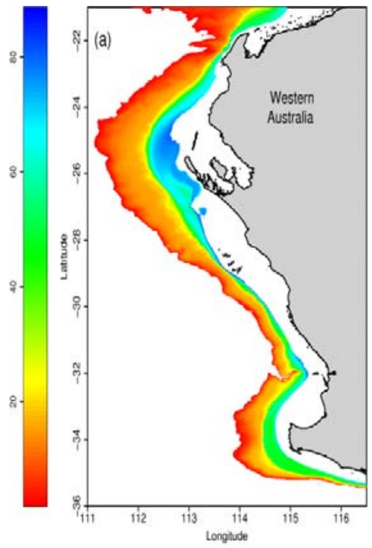
MARINE BIODIVERSITY RESEARCH
Prediction and Management of Australia's Marine Biodiversity

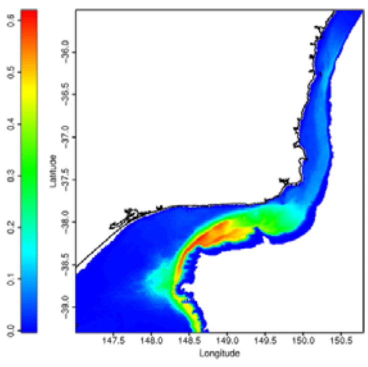
Performance of Predictive Biophysical Methods

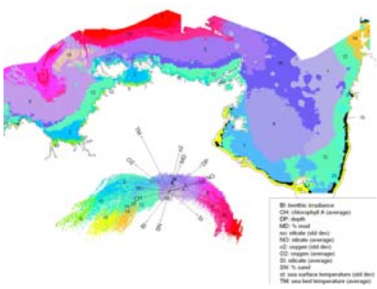
Biophysical modelling and prediction of spatial patterns in marine biodiversity

Milestone: Report on the performance of predictive biophysical methods.

22 February 2010







CERF Marine Biodiversity Hub

Prediction Program Milestone Report

Contents

1 Overview

Australia is in the midst of a highly active period of marine planning that will result in a national network of marine reserves (National Representative System of Marine Protected Areas), and bioregional plans for all the contiguous EEZ. Spatial planning is based on the spatial distribution of assets, uses and threats. A key marine asset for Australia is its biodiversity – megadiverse in the north and highly endemic in the south. Prior to the Marine Biodiversity Hub's formation no national maps of biodiversity existed at fine enough scales to assist with the siting of marine reserves, although earlier analyses through IMCRA 4.0 had identified the provinces and depths that needed to be considered to build a comprehensive network.

A major goal of the Hub was to develop approaches to predict fine-scale patterns in marine biodiversity around Australia. It was not planned that these would be ready in time to support regional marine planning but would be used later to improve implementation and monitoring of those plans. Progress was rapid despite the technical challenge of assembling large databases of diverse physical and biological data and the need to develop new approaches to analyzing these data. Unexpectedly we found ourselves in the position of being able to provide new national maps of biodiversity to DEWHA, States and conservation NGOs to support their input to regional marine planning. Maps have been provided for the South West, North West, and North regions and will soon be provided for the East region. We will be working with Atlas of Living Australia to complete maps for the South East and hence a complete national coverage in the latter half of 2010. We have worked with regional planning teams and ERIN in DEWHA to speed the adoption of these first Australian biodiversity maps in regional marine planning. Examples of these maps and supporting material are provided in an appendix to this report.

This report summarizes the development and application of the models developed to predict patterns in marine biodiversity from physical covariates, and their performance in fitting to the available data. Further work in the Marine Biodiversity Hub will focus on extending these models to the diverse areas that the partners hold data for. This will provide the means to compare these predictive methods over a wide range of environments and survey types. This work will appear in published papers and the Hub's final report.

2 Introduction

The Marine Biodiversity Hub Prediction Programs' overall goal is to develop models that predict patterns of marine biodiversity from more broadly available physical surrogates, at large regional scales around Australia. This modeling approach is necessary because biological survey data are sparse, with large gaps, yet full coverage maps of biodiversity patterns are required for marine planning and management purposes. To be useful as a surrogate in this context, the predictor variables must be provide close to complete coverage for the regions of interest. Nearly 30 potential environmental variables were provided by the Surrogates Program, and are being tested for their predictive utility.

More specifically, the Prediction Program is examining the performance of a number of methods for modeling the relationships between marine biodiversity and the physical environment, developed in areas where broad-scale biological and physical data coexist, to predict patterns of marine biodiversity in areas where little or no biological data exist. Investigations include: the explanatory performance of models and confidence of predictions; the importance of the different physical variables for prediction; the scales at which different biophysical surrogates have predictive value; sensitivity to uncertainty in interpolation of surrogates; and data requirements for appropriately characterizing biodiversity patterns. As a first step, the Prediction Program collated suitable biological survey data that provided the best available match to the broadest range of physical data from the Surrogates Program.

The Prediction Program is also examining the extent to which selected taxa (such as fishes) are biological surrogates for biodiversity patterns in other taxa (such as invertebrate groups) and other biodiversity measures (eg. species richness, diversity indices, evenness).

2.1 Definitions:

Biodiversity is not singularly definable. For the purposes of this program, given the nature of the available biological data, biodiversity will be defined as patterns in the numbers, distribution and abundance of species and their communities. These patterns may be unpacked into several components (again, not singularly definable) that may be addressed by the proposed methods.

Structure relates to numeric patterns of species at sites. This includes the number of species (*species richness*), the total number of individuals and of each species (*abundance*), and the relative distribution of abundance among species — species may be relatively even in abundance or some species may be numerically dominant (*evenness*). There are several ways of representing biodiversity structure distributions; here, these attributes will be jointly represented by rank-abundance-distributions (*RADs*). A RAD is an ordering of the observed counts of species at a site from most abundant to least abundant. Species identities are not retained. These attributes at sites are sometimes referred to as *alpha* diversity.

Composition relates to the identity and variety of species at sites, and is measured as changes in the mixture of species identities and abundances between sites in a region. A relatively homogeneous mix of species and their abundances over an area (typically represented by several sites) is sometimes called a 'community'. The latter term is often taken to imply that composition is organized by interaction among the constituent species; the not so loaded term '*assemblage*' is often used in preference. Species identities are important in composition, and several assemblages may be present in a region if composition changes appreciably among sites. Sites that are determined to have essentially the same composition may simply be called a 'site-group', and hence members of the same assemblage — and those determined to represent several assemblages as *site-groups*. The contribution to biodiversity of changes in composition over an area is sometimes referred to as *beta* diversity.

Further, some species may consistently co-occur together at high and low abundances, and be co-absent, at a number of locations in a region. This is another type of compositional pattern where species identity is important, and such species with a common spatial pattern in their abundances may be called a 'species-group'. Several such *species-groups* may occur in a region. Here, the extent to which there are groups of species with common responses to the physical surrogates will be investigated.

This report presents results of predictive modeling of these attributes of the structure and composition of biodiversity in up to four major marine biomes, the continental shelf, the continental slope, tropical coral reefs, and temperate rocky reefs.

3 Structure

3.1 Species Richness and Abundance:

The number of species and their abundances sampled at survey sites are among the fundamental attributes of *alpha* diversity. Alpha diversity incorporates all species and individuals counted in samples, including rare species; however, species identity is not retained. The individual attributes of alpha diversity were analyzed separately in models designed to predict spatial patterns of the attributes from the physical surrogate variables.

Technically, these analyses used a class of methods called Generalized Linear Models, where richness or abundance was the univariate response. In addition to the physical variable predictors, these models included space both at large scale (geographic position) and at small scale (spatial autocorrelation). The predictions include estimates of uncertainty, which are mapped to provide information on the reliability of the predicted attributes.

The key outputs are maps of predictions combining estimated uncertainty for two attributes of biodiversity: the number of species and the total abundance. These maps can be used in marine planning.

Case example 1: Spatial Generalized Linear Mixed-Effect Models (GLMM) were used to predict fish species richness and abundance on reefs of the Great Barrier Reef (GBR). The spatial GLMM showed a high predictive performance with 62.4% of deviance explained in species richness and 71.9% explained in abundance (Mellin et al. 2010). The best models gathered a combination of spatial and environmental predictors (Table 1). Predictive maps of species richness (Figure 1a) and abundance in the GBR (Figure 1b) obtained by averaging predictions from the different models weighted by their AICc (an index of model support), were in accordance with the observed gradients. Mean prediction errors were on average 7.4% and 12.3% for species richness and abundance on the GBR, respectively.

Case example 2: Spatial GLMM were used to predict fish species richness on reefs of the Torres Strait. The model explained 83.7% of deviance in species richness (Mellin et al. in prep.). The best combination of spatial and environmental predictors for TS (Table 2) differed from the GBR. The predicted maps accorded with the observed gradients of species richness in the TS (Figure 2). Mean prediction errors were 7.6% for species richness on the TS.

Further applications of this Spatial GLMM approach are currently being developed on temperate reefs of southern Australia and seabed fish assemblages of the GBR, as cross-agency collaborations within the CERF Hub. This provides the basis to compare model performance across biomes and taxa.

3.2 Rank Abundance Distributions:

Biodiversity surveys usually are characterised by a relatively small number of common species and a large number of rare species. The rare species can be difficult or impossible to include in many types of analyses, yet it can be desirable to incorporate all the species contained in the survey samples. Rank Abundance Distributions (RADs), a well established ecological distribution of all species in samples, is used as the fundamental response for this analysis approach. RADs are a quantification of community structure (i.e. the number and relative frequency of species) that trade-off species identities to include rare species, and contrast with characterisations of community composition that trade-off rare species to include species' identities. RADs are a joint distribution of several biodiversity attributes and special statistical methods were developed by the Marine Biodiversity Hub to predict RADs from physical surrogate variables.

Technically, a Rank Abundance Distribution is an ordering of the observed species counts, ranked from most abundant to least abundant. It is a joint distribution comprising total abundance, number of species, and abundance of each rank, and hence includes all species, although identities are not retained. RADs can be derived from any unbiased sample of a biological community where individuals can be and have been identified to species and counted. Because they are based on ranked species and do not depend on species identity, multiple communities with very different species compositions can be compared. Community structure is compared independent of species identity. The analysis of RADs also used the Generalized Linear Model class of methods, but developed so that richness, abundance and rank-abundance are modeled as the joint response (Foster and Dunstan 2009). Predictions were accompanied by estimates of uncertainty, which are mapped to give clear indications of the reliability of predictions and provide a key element in informing managers and planners.

The key outputs are maps of predictions and estimates of uncertainty for three key attributes of biodiversity: the number of individuals and its uncertainty, the number of species and its uncertainty, and the relative abundance of those species and the derived measure of evenness and its uncertainty. Areas with rare combinations of species richness and evenness can be identified to inform marine planning.

Case example 1: Biodiversity was analysed and predicted using rank abundance distributions for samples collected during the Voyage of Discovery on the continental shelf and slope to 1500m off southern Western Australia. Of 1548 species found, 55% were found at only 1 site and 87% were found at 5 sites or less. The most abundant species was found at only 25 of 120 sites. Such low frequencies of occurrence are very typical of data obtained from marine surveys. Predictions were made for the entire southern coast of Western Australia to a depth of 1500m for the total number of individuals, the total number of species and the evenness of the assemblages (Figure 3), using physical covariates (Dunstan and Foster in revision). Covariates included temperature, oxygen, salinity and depth. The patterns of community structure were complex, driven by physical processes other than latitude and depth. The influence of the shelf break and Leeuwin undercurrent were prominent. Species richness depended on total abundance, and evenness on species richness and total abundance. The model for total abundance had a pseudo R^2 of 0.3323, the model for species richness had a pseudo R^2 of 0.68, and the model for the relative abundance had a pseudo R^2 of 0.14.

Management applications of this approach of predicting RADs have been completed for the South Western, North Western and Northern marine planning regions. The outputs, including maps of the predictions have been made available to DEWHA to inform marine planning for these regions (see Appendices 1-3 for RAD product descriptions). The approach has also been included in the Global Ocean Biodiversity Initiative, an international partnership reporting to the Convention on Biological Diversity and the United Nations, through the International Union for the Conservation of Nature. Further applications of this RADs approach are planned for temperate rocky reefs and tropical coral reefs, as cross-agency collaborations within the Marine Biodiversity Hub.

4 Composition

The composition of biodiversity and characterization and mapping of assemblages may be approached in several different ways. Traditionally, surveyed sites could be clustered into site-groups, and the group membership of unsurveyed locations could be predicted with a range of methods, and the predicted membership inferred to represent patterns of assemblage composition. Alternatively, surveyed species, with sufficient frequency of occurrence, could be modeled individually and their distributions throughout the region predicted — the predicted abundances could be clustered and mapped to represent compositional assemblage patterns. Additional methods of predicting assemblages, beta diversity patterns, and species groups distribution, have been explored by the Prediction Project.

4.1 Assemblages:

A relatively recent method of identifying assemblage groups involves partitioning the sites, by splitting site data along gradients of the physical variables so that the splits maximize the differences in species compositions between groups and minimize differences in species composition within groups. The splitting rules for the physical variables form a decision tree that can be applied to full coverages of the physical data for the region to predict outside the area for which species data are available. The mapped partitions are categorical groups representing species assemblages with differing composition. The partitioning tree method simultaneously defines the assemblage groups and the prediction algorithm.

Technically, this approach uses the method Multivariate Regression Trees (MRT; De'Ath 2002). It is a type of constrained classification analysis because the classification of sites into groups is constrained to conform to a structure that can be explained by the physical variables. The recursive partitioning involves finding the best splits of the predictors that minimize the sums-of-squares across multiple species. Cross-validation is used to stop the splitting when no further predictive gain is achieved. The predictions are group membership of sites and average abundance of species for each group.

The key outputs are site-group identities, maps of predicted assemblages, and identification of the physical variables that appear to contribute most to the classification. Measures of overall performance, in terms of variation explained by the physical surrogates, is available but prediction uncertainty can not be specifically estimated.

Case example 1: Multivariate Regression Trees were used to predict coral reef fish assemblage composition on the GBR (Figure 4). With eight terminal nodes (one for each fish assemblage), the tree explained up to 61% of species variances and included predictors such as the percent carbonate composition of sediments, mean annual oxygen concentration, standard deviation in light attenuation and spatial predictors such as longitude and latitude. With a cross-validated relative error (CVRE) of 0.71, the model had a medium to low predictive accuracy (CVRE varies from 0 for a perfect model to 1 for a poor model). Indicator species were identified for each assemblage, and the predicted distribution of assemblages mapped across the Great Barrier Reef (Figure 5).

Case example 2: one issue with the partitioning tree method is its instability; small changes in the data can result in a very different sequence of splits and potentially the subsequent grouping of sites. Bootstrap aggregation or bagging is a technique that averages the prediction from a collection of bootstrap samples where a small proportion of the data is randomly selected and excluded from each sample. When repeated many times, this produces a result that is stable to variability in the data. Bagging was novelly applied to MRTs. Here, the aim is to form groups, however the 'bagged' predictions cannot be averaged as the group labels are arbitrary and do not correspond to consistent mixes of species. Instead a site by site similarity matrix was formed, indicating the proportion of times each pair of sites appears in the same group in the bootstrap samples. This matrix can then be ordinated or clustered to obtain site groupings that are more robust to small variations in the sample dataset. This approach was used to characterize assemblages of the 1213 species that occurred at more than 10 of the 1189 sites sampled by sled in the Great Barrier Reef. Five hundred bootstrap samples were generated. The trees fitted to the bootstrap samples had between seven and thirty terminal nodes (with a mean value of 19). The individual trees explained 13.8–27.5% of total species variance. These small values are not unexpected given the very large number of species the model was trying to fit at once. The variables contributing most to the variance explained by the trees included sediment (mud, gravel, carbonate), bathymetry and temperature. The predicted distribution of each assemblage was mapped across the region (Figure 6).

Further applications of this MRT method include extension to reefs of the Australian North West Shelf and to other biomes as cross-agency collaborations within the CERF Hub. Other partitioning methods such as Boosted Regression Trees are currently being investigated for coral reef biota in the Great Barrier Reef and the Torres Strait.

4.2 Beta diversity:

Several shortcomings of existing methods for predicting compositional patterns at national scale from disparate historic surveys, led to the search for an improved approach. Changes in species composition and abundance over a region is inferred from the sites where data were collected, rather than directly measured throughout the region. This inference is often made based on a variety of dissimilarity metrics, thus the multivariate response to be predicted and mapped from physical data is not as easily or clearly defined as richness or abundance. The existing methods work with single internally consistent datasets, typically from one or a limited number of surveys, however to achieve large scale coverage of marine regions, information from multiple often disparate datasets must be collated. Further, full coverage requires predicting from physical data layers that are typically collected independently from, or in addition to, the biological surveys. An alternative approach was developed that quantified biotic change along physical gradients, in common units across species and datasets. Combining the common units provides a biologically informed transformation of the multiple physical data layers and can be applied broadly over a region. The transformed physical variables can be presented in multiple dimensions that represent the quantitative change in the biota, and hence the expected compositional changes or beta diversity patterns. These patterns can be mapped back into geographic space.

Technically, this approach is based on modification of the random forest 'machine learning' method. This is also a partitioning tree method, but instead of a single decision tree, it forms a forest of 100s of trees to provide a smoother more stable result. The analysis is run on each species, that has sufficient frequency of occurrence in the individual survey datasets,. The method is unsuitable for rare species. The new modification to the method collates the tree split values along each physical gradient where individual species abundance changes and by how much. These split values are collated across all species, trees and forests. Results are presented as cumulative distributions of biotic change at all splits, for each physical variable. These distributions represent patterns of biological change response along gradients for each physical variable and are used to transform the more readily available physical data layers to provide continuous maps of expected patterns of compositional change of marine biodiversity in a way that better represents beta diversity patterns than raw physical variables alone. The continuous representation of beta diversity patterns can, if required, be clustered to represent expected compositional assemblage groups.

The key outputs for a region include a map of the transformed physical environment space, presented in way to represent as much of the expected compositional change as possible. For some applications, the results may be clustered to provide a map of expected assemblage groups. The outputs also summarize the overall prediction performance of physical surrogates for species, identify the physical variables that appear to contribute most to biological changes, and for each physical variable describes the shape and magnitude of multiple species responses along the gradient.

Case example 1: the compositional change of biota along gradients was quantified using the modified Random Forest method for samples collected by a sled and a trawl during the Seabed Biodiversity Project on the continental shelf in the Great Barrier Reef region. Of >5,300 taxa sampled and identified, about 850 species occurring at > 23 sites of 1190 sites were analysed. Most of the >5,300 taxa were rare and could not be included, but tend to have little influence on quantitative measures of compositional patterns. In the Random Forest models, the physical variables explained 0–70% of variation in individual species biomass (median: 13 & 22% for sled and trawl). The most influential variables were sediment attributes, bed-stress, and depth. The compositional change along physical gradients was non-linear, showing that not all portions of gradients are equally influential. For example, 80% of compositional change for invertebrates occurs in the range 0–20% mud content, whereas relatively little change occurs in the range 20-80% mud content. Similar results were seen for several other variables. The cumulative distributions of compositional change were used to transform the regional physical data layers and mapped to represent continuous patterns of compositional change in seabed biota in the region (Figure 7).

