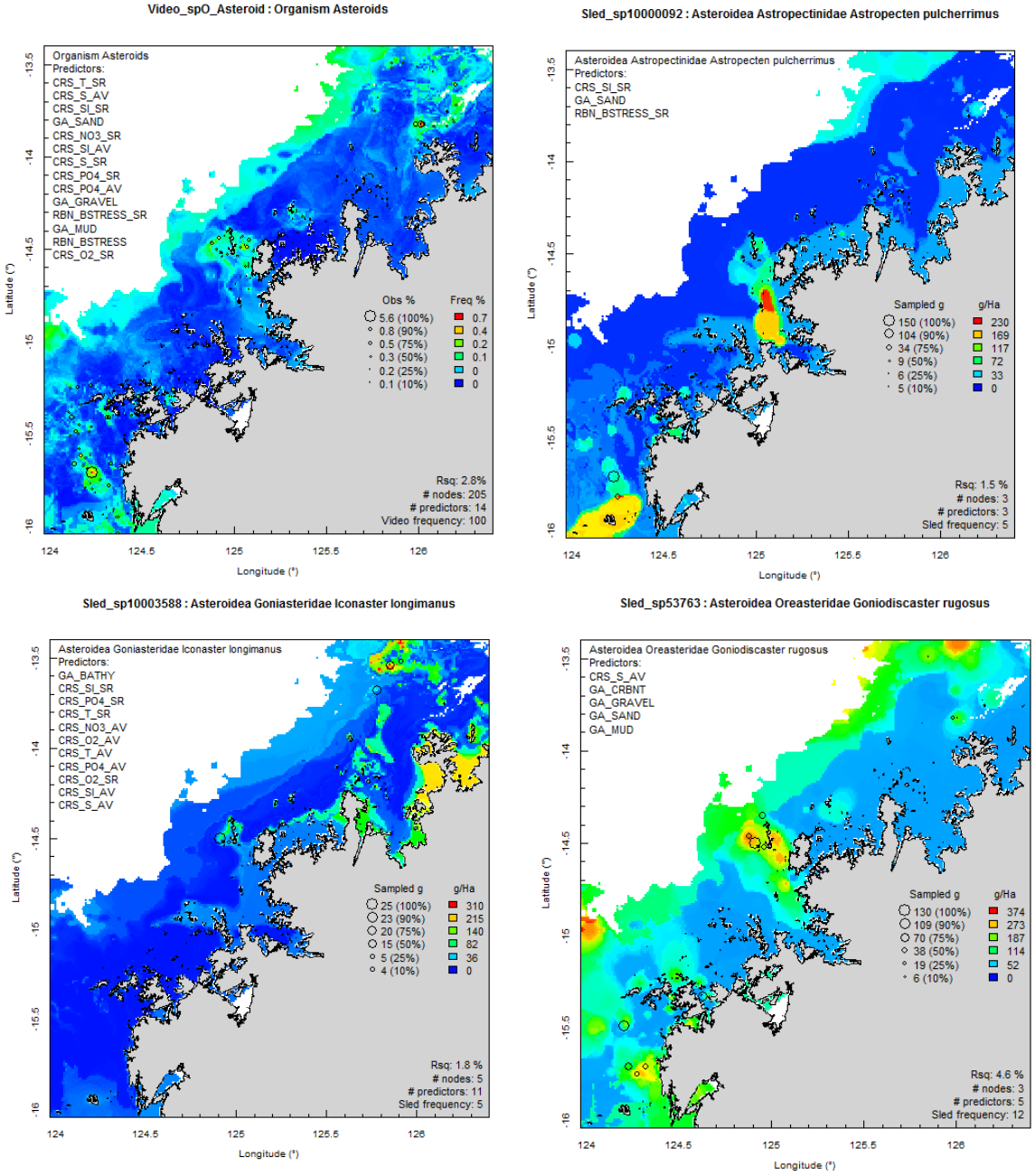


Figure 5 Predicted distribution of selected asteroid taxa throughout the study region based on videos (top left) and sled samples (other 3 panels).

3.6 Phylum Echinodermata: Class Ophiuroidea

Of the six ophiuroids species with predicted distributions, three species have quite high R squared values (19-40%) indicating a high level of confidence in those models. *Ophiochasma stellata* was predicted to have a strongly southern distribution influenced mostly strongly by temperature, sediment carbonate and bathymetry.

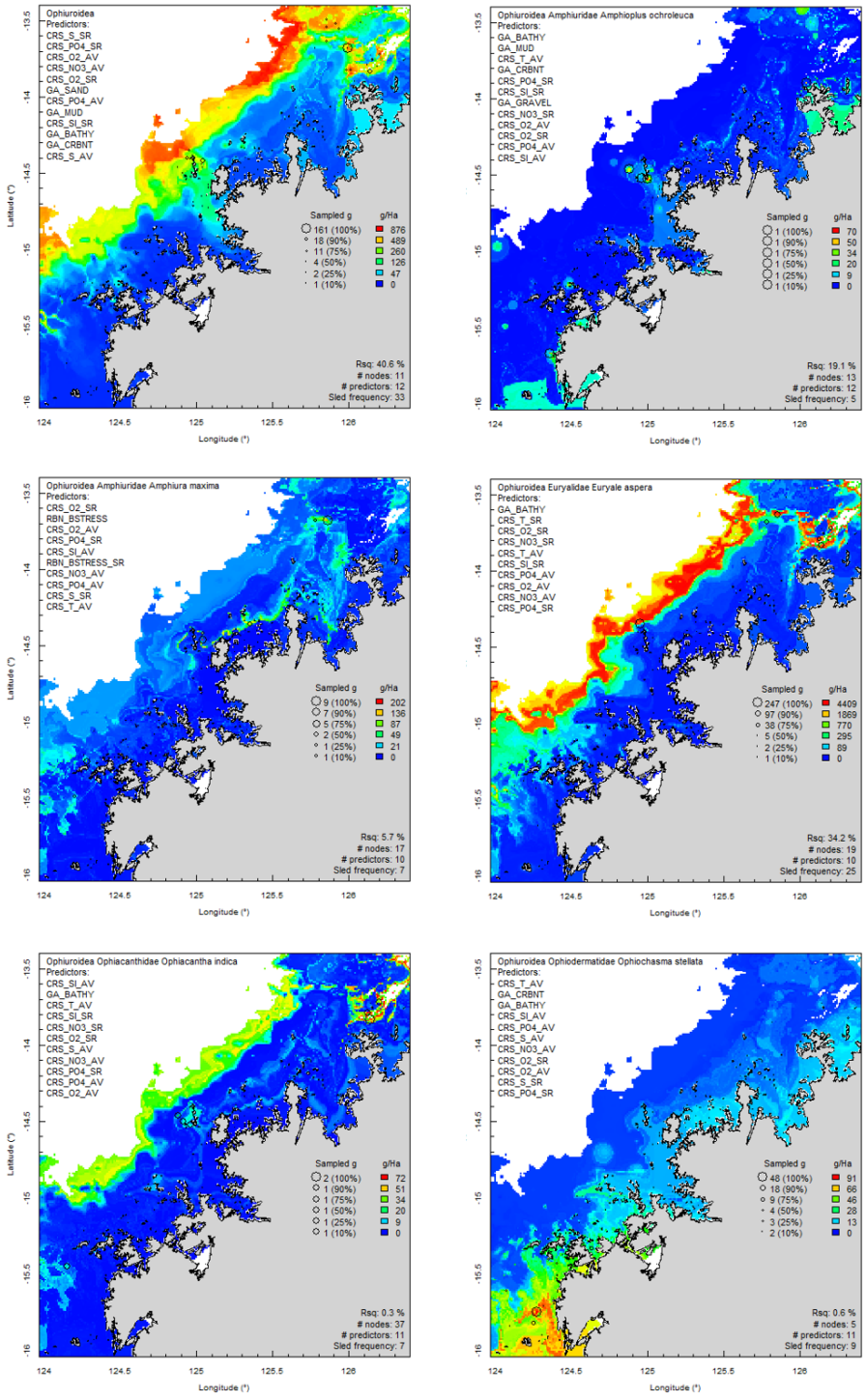


Figure 6. Predicted distribution of selected ophiuroid taxa throughout the study region based on sled samples. The top left figure includes all ophiuroids not identified beyond class level.

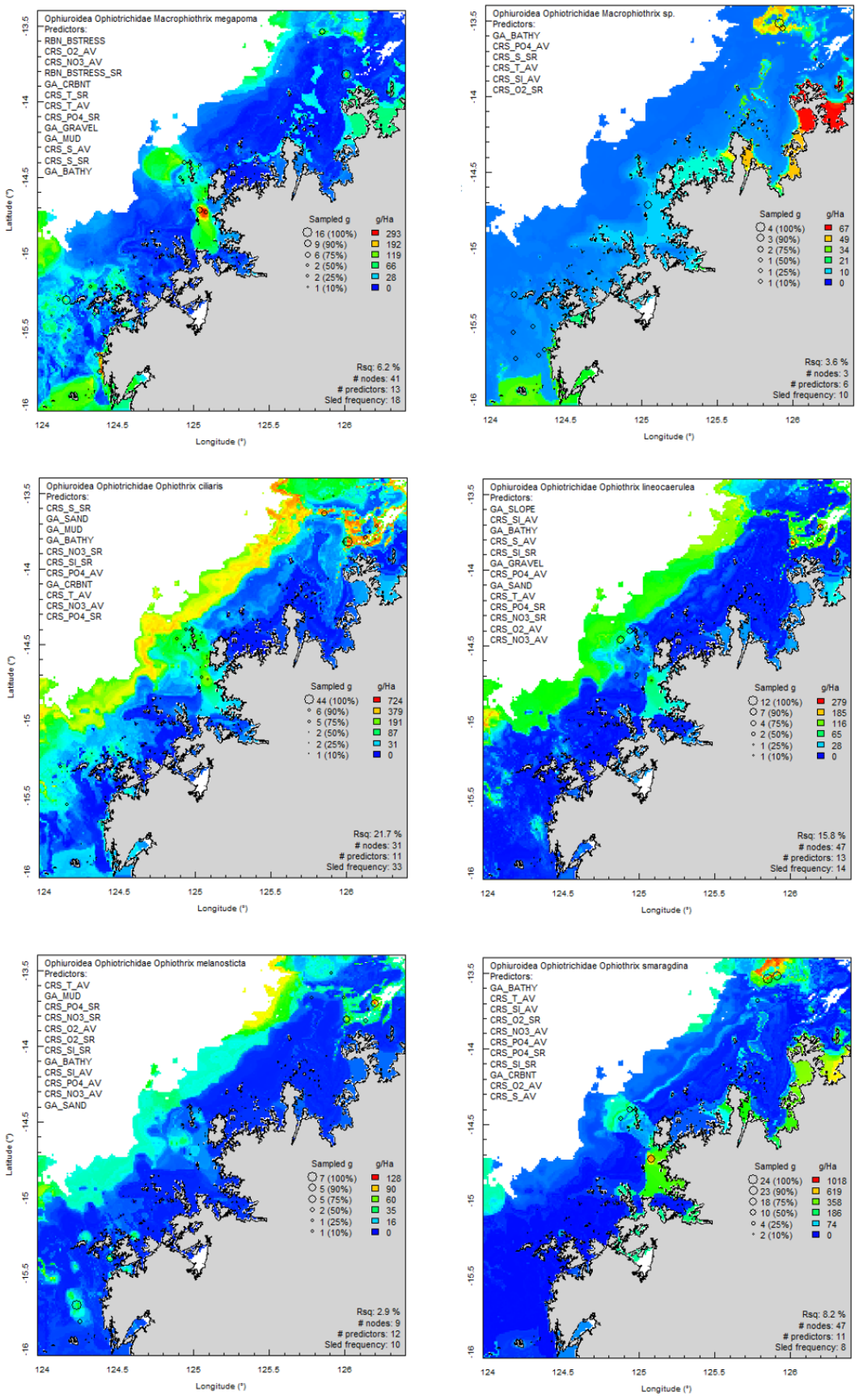


Figure 6 (continued). Predicted distribution of selected ophiuroid taxa throughout the study region based on sled samples

3.7 Phylum Echinodermata: Class Echinoidea

The highest level of predictive ability for echinoids was for *Temnotrema bothryoides* (R square = 67%) which had a strongly northern distribution and was most influenced by nutrients and temperature. On the other hand *Prionocidaris bispinosa* had a more strongly southern distribution. Among the irregular urchins which are soft sediment burrowers *Breynia desori* had a more southern distribution while *Brissopsis luzonica* had a more northerly predicted distribution.

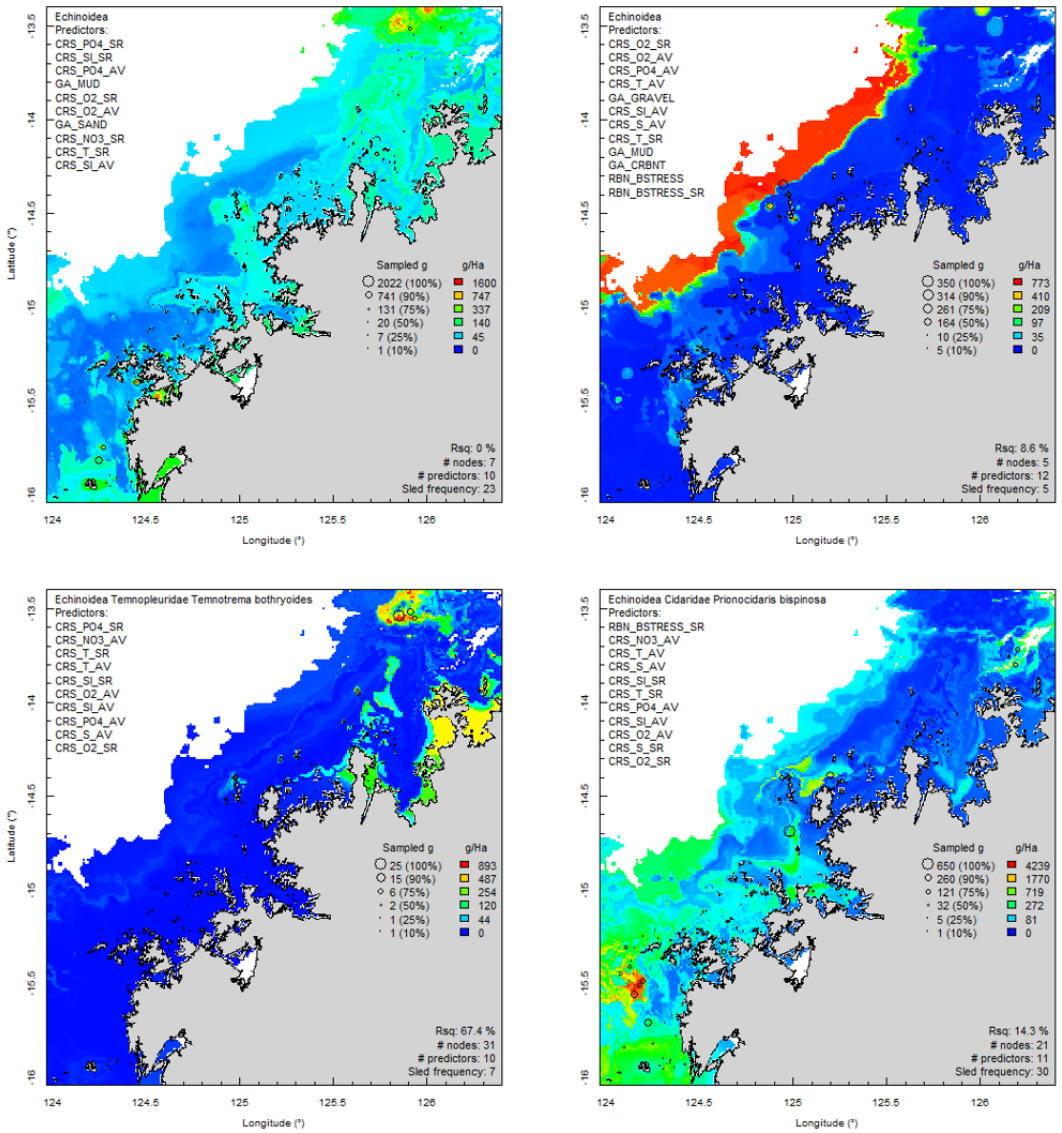


Figure 7. Predicted distribution of selected echinoid taxa throughout the study region based on sled samples. Top left is for all echinoids not identified beyond class and top right are all echinoids not identified beyond subclass (Euechinoidea).