Case example 2: the species abundance and biomass of demersal fish communities sampled on shallow rocky reefs (<10 m) across the coast of South Australia were analysed and predicted using random forests. Analyses were conducted on 76 fish species from 128 sites to identify splits along each of the 26 physical gradients (e.g. sea surface temperature, wave exposure) that correspond to observed changes in the spatial patterns of benthic species. 23 species occurred at only one site and 21 species were found at less than 5% of sites. These rare species were amalgamated to create two new classes of species (singletons and uncommon) for purposes of this analysis. The most influential physical variables for predicting biodiversity (abundance and biomass) were average and seasonal range of sea surface temperature, salinity, oxygen, sand and distance to the continental shelf.

Management applications of this approach for predicting expected Assemblages have been completed for the South West, North West and North marine bioregions, and are underway for the East marine bioregion. The outputs, including maps of the expected assemblages have been made available to DEWHA to inform marine planning for these regions (see Appendices 4-6 for Assemblages product descriptions). The approach also forms the basis of a Census of Marine Life Synthesis Project that is a collaboration between Marine Hub researchers and scientists from Canada and the USA, with the aim of comparing the physical drivers of compositional patterns between different regions. The CoML collaborators have also contributed to the development of the method. Further applications of this modified Random Forest approach are planned for temperate rocky reefs in other southern states, for tropical coral reefs, and the South East marine bioregion through a collaboration with Atlas of Living Australia. Other contemporary methods that can predict continuous patterns of compositional change include generalized dissimilarity modeling (GDM) and constrained canonical correspondence analysis (CCCA) and may be investigated for comparative purposes; however, neither can incorporate multiple disparate datasets.

4.3 Species groups:

As in the case of site-group assemblages, the composition of biodiversity and characterization and mapping of species-groups may be approached in several different ways with variable success. The Prediction Program has developed a new approach termed species '*Archetypes*'. Species archetypes are a method of simultaneously grouping and predicting the distribution of many species. Every species has a set of environmental conditions that defines its ability to survive and reproduce. Many species have very similar environmental requirements and hence respond similarly to measured environmental gradients. Species that have similar responses can be modelled as a single entity without significant information loss. An archetype is defined as a group of species that responds to the environment in a statistically similar way. For example, instead of having to model and predict 200 species, a substantially reduced set of 16 archetypes can be used to parsimoniously characterise the environmental requirements of all the species with an associated measure of the loss of information compared to the full dataset. Simultaneous prediction of multiple species has significant advantages over many separate single species predictions. Each species in an archetype contributes information to the model and improves predictions. Management can be targeted at a few archetypes rather than a large number of individual species, significantly reducing the complexity of conservation management problems.

Technically, Archetypes are a model based grouping of species presence for prediction across environmental gradients. It is a mixture modeling approach in the Generalized Linear Model class of methods (Dunstan, Foster & Darnell, in review). The approach allows simultaneous estimation of effects and definition of species groups. The most parsimonious number of archetypes can be determined by comparing models with different numbers of archetypes and using statistical criteria to determine the most appropriate number. Prediction of the probability of presence is obtained for each archetype with an associated measure of uncertainty.

The key outputs for each archetype are the predicted response of its member species to the environment, including the probability of presence of the archetype and the associated uncertainty. The number of members of each archetype can range from 1 to the number of species analysed. Archetypes capture both species with restricted distributions and ubiquitous species. Critically, each archetype represents a group of species that responds in the same way to the measured environment and can be treated as a single management unit. Spatial management to include an archetype can be expected to result in the inclusion of all species represented by that archetype.

Case Study 1: Archetypes were calculated for 200 benthic species including algae, molluscs, echinoderms and crustaceans found in an extensive survey conducted on the GBR shelf. The optimal number of archetypes was 15 and a model was fitted to estimate the responses of all archetypes to physical covariates. The covariates include temperature, depth, oxygen, salinity, %mud, %gravel, nitrogen and phosphate concentrations. Archetype models with covariates performed significantly better than models that did not include covariates, indicating that archetypes described, parsimoniously and without significant loss of information, the relationship to the physical environment of many species simultaneously (eg. Figure 8). Oceanographic patterns (i.e. temperature, oxygen and salinity) were very important for describing archetype patterns. Maps of uncertainty indicated that the models predicted the probability of presence with a high level of certainty (Dunstan, Foster & Darnell, in review).

Case Study 2: Archetypes were estimated for demersal fish communities on the continental shelf and slope off the coast of SE Australia. These regions have significant fishery activity and many commercially important species. One hundred common species could be aggregated into 9 archetypes representing species groups that used different environmental space. Again, archetype models performed significantly better than models that did not include covariates. Each archetype comprised an ecologically reasonable group based on expert knowledge. For example, Figure 9 top shows species that are located close to the coast and include eastern school whiting and longspine flathead. Figure 9 bottom shows species that are found on the deeper part of the shelf and include gummy shark and latchet.

Case Study 3: Archetypes were estimated for demersal fish communities on shallow rocky reefs on the coast South Australia. This region has the longest stretch of south facing coastline in the southern hemisphere and has remarkably high levels of endemism. The optimal number of archetypes from a set of 64 common species was 7. A model was fitted to estimate the responses of all archetypes to environmental covariates. The covariates account for both broad scale environmental gradients and spatial context. Each archetype represented species that used different environmental space. For example, species-archetype 6 is present in environments with low exposure and wave swell and low temperatures. Membership of archetype 6 is mainly restricted to species typically found in higher latitudes on the eastern south coast of Australia including the marblefish.

Further applications of this method include extension to other shallow rocky reefs across southern Australia, and to tropical coral reefs. Further development will allow the use of count or biomass data and the identification of “habitats” based on archetypes.

5 Additional Results

The prediction of patterns in biodiversity from datasets collated from a variety of surveys has many potential sources of bias and error. The Marine Biodiversity Hub Prediction Program has been examining the effects of these on biodiversity prediction and developing solutions as possible.

5.1 Influence of spatial scale:

The influence of spatial scale on predictor importance was investigated by developing a novel procedure that used spatial weights to investigate spatial scale (i.e. local vs. regional scales) effects on the performance of distribution models and on the relative importance of different model predictors (Mellin et al. in prep). Investigating spatial scale effects in each of the three models (GLMMS in Case example 1 on page 2) showed consistent patterns between regions and response variables, such as the importance of spatial predictors appearing at a medium scale (20 km) only, below which local variation in environmental variables provided better predictors of species richness. These results showed that (i) the relative performance of different predictors is scale dependent and (ii) the potential of geographic location for providing a complementary information to multivariate and complex environmental processes, hence a cost-effective descriptor of biodiversity patterns (Mellin et al. 2010), requires the consideration of a minimum spatial scale to be effective. This approach is being extended to other regions and biomes.

5.2 Sensitivity to error in covariates:

Preliminary analyses have been conducted on the implications of uncertainty in the interpolated covariates; ie. the physical predictor variables typically are not measured at locations of the biological samples but have been interpolated and the interpolated values have error. This leads to biased estimates and biased variance, and interpretation of the model and predictions may be unreliable. Work on this objective is continuing.

5.3 Data requirements to properly characterize biodiversity:

The examination of the data density/quality required to properly characterize patterns of biodiversity, on the basis of attributes of the biological data, is being developed with a post-doc jointly appointed by AIMS and the JCU Centre of Excellence in Coral Reef Studies.

For some datasets, the implications of various issues relating to sampling on vessels have been examined. In particular, the consequences of sub-sampling for underestimating species richness and introducing bias in data has been quantified. A manuscript on this investigation is being prepared for publication.

5.4 Biological Surrogates:

The extent to which selected taxa (such as fishes) are biological surrogates for biodiversity pattern in other taxa (such as invertebrate groups) and other biodiversity measures (eg. species richness, diversity indices, evenness) has been investigated with the taxonomically diverse GBR and TS datasets. For species richness, a few groups may sometimes be reasonably well correlated, such as green and brown algae or seagrasses; however, this result is not consistent. In the case of beta diversity and assemblage patterns, the correlations of dissimilarity matrices and similarity of clusterings across phyla and nested taxonomic levels has been examined at a range of spatial scales for datasets from GBR and TS. Generally these indicate that cross-taxa surrogacy is typically poor and that nested taxonomic levels are somewhat better, but decline with coarser taxonomy. In some analyses there are indications that biological surrogacy improves at larger scales, but again this result is not consistent. This work involves a PhD student at UQ with the AEDA Hub and is ongoing.

6 Supporting datasets

A precursor to the analytical work presented here has been the collation of extensive datasets for physical variables and biota distribution. This was not a trivial task and the datasets collated and made available provide access to a very large historic investment in marine science in Australia from the partners in the Hub and other groups who have contributed their data. This extensive data collation re-enforces the value of a collaborative approach. Information on the collation of physical and biological data has been provided in earlier Marine Hub Milestone Report. Additional or new datasets have since been collated and are outlined below.

6.1 Biological survey datasets:

The biological database for the shallow temperate rocky reefs has now been completed by Marine Hub researchers from TAFI. This includes underwater visual census (UVC) data for temperate reef fish, mega-invertebrates and macro-algae. Rapid progress is now being made with analyses of these data.

Four additional broad-scale continental shelf trawl survey datasets have also been collated to enable extension of predictive methods developed by the Hub to provide products suitable for marine regional planning by DEWHA in the SW, NW, North and East Marine Regions (see Appendices)(.

6.2 Physical surrogates:

Prediction staff have also contributed outputs to the Surrogates Program. Recently, a fine scale wave exposure model for coastal regions has been developed that is effective for shallow coastal habitats given that the existing disturbance coverages were uncertain in waters shallower than 20m. The model incorporates fetch, local winds and direction, and bathymetry. Subsequently, analyses have identified wave exposure as being a critically important physical variable for prediction in these habitats. Further, a database of surficial geology for shallow coastal habitats is being developed, as underlying geology contributes to determining the biological habitats that may develop in an area.

7 Publications

Dunstan, P.K. Foster, S.D., (in revision) RAD Biodiversity: Prediction of Rank Abundance Distributions from Deep Water Benthic Assemblages

Dunstan, P.K., Foster, S.D. and Darnell R.D. (in review) Model Based Grouping of Species across Environmental Gradients.

Foster, S.D., Dunstan, P.K. (2009) The Analysis of Biodiversity Using Rank Abundance Distributions. Biometrics

Mellin C, Bradshaw CJA, Meekan MG, Caley MJ (2010) Environmental and spatial predictors of species richness and abundance in coral reef fishes. Global Ecology and Biogeography 19: 212-222

Mellin C, Bradshaw CJA, Venables WN, Pitcher CR, Meekan MG, Caley MJ (in prep) Detecting and quantifying spatial scale effects in biodiversity distribution models. To be submitted to American Naturalist.

Mellin, C.; M J Caley; M G Meekan; A Williams; P Dunstan; G J Edgar; R Przeslawski; C R Pitcher; CJA Bradshaw (in revision) The effectiveness of biological surrogates for predicting biodiversity patterns. Ecological Applications

Shimadzu, H. Foster, S. The Problem with Using Spatially Interpolated Covariates in a GLM and a Potential Solution.

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Camille Mellin (AIMS), Corey Bradshaw (AU), Emma Lawrence (CSIRO), Graham Edgar (TAFI), Hideyasu Shimadzu (GA), Johnathan Kool (JCU–AIMS), Julian Caley (AIMS), Mark Meekan (AIMS), Neville Barrett (TAFI), Nick Ellis (CSIRO), Nicole Hill (TAFI), Patricia Sutcliffe (QM–UQ), Piers Dunstan (CSIRO), Rebecca Leaper (TAFI), Roland Pitcher (CSIRO), Ross Darnell (CSIRO), Russell Thomson (UTAS, Scott Foster (CSIRO), William Venables (CSIRO).

9 Tables

Table 1. Summary of generalized linear model (GLM) comparisons using Akaike's information criterion corrected for small sample sizes (AIC_c) and the Bayesian information criterion (BIC) for the Great Barrier Reef. Only the models outperforming the null model, and the null models themselves, are shown. Response variables are species richness (*S*) and log-transformed abundance (*N*) of reef fishes. Shown are the number of samples (*n*), model maximum log-likelihood (LL), number of parameters (*k*), change in AIC_c (ΔAIC_c), AIC_c weight ($wAIC_c$), change in BIC (ΔBIC), BIC weight (*w*BIC) and the percent deviance explained (%DE). %DE is a measure of the structural goodness-of-fit of the model. Model sequences are ordered by increasing BIC for the two model sets. Spatial predictors include minimum distance to the coast (Dc) and minimum distance to the ocean (Do). Environmental predictors include Tm: annual mean sea surface temperature, Ts: standard deviation in sea surface temperature, Sm: annual mean salinity, Om: annual mean oxygen concentration, Os: standard deviation in oxygen concentration, Si: annual mean silicate concentration, Ks: standard deviation in K490 (the diffuse attenuation coefficient at wavelength 490 nm). All_env include all candidate environmental predictors, including four water chemistry variables, one substrate descriptor, three indices of ocean productivity and depth.

Model	LL	*k*	ΔAIC_c	$wAIC_c$	ΔBIC	*w*BIC	%DE
S (*n* = 137)							
Dc + Do	-344.0	4	7.7	0.016	0.0	0.989	36.8
Tm^2 + Ts + Sm^2 + Om + Os	-339.2	9	7.6	0.016	9.6	0.008	43.2
Tm^2 + Ts + Sm^2 + Om + Os + Dc + Do	-334.8	11	6.6	0.028	15.4	0.003	48.3
All_env	-331.2	13	2.8	0.180	17.7	0.000	51.5
All_env + Dc + Do	-326.8	15	0.0	0.760	18.8	0.000	55.9
Null	-367.1	2	47.3	0.000	31.7	0.000	0.0
N (*n* = 137)							
Nm + Sm^2 + Dc + Do + Si + Ks	-47.6	8	6.5	0.042	0.0	0.529	21.5
Nm + Sm^2 + Si + Ks	-52.6	6	11.8	0.004	0.3	0.455	17.8
Nm + Sm^2 + Dc + Do + Si + Ks + Om + Os	-47.0	10	9.9	0.008	8.2	0.010	22.4
All_env + Dc + Do	-35.7	15	0.0	0.946	9.4	0.006	35.4
Null	-73.3	2	44.5	0.000	22.7	0.000	0.0

Table 2. Summary of generalized linear model (GLM) comparisons using Akaike's Information Criterion corrected for small sample sizes (AIC_c) and the Bayesian Information Criterion (BIC) for fish species richness. Shown are the number of parameters (*k*), model maximum log-likelihood (LL), change in AIC_c (ΔAIC_c), AIC_c weight ($wAIC_c$), BIC weight (*w*BIC), change in BIC (ΔBIC) and the percent deviance explained (%DE). %DE is a measure of the structural goodness-of-fit of the model. Model sequences are ordered by increasing BIC. Spatial predictors include longitude and latitude. 'ALL' include all predictors and 'NULL' is the null model.

Model	*k*	LL	ΔAIC_c	$wAIC_c$	ΔBIC	*w*BIC	%DE
ALL	18	-723.00	0.00	1.000	0.00	0.999	83.74
Longitude * Latitude	4	-771.69	65.29	0.000	23.78	0.001	80.99
Nitrate + Phosphate	5	-986.04	496.13	0.000	457.75	0.000	68.87
Salinity + Temperature	5	-1020.99	566.02	0.000	527.64	0.000	66.89
Oxygen + Chlorophyll *a*	5	-1298.64	1121.33	0.000	1082.94	0.000	51.20
Depth + Gravel	3	-1656.30	1832.39	0.000	1787.74	0.000	30.98
NULL	1	-2204.30	2924.25	0.000	2873.22	0.000	0.00

10 Figures

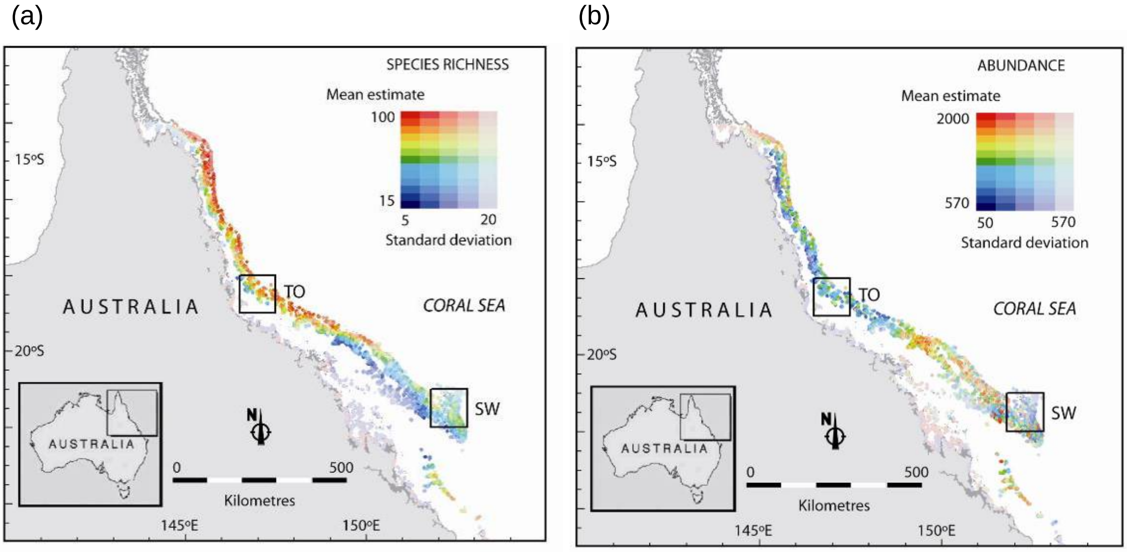


Figure 1. Spatial predictions of species richness (a) and abundance (b) of coral reef fishes on the Great Barrier Reef. A 2-D colour key is used to represent both mean estimate (hue) and standard deviation (saturation) of predictions.

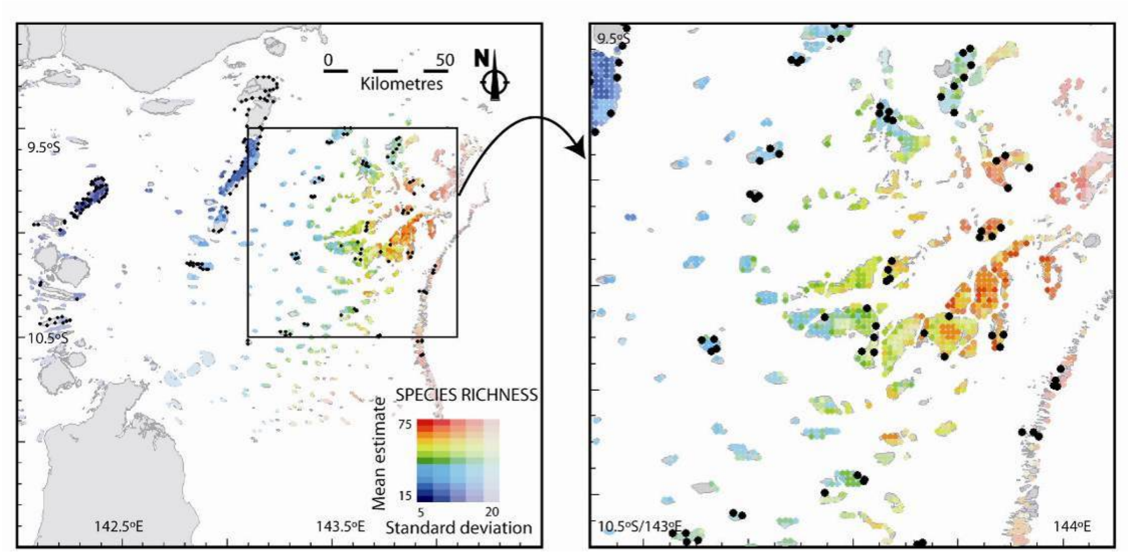


Figure 2. Spatial predictions of coral reef fish species richness across the Torres Strait. A 2-D colour key is used to represent both mean estimate (hue) and standard deviation (saturation) of predictions. Black dots indicate the position of sampled reefs.

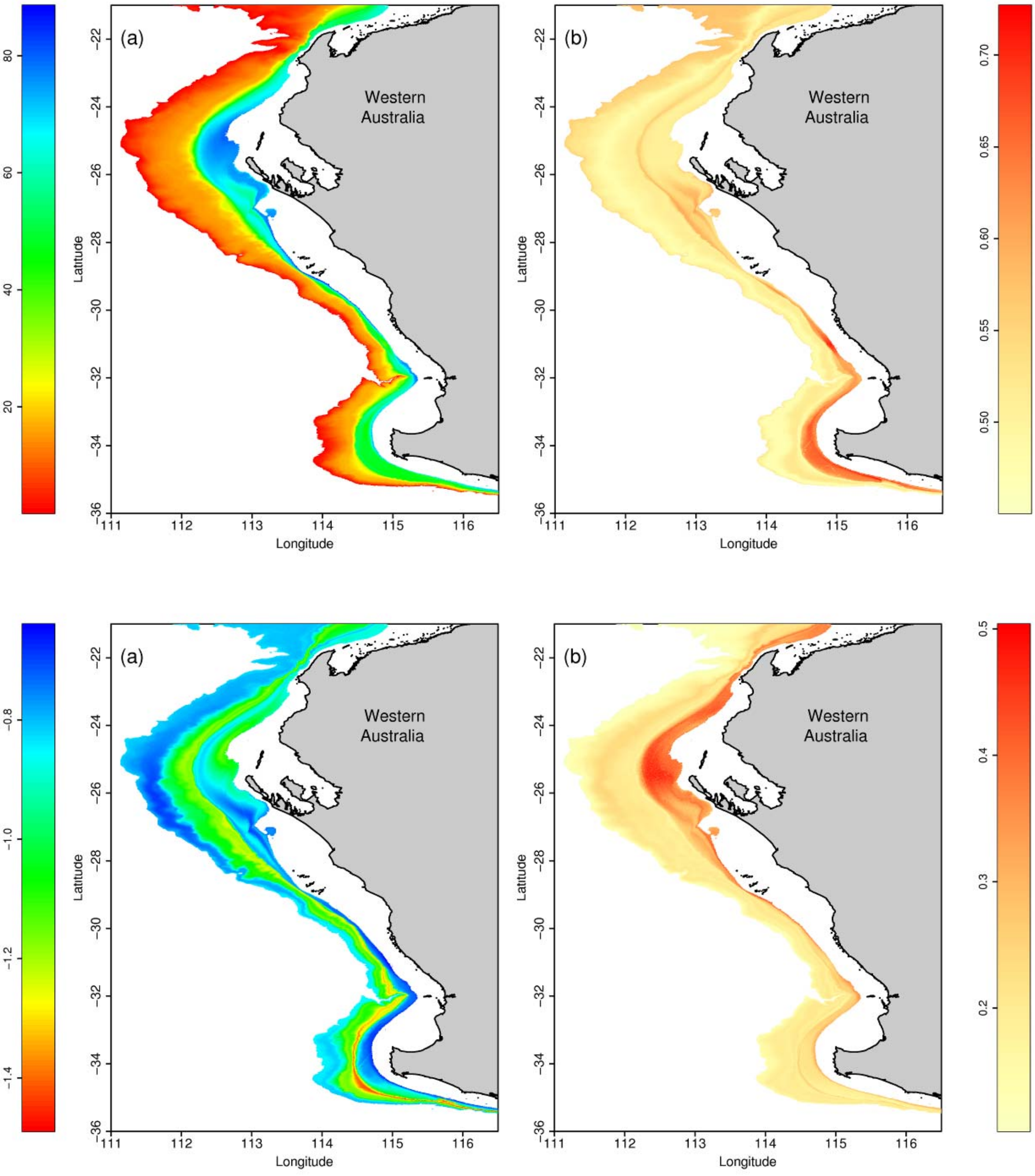


Figure 3: (top) Predicted values of species richness (a) and uncertainty (b), and (bottom) predicted values of evenness (a) and uncertainty (b) for the Western Australian slope Voyage of Discovery.

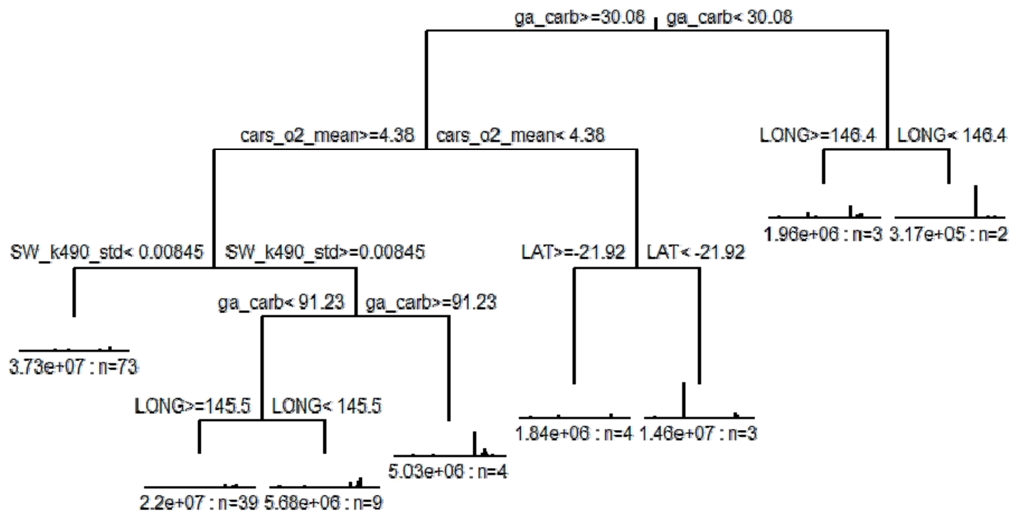


Figure 4. Multivariate Regression Tree of fish assemblage composition. Eight groups of sites with similar fish assemblage composition (tree leaves) define eight fish assemblages and are primarily split according to the percent cover of carbonate sediments (ga_carb, %), followed by the mean annual oxygen levels (cars_o2_mean, mL.L-1), longitude (LONG, degrees), the standard deviation in the light attenuation coefficient K490 (SW_k490_std, m-1), latitude (LAT, degrees). Each tree leaf is characterized by the total species variance and the number of sites (n). Error=0.39, Cross-validated error= 0.71, standard error in the cross-validated error =0.13.

Class	Indicator fish taxa		Associated physical characteristics
1	*Acanthurus nigrofuscus* *Chromis margaritifer* *Ctenochaetus spp* *Forcipiger flavissimus* *Gomphosus varius*	*Halichoeres hortulanus* *Pomacentrus bankanensis* *Pomacentrus philippinus* *Scarus frenatus* *Zanclus cornutus*	Carb > 30.1% 02 mean > 4.4 K490 std < 0.01
2			30 % < Carb < 91.2 % 02 mean > 4.4 K490 std > 0.01 LONG > 145°
3	*Acanthurus blochii* *Acanthurus nigricauda* *Chaetodon baronessa* *Chaetodon plebeius* *Chaetodon trifasciatus*	*Chaetodon vagabundus* *Chromis viridis* *Dascyllus reticulatus* *Pomacentrus amboinensis* *Pomacentrus brachialis*	30 % < Carb < 91.2 % 02 mean > 4.4 K490 std > 0.01 LONG < 145°
4	*Neopomacentrus azysron* *Pomacentrus lepidogenys*		Carb > 30.1% 02 mean < 4.4 LAT > -21.9
5	*Chlorurus sordidus* *Halichoeres hortulanus* *Pomacentrus vaiuli*	*Scarus chameleon* *Scarus globiceps* *Scarus spinus*	Carb > 30.1% 02 mean < 4.4 LAT < -21.9
6	*Chromis nitida* *Hemigymnus fasciatus* *Lethrinus miniatus* *Plectropomus leopardus*	*Scarus niger* *Zebrasoma veliferum*	Carb < 30.1% LONG > 146.4°
7	*Lutjanus russellii* *Plectropomus maculatus*		Carb < 30.1% LONG < 146.4°
8	*Chaetodon lineolatus* *Lethrinus harak* *Lethrinus laticaudis* *Lutjanus argentimaculats* *Lutjanus lemniscatus* *Siganus lineatus*		LAT > -14.6° SST_std < 1.6°C

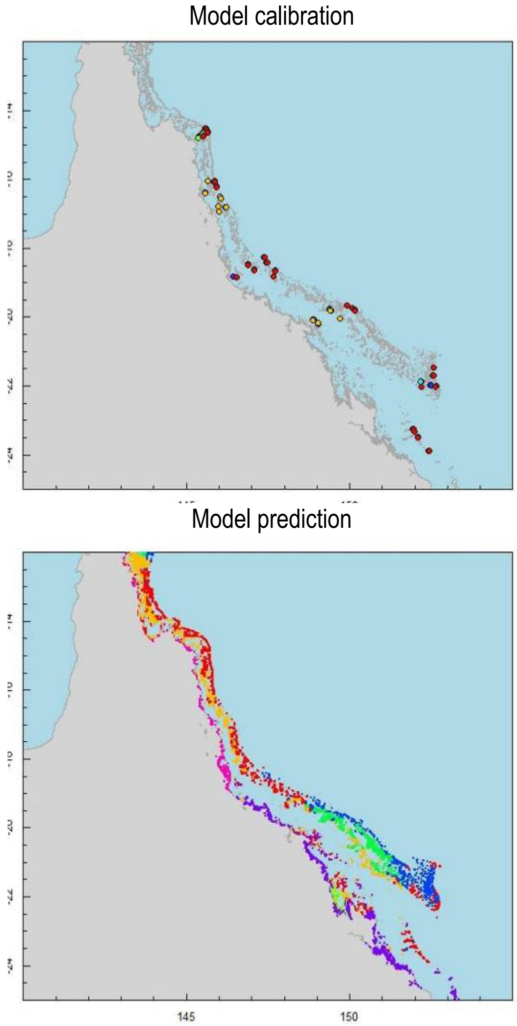


Figure 5. Fish assemblages predicted using Multivariate Regression Trees (Fig. 4), associated indicator fish taxa and physical characteristics of their habitat, including the percent cover of carbonate sediments (Carb, %), the mean annual oxygen levels (O2 mean, mL.L-1), longitude (LONG, degrees), the standard deviation in the light attenuation coefficient K490 (K490 std, m-1), latitude (LAT, degrees). Model calibration data were from the AIMS LTMP Program.

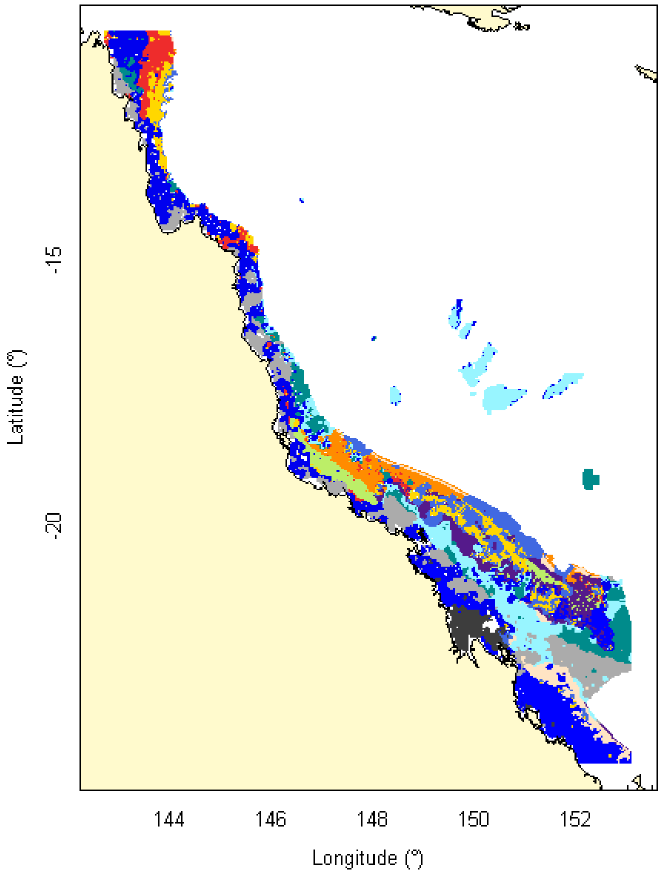


Figure 6. Map of 13 predicted assemblages from 500 bagged MRT analyses of the GBR Seabed Biodiversity Project epibenthic sled sample data.

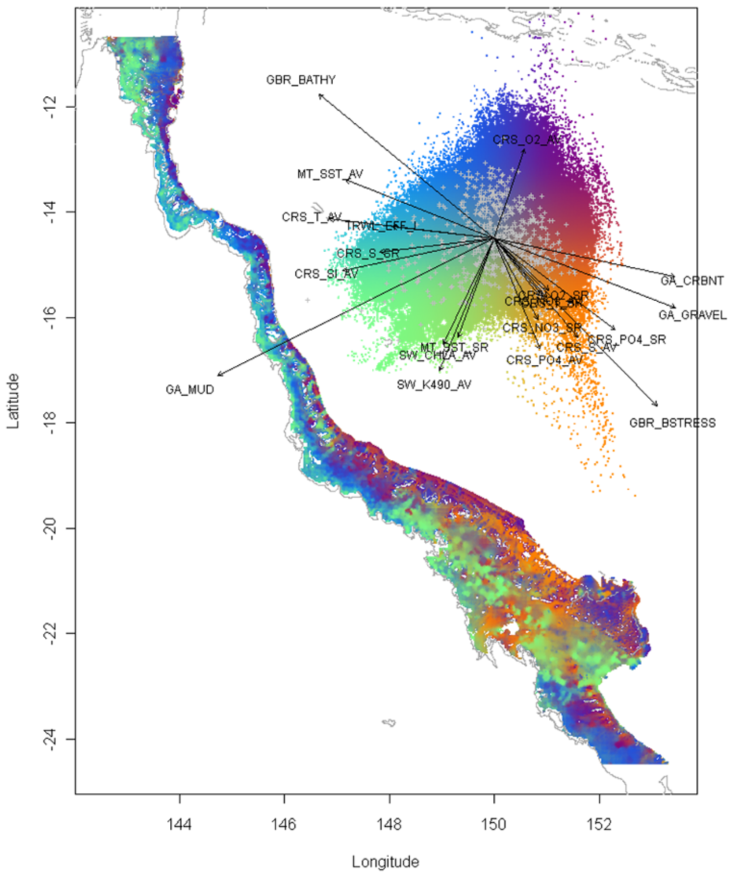


Figure 7. Map of transformed physical variables following Random Forest analyses of epibenthic sled data from the GBR Seabed Biodiversity Project, representing expected continuous patterns of compositional change in seabed biota.

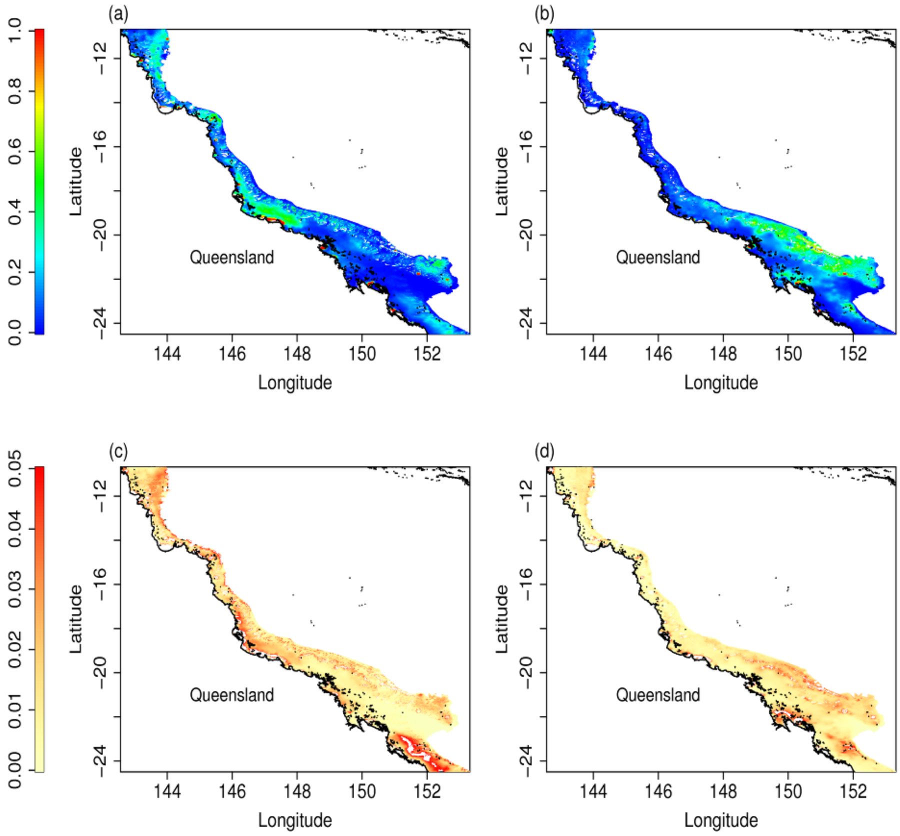


Figure 8: Probability of presence for two archetypes from the GBR (a & b) and uncertainty of these archetypes (c & d)

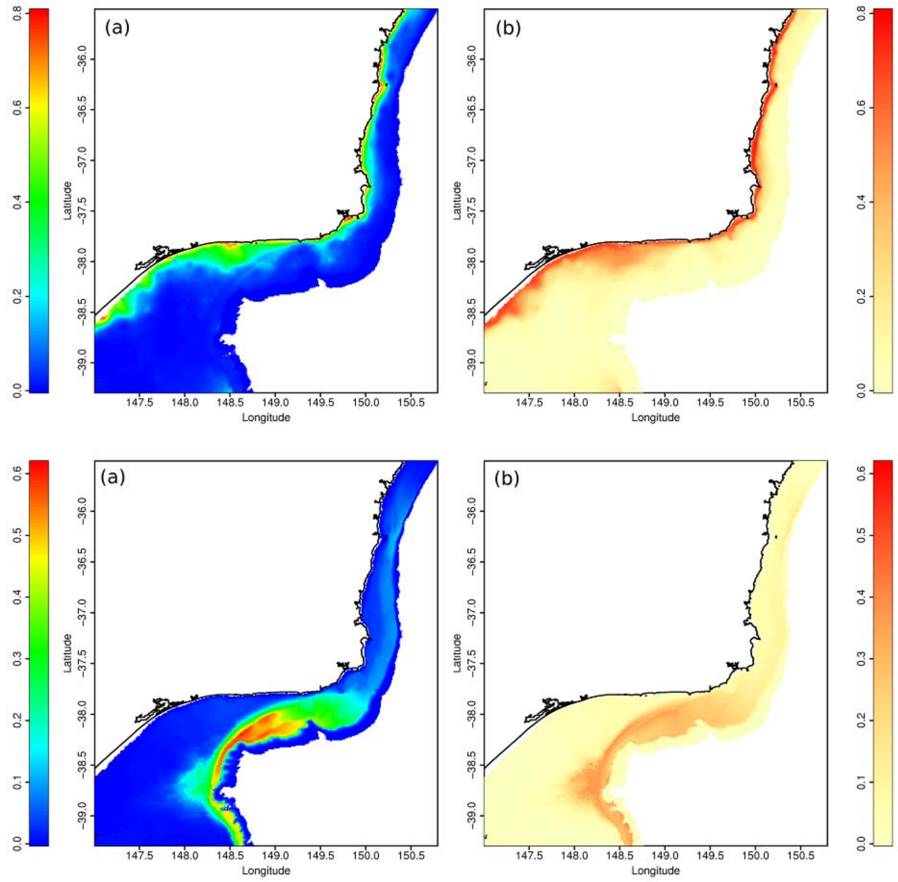


Figure 9: Maps of archetypes of demersal fish from SE Australia showing probability of presence (a) and uncertainty (b). Top shows species that are located close to the coast and includes eastern school whiting and longspine flathead; the bottom group includes Gummy Shark and Latchet.