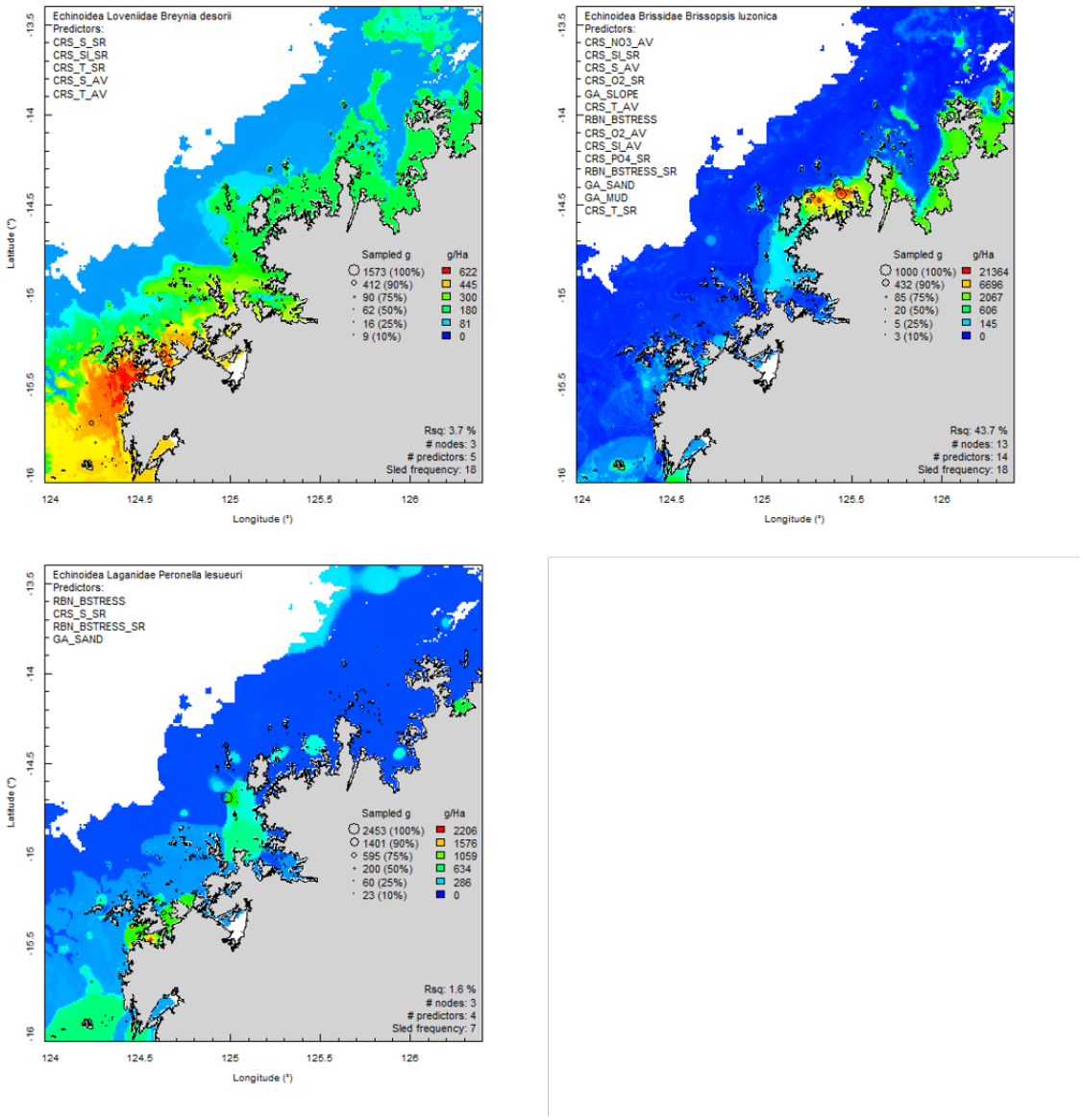


Figure 7 (continued). Predicted distribution of selected echinoid taxa throughout the study region based on sled samples

3.8 Echinoids and bioturbated habitat

There was a modest agreement among the extent of bioturbated habitat and urchin abundance predicted from the tow video stations (Figure 8) indicating the importance of urchins, particularly heart urchins as bioturbators. *Breynia desori* in particular is known to be a very abundant and important bioturbator in southern Kimberley (Keesing et al. 2011; Keesing and Irvine 2013). The models for both bioturbated habitat (R square = 48%) and echinoid occurrence (R square = 36%) performed well.

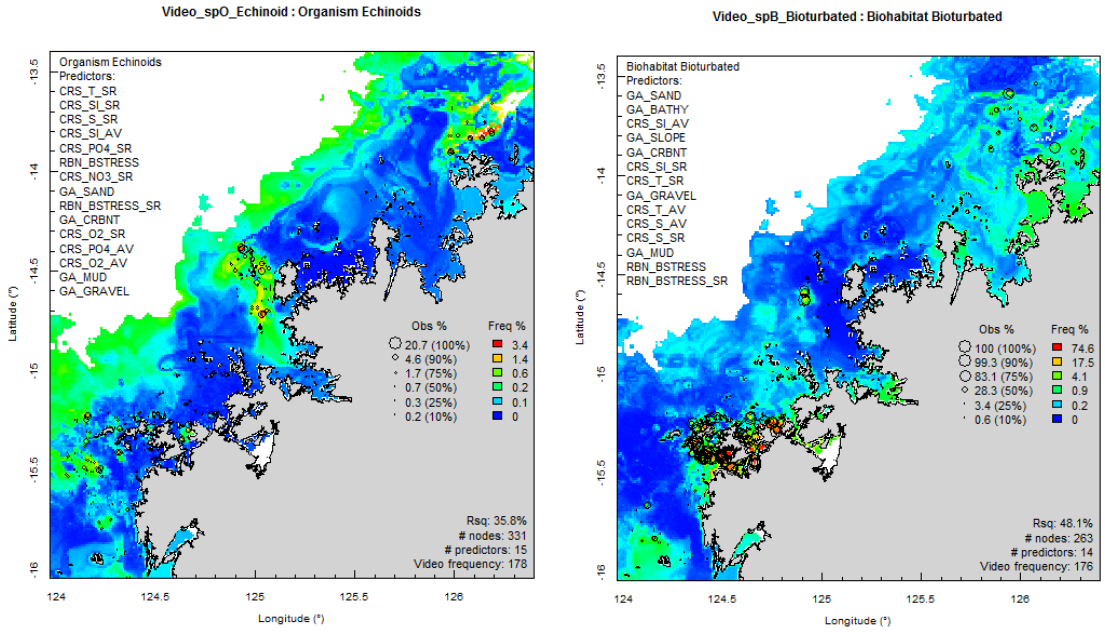


Figure 8. Predicted distribution of selected echinoid taxa and bioturbated habitat throughout the study region based on tow video transects

3.9 Phylum Echinodermata: Class Holothuroidea

Ten species of sea cucumbers had successful models (Figure 9) with most showing a trend of increasing abundance with distance offshore although some also had a higher predicted abundance in the northern area of the study. This was consistent with that predicted from the video data (Figure 9).

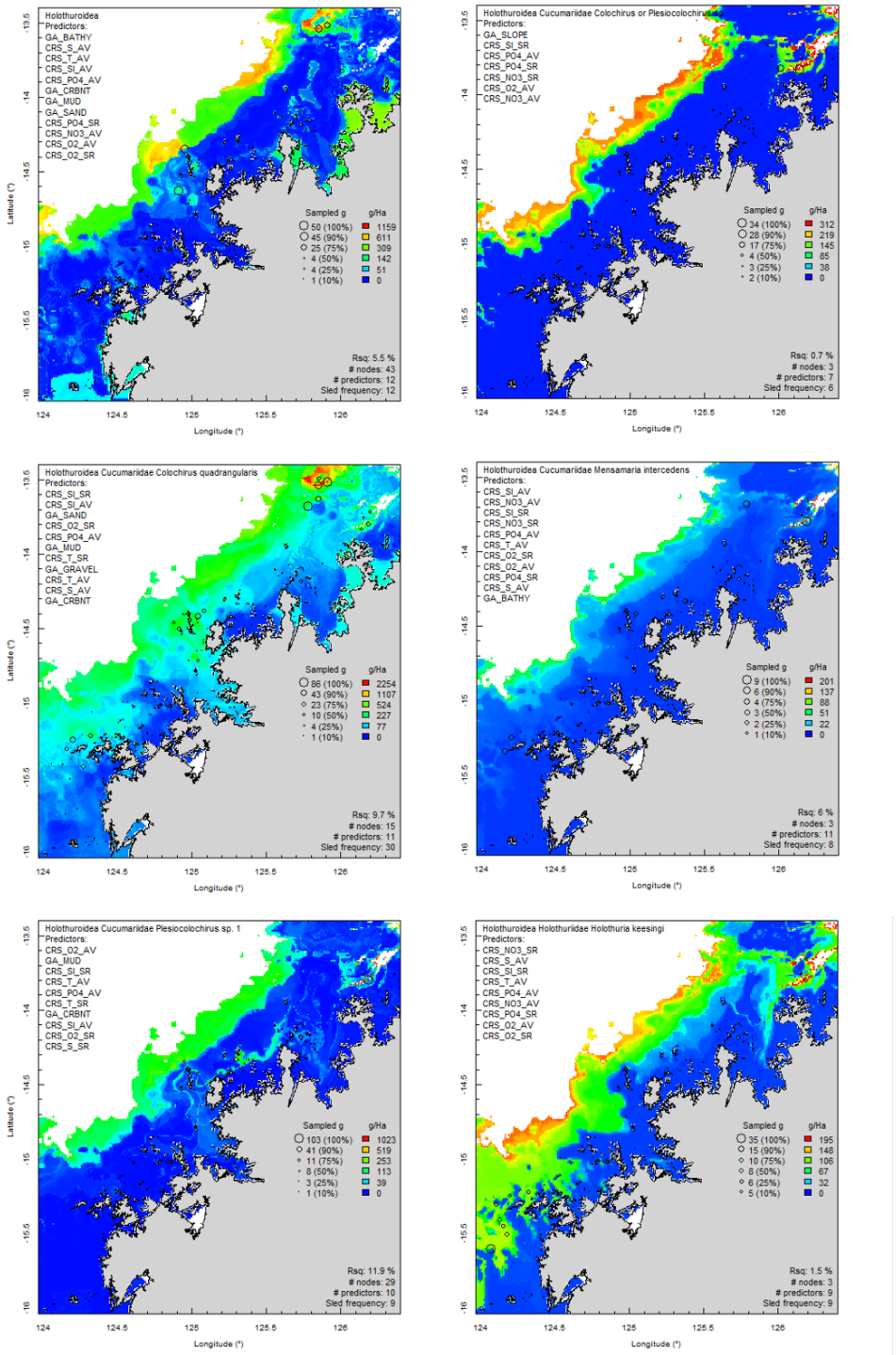
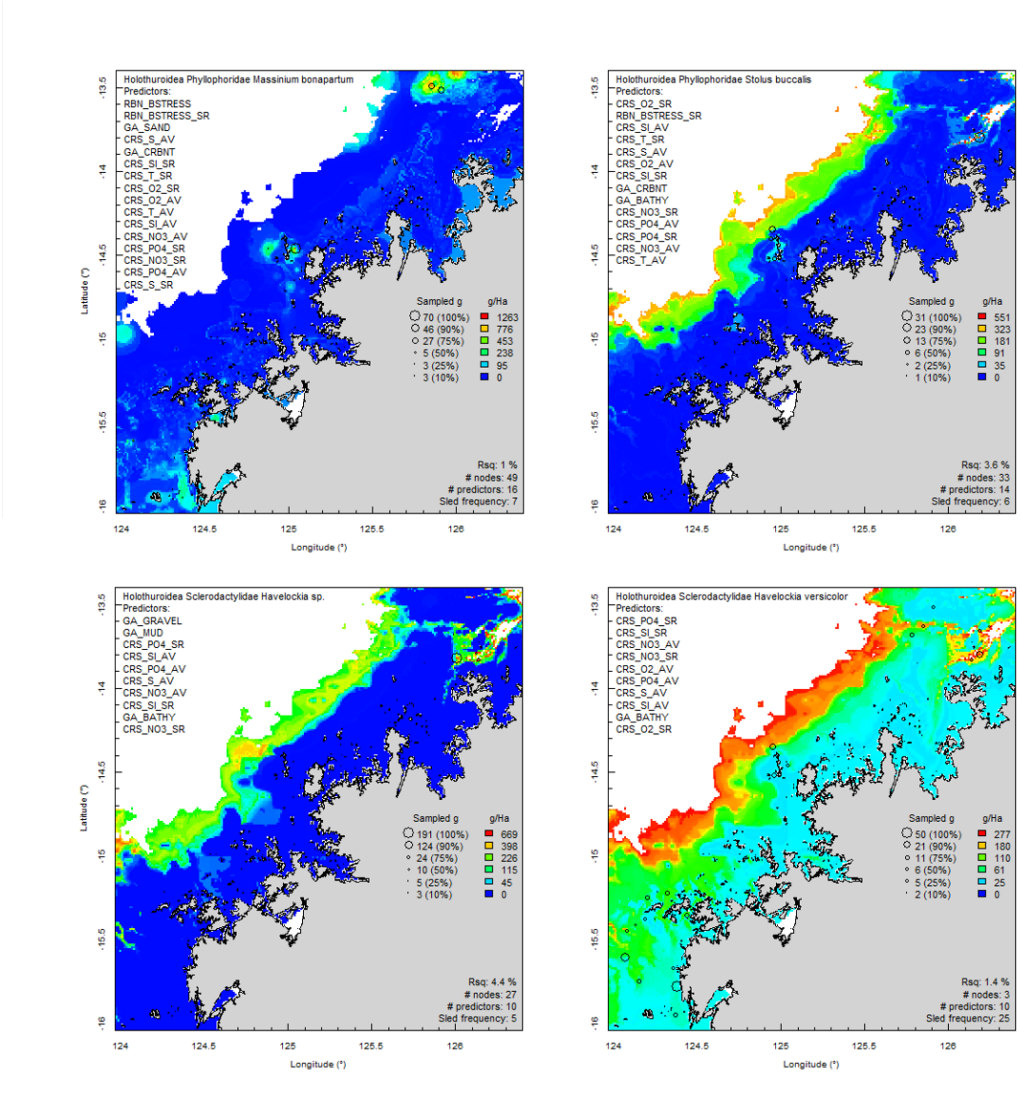


Figure 9. Predicted distribution of selected holothuroid taxa throughout the study region based on sled samples. Top left figure includes all holothurians not identified beyond class.



Video_spO_Holothurian : Organism Holothurians

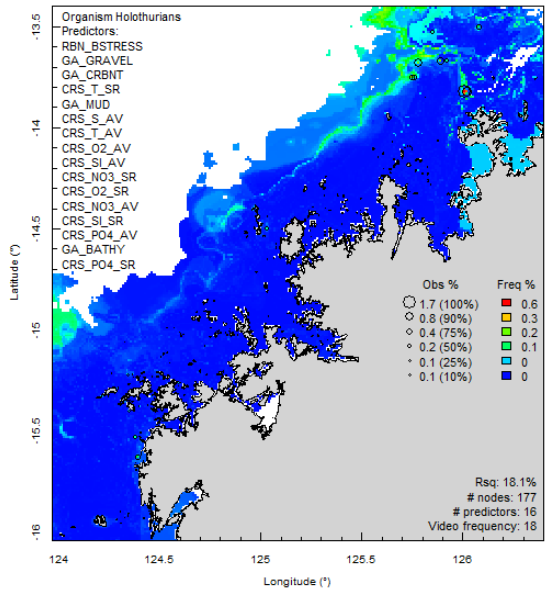


Figure 9 (continued). Predicted distribution of selected holothuroid taxa throughout the study region based on sled samples (top 4 panels) and video (bottom panel).

3.10 Sponges

Sponges are the main habitat forming invertebrate taxa in the subtidal areas of the Kimberley surveyed in this project. Figure 10 shows their overall predicted distribution based on the tow video transects. Predictability was high (R square = 56%). Sponges were important at all three survey locations and the best predictors included substrate type, bottom stress and a range of water column properties such as silicate, phosphate, temperature and oxygen.

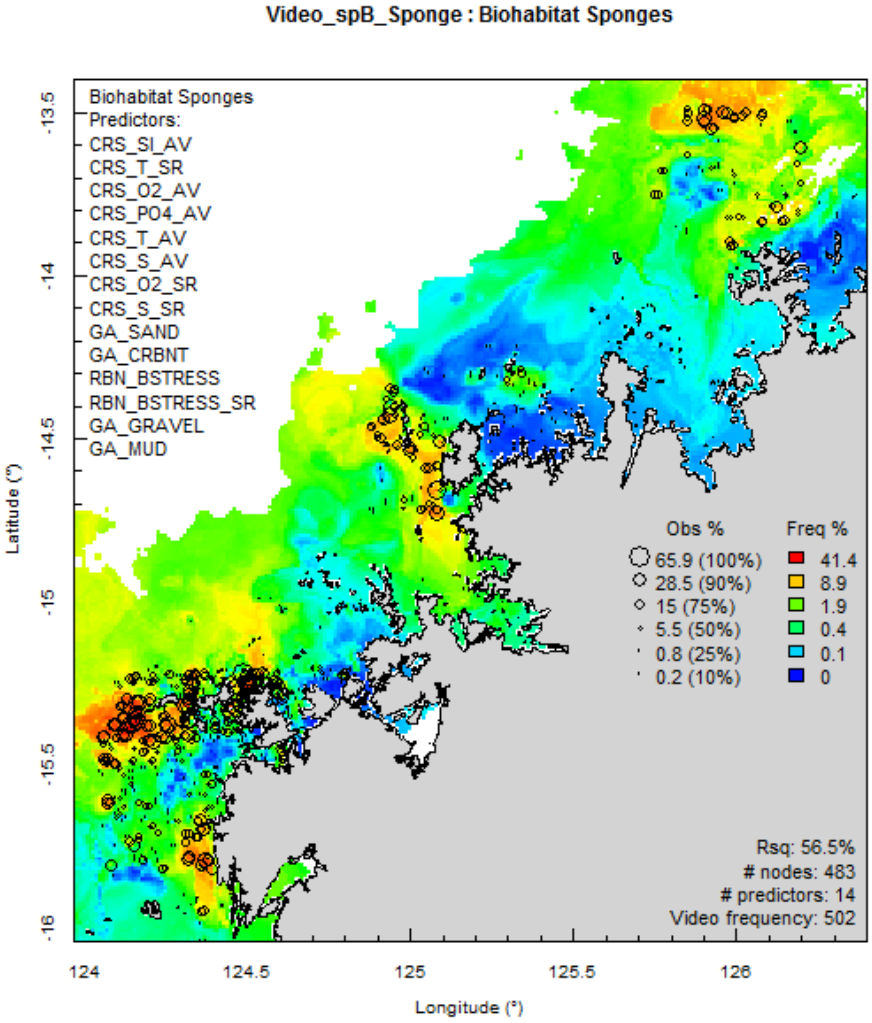


Figure 10. Predicted distribution of sponges throughout the study region based on video transects.