Product title: Predicted patterns of seabed biodiversity in the South-west Marine Region (SWMR).

Relevance of product to marine planning and management

This product provides planners and managers with biologically informed predictions about the patterns in species abundance, species richness and species evenness of seabed fishes and invertebrates on the outer shelf and slope in the SWMR. It can be used as follows:

1. To provide scientific analysis and input to planners and managers with the responsibility to conserve and managed marine biodiversity in the SWMR;
2. As a biological data input to models, where appropriate, of the marine environment in the SWMR (e.g. Marxan);
3. To compare predictions in patterns of seabed biodiversity in the SWMR with the findings of future biological surveys; and
4. To produce maps of predicted spatial patterns of species abundance, species richness and species evenness for seabed fishes and invertebrates in depths from 50 to 1500 metres;

It will be of value in planning and managing the conservation of marine biological diversity in the SWMR, particularly in relation to predicting areas of high biodiversity when there is very little or no biological data.

Product description

This product (i.e. Access data base) contains data (longitudes, latitude and biodiversity attribute variables) that describes the predicted spatial patterns of total species abundance, species richness and species evenness for both benthic invertebrates and demersal fish in the SWMR. The predicted patterns are represent as point data arranged on a 0.1 degree grid (~ 1.2 km^2) covering depths 50-1500 metres in the SWMR.

Interpretation of product

This product represents the predicted spatial patterns of species abundance, species richness and species evenness of benthic invertebrate and demersal fish communities in the SWMR. It provides a description of the structure rather than the composition (i.e. specific species) of benthic assemblages. Structure equates to total species abundance (the total number of individuals), species richness (the total number of species) and species evenness (relative proportions of species).

Data and information on the levels of uncertainty associated with predictions can be produced and made available but it is not provided in this product. If this matter is important to your work please phone or email the contact for further information.

Brief description of methods/data used develop output

The following provides a basic description of the methods and data used to produce this product:

1. Existing biological data (i.e. demersal fish and benthic invertebrate species) and physical data (i.e. dissolved oxygen, temperature, mud content of sediments, etc.) for the SWMR was collated from the following sources; CSIRO Atlas of Regional Seas (CARS) and range of biological surveys within the SWMR (e.g. West Australian Voyage of Discovery);

2. Biological data was used to identify biodiversity values (i.e. for total species abundance, species richness and species evenness) for all known biological sample sites in the SWMR;

3. Analyses were conducted to determine which physical variables/combinations of physical variables best explain the spatial patterns in biodiversity values identified in step 1 (i.e. looking for covariate physical variables that can be reliably used to predict benthic biodiversity);

4. The most reliable/meaningful covariate physical variables were identified and subsequently used as the basis to make a database of predictions of biological diversity values for all points on a 1 km2 grid for the SWMR between 50-1500 metres depths; and

5. A database was developed to capture latitude, longitude and biodiversity values. This was used to produce maps displaying patterns in benthic biodiversity.

Please phone or email the contact for a more detailed and technical explanation of the methods or data used to develop this product.

Advantages/improvements over existing products

The product provides the only available means to robustly predict patterns of benthic biodiversity at a range of spatial scales in the SWMR. The product uses the most recently available data on the physical environment and biology (demersal fish and benthic invertebrates) in the SWMR.

Conditions of use

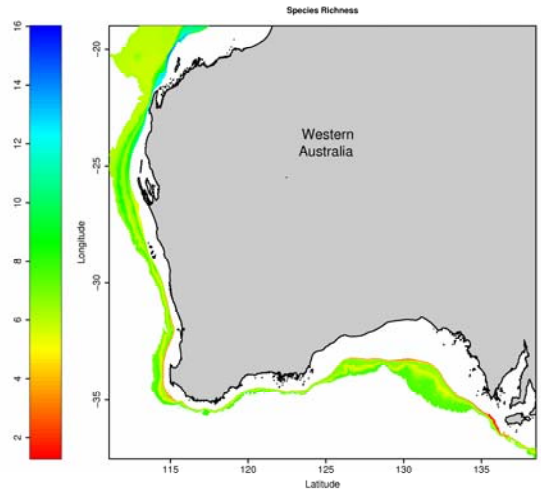
The product does not contain any confidential information. Data sets provided can be used by planners and managers, but contact the author if intending to use data in publications.

Contact for further information
Piers Dunstan 03 6232 5382 Piers.Dunstan@csiro.au

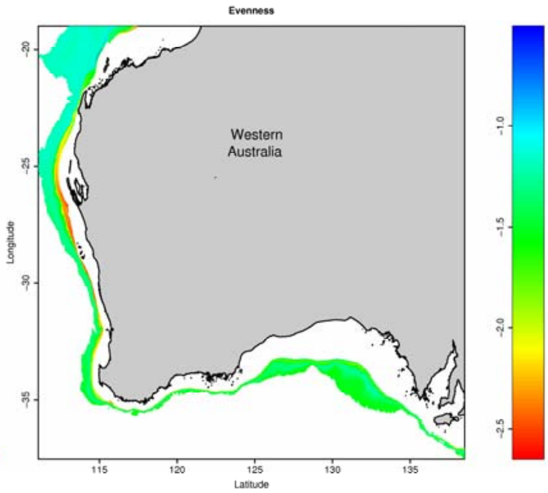
Attachments

1. Maps of species richness predictions of benthic invertebrates and demersal fish for the South-west Marine Region.
2. Metadata record for Predicted patterns of seabed biodiversity in SWMR (to be provided).

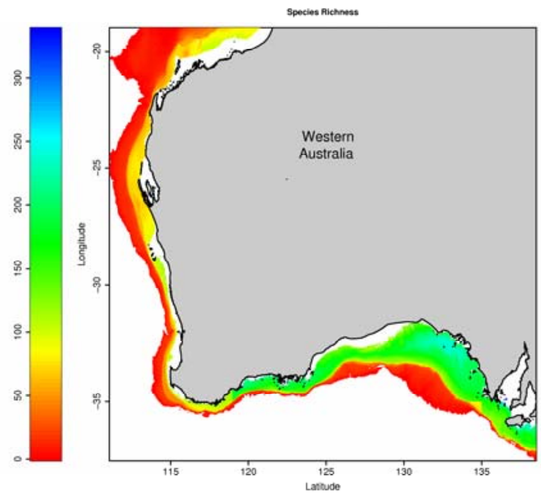
Attachment 1: Maps for species richness and species evenness predictions for South-west Marine Region; a) demersal fish species richness, 1b) demersal fish species evenness, 1c) benthic invertebrates species richness, and 1d) benthic invertebrates species evenness.



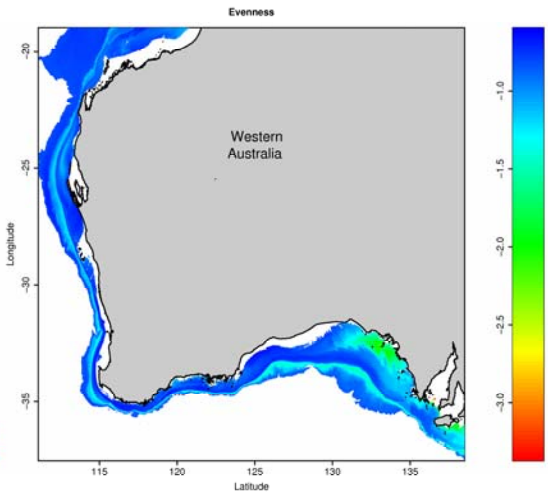
1a)



1b)



1c)



1d)

Attachment 2: Metadata record for database of benthic biodiversity predictions in SWMR.

To be provided

Product title: Predicted patterns of seabed biodiversity in the North West Marine Region (NWMR).

Relevance of product to marine planning and management

This product provides planners and managers with biologically informed predictions about the patterns in species abundance, species richness and species evenness of seabed fishes on the outer shelf and slope in the NWMR
. It can be used as follows:

1. To provide scientific analysis and input to planners and managers with the responsibility to conserve and managed marine biodiversity in the NWMR;

2. As a biological data input to models, where appropriate, of the marine environment in the NWMR (e.g. Marxan);

3. To compare predictions in patterns of seabed biodiversity in the NWMR with the findings of future biological surveys; and

4. To produce maps of predicted spatial patterns of species abundance, species richness and species evenness for seabed fishes in depths from 50 to 1500 metres;

It will be of value in planning and managing the conservation of marine biological diversity in the NWMR, particularly in relation to predicting areas of high biodiversity when there is very little or no biological data.

Product description

This product (i.e. Access data base) contains data (longitudes, latitude and biodiversity attribute variables) that describes the predicted spatial patterns of biodiversity categories based on species richness and evenness of demersal fish in the NWMR. This product provides predictions for total species abundance, species richness and species evenness and estimates of uncertainty for demersal fish. The predicted patterns are represent as point data arranged on a 0.1 degree grid (~ 1.2 km^2) covering depths 50-1500 metres in the NWMR

Interpretation of product

This product represents the predicted spatial patterns of species abundance, species richness and species evenness of demersal fish communities in the NWMR. It provides a description of the structure rather than the composition (i.e. specific species) of these assemblages. Structure equates to total species abundance (the total number of individuals), species richness (the total number of species) and species evenness (relative proportions of species). The product can also be used to identify areas in the NWMR that are predicted to have unique combinations of species richness and evenness. This allows managers to identify areas that are predicted to have common or rare types of community structure.

Data and information on the levels of uncertainty associated with predictions have been produced. For more information please phone or email the contact.

Brief description of methods/data used develop output

The following provides a basic description of the methods and data used to produce this product:

1. Existing biological data (i.e. demersal fish) and physical data (i.e. dissolved oxygen, temperature, mud content of sediments, etc.) for the NWMR was collated from the following sources; CSIRO Atlas of Regional Seas (CARS) and range of biological surveys within the NWMR (e.g. Torres Strait Surveys);

2. Biological data was used to identify biodiversity values (i.e. for total species abundance, species richness and species evenness) for all known biological sample sites in the NWMR;

3. Analyses were conducted to determine which physical variables/combinations of physical variables best explain the spatial patterns in biodiversity values identified in step 1 (i.e looking for covariate physical variables that can be reliably used to predict benthic biodiversity);

4. The most reliable/meaningful covariate physical variables were identified and subsequently used as the basis to make a database of predictions of biological diversity values for all points on a 1 km2 grid for the NWMR between 50-1500 metres depths; and

5. Categories representing unique combinations of species richness and evenness where created by assigning the values of richness one of five ranks and values of evenness one of five ranks. Combining the two sets of ranks gave 25 different possible categories

6. A database was developed to capture latitude, longitude and biodiversity values. This was used to produce maps displaying patterns in benthic biodiversity and map biodiversity categories.

Please phone or email the contact for a more detailed and technical explanation of the methods or data used to develop this product.

Advantages/improvements over existing products

The product provides the only available means to robustly predict patterns of benthic biodiversity at a range of spatial scales in the NWMR. The product uses the most recently available data on the physical environment and biology (demersal fish) in the NWMR.

Conditions of use

The product does not contain any confidential information. Data sets provided can be used by planners and managers, but contact the author if intending to use data in publications.

Contact for further information

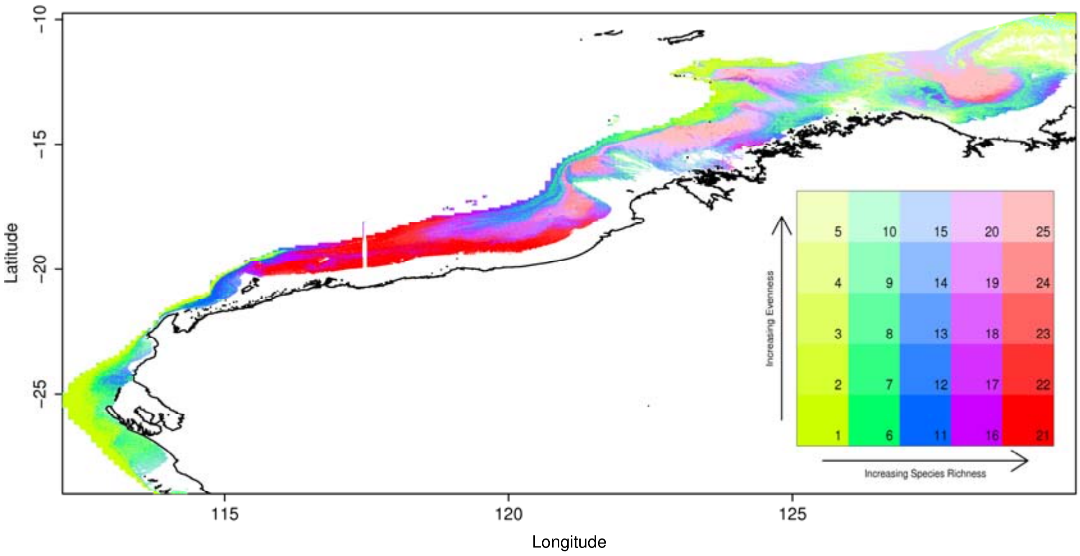
Piers Dunstan 03 6232 5382 Piers.Dunstan@csiro.au

Attachments

1. Map and interpretive key to identify areas in the North West Marine Region that are predicted to have unique combinations of species richness and evenness for demersal fish.
2. Metadata record for Predicted patterns of seabed biodiversity in NWMR (to be provided).

3.

4. **Attachment 1:** Map and interpretive key to identify areas in the North West Marine Region that are predicted to have unique combinations of species richness and evenness for demersal fish.



The proportion of the total area in the North West Marine Region in each combination of species richness and evenness is shown below. This give an indication of the rarity of each of the combinations. For example, uneven and high richness assemblages are the most common (category 21 in the interpretative key) and species rich and moderately even assemblages are the least common (category 23 in the interpretative key)

				Species Richness		
		0.16 to 1.21	1.21 to 1.57	1.57 to 2.08	2.08 to 2.79	2.79 to 30.8
	-1.15 to -0.00547	1.61	1.81	3.83	6.31	6.56
Evenness	-1.32 to -1.15	4.46	4.87	5.06	3.8	1.93
	-1.49 to -1.32	3.37	6.97	5.42	3.76	0.6
	-1.71 to -1.49	4.55	4.99	4.46	3.35	2.77
	-4 to -1.71	6.36	1.32	1.3	2.75	7.82

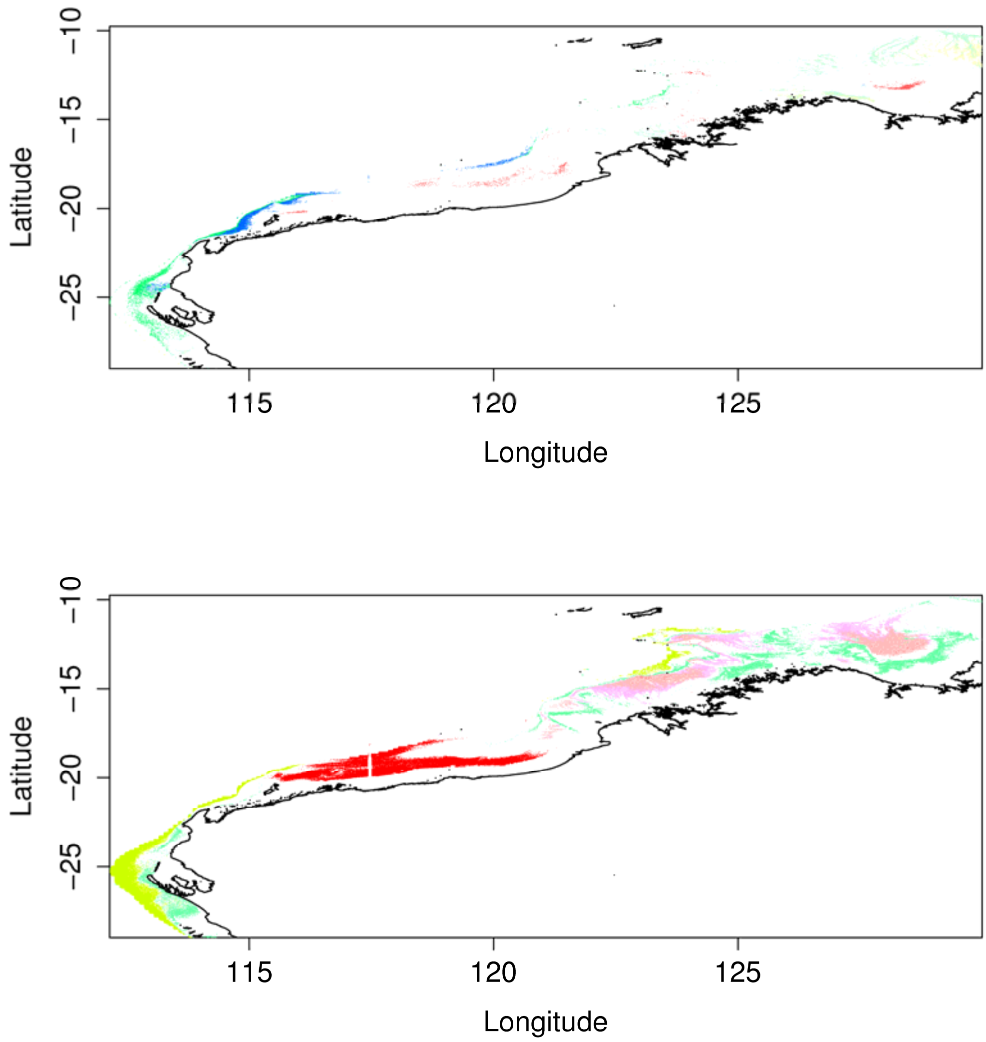


Figure 2: Plots of the 5 least abundant categories (top panel) and the 5 most abundant categories (lower panel)

Attachment 2: Metadata record for database of benthic biodiversity predictions in the NWMR.

To be provided

Product title: Predicted patterns of seabed biodiversity in the Northern Marine Region (NMR).

Relevance of product to marine planning and management
This product provides planners and managers with biologically informed predictions about the patterns in species abundance, species richness and species evenness of seabed fishes on the outer shelf and slope in the NMR
. It can be used as follows:

1. To provide scientific analysis and input to planners and managers with the responsibility to conserve and managed marine biodiversity in the NMR;

2. As a biological data input to models, where appropriate, of the marine environment in the NMR (e.g. Marxan);

3. To compare predictions in patterns of seabed biodiversity in the NMR with the findings of future biological surveys; and

4. To produce maps of predicted spatial patterns of species abundance, species richness and species evenness for seabed fishes in depths from 50 to 1500 metres;

It will be of value in planning and managing the conservation of marine biological diversity in the NMR, particularly in relation to predicting areas of high biodiversity when there is very little or no biological data.

Product description

This product (i.e. Access data base) contains data (longitudes, latitude and biodiversity attribute variables) that describes the predicted spatial patterns of biodiversity categories based on species richness and evenness of demersal fish in the NMR. This product provides predictions for total species abundance, species richness and species evenness and estimates of uncertainty for demersal fish. The predicted patterns are represent as point data arranged on a 0.1 degree grid (~ 1.2 km^2) covering depths 50-1500 metres in the NMR

Interpretation of product

This product represents the predicted spatial patterns of species abundance, species richness and species evenness of demersal fish communities in the NMR. It provides a description of the structure rather than the composition (i.e. specific species) of these assemblages. Structure equates to total species abundance (the total number of individuals), species richness (the total number of species) and species evenness (relative proportions of species). The product can also be used to identify areas in the NMR that are predicted to have unique combinations of species richness and evenness. This allows managers to identify areas that are predicted to have common or rare types of community structure.

Data and information on the levels of uncertainty associated with predictions have been produced. The predictions for the NMR have large standard errors that are related to a general lack of data. Consequently, it would be wise to consider uncertainty levels before making use of this product. For more information please phone or email the contact.

Brief description of methods/data used develop output

The following provides a basic description of the methods and data used to produce this product:

1. Existing biological data (i.e. demersal fish) and physical data (i.e. dissolved oxygen, temperature, mud content of sediments, etc.) for the NMR was collated from the following sources; CSIRO Atlas of Regional Seas (CARS) and range of biological surveys within the NMR (e.g. Torres Strait Surveys);

2. Biological data was used to identify biodiversity values (i.e. for total species abundance, species richness and species evenness) for all known biological sample sites in the NMR;

3. Analyses were conducted to determine which physical variables/combinations of physical variables best explain the spatial patterns in biodiversity values identified in step 1 (i.e looking for covariate physical variables that can be reliably used to predict benthic biodiversity);

4. The most reliable/meaningful covariate physical variables were identified and subsequently used as the basis to make a database of predictions of biological diversity values for all points on a 1 km2 grid for the NMR between 50-1500 metres depths; and

5. Categories representing unique combinations of species richness and evenness where created by assigning the values of richness one of five ranks and values of evenness one of five ranks. Combining the two sets of ranks gave 25 different possible categories

6. A database was developed to capture latitude, longitude and biodiversity values. This was used to produce maps displaying patterns in benthic biodiversity and map biodiversity categories.

Please phone or email the contact for a more detailed and technical explanation of the methods or data used to develop this product.

Advantages/improvements over existing products

The product provides the only available means to robustly predict patterns of benthic biodiversity at a range of spatial scales in the NMR. The product uses the most recently available data on the physical environment and biology (demersal fish) in the NMR.

Conditions of use

The product does not contain any confidential information. Data sets provided can be used by planners and managers, but contact the author if intending to use data in publications.

Contact for further information

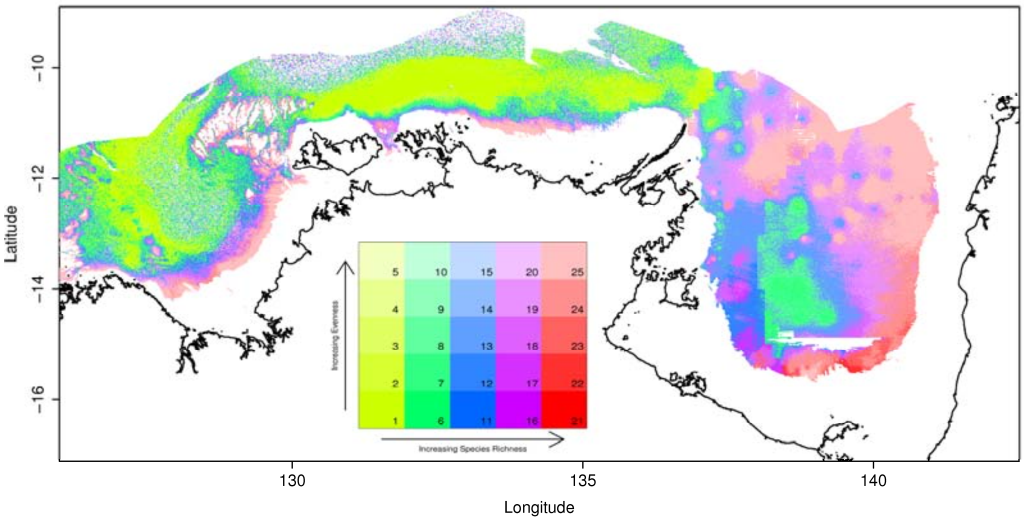
Piers Dunstan 03 6232 5382 Piers.Dunstan@csiro.au

Attachments

1. Map and interpretive key to identify areas in the North Marine Region that are predicted to have unique combinations of species richness and evenness for demersal fish.
2. Metadata record for Predicted patterns of seabed biodiversity in NMR (to be provided).

3.

4. **Attachment 1:** Map and interpretive key to identify areas in the North Marine Region that are predicted to have unique combinations of species richness and evenness for demersal fish.



The proportion of the total area in the North Marine Region in each combination of species richness and evenness is shown below. This give an indication of the rarity of each of the combinations. For example, low richness and uneven assemblages are the most common (category 5 in the interpretative key). High richness and uneven assemblages are the rarest category found in the North Marine Region. (category 16 in the interpretative key)

				Species Richness		
		11 to 66.9	66.9 to 93.8	93.8 to 121	121 to 162	162 to 622
	-0.886 to 0	0.15	1.09	1.91	2.79	14.08
Evenness	-0.975 to -0.886	0.06	0.39	2.31	12.39	4.84
	-1.07 to -0.975	0.12	4.44	10.6	3.95	0.9
	-1.26 to -1.07	3.33	10.79	4.86	0.84	1.84
	-3.23 to -1.26	16.35	3.3	0.31	0.04	0

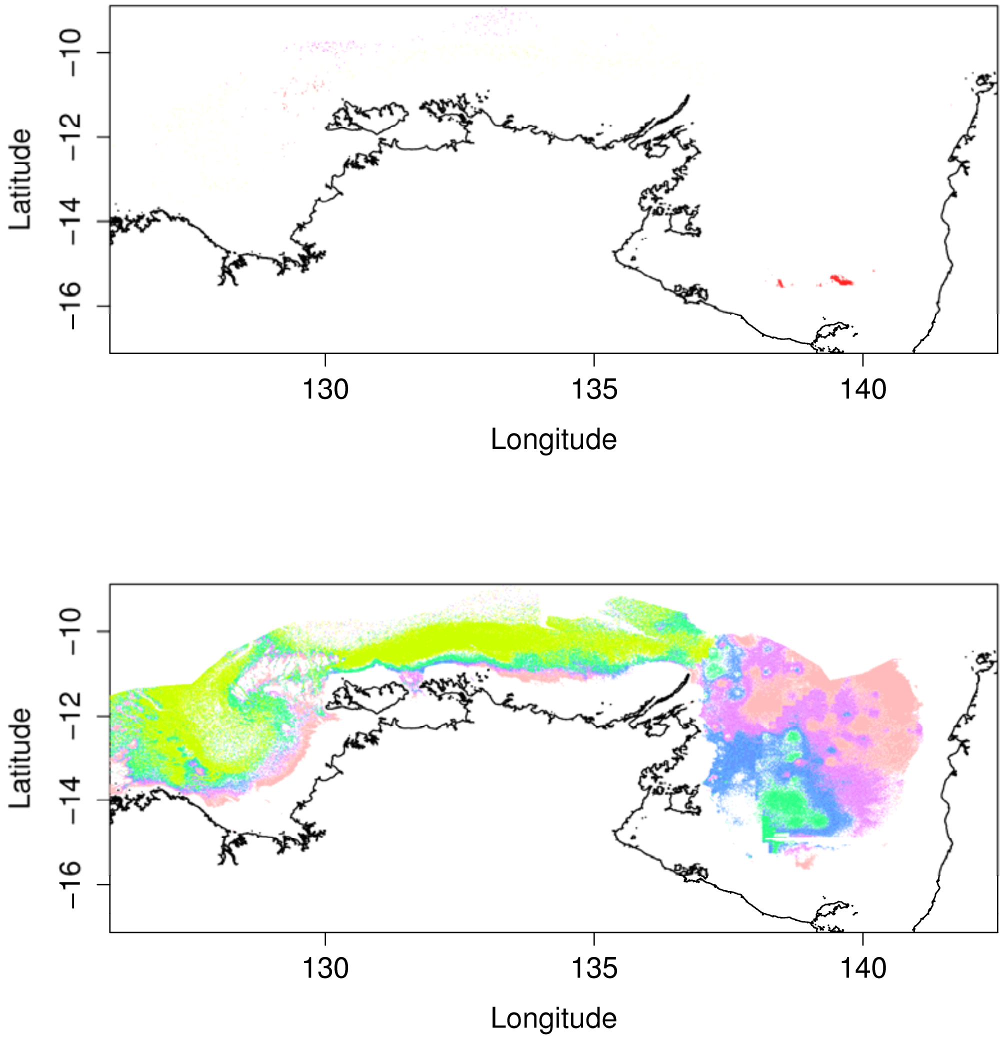


Figure 2: Plots of the 5 least abundant categories (top panel) and the 5 most abundant categories (lower panel)

Attachment 2: Metadata record for database of benthic biodiversity predictions in the NMR.

To be provided

PRODUCT DESCRIPTION FOR STAKEHOLDERS
CERF Marine Biodiversity Hub

MARINE BIODIVERSITY RESEARCH
Prediction and Management of Australia's Marine Biodiversity

Product title: Predicted seabed assemblage patterns of marine fauna in the Southwest Marine Region (SWMR).

Relevance of product to marine planning and management
This product provides planners and managers with the most recent and complete information about the predicted seabed assemblage patterns of marine fauna, at a range of scales, in the SWMR, based on extensive analyses of species responses to the physical environment. It can be used as follows:

1. To produce maps of predicted patterns of seabed assemblage of marine fauna (i.e. benthic invertebrates and demersal fish combined) in the SWMR;
2. To provide the results of scientific analysis of extensive biological data to planners and managers with the responsibility to conserve and manage seabed biodiversity in the SWMR (e.g. MPA planning and management);
3. As a biologically informed data input to models of the marine environment in the SWMR, where appropriate (e.g. Marxan); and
4. To identify areas of highest priority for future seabed biodiversity surveys, the findings of which can be compared with these predictions of seabed assemblage patterns of marine fauna in the SWMR.

Product description
This product (i.e. an Access database and csv files) contains data (longitude, latitude and attribute variables) that describe the predicted spatial patterns of the seabed assemblages of demersal fish and benthic invertebrates in the SWMR. The predicted patterns are represented as point data on a 0.01 degree grid (~1.2 km^2) covering most of the SWMR (approximately 400,000 km^2). Four separate meso-scale (10's-100's km) predictions have been provided that subdivide the SWMR into 20, 40, 60, 80 sub-units (i.e. the 20 prediction divides the region into 20 sub-units called clusters, collectively they form a cluster set).

Interpretation of product
The product represents the predicted spatial patterns of seabed assemblages of marine fauna (i.e. demersal fish and benthic invertebrates) in the SWMR. Each predicted assemblage is represented as a cluster in the data-product that should be interpreted as areas of seabed where the mixture of demersal fish and benthic invertebrate species and their abundances are characteristic of a particular physical environment, reasonably homogeneous and to varying extents distinct from other assemblages in the cluster set. Some clusters will be more distinct compared to others, and the boundaries between them will have varying levels of fuzziness; some are gradual, some are steep — the accompanying continuous colour maps provide insight into this (this information to be provided soon).

The different scales of clusters (i.e. cluster sets of 20, 40, 60 and 80) provide progressively finer scale information. The individual clusters of finer-scale cluster sets are expected to represent more homogeneous assemblages, compared to those in coarser scale cluster sets, but at finer scales the differences between individual clusters are smaller and less certain. In coarser scale cluster sets, individual clusters may not be as homogenous, but are expected to have greater and more certain differences compared to their neighbouring clusters. For more information on certainty please phone or email the contact.

Brief description of methods/data used develop output:

The following provides a basic description of methods/data used to develop this product:

1. All suitable available biological data (i.e. primarily demersal fish and some benthic invertebrate surveys) for the SWMR were collated from four different sources: the Russian fishing fleet, the Voyage of Discovery survey, the WA slope fish survey, and the Data Trawler archive data set of older broad-scale voyages in the region.
2. All suitable available physical data, comprising 28 physical variables (e.g. bathymetry, mud content of sediment, dissolved oxygen, temperature, light availability, etc.) were collated to provide full coverages of the region.
3. Analyses were conducted on about 200 seabed fish and invertebrate species to identify thresholds along each of the 28 physical gradients (e.g. percentage of mud content in sediment) that correspond to observed changes in the spatial patterns of benthic species;
4. Thresholds of each of physical gradient (i.e. within a single physical variable such as percentage of mud content in sediment) were then used to transform that physical variable to a biologically-informed variable. Thresholds that corresponded to relatively large changes in benthic assemblages were more influential in transforming the variable than those corresponding to small changes;
5. Each of the 28 biologically informed variables was weighted based on the importance of that variable in determining seabed assemblages. Physical variables that corresponded to relatively large changes in benthic assemblages were considered more important than those corresponding to small changes; and
6. The 28 biologically informed variables were then used to populate each 0.01° × 0.01° grid cell in the SWMR. The data were used to produce maps to display predicted spatial patterns in seabed assemblages.

It should be note that this method identifies the physical attributes that are associated with the predicted seabed assemblages of marine fauna; it does not identify the suite of species that typify the assemblages. The method has been developed in collaboration with and reviewed by an international team of 10 scientists from Australia, Canada, USA (Maine and Texas) and is being applied in these regions also.

Advantages/improvements over existing products

The product is based on a novel technique that uses biological information to transform physical data and predict spatial patterns of seabed assemblages of marine fauna at a range of scales in the SWMR. This product uses the most recently available and broadest collation of data on the physical environment and of biology (surveys of demersal fish and benthic invertebrates) in the SWMR. The data sources have been newly collated to provide input to this product, and include additional data for some variables (e.g. bathymetry and sediments), as well as many new variables (eg. bottom water attributes) and new biological surveys that have not been used previously for this purpose.

Conditions of use

This product does not contain any confidential information. It is a preliminary product subject to further development by the CERF Marine Biodiversity Hub. Final product is due around May 2010 .The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.

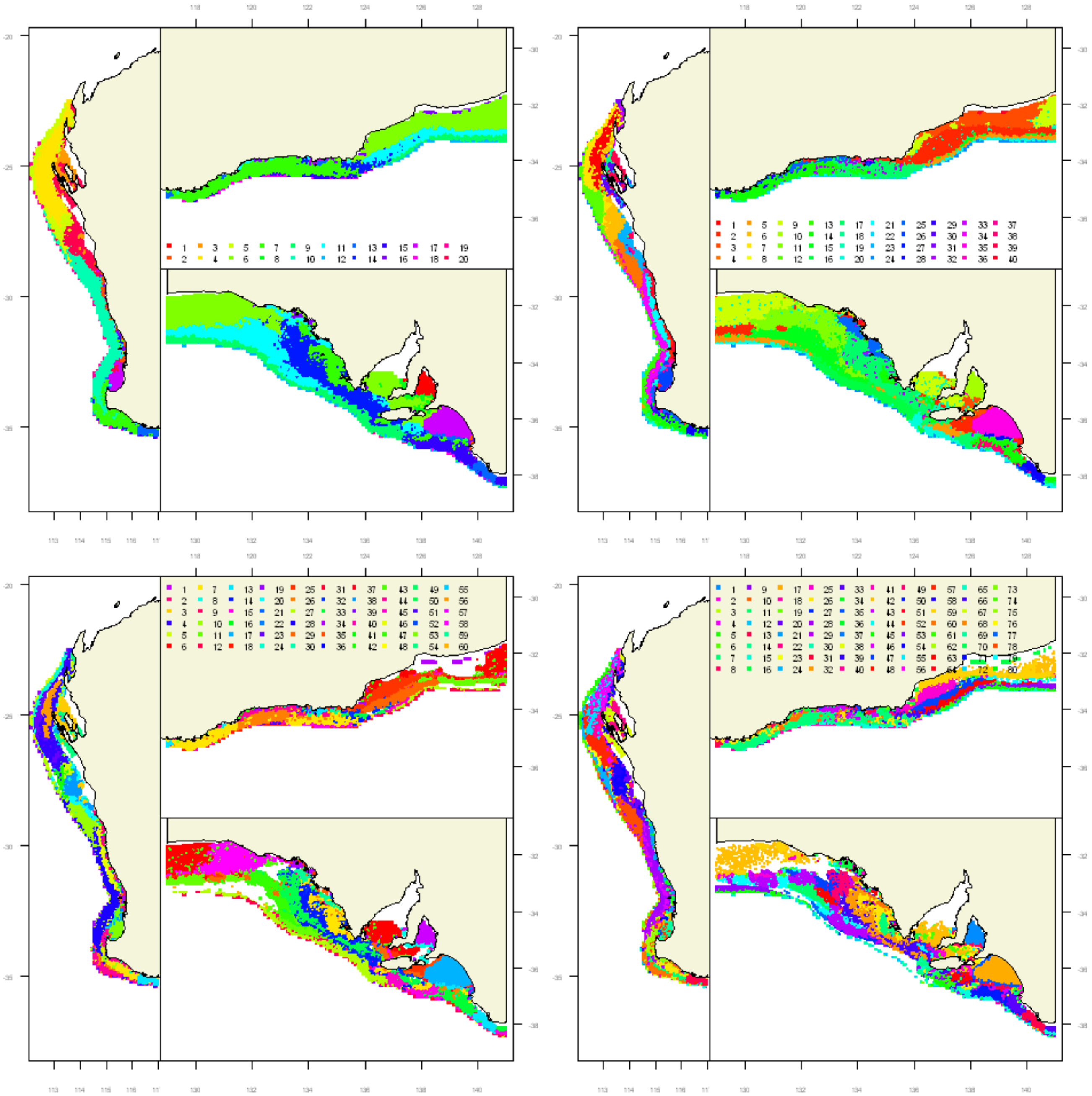
Contact for further information

Nick Ellis 07 3826 7260 nick.ellis@csiro.au
Roland Pitcher 07 3826 7250 roland.pitcher@csiro.au