There are predicted distributions given for 50 species/taxa of sponges shown in Figure 11 with *Axinella* sp. having the highest level of predictability (R square = 42%). This species had a markedly shallow, northerly distribution and predictors included bathymetry and temperature. Other species also show quite heterogeneous distributions with strong spatial patterns or concentrated distributions. A number of species including *Stelletta* sp., *Raspalia australensis* and *Pseudoceratina* sp. have a predominantly offshore distribution while *Stelletta* sp SS11 has a more southern distribution. *Arcarnus thielei* and *Axinella aruensis* have distributions mostly centred on the area between Bigge Island and the Coronation Islands.

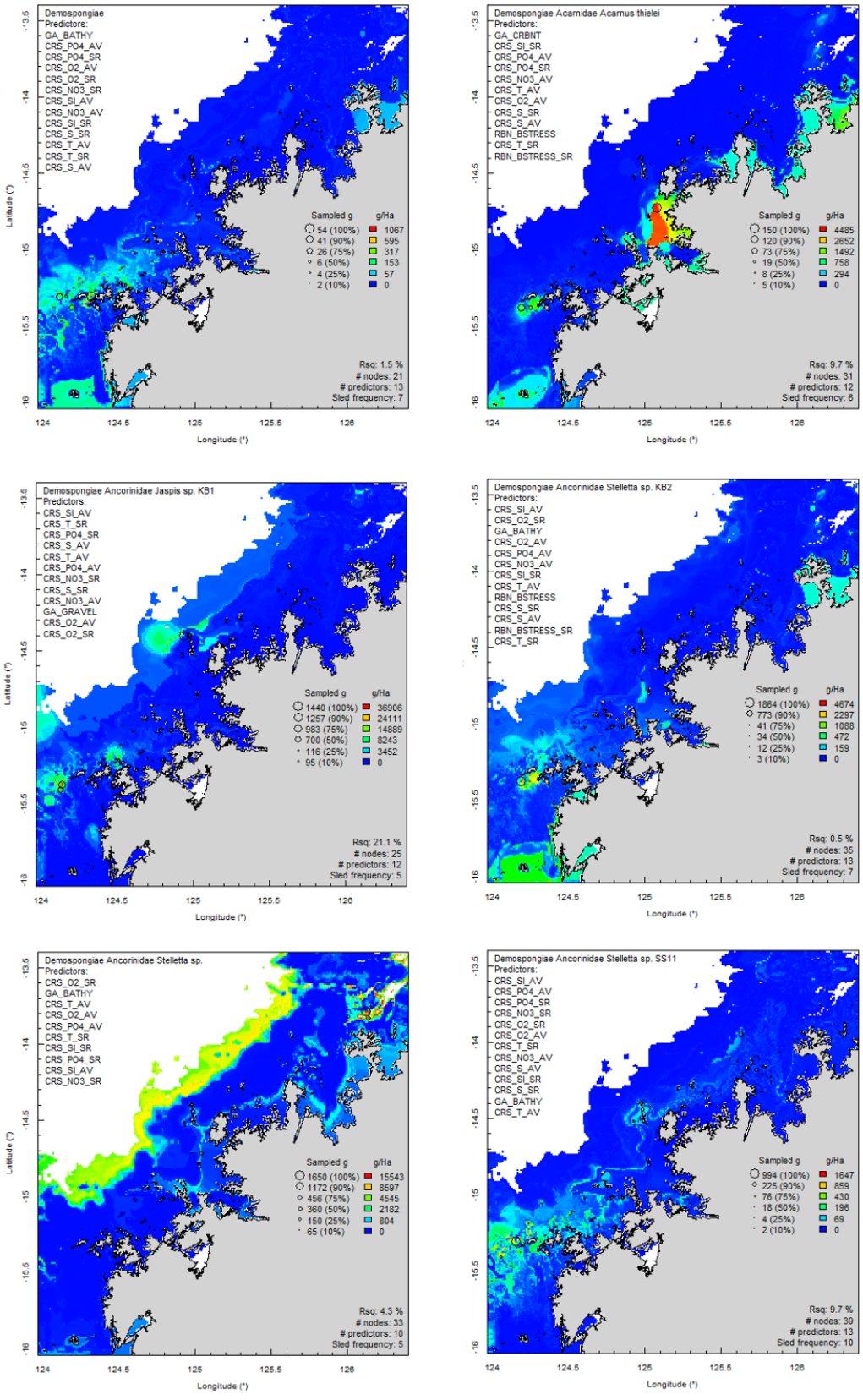


Figure 11. Predicted distribution of selected sponge taxa throughout the study region based on sled samples. The top left figure is sponges not identified beyond Order Dendroceratida.