Attachments

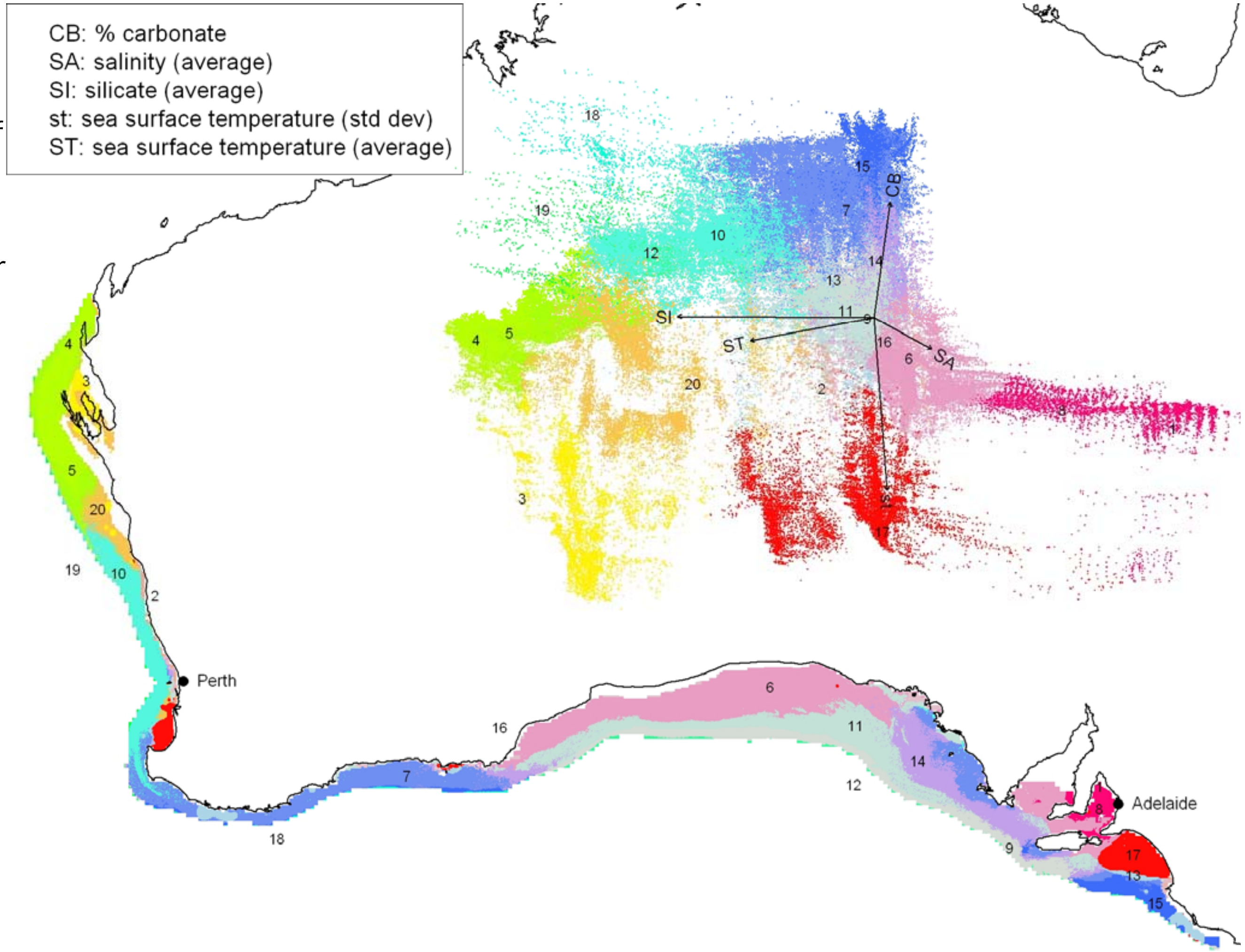
1. Four maps for a quick view of the each of the clusters (i.e. 20, 40, 60 and 80 clusters).
2. A map of the 20-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the SWMR.
3. Maps identifying the spatial limits of each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the Southwest Marine Region.
4. Description of physical attributes for each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the Southwest Marine Region.
5. Metadata record for database of seabed assemblage patterns of marine fauna in the Southwest Marine Region.

Attachment 1: Four maps for a quick view of the each of the cluster sets (i.e. 20, 40, 60 and 80 clusters) predicting seabed assemblage patterns of marine fauna in the Southwest Marine Region.

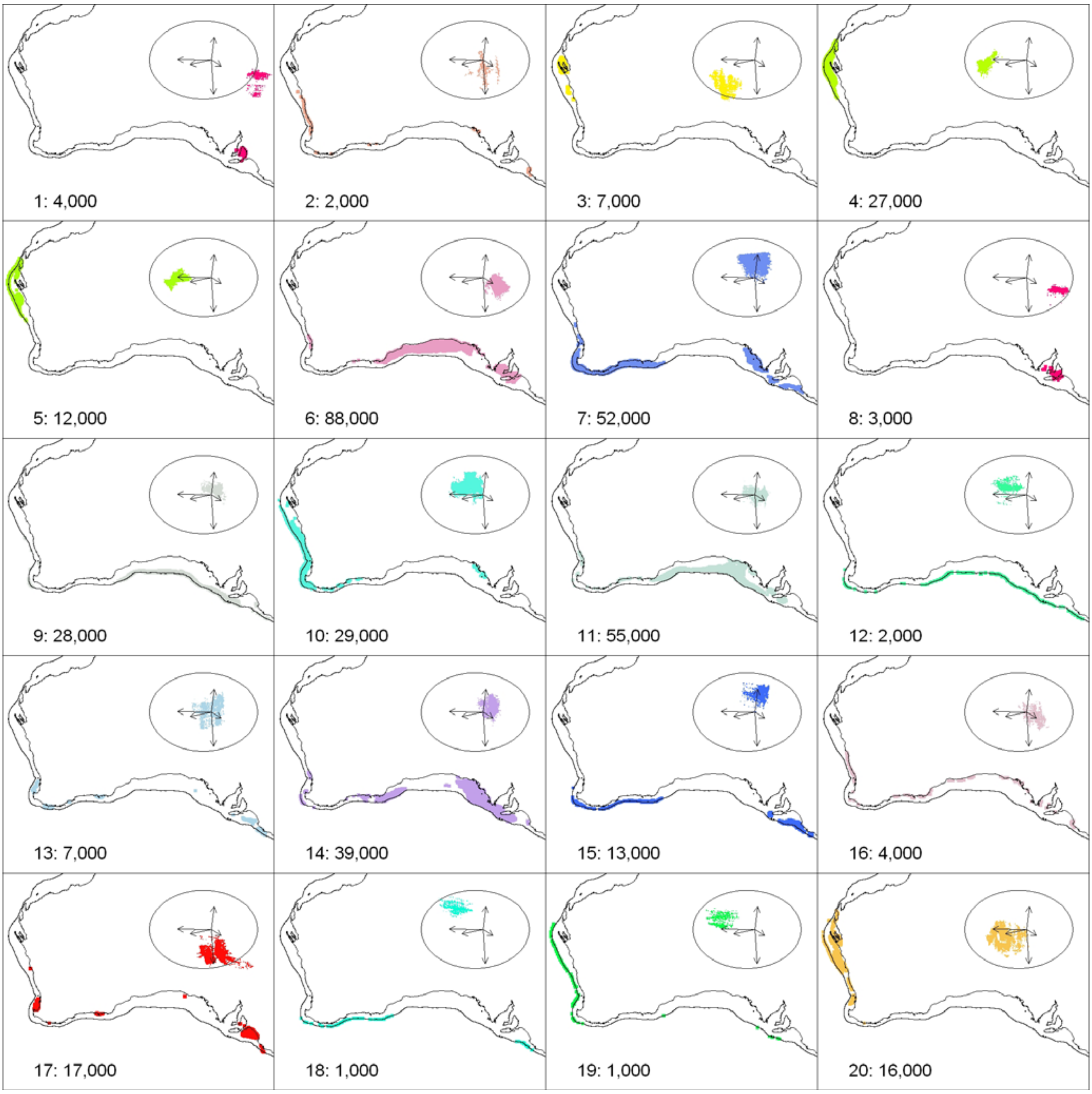


Attachment 2: A map of the 20-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the SWMR. The interpretive colour key can be used to identify the physical variables having most influence on predicted patterns. For example, the colour green is associated with high silicate average, red with high sea surface temperature variation, blue with high sediment carbonate average. The gray area near the origin of the arrows corresponds to medium values of the physical variables. Also shown in the colour key are the centres (medoids) of each cluster in the 20-cluster set. Many clusters are disjointed (see Attachment 3 to identify their spatial limits). A brief description of the physical variables having most influence on predicted seabed assemblage patterns is provided in Attachment 4.

Note - The map and interpretive colour key account for 60% of the total variation; the remaining 40% is not shown as it cannot be displayed in 2 dimensions (if more information is required please phone the provided contact person)



Attachment 3: Maps identifying the spatial limits of each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the Southwest Marine Region. The number of 0.01° × 0.01° grids in the cluster is shown to the nearest thousand.



Attachment 4: Description of physical attributes for each individual cluster in the 20 cluster set prediction for seabed assemblage patterns of marine fauna in the Southwest Marine Region

The physical attributes of each predicted assemblage of the 20 cluster output are distinguished by multiple variables used to characterise the region. Many clusters are distinguished on multi-variable combinations rather than individual variables. The following descriptions identify the most influential physical variables for each of the predicted seabed assemblages of marine fauna in the cluster set, clusters particularly distinctive on one variable are indicated by * (typical range shown in parentheses).

1. upper Gulf St Vincent SA [~4K km^2]: very high salinity average (S: 36.6–36.8 ‰)*, very large variation in sea surface temperature (SST SD: 3.1–3.5°C)*, very low silicate average (Si: 0.45–0.48 µM)*, relatively high turbidity (K490: 0.083–0.154 m^{-1}), moderately high average water temperature at the seabed (CRS T: 17.6–17.9°C), moderately shallow depth (14.5–31 m),
2. Cervantes coast WA [~2K km^2]: shallow depth (8–22 m), moderately high average water temperature at the seabed (CRS T: 19.5–20.2) and surface (SST: 19.7–20.7), moderately high turbidity (K490: 0.074–0.11),
3. Shark Bay/Coral Coast WA [~7K km^2]: very high average water temperature at the seabed (CRS T: 22.7–23.1)* and relatively high sea surface temperature (SST: 22.3–22.8), very shallow depth (8–26 m), relatively high turbidity (K490: 0.081–0.13), relatively low sediment carbonate (CRBNT: 49–62 %), moderately low oxygen average at the seabed (O2: 4.84–4.92 mg/l),
4. Carnarvon offshore WA [~27K km^2]: very low oxygen average at the seabed (O2: 4.56–4.67)*, very high sea surface temperature (SST: 23.1–24), high average water temperature at the seabed (CRS T: 20.7–22.5), high silicate average (Si: 3.73–4.47), moderate outer-shelf depth range (84–136 m),
5. Carnarvon outer shelf WA [~12K km^2]: low oxygen average at the seabed (O2: 4.68–4.82)*, very high surface temperature (SST: 22.5–24.1), high silicate average (Si: 2.81–3.63), shelf-break depth range (86–204 m), moderately high average water temperature at the seabed (CRS T: 18.6–21.2), relatively high sediment carbonate (CRBNT: 86–91),
6. Great Australian Bight & SA gulf entrances [~88K km^2]: high sediment carbonate (CRBNT: 89–94), moderately large variation in sea surface temperature (SST SD: 1.73–2.11), moderately high salinity average (S: 36–36.2)*, intermediate average water temperature at the seabed (CRS T: 16.6–17.6), inner-shelf depth range (43–60 m),
7. SW and SA mid-shelf [~52K km^2]: moderately small variation in sea surface temperature (SST SD: 1.13–1.21), relatively high sediment carbonate (CRBNT: 84–93), moderate salinity average (S: 35.7–35.8), mid-shelf depth range (58–82 m),
8. Lower SA gulfs [~3K km^2]: high salinity average (S: 36.2–36.6)*, large variation in sea surface temperature (SST SD: 2.39–2.94)*, low silicate average (Si: 0.57–0.66)*, moderately low average water temperature at the surface (SST: 16.9–17.3), moderately high turbidity (K490: 0.078–0.1), moderately shallow depth (11–31 m),
9. Great Australian Bight shelf-break [~28K km^2]: low turbidity (K490: 0.043–0.049), high sediment carbonate (CRBNT: 89–93), moderately low silicate average (Si: 1.2–1.46), high oxygen average at the seabed (O2: 5.37–5.45), shelf-break depth range (122–148 m), low moderate average water temperature at the seabed (CRS T: 14.4–15.8),
10. South Western shelf [~29K km^2]: shelf depth range (44–117 m), moderately high average water temperature at the seabed (CRS T: 19–20.6) and surface (SST: 20.6–21.4), moderate low variation in sea surface temperature (SST SD: 1.21–1.27), intermediate low oxygen average at the seabed (O2: 4.96–5.14), moderately high sediment carbonate (CRBNT: 87–92),
11. Great Australian Bight outer shelf [~55K km^2]: high sediment carbonate (CRBNT: 91–95), high intermediate salinity average (S: 35.8–35.9), outer-shelf depth range (71–102 m),

12. Southern upper slope [~2K km^2]: upper slope depth range (307–381 m), low salinity average (S: 34.9–35.1), low average water temperature at the seabed (CRS T: 10.6–11.9), low turbidity (K490: 0.043–0.047), high nutrients (NO_3: 9.42–13.15 µM), high oxygen average at the seabed (O2: 5.39–5.46), high sediment carbonate (CRBNT: 89–92), steep slope (1.22–3.19),
13. Mid-shelf patches [~7K km^2]: relatively low sediment carbonate (CRBNT: 57–63), mid-shelf depth range (49–78 m), some areas of high sediment mud content (typical range: 3–47 %),
14. East & west GAB fringes [~39K km^2]: very high sediment carbonate (CRBNT: 94–96), moderately high salinity average (S: 35.7–35.9), shelf depth range (72–97 m), moderate average water temperature at the seabed (CRS T: 15.3–15.9),
15. SW and SE outer shelf and break [~13K km^2]: very low surface water temperature average (SST: 15.8–16.7) and variation (SST SD: 0.9–1.2), moderately low average seabed water temperature (CRS T: 14.2–15.1), high average seabed oxygen (O2: 5.35–5.5), relatively low silicate average (Si: 1.11–1.35) and variation (Si SD: 0.44–0.56), outer shelf/break depth range (61–118 m),
16. Coastal patches [~4K km^2]: shallow coastal depth range (8–27 m), moderate high turbidity (K490: 0.071–0.107), high sediment carbonate (CRBNT: 82–94), moderate high salinity average (S: 35.8–36),
17. large coastal embayment's [~17K km^2]: low carbonate (CRBNT: 30–51)*, low surface water temperature average (SST: 14.8–18.3) and variation (SST SD: 0.9–1.2), inner shelf depth range (33–52 m),
18. SW & SE upper slope [~1K km^2]: very low salinity average (S: 34.6–35), very low average seabed water temperature (CRS T: 9–11.4), very high nutrients (NO_3: 10.4–18.3), high average seabed oxygen (O2: 5.36–5.47), high silicate average (Si: 2.93–5.83), upper slope depth range (320–523 m),
19. Western upper slope [~1K km^2]: very high average seabed oxygen (O2: 5.4–5.5), upper slope depth range (386–498 m), very low salinity average (S: 34.7–35), very low average seabed water temperature (CRS T: 9.2–11.2), very high nutrients (NO_3: 9.6–16.9), high silicate average (Si: 2.7–5.3), moderately high average surface water temperature (SST: 20.7–23),
20. Western shelf [~16K km^2]: very high average seabed water temperature (CRS T: 21.2–22.3), moderately high sea surface temperature (SST: 21.5–22.3), moderately low oxygen average at the seabed (O2: 4.89–4.95 mg/l), shelf depth range (14–52 m).

Attachment 5: Metadata record for benthic habitat database for SWMR.

Database for benthic habitat prediction in the Southwest Marine Region (SWMR). Version 1.0

Short title :
MarLIN record number : 8526
Anzlic Identifier : ANZCW0306008526
ISO Topic

Category/s Oceans

Data Type Aggregated/Derived Data

Area of Interest Southwestern Bioreg Data

Custodian Organisation :
CSIRO Division of Marine and Atmospheric Research - Cleveland
PO Box 120
Cleveland
QLD Australia
4163
http://www.cmar.csiro.au/

Jurisdiction : Australia

Contributors : Nick Ellis

Acknowledgements : Geoscience Australia for sediment, bathymetry and benthic stress, CSIRO Marine and Atmospheric Research for CARS data SeaWifs for turbidity data. Funding: CERF Marine Biodiversity Hub

References :

Abstract : This product (i.e. an Access database and csv files) contains data (longitude, latitude and attribute variables) that describe the predicted spatial patterns of seabed biodiversity composition for demersal fish and benthic invertebrates in the SWMR. The predicted patterns are represented as point data on a 0.01 degree grid (~1.2 km2) covering most of the SWMR (approximately 400,000 km^2). Four separate meso-scale (10's-100's km) predictions have been provided that subdivide the SWMR into 20, 40, 60, 80 sub-units (i.e. cluster sets).

Attributes Overview :

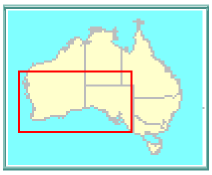
CERF_ID:	a primary key
LON:	longitude
LAT:	latitude

component01-10:	the 10-dimensional principal component data that was clustered
probweight:	cell weighting used in two-stage CLARA/PAM clustering
cluster20:	the 20-cluster clustering
cluster40:	the 40-cluster clustering
cluster60:	the 60-cluster clustering
cluster80:	the 80-cluster clustering
r:	red value for rendering on a map (scale 0-1)
g:	green value for rendering on a map (scale 0-1)
b:	blue value for rendering on a map (scale 0-1)

Geographic Extent

22.51 S

112.15 E



140.99 E

38.44 S

Dataset contains GIS spatial data in format Geocentric Australia (New Standard GDA).

Maximum Depth

1341

Subject Categories and Search Word(s)

MarLIN Subject Categories

1383. Biogeography and biogeographic regions

Habitat Keywords

EARTH SCIENCE > Biosphere > Aquatic Habitat > Benthic Habitat

GCMD Keywords

EARTH SCIENCE > Land Surface > Landscape > Landscape Ecology
EARTH SCIENCE > Oceans > Marine Biology > Marine Habitat

ANZLIC Search Words

ECOLOGY
ECOLOGY Habitat
ECOLOGY Landscape
MARINE Biology

Southwestern Bioreg Data
Oceans

Originating Research Project

Not Entered

Beginning date : Not Known
Ending date : Not Known
Progress : Complete
Maintenance and Update Frequency : As required
Stored Data Format(s) DIGITAL - Database Files - MS Access
Stored Data Volume 71 MB of digital data
Specific Software Requirements Requires Microsoft Access
Stored Data Documentation
Stored Data Location
Available Format Type(s) Same As Stored
Access constraint
The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.
Lineage
This is an original derivation.
Positional accuracy
Data are based on interpolated values from a variety of sources. E.g. see CARS (Anzlic Identifier : ANZCW0306005960)
Parameter accuracy
Logical consistency report
Completeness
About 175,000 cells have been omitted from the outer shelf and slope owing to missing values for benthic stress. About 32,000 cells have been omitted from inshore areas owing to missing values for SeaWifs and CARS data.
Contact
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PO Box 120
Cleveland
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nick.ellis@csiro.au

Metadata Access Public
Metadata Entry Created 22-Jul-2009 by Nick Ellis
Metadata Export
Show ANZLIC core metadata in ANZLIC XML format
Show full metadata in MarLIN (extended ANZLIC) XML format
Metadata Updateable By
Nick Ellis
Edit this MarLIN record (authorisation required)

Product title: Predicted seabed assemblage patterns of marine fauna in the Northwest Marine Region (NWMR).

Relevance of product to marine planning and management

This product provides planners and managers with the most recent and complete information about the predicted seabed assemblage patterns of marine fauna, at a range of scales, in the NWMR, based on extensive analyses of species responses to the physical environment. It can be used as follows:

1. To produce maps of predicted patterns of seabed assemblage of marine fauna (i.e. benthic invertebrates and demersal fish combined) in the NWMR;
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3. As a biologically informed data input to models of the marine environment in the NWMR, where appropriate (e.g. Marxan); and
4. To identify areas of highest priority for future seabed biodiversity surveys, the findings of which can be compared with these predictions of seabed assemblage patterns of marine fauna in the NWMR.

Product description

This product (i.e. an Access database) contains data (longitude, latitude and attribute variables) that describe the predicted spatial patterns of the seabed assemblages of demersal fish and benthic invertebrates in the NWMR. The predicted patterns are represented as point data on a 0.01 degree grid (~1.2 km^2) covering most of the NWMR (approximately 940,000 km^2). Four separate meso-scale (10's-100's km) predictions have been provided that subdivide the NWMR into 20, 40, 60, 80 sub-units (i.e. the 20 prediction divides the region into 20 sub-units called clusters, collectively they form a cluster set).

Interpretation of product

The product represents the predicted spatial patterns of seabed assemblages of marine fauna (i.e. demersal fish and benthic invertebrates) in the NWMR. Each predicted assemblage is represented as a cluster in the data-product that should be interpreted as areas of seabed where the mixture of demersal fish and benthic invertebrate species and their abundances are characteristic of a particular physical environment, reasonably homogeneous and to varying extents distinct from other assemblages in the cluster set. Some clusters will be more distinct compared to others, and the boundaries between them will have varying levels of fuzziness; some are gradual, some are steep — the accompanying continuous colour maps provide insight into this (this information to be provided soon).

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The following provides a basic description of methods/data used to develop this product:

1. All suitable available biological data (i.e. demersal fish and benthic invertebrate species) for the NWMR were collated from four different sources: the Northwest Shelf seabed biodiversity survey, the Russian fishing fleet, the Voyage of Discovery survey, and the Data Trawler archive data set of older broad-scale voyages in the region.
2. All suitable available physical data, comprising 29 physical variables (e.g. bathymetry, mud content of sediment, dissolved oxygen, temperature, light availability, etc.) were collated to provide full coverages of the region.
3. Analyses were conducted on about 1000 seabed fish and invertebrate species to identify thresholds along each of the 29 physical gradients (e.g. percentage of mud content in sediment) that correspond to observed changes in the spatial patterns of benthic species;
4. Thresholds of each of physical gradient (i.e. within a single physical variable such as percentage of mud content in sediment) were then used to transform that physical variable to a biologically-informed variable. Thresholds that corresponded to relatively large changes in benthic assemblages were more influential in transforming the variable than those corresponding to small changes;
5. Each of the 29 biologically informed variables was weighted based on the importance of that variable in determining seabed assemblages. Physical variables that corresponded to relatively large changes in benthic assemblages were considered more important than those corresponding to small changes; and
6. The 29 biologically informed variables were then used to populate each 0.01° × 0.01° grid cell in the NWMR. The data were used to produce maps to display predicted spatial patterns in seabed assemblages (see attachments).

It should be note that this method identifies the physical attributes that are associated with the predicted seabed assemblages of marine fauna; it does not identify the suite of species that typify the assemblages. The method has been developed in collaboration with and reviewed by an international team of 10 scientists from Australia, Canada, USA (Maine and Texas) and is being applied in these regions also.

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The product is based on a novel technique that uses biological information to transform physical data and predict spatial patterns of seabed assemblages of marine fauna at a range of scales in the NWMR. This product uses the most recently available and broadest collation of data on the physical environment and of biology (surveys of demersal fish and benthic invertebrates) in the NWMR. The data sources have been newly collated to provide input to this product, and include additional data for some variables (e.g. bathymetry and sediments), as well as many new variables (eg. bottom water attributes) and new biological surveys that have not been used previously for this purpose.

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Contact for further information
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Roland Pitcher 07 3826 7250 roland.pitcher@csiro.au

Attachments

1. Four maps for a quick view of the each of the cluster sets (i.e. 20, 40, 60 and 80 clusters) predicting seabed assemblage patterns of marine fauna in the Northwest Marine Region.
2. A map of the 20-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the Northwest Marine Region.
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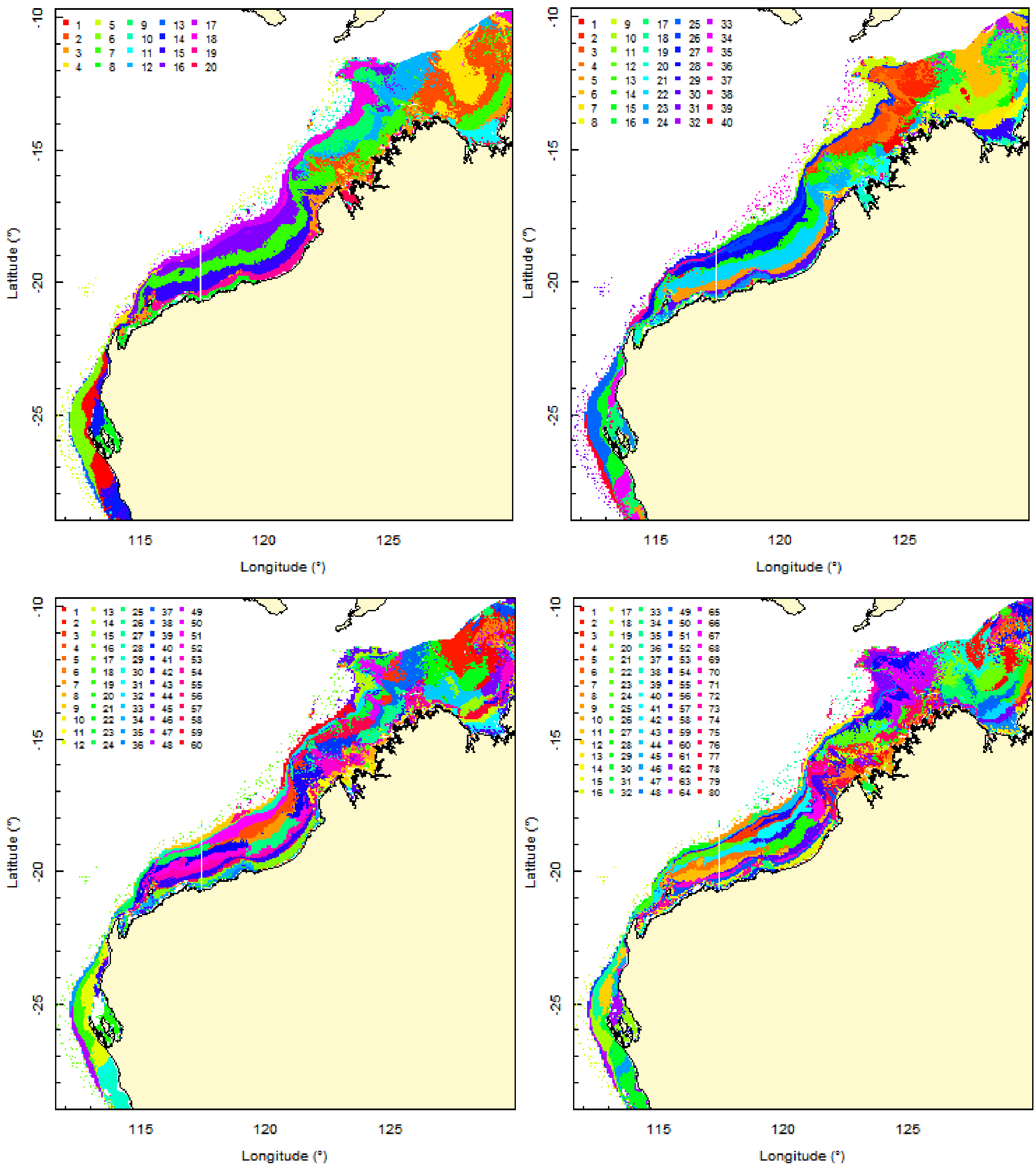


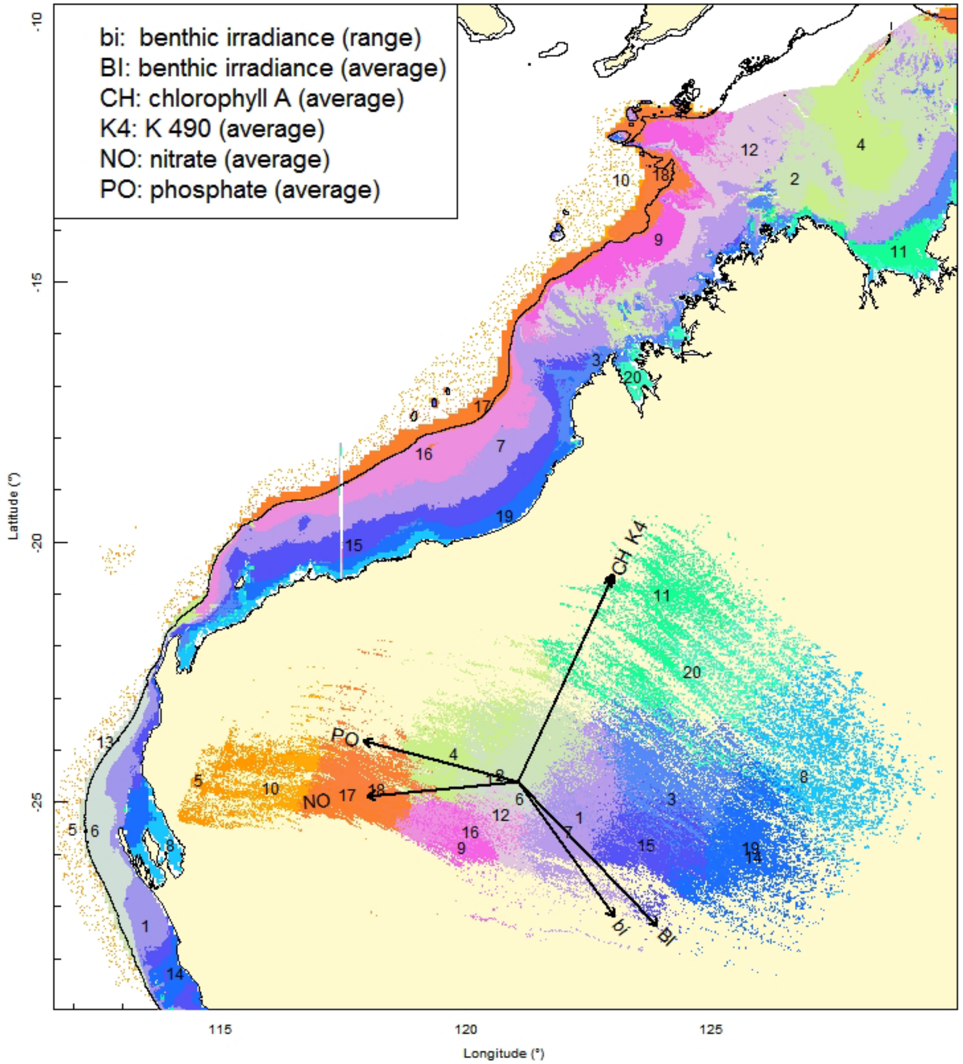
26 November 2009

Attachment 2: A map of the 20-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the Northwest Marine Region. The black line offshore is the 200m depth contour.

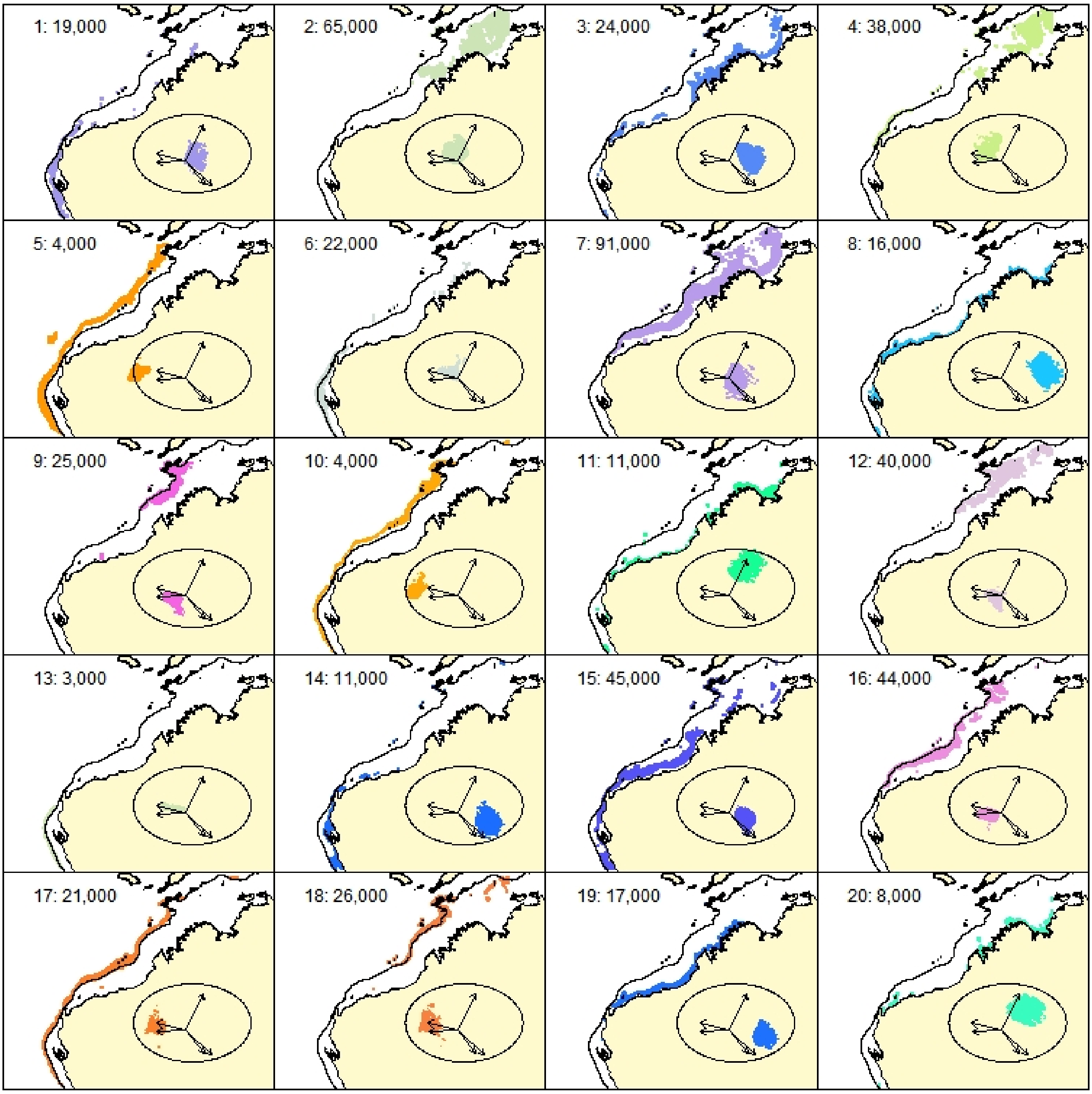
The interpretive colour key (bottom right) can be used to identify the physical variables having most influence on predicted patterns. For example, the colour green is associated with high chlorophyll A average, orange with high nitrate average, blue with high benthic irradiance predictors. The grayer area near the origin of the arrows corresponds to medium values of the physical variables.

Also shown in the colour key are the centres (medoids) of each cluster in the 20-cluster set. Many clusters are disjointed (see Attachment 3 to identify their spatial limits). A brief description of the physical variables having most influence on predicted seabed assemblage patterns is provided in Attachment 4.

Note - The map and interpretive colour key account for 71% of the total variation; the remaining 29% is not shown as it cannot be displayed in 2 dimensions (if more information is required please phone the provided contact person)



Attachment 3: Maps identifying the spatial limits of each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the Northwest Marine Region. The number of 0.01° × 0.01° grids in the cluster is shown to the nearest thousand.



Attachment 4: Description of physical attributes for each individual cluster in the 20 cluster set prediction for seabed assemblage patterns of marine fauna in the Northwest Marine Region

The physical attributes of each predicted assemblage of the 20 cluster output are distinguished by multiple variables used to characterise the region. Many clusters are distinguished on multi-variable combinations rather than individual variables. The following descriptions identify the most influential physical variables for each of the predicted seabed assemblages of marine fauna in the cluster set, clusters particularly distinctive on one variable are indicated by * (typical range shown in parentheses).