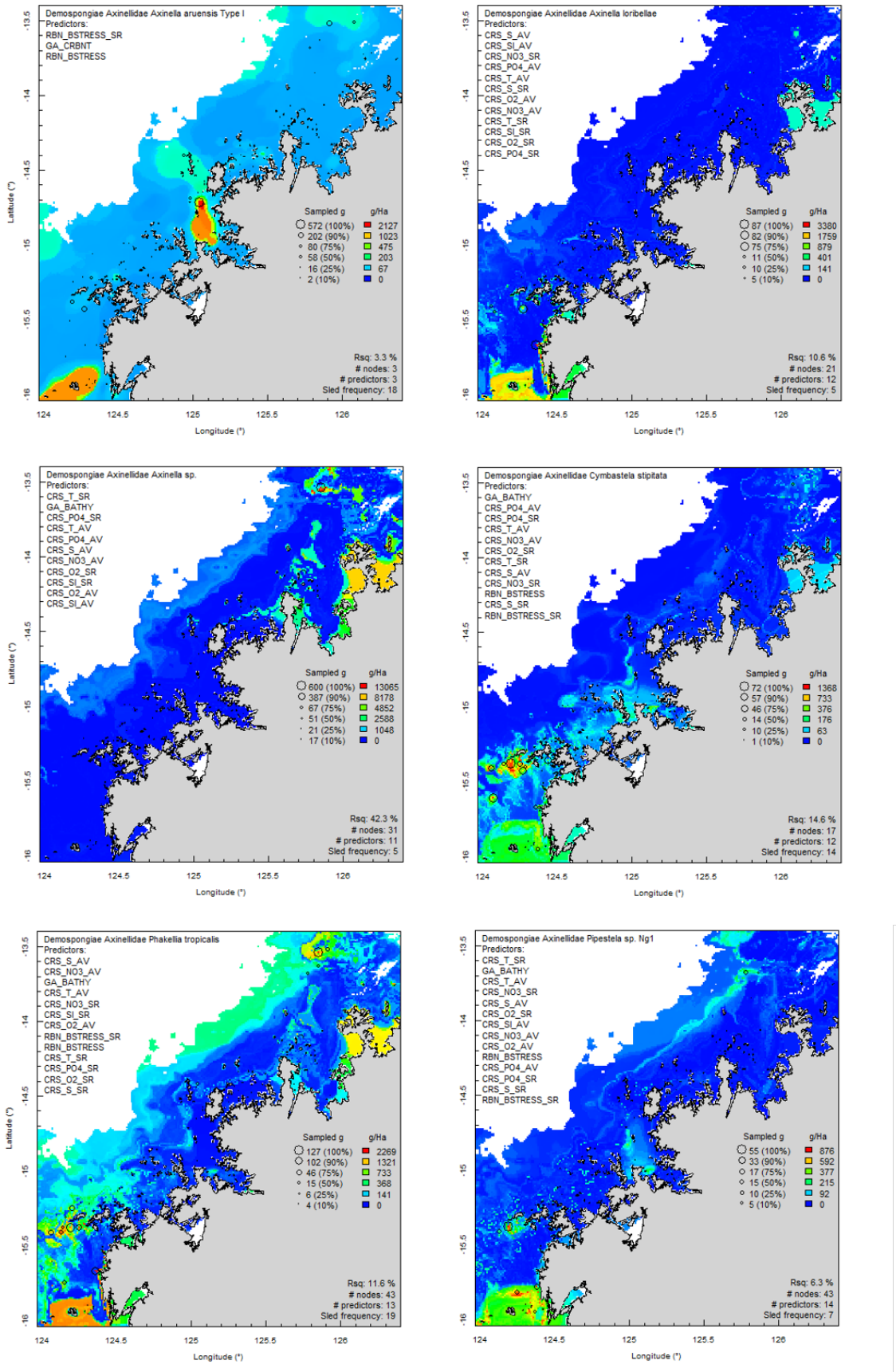


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

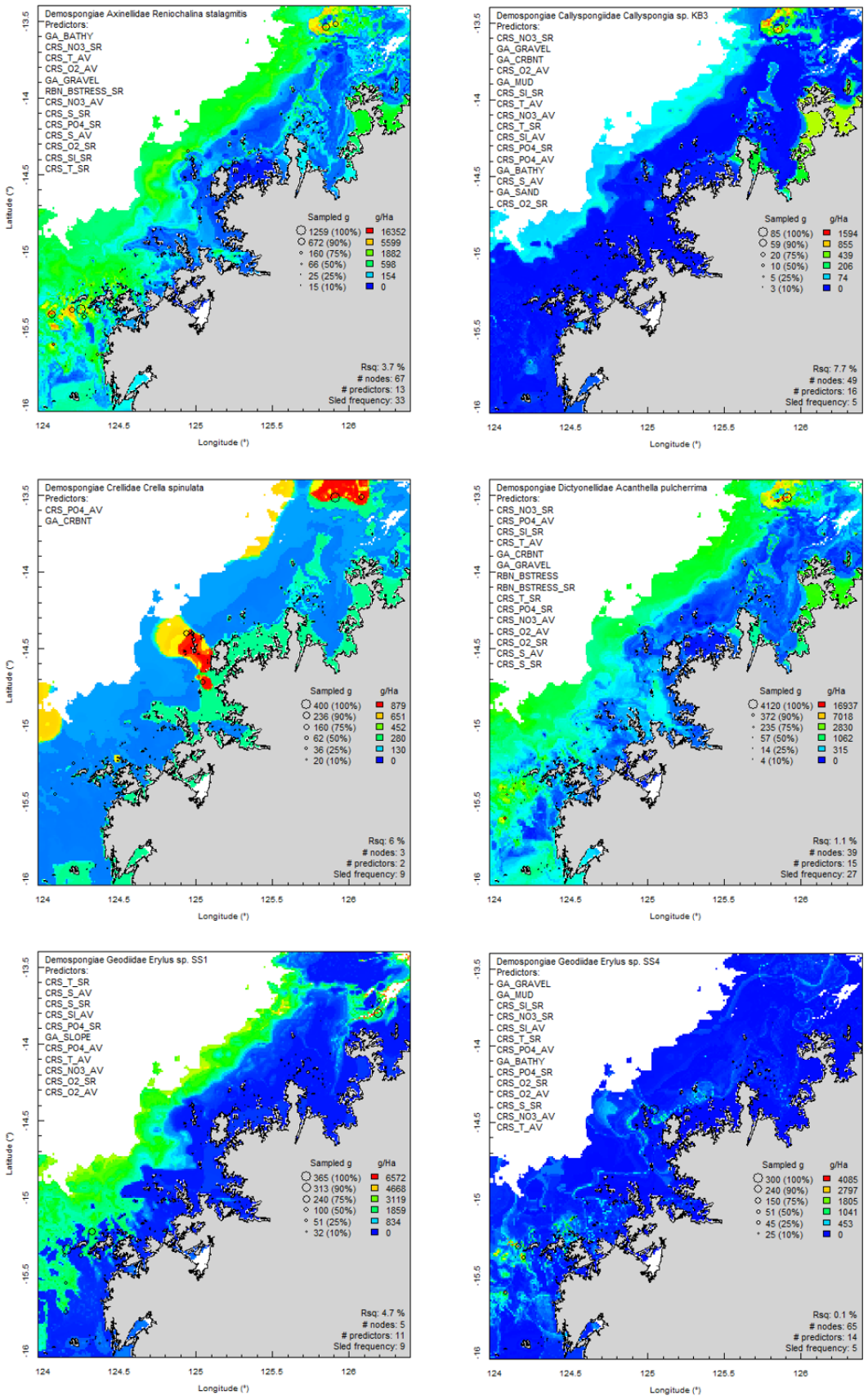


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

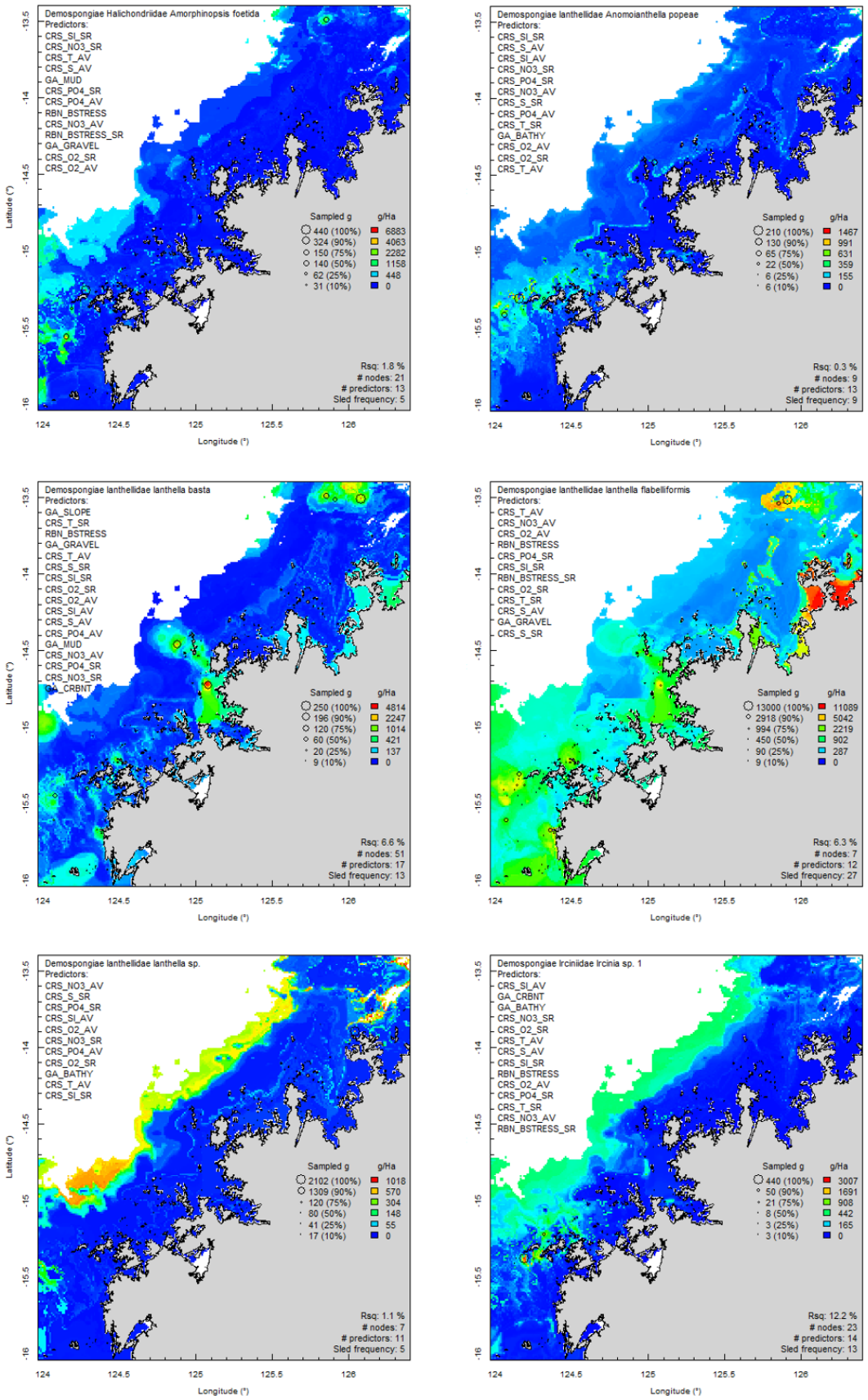


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

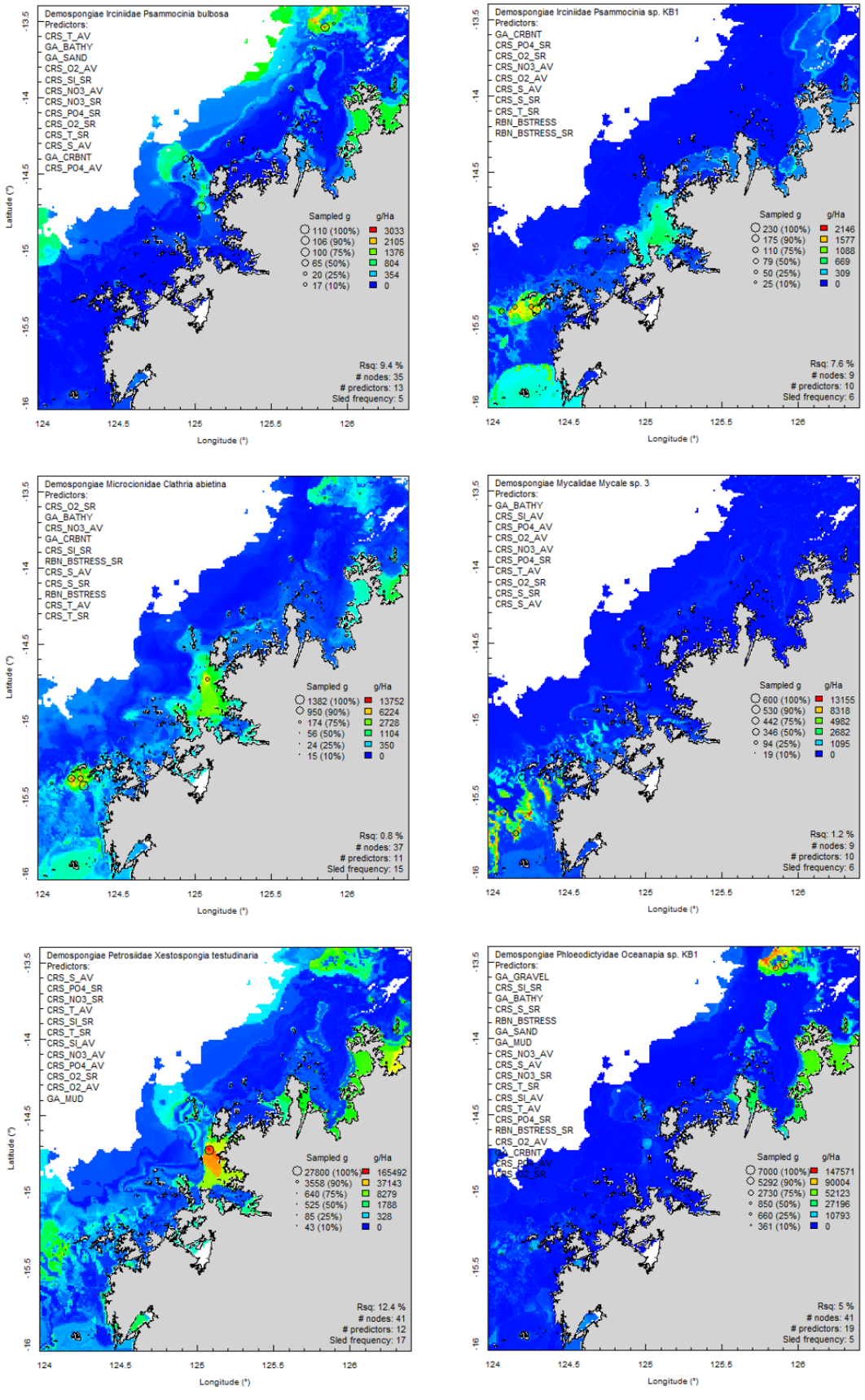


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

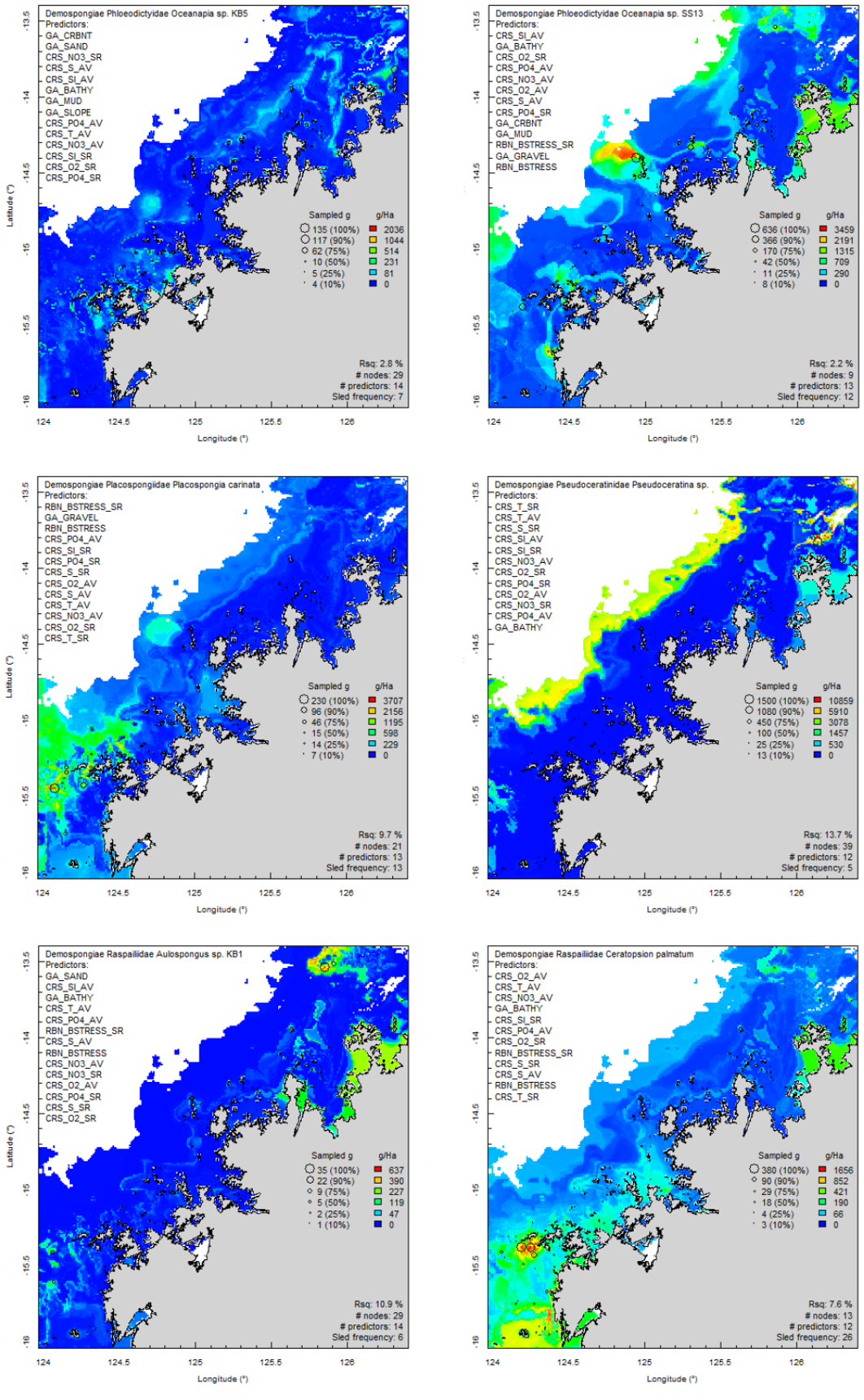


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

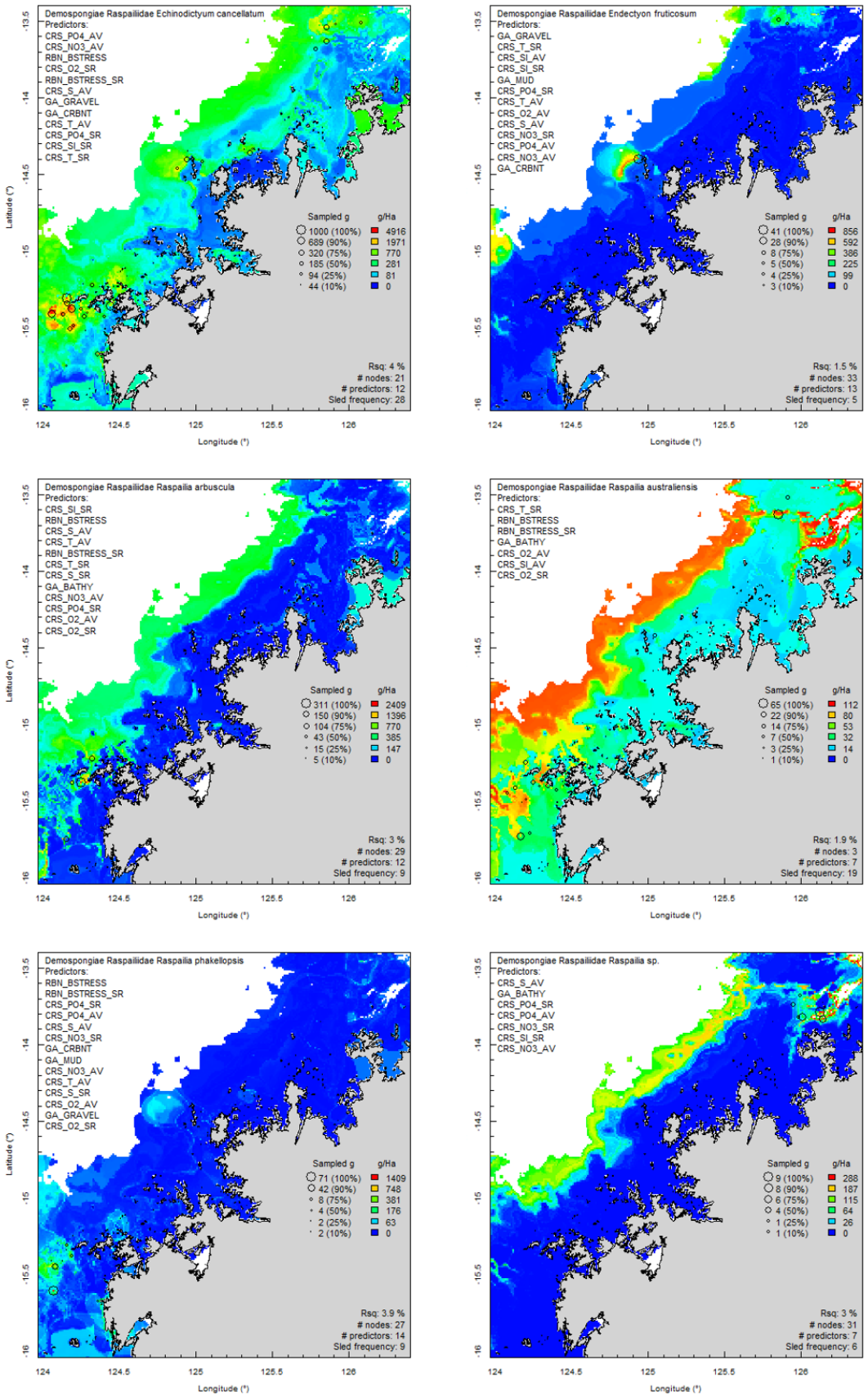


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

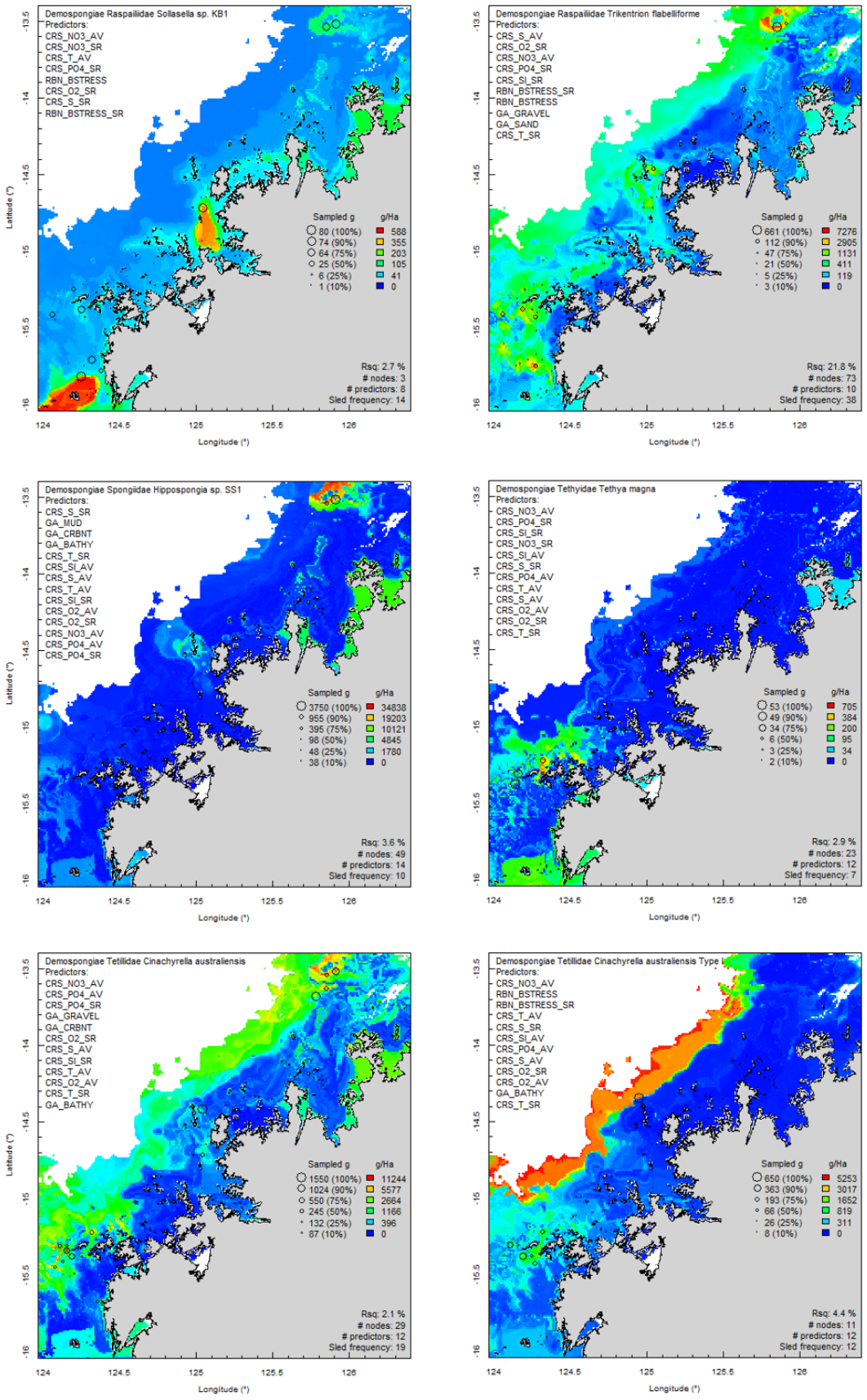


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

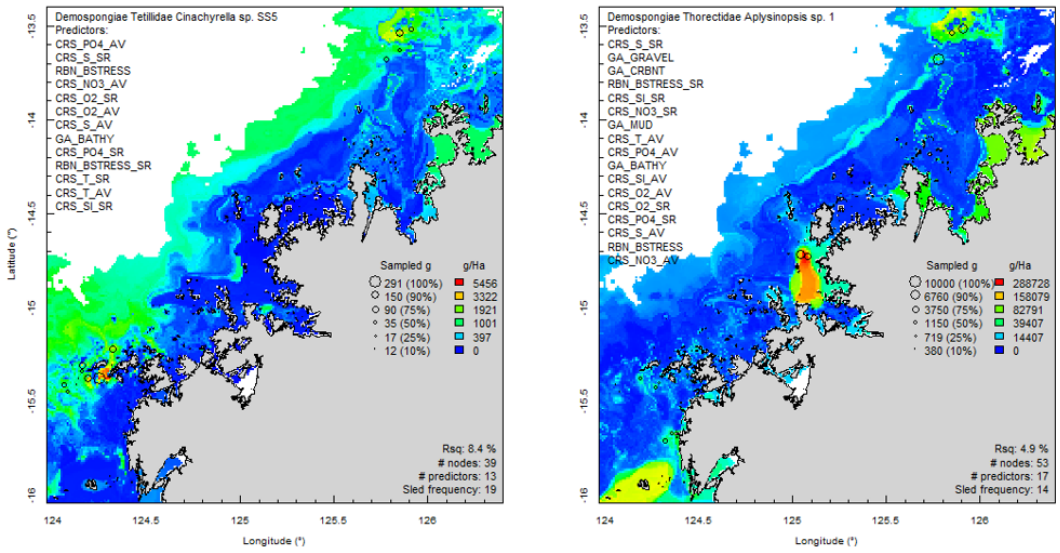


Figure 11 (continued). Predicted distribution of selected sponge taxa throughout the study region based on sled samples.

3.11 Hydrozoa (Cnidaria)

Hydroids are an abundant component of the sessile benthic fauna, often epizootic on other sessile invertebrates. Although they require an anchorage point they were very common on soft bottom habitats attached to shells and small stones. Both video (R square = 39%) and sled samples (R square 38%) provided high levels of predicted distribution (Figure 12.).

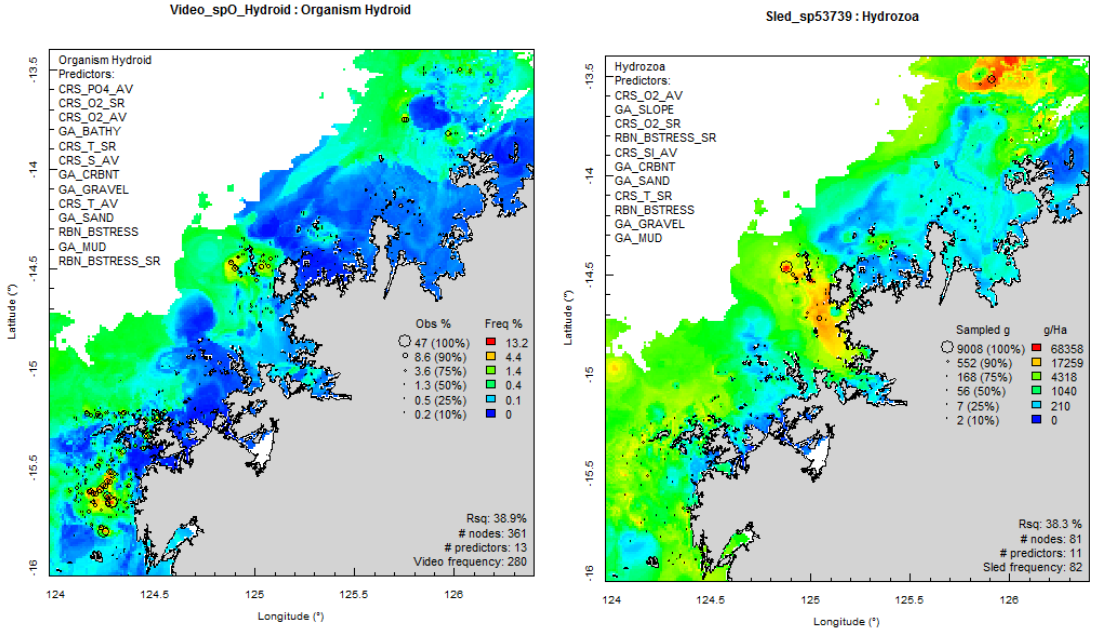


Figure 12. Predicted distribution of hydroids throughout the study region based on sled samples and video transects.

3.12 Anthozoans (Cnidaria)

This group includes the hexacorals subclass (Actinarians including “anemones”, Scleractinian hard corals, Antipatharians and Zoantharians) and the important habitat forming octocoral subclass which includes species commonly referred to as soft corals or gorgonians, fans and whips. Predicted distributions were made for 24 species/taxa of anthozoans. This includes two scleractinians, but hard corals were not a dominant habitat forming feature of our surveys in the subtidal areas where light levels are low.

3.13 Whips

Predicted distribution of whips had a high R square value (31%) from tow video transects as did the predicted distribution of the most common and distinctive whip species *Junceela fragilis* (26%) which was very abundant in the area between Bigge Island and the Coronation Islands. (Figure 13).

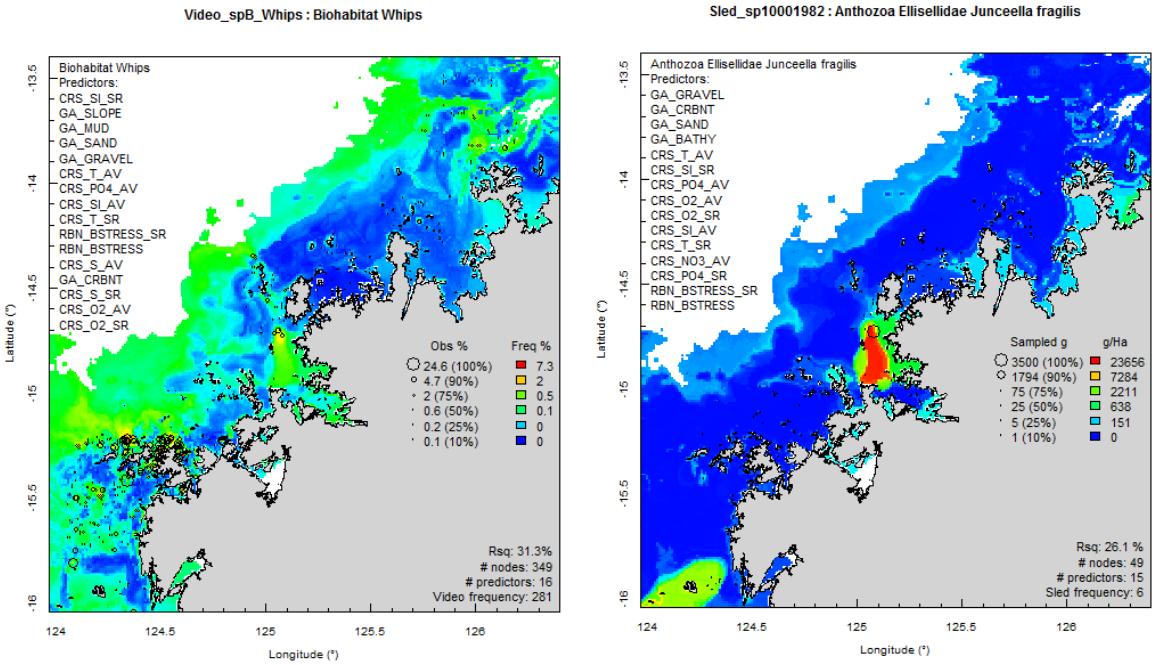


Figure 13. Predicted distribution of whips throughout the study region based on sled samples and video transects.

3.14 Gorgonians

Gorgonian octocorals or “fans” are an important and prominent feature of filter feeder communities. Their distribution pattern predicted from tow video is shown in Figure 14 and had a high R square of 42% indicating a reliable model with a range of substrate type and water column characteristics as good predictors. Figure 15 shows the predicted distributions for two gorgonian taxa, both Family Melithaeidae, one having a strongly southern distribution with a high R square value of 26%. There are predicted distributions for four *Echinogorgi*a species of fans with two showing strongly offshore distributions predicted (Figure 15).

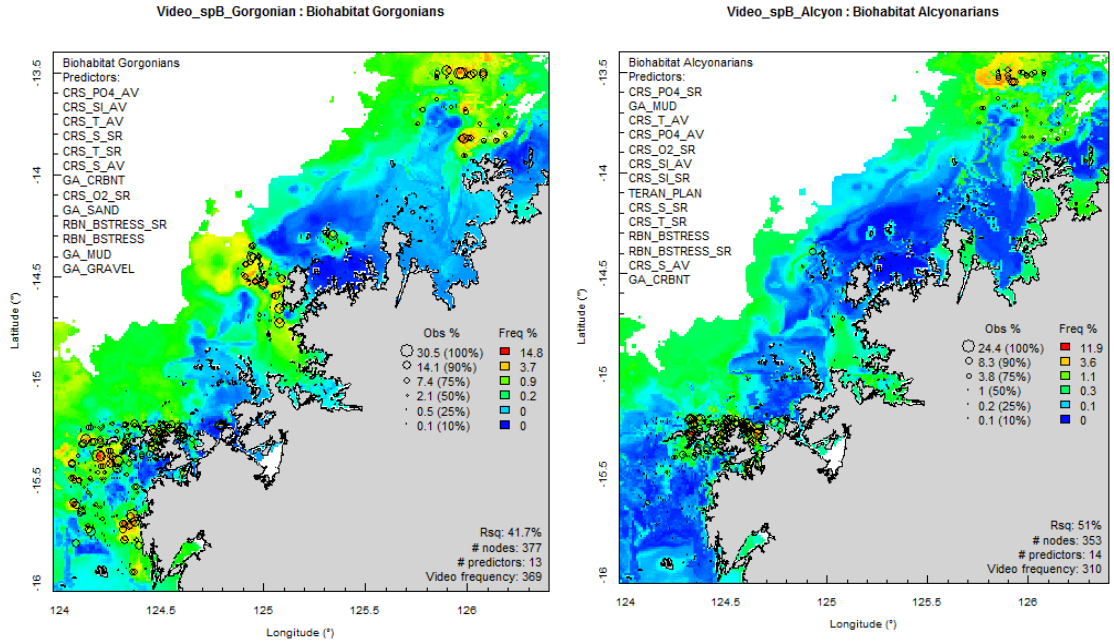


Figure 14. Predicted distribution of gorgonians and alcyonarians (principally non gorgonian octocorals commonly called soft corals) throughout the study region based on video transects.

3.15 Other octocorals (principally Nephtheidae, Nidaliidae and Paralcyoniidae)

These comprise the commonest “soft” corals in the area. Figure 14 shows the predicted distribution for soft corals based on tow video surveys (R square = 51%) is very similar to that of gorgonians. There are predicted distribution models for seven species shown in Figure 15. *Nephthyigorgia kükenthali* has a notably northern predicted distribution while *Nephthyigorgia* sp. has a much more southerly distribution. *Chromonephthea* sp. has a distribution centred the area between Bigge Island and the Coronation Islands, while *Dendronephthya* sp. has a gradient of distribution increasing from onshore to offshore across a wide range of latitude (Figure 15).

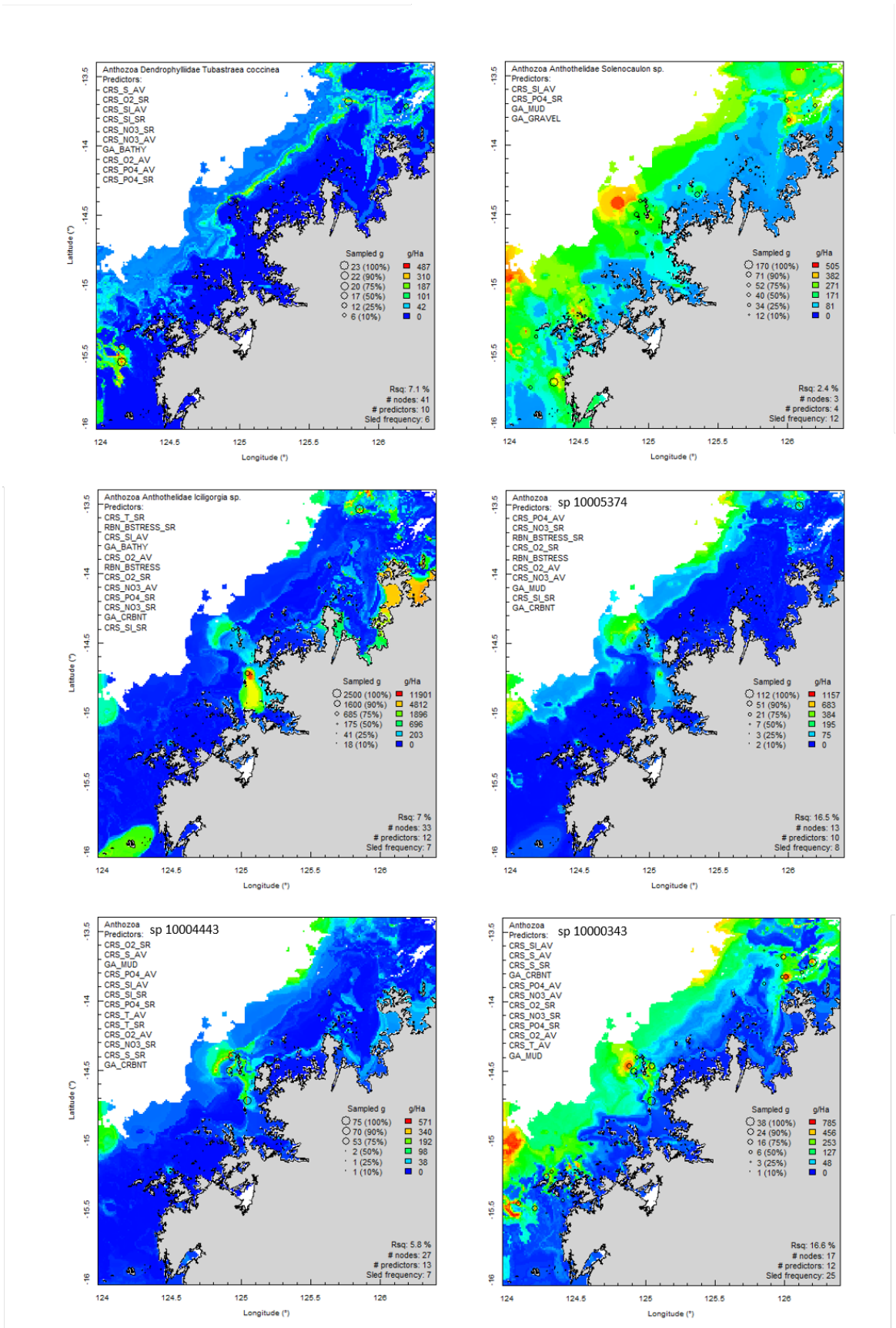


Figure 15 Predicted distribution of selected hexacoral and octocoral taxa throughout the study region based on sled samples. Some specimens only identified to Order: Middle right panel are unidentified Antipatharians, lower left panel are unidentified scleractinians and the lower right panel are unidentified Zoantharians

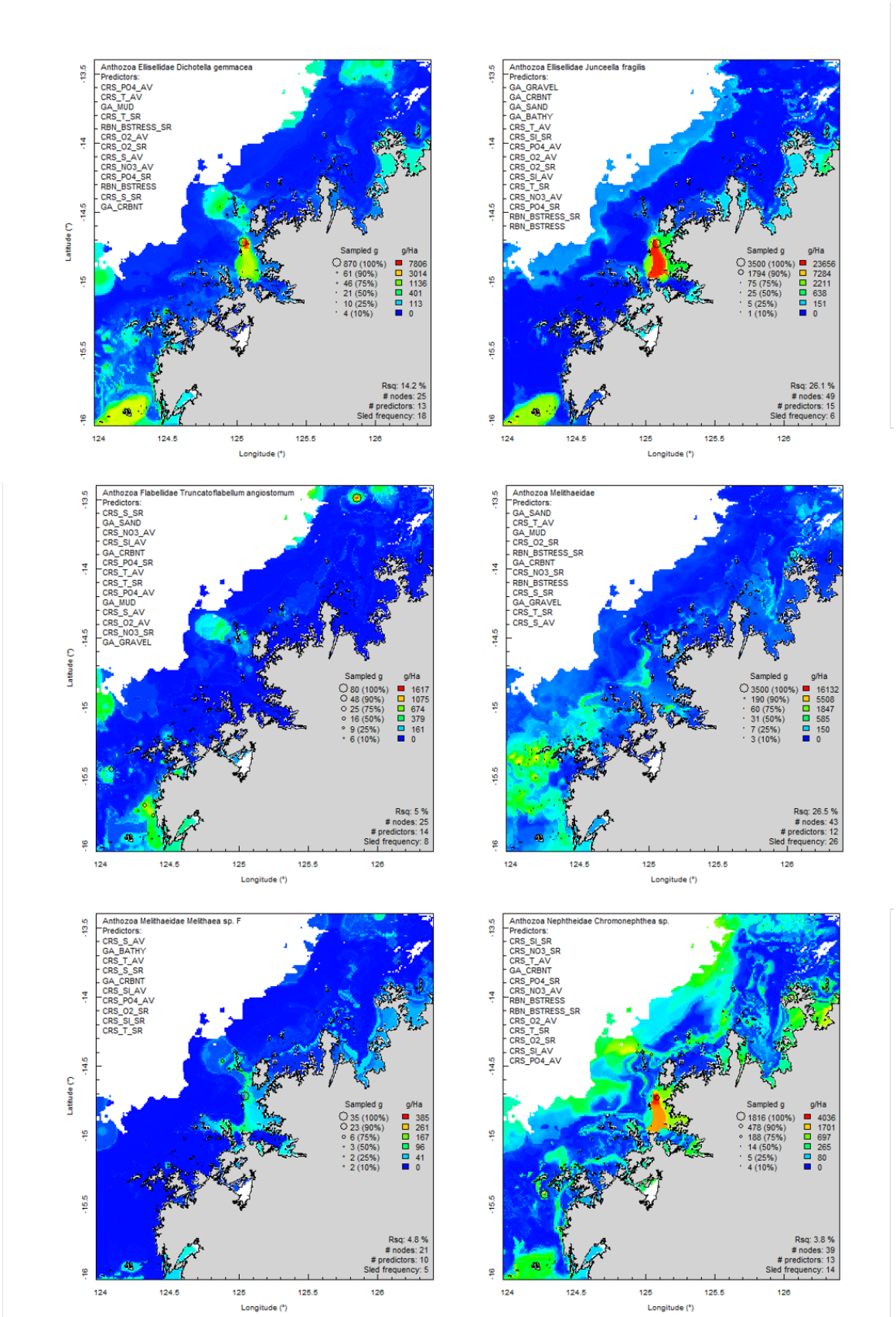


Figure 15 (continued). Predicted distribution of selected hexacoral and octocoral taxa throughout the study region based on sled samples.

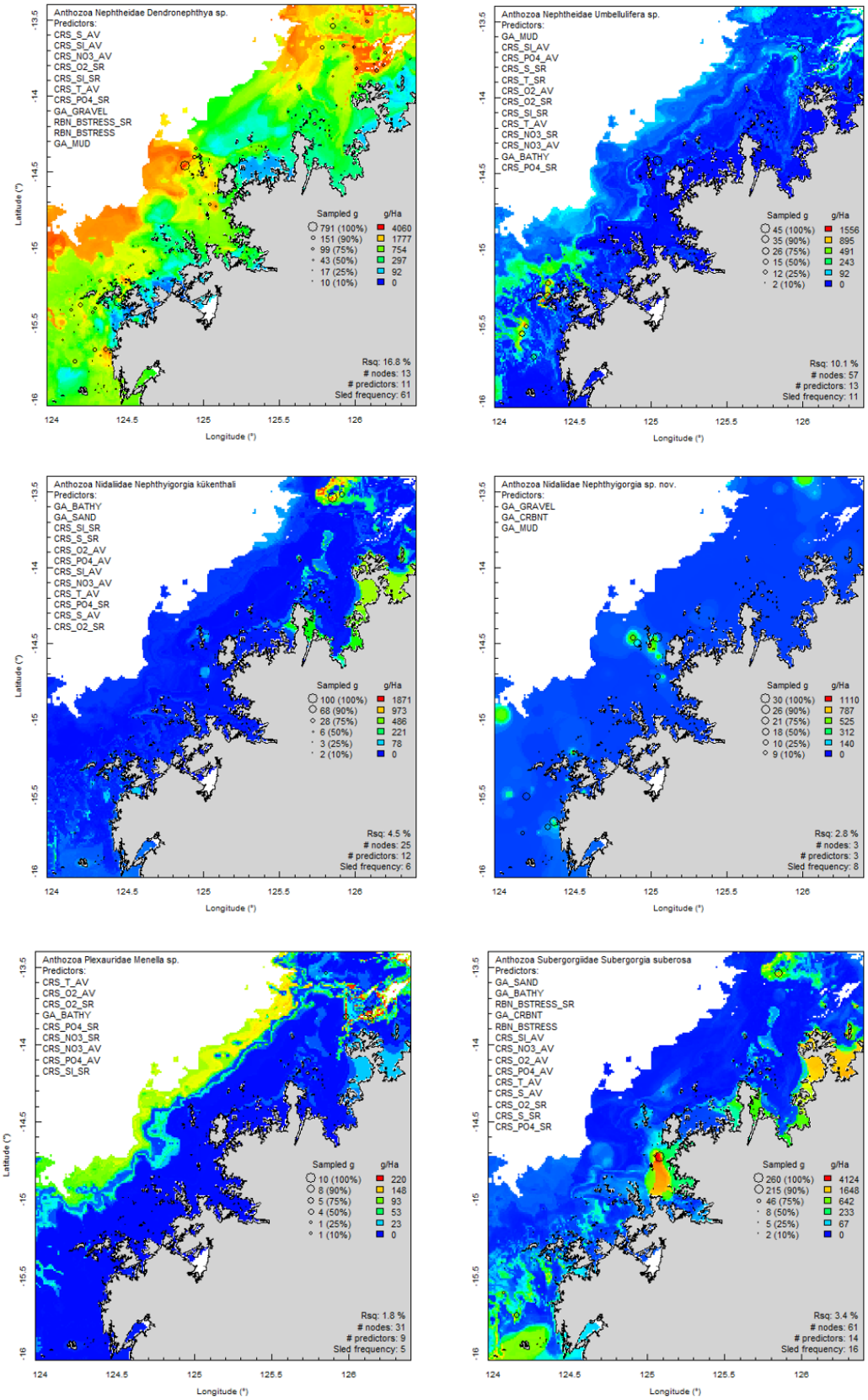


Figure 15 (continued). Predicted distribution of selected hexacoral and octocoral taxa throughout the study region based on sled samples.

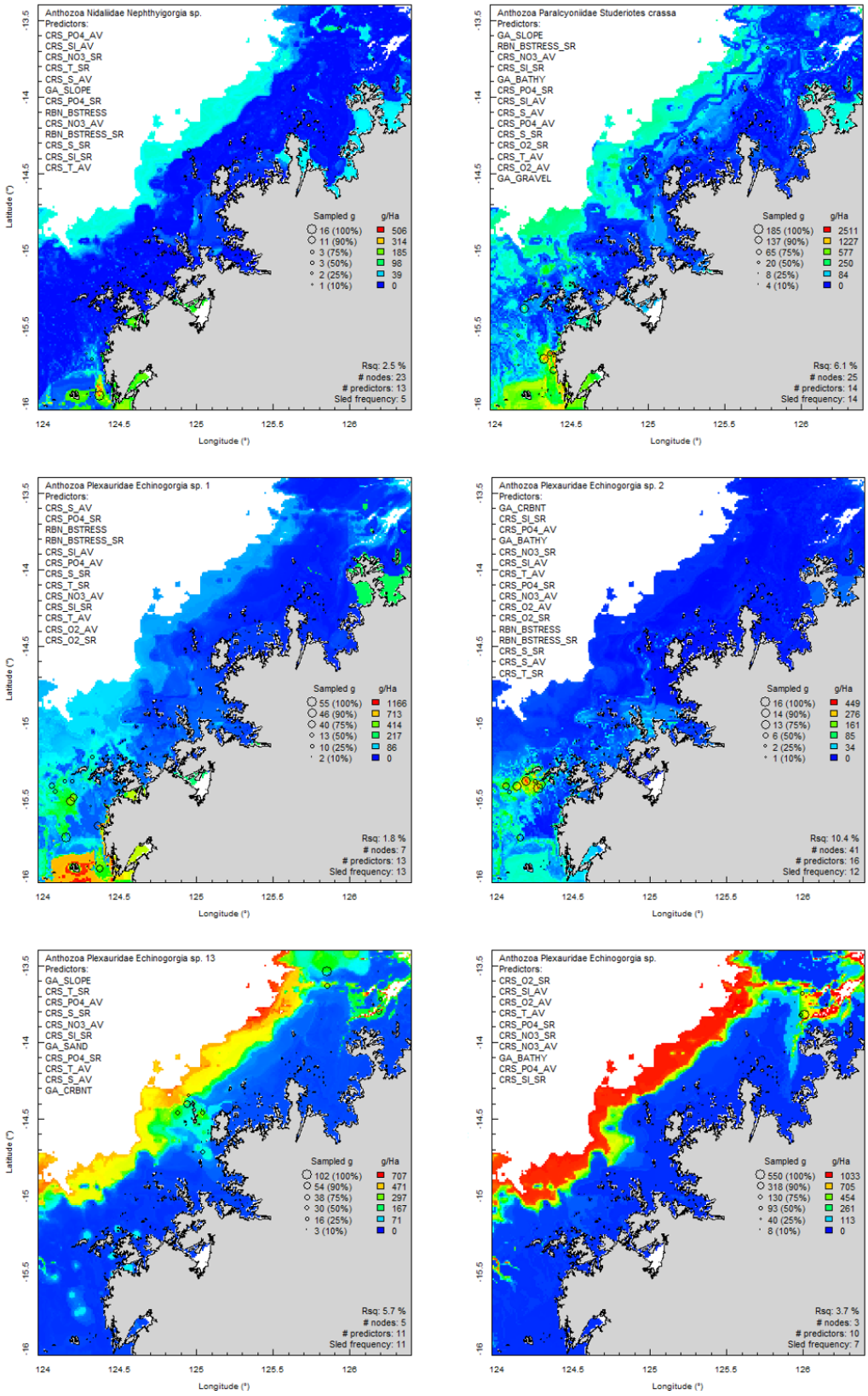


Figure 15 (continued). Predicted distribution of selected hexacoral and octocoral taxa throughout the study region based on sled samples.

3.16 Molluscs

Most molluscs are difficult to detect on tow video and their distribution was poorly predicted using this methods (R square = 0.4%) (Figure 16). Although many small species are not adequately sampled by the coarse mesh in the sled, some gastropods, scaphopods and bivalves were effectively sampled and Figure 16 shows predicted distributions for three taxa of molluscs with R square values between 11% and 31% (*Tudivasum inerme*, *Chicoreus cervicornis* and scaphopods).

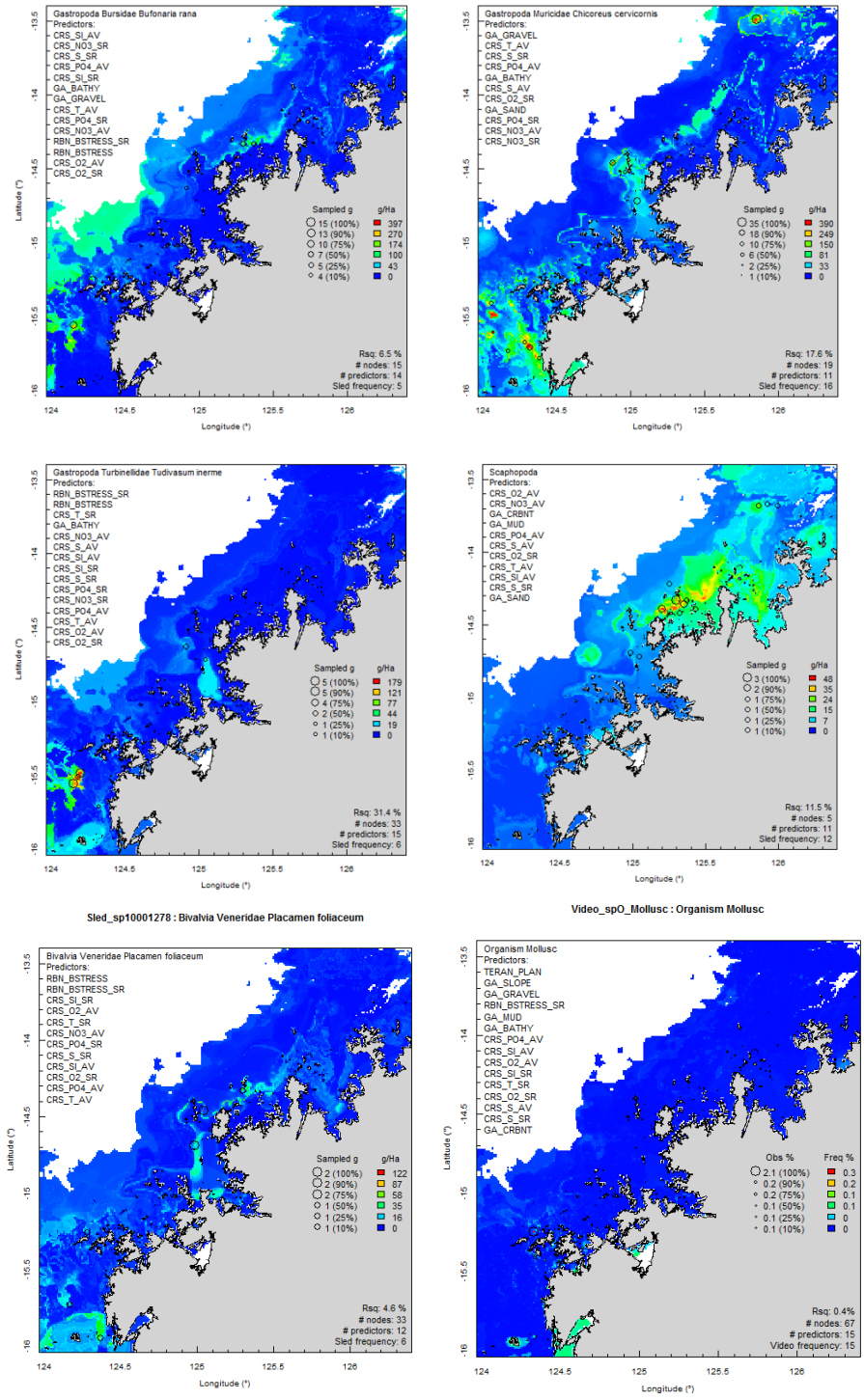


Figure 16. Predicted distribution of selected molluscan taxa throughout the study region based on sled samples and mollusc occurrence in the video tows (lower right panel)

3.17 Crustaceans

Crustaceans are also difficult to survey quantitatively using video and so their distribution is poorly predicted (R square = 0.6%; Figure 17). However they are very well sampled by the sled and successful species prediction models were made for 24 species (Figure 18), twelve of which had R square values between 11% and 39%. Eight species had predicted distributions increasing from onshore to offshore but occurring over the whole latitudinal extent of the survey region. Other species had more localised in shore distributions predicted (Figure 18).

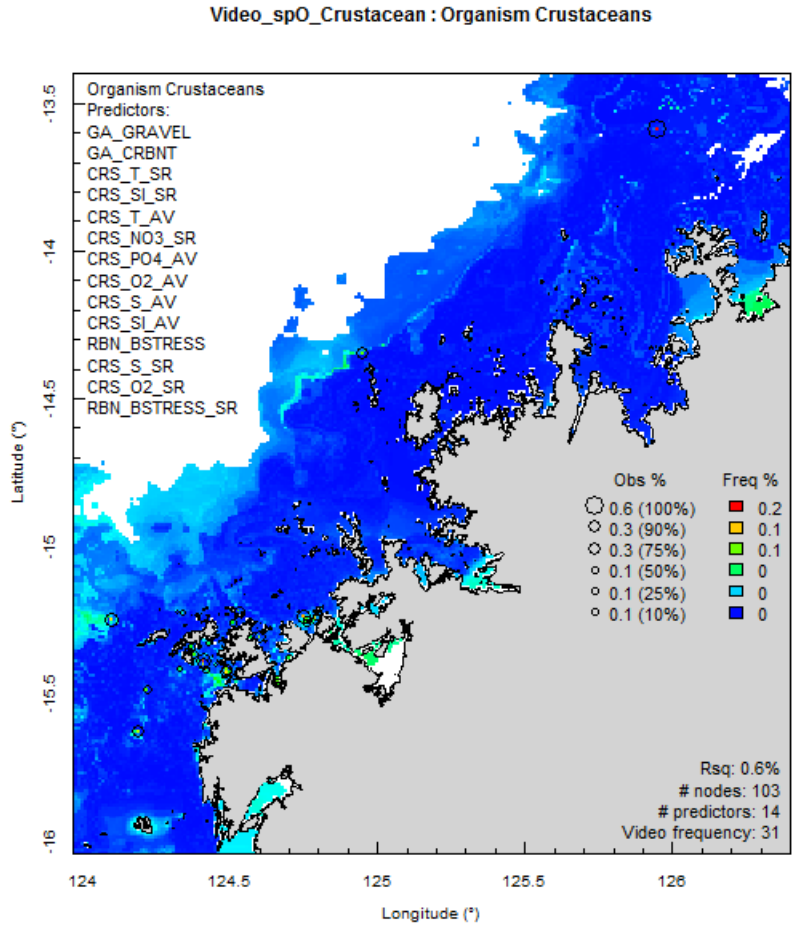


Figure 17. Predicted distribution of crustacean taxa throughout the study region based on tow video samples

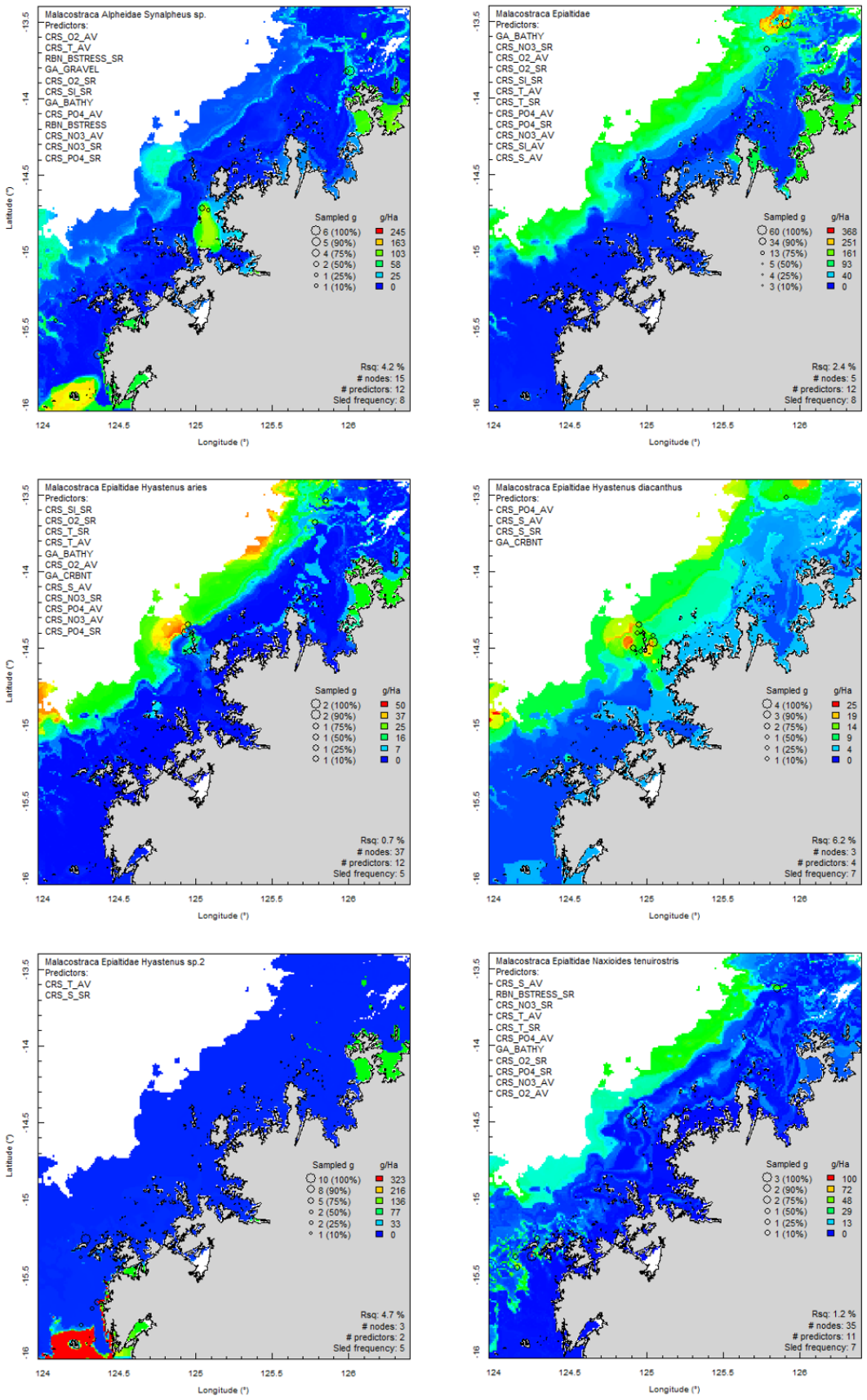


Figure 18. Predicted distribution of selected crustacean taxa throughout the study region based on sled samples

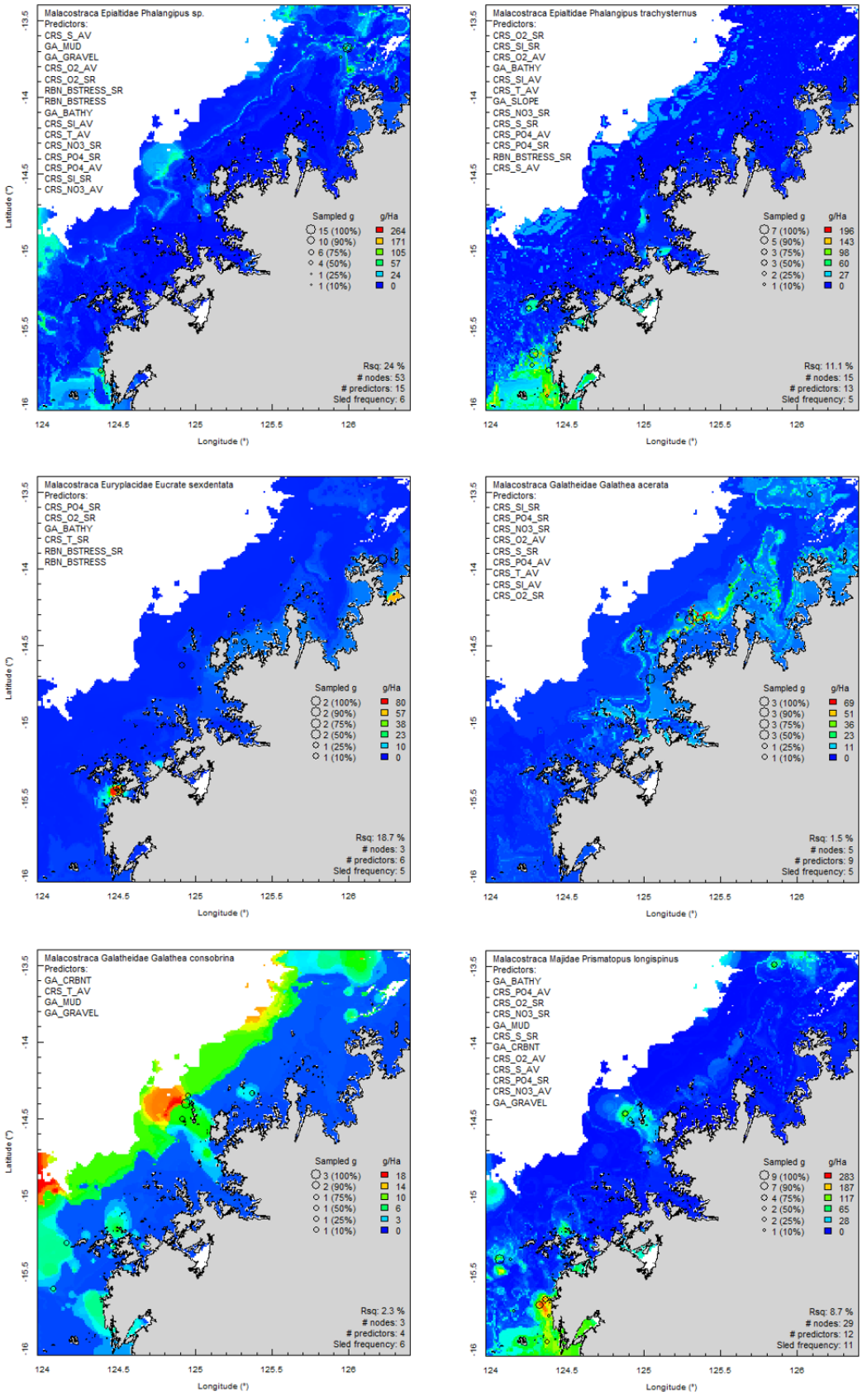


Figure 18 (continued). Predicted distribution of selected crustacean taxa throughout the study region based on sled samples

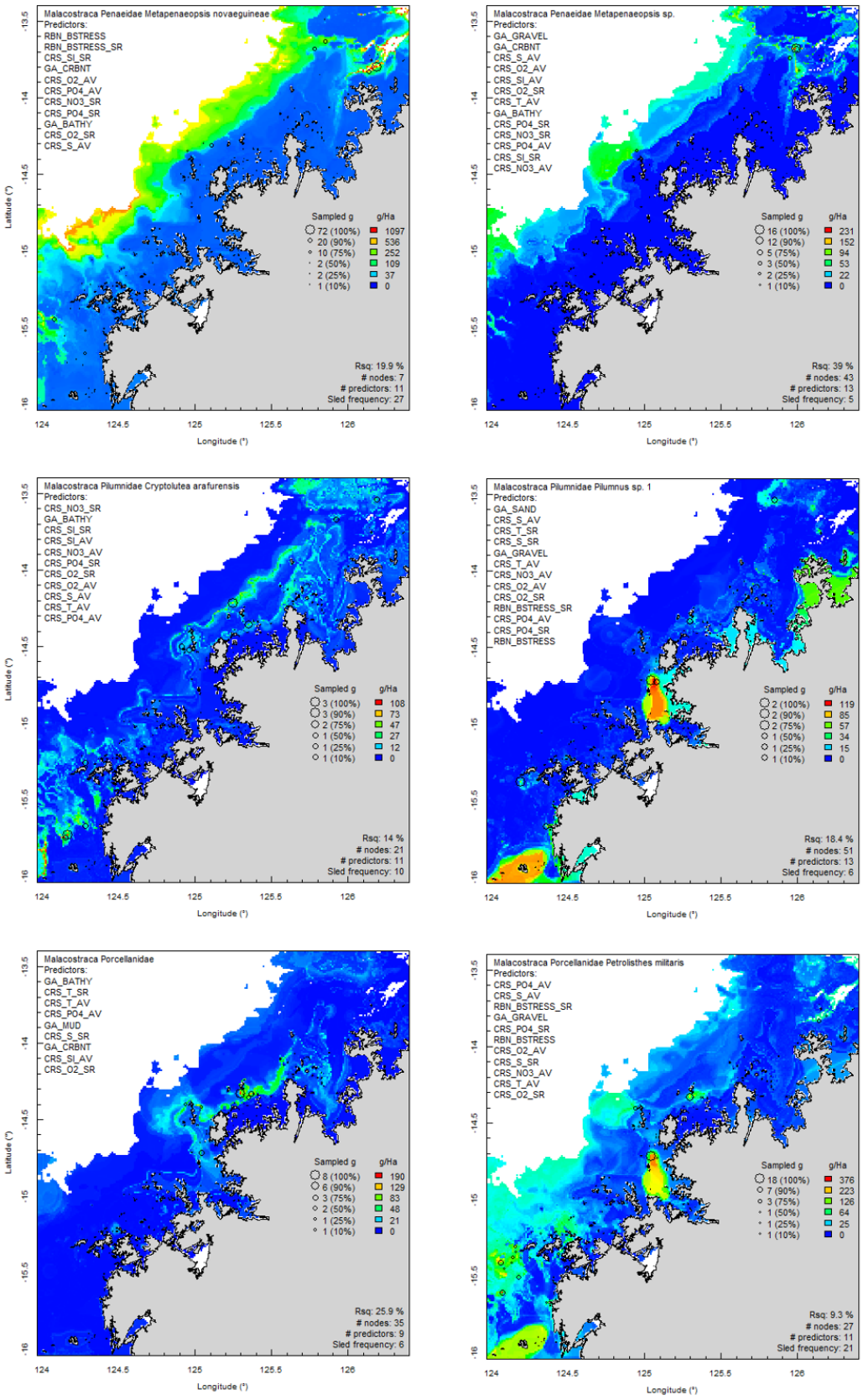


Figure 18 (continued). Predicted distribution of selected crustacean taxa throughout the study region based on sled samples

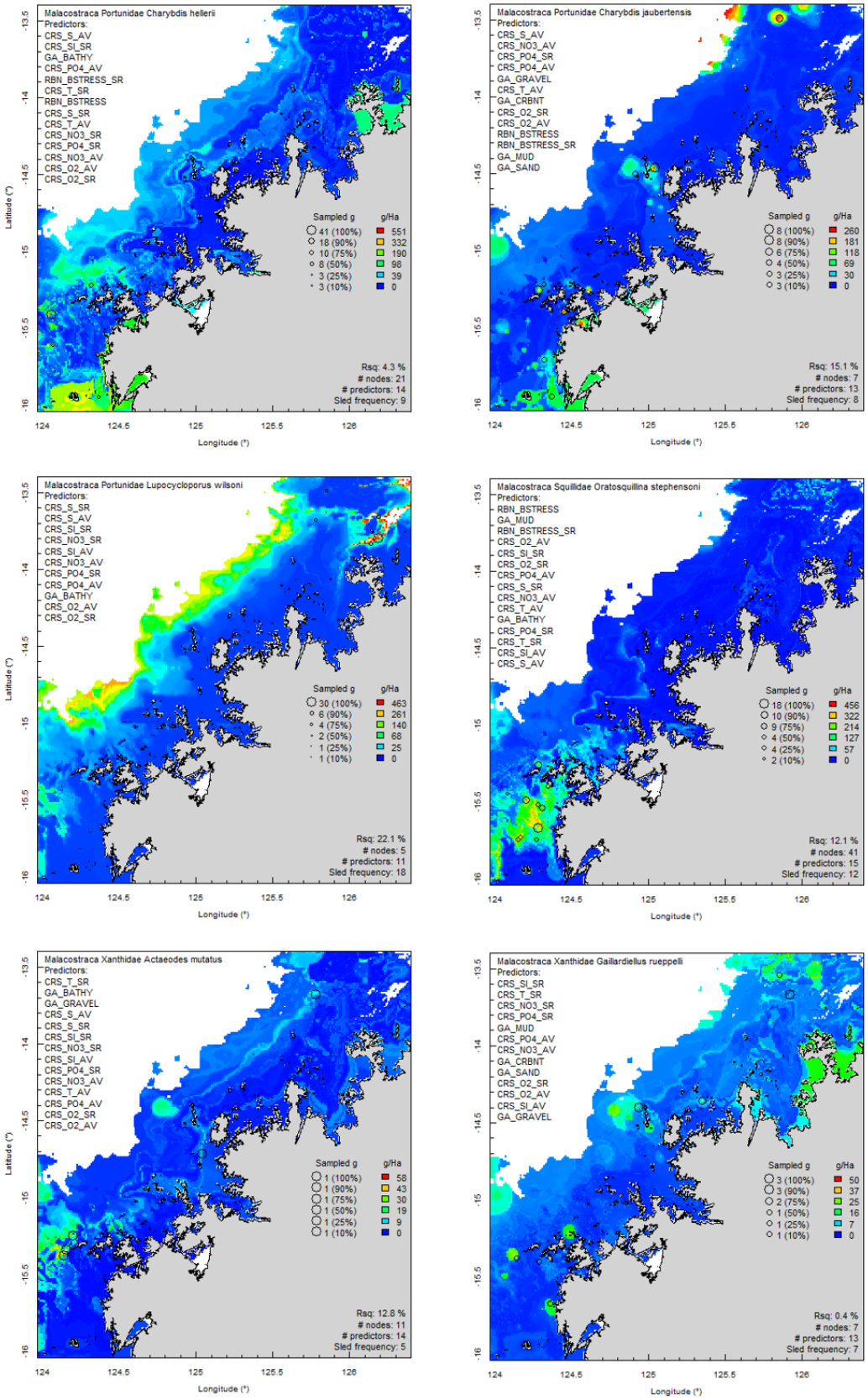


Figure 18 (continued). Predicted distribution of selected crustacean taxa throughout the study region based on sled samples

3.18 Worms (Annelida)

Given their small size worms were not well sampled by the sled although they were present in most samples. Figure 19 shows their predicted distribution based on sled samples and indicates that biomass is highest in the areas closest to shore.

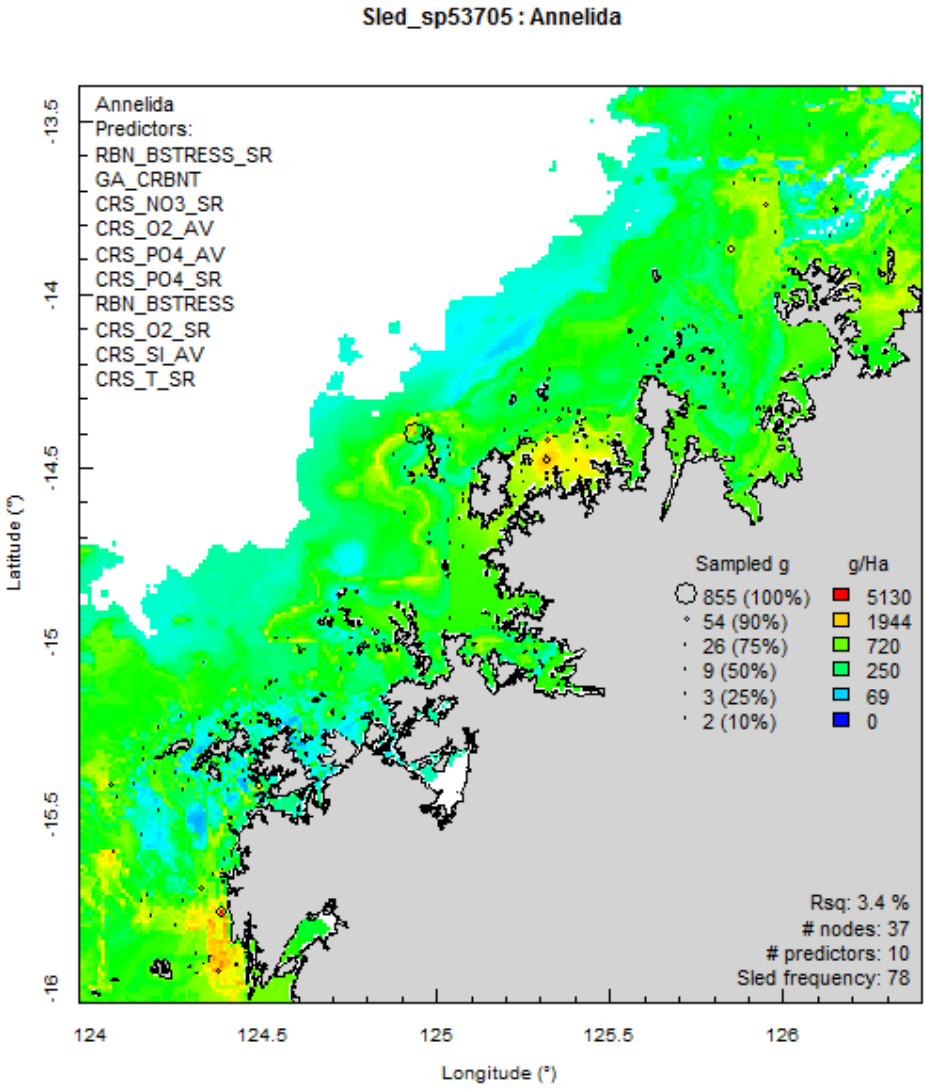


Figure 19 Predicted distribution of annelids throughout the study region based on sled samples

3.19 Ascidians

Ascidians were abundant on both hard and soft substrates in the study area. Unfortunately they are difficult to identify and in this study are analysed as a group. Their distribution had a good level of predictability on the basis of both video (R square = 18%) and sleds (R square = 28%) (Figure 20).

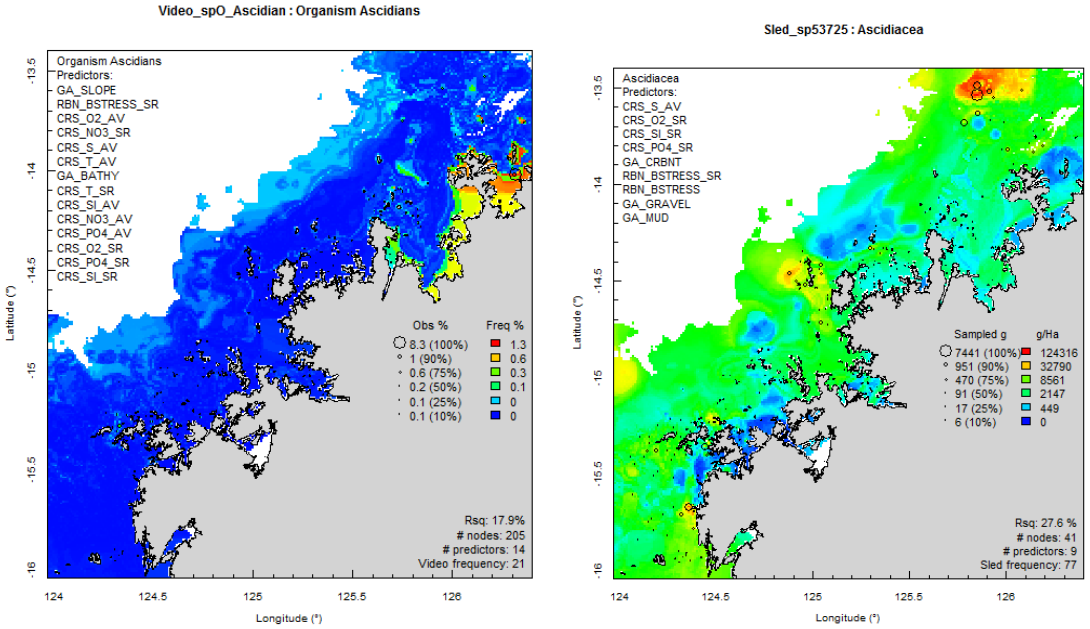


Figure 20. Predicted distribution of ascidians in the study region based on tow video (left) and sled samples (right).

3.20 Bryozoa

Bryozoa distribution showed a high level of predictability from both tow video (R square = 35%) and sleds (R square = 30%) although two areas of high abundance of bryozoa predicted from sleds (off Eclipse Archipelago and south of Bigge Island) were not predicated from the video tows.

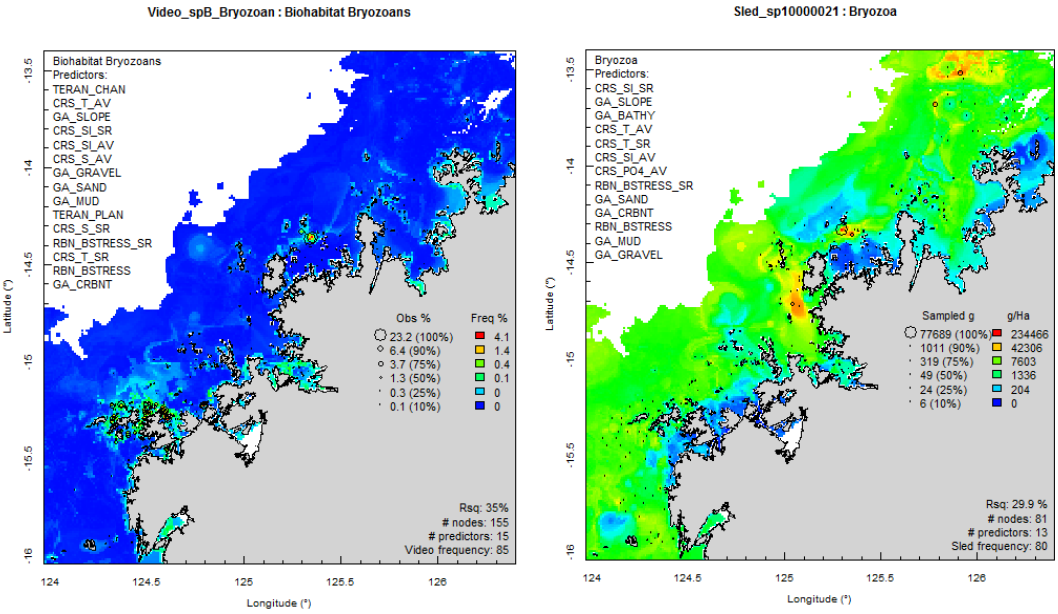


Figure 21. Predicted distribution of bryozoa in the study region based on tow video (left) and sled samples (right).

4 References

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Keesing, J.K., Irvine, T.R., Alderslade, P., Clapin, G., Fromont, J., Hosie, A.M., Huisman, J.M., Phillips, J.C., Naughton, K.M., Marsh, L.M. and Slack-Smith, S.M., 2011. Marine benthic flora and fauna of Gourdon Bay and the Dampier Peninsula in the Kimberley region of north-western Australia. Journal of the Royal Society of Western Australia, 94(2): 285-301.

Keesing J.K., Irvine, T.R., (2013). Aspects of the biology of an abundant spatangoid urchin, Breynia desori in the Kimberley region of north-western Australia. p165-174, in: Johnson, C.R. (ed.) Echinoderms in a Changing World. CRC Press/Balkema, The Netherlands.

Pitcher CR., Lawton P, Ellis N, Smith S J, Incze L S, Wei CL, Greenlaw M E, Wolff, NH, Sameoto J A, Snelgrove PVR. (2012) Exploring the role of environmental variables in shaping patterns of seabed biodiversity composition in regional-scale ecosystems. Journal of Applied Ecology, 49:670–679.

Table 1. List of species/taxa for which successful predicted distribution models were developed and mapped from sled catches (see Figures 3-21).

PHYLUM	CLASS	SUBCLASS	ORDER	FAMILY	GENUS	SPECIES	CSIRO_CODE	SumOfFREQUENCY
Annelida	-	-	-	-	-	-	53705	253
Arthropoda/Crustacea	-	-	-	-	-	-	53701	24
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Penaeidae	Metapenaeopsis	novaeguineae	53722	30
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Penaeidae	Metapenaeopsis	sp.	10005460	6
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Alpheidae	Synalpheus	sp.	10001322	16
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	-	-	10006077	12
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	Hyastenus	aries	10005285	6
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	Hyastenus	diacanthus	10005331	7
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	Hyastenus	sp.2	10009504	5
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	Naxioides	tenuirostris	10000232	8
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	Phalangipus	sp.	10002544	6
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Epialtidae	Phalangipus	trachysternus	10000238	5
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Euryplacidae	Eucrate	sexdentata	10000951	5
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Galatheidae	Galathea	acerata	10000893	11
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Galatheidae	Galathea	consobrina	10000547	8
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Majidae	Prismatopus	longispinus	10001558	13
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Pilumnidae	Cryptolutea	arafurensis	10001229	10
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Pilumnidae	Pilumnus	sp. 1	10001438	7
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Porcellanidae	-	-	10004627	17
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Porcellanidae	Petrolisthes	militaris	10000039	54

Arthropoda/Crustacea	Malacostraca	-	Decapoda	Portunidae	Charybdis	hellerii	10001131	9
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Portunidae	Charybdis	jaubertensis	10009513	10
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Portunidae	Lupocycloporus	wilsoni	10000236	24
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Xanthidae	Actaeodes	mutatus	10000498	5
Arthropoda/Crustacea	Malacostraca	-	Decapoda	Xanthidae	Gaillardiellus	rueppelli	10000142	8
Arthropoda/Crustacea	Malacostraca	-	Stomatopoda	Squillidae	Oratosquillina	stephensoni	10000107	12
Bryozoa	-	-	-	-	-	-	10000021	329
Chordata	Ascidiacea	-	-	-	-	-	53725	446
Cnidaria	Anthozoa	Hexacorallia	Actiniaria	-	-	-	10000110	16
Cnidaria	Anthozoa	Hexacorallia	Antipatharia	-	-	-	10005374	10
Cnidaria	Anthozoa	Hexacorallia	Scleractinia	-	-	-	10004443	9
Cnidaria	Anthozoa	Hexacorallia	Scleractinia	Dendrophylliidae	Tubastraea	coccinea	10000070	6
Cnidaria	Anthozoa	Hexacorallia	Scleractinia	Flabellidae	Truncatoflabellum	angiostomum	10001655	9
Cnidaria	Anthozoa	Hexacorallia	Zoantharia	-	-	-	10000343	30
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Nephtheidae	Chromonephthea	sp.	10009461	30
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Nephtheidae	Dendronephthya	sp.	53730	153
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Nephtheidae	Umbellulifera	sp.	10000011	13
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Nidaliidae	Nephthyigorgia	kükenthali	10000207	7
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Nidaliidae	Nephthyigorgia	sp.	10009446	5
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Nidaliidae	Nephthyigorgia	sp. nov.	10000013	8
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Paralcyoniidae	Studeriotes	crassa	10000101	16
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Ellisellidae	Dichotella	gemmacea	10000010	32
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Ellisellidae	Junceella	fragilis	10001982	7

Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Plexauridae	Echinogorgia	sp.	10006230	26
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Plexauridae	Echinogorgia	sp. 1	10000015	16
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Plexauridae	Echinogorgia	sp. 13	10005383	16
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Plexauridae	Echinogorgia	sp. 2	10000169	14
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Plexauridae	Menella	sp.	10006376	6
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Anthothelidae	Iciligorgia	sp.	10004206	7
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Anthothelidae	Solenocaulon	sp.	10001377	22
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Melithaeidae	-	-	10000009	49
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Melithaeidae	Melithaea	sp. F	10004342	5
Cnidaria	Anthozoa	Octocorallia	Alcyonacea	Subergorgiidae	Subergorgia	suberosa	10000172	17
Cnidaria	Anthozoa	Octocorallia	Pennatulacea	-	-	-	10000118	11
Cnidaria	Hydrozoa	-	-	-	-	-	53739	202
Echinodermata	Asteroidea	-	Paxillosida	Astropectinidae	Astropecten	pulcherrimus	10000092	5
Echinodermata	Asteroidea	-	Valvatida	Goniasteridae	Iconaster	longimanus	10003588	5
Echinodermata	Asteroidea	-	Valvatida	Oreasteridae	Goniodiscaster	rugosus	53763	13
Echinodermata	Crinoidea	-	-	-	-	-	10001161	105
Echinodermata	Crinoidea	Articulata	Comatulida	Colobometridae	Oligometra	carpenteri	10000228	78
Echinodermata	Crinoidea	Articulata	Comatulida	Colobometridae	Oligometrides	adeonae	10000405	76
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Capillaster	mariae	10001119	24
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Capillaster	multiradiata	10003963	17
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Comanthus	briareus	10003994	11
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Comanthus	gisleni	10005339	42
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Comanthus	parvicirrus	10003050	32

Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Comaster	multifidus	10000418	92
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Comatella	maculata	10009255	36
Echinodermata	Crinoidea	Articulata	Comatulida	Comatulidae	Comatula	pectinata	10000037	855
Echinodermata	Crinoidea	Articulata	Comatulida	Himerometridae	Amphimetra	tessellata	10009575	54
Echinodermata	Crinoidea	Articulata	Comatulida	Himerometridae	Heterometra	crenulata	53757	190
Echinodermata	Crinoidea	Articulata	Comatulida	Zygometridae	Zygometra	elegans	10003039	47
Echinodermata	Crinoidea	Articulata	Comatulida	Zygometridae	Zygometra	punctata	10000908	61
Echinodermata	Echinoidea	-	-	-	-	-	53715	37
Echinodermata	Echinoidea	Cidaroidea	Cidaroida	Cidaridae	Prionocidaris	bispinosa	53751	37
Echinodermata	Echinoidea	Cidaroidea	Cidaroida	Cidaridae	Prionocidaris	sp.	10006329	10
Echinodermata	Echinoidea	Euechinoidea	-	-	-	-	10000778	14
Echinodermata	Echinoidea	Euechinoidea	Camarodonta	Temnopleuridae	Temnotrema	bothryoides	10008429	14
Echinodermata	Echinoidea	Euechinoidea	Clypeasteroida	Laganidae	Peronella	lesueuri	53728	10
Echinodermata	Echinoidea	Euechinoidea	Spatangoida	Brissidae	Brissopsis	luzonica	53732	19
Echinodermata	Echinoidea	Euechinoidea	Spatangoida	Loveniidae	Breynia	desorii	53737	36
Echinodermata	Holothuroidea	-	-	-	-	-	10002323	20
Echinodermata	Holothuroidea	-	Aspidochirotida	Holothuriidae	Holothuria	keesingi	10000043	11
Echinodermata	Holothuroidea	-	Dendrochirotida	Cucumariidae	Colochirus	quadrangularis	10000001	43
Echinodermata	Holothuroidea	-	Dendrochirotida	Cucumariidae	Colochirus or Plesiocolochirus	sp.	10006104	11
Echinodermata	Holothuroidea	-	Dendrochirotida	Cucumariidae	Mensamaria	intercedens	10000685	10
Echinodermata	Holothuroidea	-	Dendrochirotida	Cucumariidae	Plesiocolochirus	sp. 1	10004700	23
Echinodermata	Holothuroidea	-	Dendrochirotida	Phyllophoridae	Massinium	bonapartum	10002243	7
Echinodermata	Holothuroidea	-	Dendrochirotida	Phyllophoridae	Stolus	buccalis	10004619	13

Echinodermata	Holothuroidea	-	Dendrochirotida	Sclerodactylidae	Havelockia	sp.	10006335	12
Echinodermata	Holothuroidea	-	Dendrochirotida	Sclerodactylidae	Havelockia	versicolor	10000277	32
Echinodermata	Ophiuroidea	-	-	-	-	-	10000397	117
Echinodermata	Ophiuroidea	-	Euryalida	Euryalidae	Euryale	aspera	10000230	52
Echinodermata	Ophiuroidea	-	Ophiurida	Amphiuridae	Amphioplus	ochroleuca	10002320	5
Echinodermata	Ophiuroidea	-	Ophiurida	Amphiuridae	Amphiura	maxima	10001256	11
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiacanthidae	Ophiacantha	indica	10001958	8
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiodermatidae	Ophiochasma	stellata	53767	10
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiotrichidae	Macrophiothrix	megapoma	10000005	24
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiotrichidae	Macrophiothrix	sp.	10000069	11
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiotrichidae	Ophiothrix	ciliaris	10000067	141
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiotrichidae	Ophiothrix	lineocaerulea	10000664	31
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiotrichidae	Ophiothrix	melanosticta	53752	19
Echinodermata	Ophiuroidea	-	Ophiurida	Ophiotrichidae	Ophiothrix	smaragdina	10004006	38
Mollusca	Bivalvia	Heterodonta	-	Veneridae	Placamen	foliaceum	10001278	6
Mollusca	Gastropoda	Caenogastropoda	-	Bursidae	Bufonaria	rana	10000076	6
Mollusca	Gastropoda	Caenogastropoda	-	Muricidae	Chicoreus	cervicornis	10000025	24
Mollusca	Gastropoda	Caenogastropoda	-	Turbinellidae	Tudivasum	inerme	10000028	6
Mollusca	Scaphopoda	-	-	-	-	-	10004638	13
Ochrophyta	Phaeophyceae	-	Fucales	Sargassaceae	Sargassum	polycystum	10000147	7
Porifera	-	-	-	-	-	-	10000047	18
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Axinella	aruensis Type I	10000049	23

Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Axinella	loribellae	10001032	5
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Axinella	sp.	10006936	8
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Cymbastela	stipitata	10000185	16
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Phakellia	tropicalis	10000219	23
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Pipestela	sp. Ng1	10001512	7
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Axinellidae	Reniochalina	stalagmitis	10000187	54
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Trikentrion	flabelliforme	10000126	62
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Echinodictyum	cancellatum	10000032	30
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Aulospongus	sp. KB1	10000171	6
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Endectyon	fruticosum	10001683	5
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Raspailia	arbuscula	10000303	14
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Raspailia	australiensis	10013321	23
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Raspailia	sp.	10006235	7
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Raspailia	phakellopsis	10000620	11
Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Sollasella	sp. KB1	10000243	14

Porifera	Demospongiae	Heteroscleromorpha	Axinellida	Raspailiidae	Ceratopsion	palmatum	53764	34
Porifera	Demospongiae	Heteroscleromorpha	Bubarida	Dictyonellidae	Acanthella	pulcherrima	10000033	44
Porifera	Demospongiae	Heteroscleromorpha	Clionaida	Placospongiidae	Placospongia	carinata	10000309	13
Porifera	Demospongiae	Heteroscleromorpha	Haplosclerida	Callyspongiidae	Callyspongia	sp. KB3	10000345	5
Porifera	Demospongiae	Heteroscleromorpha	Haplosclerida	Petrosiidae	Xestospongia	testudinaria	10000305	19
Porifera	Demospongiae	Heteroscleromorpha	Haplosclerida	Phloeodictyidae	Oceanapia	sp. KB1	10000242	6
Porifera	Demospongiae	Heteroscleromorpha	Haplosclerida	Phloeodictyidae	Oceanapia	sp. KB5	10000052	7
Porifera	Demospongiae	Heteroscleromorpha	Haplosclerida	Phloeodictyidae	Oceanapia	sp. SS13	10000858	15
Porifera	Demospongiae	Heteroscleromorpha	Poecilosclerida	Acarnidae	Acarnus	thielei	10000201	8
Porifera	Demospongiae	Heteroscleromorpha	Poecilosclerida	Crellidae	Crella	spinulata	10001338	11
Porifera	Demospongiae	Heteroscleromorpha	Poecilosclerida	Microcionidae	Clathria	abietina	10000179	30
Porifera	Demospongiae	Heteroscleromorpha	Poecilosclerida	Mycalidae	Mycale	sp. 3	10000509	7
Porifera	Demospongiae	Heteroscleromorpha	Suberitida	Halichondriidae	Amorphinopsis	foetida	10000094	5
Porifera	Demospongiae	Heteroscleromorpha	Tethyida	Tethyidae	Tethya	magna	10000221	7
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Ancorinidae	Jaspis	sp. KB1	10000415	9

Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Ancorinidae	Stelletta	sp.	10003186	8
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Ancorinidae	Stelletta	sp. KB2	10000323	9
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Ancorinidae	Stelletta	sp. SS11	10000358	13
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Geodiidae	Erylus	sp. SS1	10000095	12
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Geodiidae	Erylus	sp. SS4	10000495	5
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Tetillidae	Cinachyrella	australiensis	10000051	23
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Tetillidae	Cinachyrella	australiensis Type I	10000359	17
Porifera	Demospongiae	Heteroscleromorpha	Tetractinellida	Tetillidae	Cinachyrella	sp. SS5	10000199	22
Porifera	Demospongiae	Keratosa	Dendroceratida	-	-	-	10000429	9
Porifera	Demospongiae	Keratosa	Dictyoceratida	Irciniidae	Ircinia	sp. 1	10000212	13
Porifera	Demospongiae	Keratosa	Dictyoceratida	Irciniidae	Psammocinia	bulbosa	10004149	5
Porifera	Demospongiae	Keratosa	Dictyoceratida	Irciniidae	Psammocinia	sp. KB1	10000188	6
Porifera	Demospongiae	Keratosa	Dictyoceratida	Spongiidae	Hippospongia	sp. SS1	10000310	12
Porifera	Demospongiae	Keratosa	Dictyoceratida	Thorectidae	Aplysinopsis	sp. 1	10000181	14
Porifera	Demospongiae	Verongimorpha	Verongiida	Ianthellidae	Anomoianthella	popeae	10000355	9
Porifera	Demospongiae	Verongimorpha	Verongiida	Ianthellidae	Ianthella	basta	10000175	13
Porifera	Demospongiae	Verongimorpha	Verongiida	Ianthellidae	Ianthella	flabelliformis	10000053	55
Porifera	Demospongiae	Verongimorpha	Verongiida	Ianthellidae	Ianthella	sp.	10001724	9
Porifera	Demospongiae	Verongimorpha	Verongiida	Pseudoceratinidae	Pseudoceratina	sp.	10001707	5