1. Carnarvon offshore [~56K km^2]: depth (Depth: 66–89 m), very high sediment sand content (Sand: 83–95 %)
2. Kimberley/Timor mid-shelf [~40K km^2]: depth (Depth: 63–83 m), low sediment carbonate (CRBNT: 53–80 %), high variation in seabed oxygen (O2 SR: 0.80–1.29 mg l^{-1}), high variation in salinity (S SR: 0.5–0.6 ‰), high variation in silicate (Si SR: 6.45–8.82 μM)
3. Kimberley inner-shelf [~58K km^2]: moderately low depth (Depth: 17–28 m), high average water temperature at the seabed (CRS T: 27.1–28.2 °C)
4. Timor mid-shelf [~41K km^2]: depth (Depth: 97–125 m), very low sediment sand content (Sand: 33–59 %), very high average sea surface temperature (SST: 28.6–28.9 °C)
5. NW Deep slope [~4K km^2]: very high depth (Depth: 569–821 m)*, very high nitrate (NO3: 30.7–36.0 μM), very high phosphate average (PO4: 1.95–2.46 μM), very low average water temperature at the seabed (CRS T: 5.6–7.6 °C)*, very high silicate average (Si: 39.47–72.40 μM), low chlorophyll A (Chl A: 0.129–0.168 mg m^{-3}), low turbidity (K490: 0.033–0.039 m^{-1}), very low benthic irradiance (BI: 0–0)*, very low variation in benthic irradiance (BI SR: 0–0)*
6. Carnarvon outer shelf [~20K km^2]: depth (Depth: 121–168 m), very low variation in chlorophyll A (Chl A SR: 0.110–0.129 mg m^{-3}), very low variation in turbidity (K490 SR: 0.014–0.016 m^{-1})
7. NW mid-shelf [~51K km^2]: depth (Depth: 50–71 m), high bottom stress (BS: 0.1–0.4 Nm^{-2}), high variation in bottom stress (BS IQR: 0.2–1.1 Nm^{-2})
8. NW shallow coastal strip [~64K km^2]: very low depth (Depth: 2–8 m), very low nitrate (NO3: 0.2–0.2 μM), very low phosphate average (PO4: 0.09–0.14 μM), very high variation in chlorophyll A (Chl A SR: 1.548–2.493 mg m^{-3}), high turbidity (K490: 0.157–0.224 m^{-1}), high variation in sea surface temperature (SST SR: 7.2–8.6 °C), very high benthic irradiance (BI: 0.204–0.614), high variation in benthic irradiance (BI SR: 0.127–0.241)
9. Kimberley outer-shelf [~20K km^2]: depth (Depth: 98–113 m), very high variation in nitrate (NO3 SR: 7.7–10.2 μM), very high variation in phosphate (PO4 SR: 0.65–0.70 μM)*, high variation in water temperature at the seabed (CRS T SR: 4.5–5.3 °C), very high variation in silicate (Si SR: 10.44–11.50 μM), very low variation in sea surface temperature (SST SR: 3.5–3.7 °C)
10. NW upper slope [~6K km^2]: high depth (Depth: 306–415 m)*, high nitrate (NO3: 28.7–31.6 μM), high phosphate average (PO4: 1.95–2.15 μM), very low average seabed oxygen (O2: 2.22–2.38 mg l^{-1}), very low variation in salinity (S SR: 0–0 ‰), low average water temperature at the seabed (CRS T: 9.2–11.1 °C)*, low variation in water temperature at the seabed (CRS T SR: 0.5–0.8 °C), high silicate average (Si: 44.52–50.84 μM), very low chlorophyll A (Chl A: 0.136–0.182 mg m^{-3}), very low turbidity (K490: 0.034–0.041 m^{-1}), low benthic irradiance (BI: 0–0), low variation in benthic irradiance (BI SR: 0–0)
11. NW inshore [~54K km^2]: depth (Depth: 19–34 m), very high bottom stress (BS: 0.1–0.7 Nm^{-2}), very high variation in bottom stress (BS IQR: 0.1–1.8 Nm^{-2}), very low sediment carbonate (CRBNT: 45–57 %), very high sediment gravel content (Gravel: 16–38 %), low nitrate (NO3: 0.2–0.4 μM), very high average water temperature at the seabed (CRS T: 27.6–28.2 °C), very high chlorophyll A (Chl A: 2.313–5.444 mg m^{-3}), very high turbidity (K490: 0.164–0.277 m^{-1})

12. Timor outer-shelf [~24K km^2]: depth (Depth: 76–90 m), high variation in phosphate (PO4 SR: 0.53–0.63 μM)*, very high variation in seabed oxygen (O2 SR: 0.86–1.18 mg l^{-1}), very low salinity average (S: 34.5–34.6 ‰), low variation in sea surface temperature (SST SR: 3.5–3.9 °C)
13. Western upper slope [~23K km^2]: moderately high depth (Depth: 204–296 m), very high slope (Slope: 0.38–1.37), very high average seabed oxygen (O2: 4.91–5.11 mg l^{-1}), very high salinity average (S: 35.6–35.8 ‰), very low silicate average (Si: 2.21–2.45 μM), very low variation in silicate (Si SR: 0.23–0.90 μM), low benthic irradiance (BI: 0–0), low variation in benthic irradiance (BI SR: 0–0)
14. Western shelf [~38K km^2]: moderately low depth (Depth: 12–37 m), low nitrate (NO3: 0.2–0.2 μM), very low variation in nitrate (NO3 SR: 0.2–0.2 μM), low phosphate average (PO4: 0.11–0.15 μM), high average seabed oxygen (O2: 4.88–4.96 mg l^{-1}), low silicate average (Si: 2.42–2.88 μM), very low average sea surface temperature (SST: 21.6–22.5 °C), high benthic irradiance (BI: 0.113–0.290), very high variation in benthic irradiance (BI SR: 0.158–0.239)
15. West-NW inner shelf [~48K km^2]: depth (Depth: 34–50 m), low slope (Slope: 0.04–0.14), high sediment carbonate (CRBNT: 88–93 %), high sediment sand content (Sand: 79–94 %), low sediment mud content (Mud: 1–6 %)
16. NW outer shelf [~45K km^2]: depth (Depth: 107–139 m), very high sediment carbonate (CRBNT: 89–94 %)
17. NW shelf break [~6K km^2]: high depth (Depth: 232–287 m), very high aspect (Aspect: 270–333 degrees), high nitrate (NO3: 20.3–25.7 μM), high phosphate average (PO4: 1.36–1.78 μM), low average water temperature at the seabed (CRS T: 12.2–14.3 °C), low variation in water temperature at the seabed (CRS T SR: 1–2 °C), low chlorophyll A (Chl A: 0.144–0.156 mg m^{-3}), low turbidity (K490: 0.035–0.036 m^{-1})
18. Kimberley shelf break [~3K km^2]: moderately high depth (Depth: 180–236 m), low average seabed oxygen (O2: 2.37–2.59 mg l^{-1}), very low variation in seabed oxygen (O2 SR: 0.05–0.10 mg l^{-1}), high silicate average (Si: 27.84–34.91 μM), low variation in sea surface temperature (SST SR: 3.6–3.8 °C)
19. NW coast [~27K km^2]: low depth (Depth: 9–18 m), very low sediment mud content (Mud: 1–2 %), low phosphate average (PO4: 0.13–0.16 μM), very high variation in water temperature at the seabed (CRS T SR: 5.9–6.4 °C), very high variation in turbidity (K490 SR: 0.063–0.091 m^{-1}), very high variation in sea surface temperature (SST SR: 7.2–8.9 °C), high benthic irradiance (BI: 0.158–0.352), high variation in benthic irradiance (BI SR: 0.173–0.223)
20. Kimberley coast [~15K km^2]: low depth (Depth: 7–19 m), very low variation in phosphate (PO4 SR: 0.07–0.09 μM), very high variation in salinity (S SR: 0.3–0.9 ‰), high average water temperature at the seabed (CRS T: 27.6–28.4 °C), high chlorophyll A (Chl A: 2.174–5.293 mg m^{-3}), high turbidity (K490: 0.164–0.280 m^{-1}), high variation in sea surface temperature (SST SR: 5.8–7.6 °C)

Attachment 5: Metadata record for benthic habitat database for the Northwest Marine Region

Database for benthic habitat prediction in the Northwest Marine Region (NWMR). Version 1.0

Short title :
MarLIN record number : 8593
Anzlic Identifier : ANZCW0306008593
ISO Topic Category/s
Oceans
Data Type
Aggregated/Derived Data
Area of Interest
Northern Bioreg Data
Custodian Organisation :
CSIRO Division of Marine and Atmospheric Research - Cleveland
PO Box 120
Cleveland
QLD Australia
4163
http://www.cmar.csiro.au/
Jurisdiction : Australia

Contributors : Nick Ellis
Acknowledgements : Geoscience Australia for sediment, bathymetry and benthic stress CSIRO Marine and Atmospheric Research for CARS data SeaWifs for turbidity data Funding: CERF Marine Biodiversity Hub
References :

Abstract : This product (i.e. an Access database and csv files) contains data (longitude, latitude and physical data) that explains the predicted spatial patterns of benthic habitats for demersal fish and benthic invertebrates in the NWMR. Predicted patterns for habitats represent point data on a 0.01 decimal degree grid covering most of the NWMR (approximately 600,000 square km).
Attributes Overview :
CERF_ID: a primary key
LON: longitude
LAT: latitude
component01-10: the 10-dimensional principal component data that was clustered
probweight: cell weighting used in two-stage CLARA/PAM clustering
cluster20: the 20-cluster clustering
cluster40: the 40-cluster clustering
cluster60: the 60-cluster clustering
cluster80: the 80-cluster clustering
Location Keywords

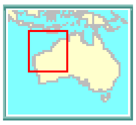
Australia > Western Australia Coast North > Australian North West Shelf

ANZLIC Geographic Extent Names (Category, [Jurisdiction], Name)

Ocean and Sea Regions, [Australia], Australian NW Shelf

Geographic Extent

9.68 S

111.61 E  129.99 E

28.99 S

Dataset contains GIS spatial data in format Geocentric Australia (New Standard GDA).

Subject Categories and Search Word(s)

MarLIN Subject Categories
1383. Biogeography and biogeographic regions

Habitat Keywords
EARTH SCIENCE > Biosphere > Aquatic Habitat > Benthic Habitat

GCMD Keywords
EARTH SCIENCE > Land Surface > Landscape > Landscape Ecology
EARTH SCIENCE > Oceans > Marine Biology > Marine Habitat

ANZLIC Search Words
ECOLOGY
ECOLOGY Habitat
ECOLOGY Landscape
MARINE Biology
Northern Bioreg Data
Oceans

Originating Research Project

Not Entered

Beginning date : Not Known
Ending date : Not Known
Progress : Complete
Maintenance and Update Frequency : As required

Stored Data Format(s)
DIGITAL - Database Files - MS Access

Stored Data Volume
93 MB of digital data

Specific Software Requirements

Requires Microsoft Access

Stored Data Documentation

Stored Data Location

Available Format Type(s)

Same As Stored

Access constraint

The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.

Lineage

This is an original derivation.

Positional accuracy

Data are based on interpolated values from a variety of sources. E.g. see CARS (Anzlic Identifier : ANZCW0306005960)

Parameter accuracy

Logical consistency report

Completeness

There are many cells missing in the deeper waters beyond the 200m depth contour. The data have a glitch running cross-shelf near longitude 117.5E.

Contact

Nick Ellis
CSIRO Division of Marine and Atmospheric Research - Cleveland
PO Box 120
Cleveland
QLD Australia
4163
nick.ellis@csiro.au

Metadata Access

Public

Metadata Entry Created

26-Nov-2009 by Nick Ellis

Metadata Export

Show ANZLIC core metadata in ANZLIC XML format
Show full metadata in MarLIN (extended ANZLIC) XML format

Metadata Updateable By

Nick Ellis

Edit this MarLIN record (authorisation required)

Product title: Predicted seabed assemblage patterns of marine fauna in the North Marine Region (NMR).

Relevance of product to marine planning and management

This product provides planners and managers with the most recent and complete information about the predicted seabed assemblage patterns of marine fauna, at a range of scales, in the NMR, based on extensive analyses of species responses to the physical environment. It can be used as follows:

1. To produce maps of predicted patterns of seabed assemblage of marine fauna (i.e. benthic invertebrates and demersal fish combined) in the NMR;
2. To provide the results of scientific analysis of extensive biological data to planners and managers with the responsibility to conserve and manage seabed biodiversity in the NMR (e.g. MPA planning and management);
3. As a biologically informed data input to models of the marine environment in the NMR, where appropriate (e.g. Marxan); and
4. To identify areas of highest priority for future seabed biodiversity surveys, the findings of which can be compared with these predictions of seabed assemblage patterns of marine fauna in the NMR.

Product description

This product (i.e. an Access database and csv files) contains data (longitude, latitude and attribute variables) that describe the predicted spatial patterns of the seabed assemblages of demersal fish and benthic invertebrates in the NMR. The predicted patterns are represented as point data on a 0.01 degree grid (~1.2 km^2) covering most of the NMR (approximately 780,000 km^2). Four separate meso-scale (10's-100's km) predictions have been provided that subdivide the NMR into 20, 40, 60, 80 sub-units (i.e. the 20 prediction divides the region into 20 sub-units called clusters, collectively they form a cluster set).

Interpretation of product

The product represents the predicted spatial patterns of seabed assemblages of marine fauna (i.e. demersal fish and benthic invertebrates) in the NMR. Each predicted assemblage is represented as a cluster in the data-product that should be interpreted as areas of seabed where the mixture of demersal fish and benthic invertebrate species and their abundances are characteristic of a particular physical environment, reasonably homogeneous and to varying extents distinct from other assemblages in the cluster set. Some clusters will be more distinct compared to others, and the boundaries between them will have varying levels of fuzziness; some are gradual, some are steep — the accompanying continuous colour maps provide insight into this (this information to be provided soon).

The different scales of clusters (i.e. cluster sets of 20, 40, 60 and 80) provide progressively finer scale information. The individual clusters of finer-scale cluster sets are expected to represent more homogeneous assemblages, compared to those in coarser scale cluster sets, but at finer scales the differences between individual clusters are smaller and less certain. In coarser scale cluster sets, individual clusters may not be as homogenous, but are expected to have greater and more certain differences compared to their neighbouring clusters. For more information on certainty please phone or email the contact.

Brief description of methods/data used develop output
The following provides a basic description of methods/data used to develop this product:

1. All suitable available biological data (i.e. demersal fish and benthic invertebrate species) for the NMR were collated from three different sources: the Torres Strait seabed biodiversity survey, various surveys in the Gulf of Carpentaria by the Southern Surveyor and several other vessels, and the Data Trawler archive data set of older broad-scale voyages in the region.
2. All suitable available physical data, comprising 28 physical variables (e.g. bathymetry, mud content of sediment, dissolved oxygen, temperature, light availability, etc.) were collated to provide full coverages of the region.
3. Analyses were conducted on about 900 seabed fish and invertebrate species to identify thresholds along each of the 28 physical gradients (e.g. percentage of mud content in sediment) that correspond to observed changes in the spatial patterns of benthic species;
4. Thresholds of each of physical gradient (i.e. within a single physical variable such as percentage of mud content in sediment) were then used to transform that physical variable to a biologically-informed variable. Thresholds that corresponded to relatively large changes in benthic assemblages were more influential in transforming the variable than those corresponding to small changes;
5. Each of the 28 biologically informed variables was weighted based on the importance of that variable in determining seabed assemblages. Physical variables that corresponded to relatively large changes in benthic assemblages were considered more important than those corresponding to small changes; and
6. The 28 biologically informed variables were then used to populate each 0.01° × 0.01° grid cell in the NMR. The data were used to produce maps to display predicted spatial patterns in seabed assemblages (see attachments).

It should be note that this method identifies the physical attributes that are associated with the predicted seabed assemblages of marine fauna; it does not identify the suite of species that typify the assemblages. The method has been developed in collaboration with and reviewed by an international team of 10 scientists from Australia, Canada, USA (Maine and Texas) and is being applied in these regions also.

Advantages/improvements over existing products
The product is based on a novel technique that uses biological information to transform physical data and predict spatial patterns of seabed assemblages of marine fauna at a range of scales in the NMR. This product uses the most recently available and broadest collation of data on the physical environment and of biology (surveys of demersal fish and benthic invertebrates) in the NMR. The data sources have been newly collated to provide input to this product, and include additional data for some variables (e.g. bathymetry and sediments), as well as many new variables (eg. bottom water attributes) and new biological surveys that have not been used previously for this purpose.

Conditions of use
This product does not contain any confidential information. It is a preliminary product subject to further development by the CERF Marine Biodiversity Hub. Final product is due around May 2010 .The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.

Contact for further information
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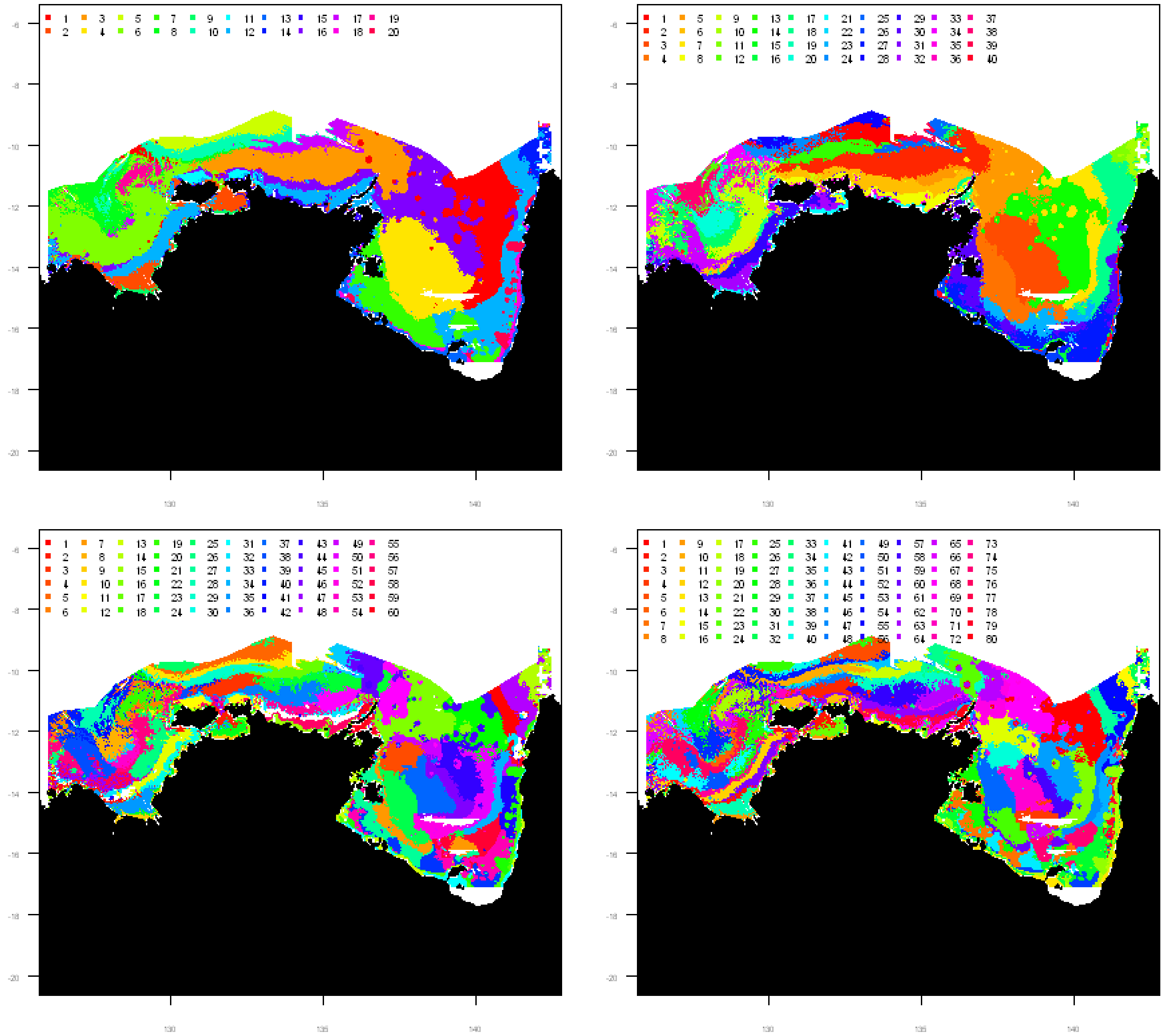
Roland Pitcher 07 3826 7250 roland.pitcher@csiro.au

Attachments

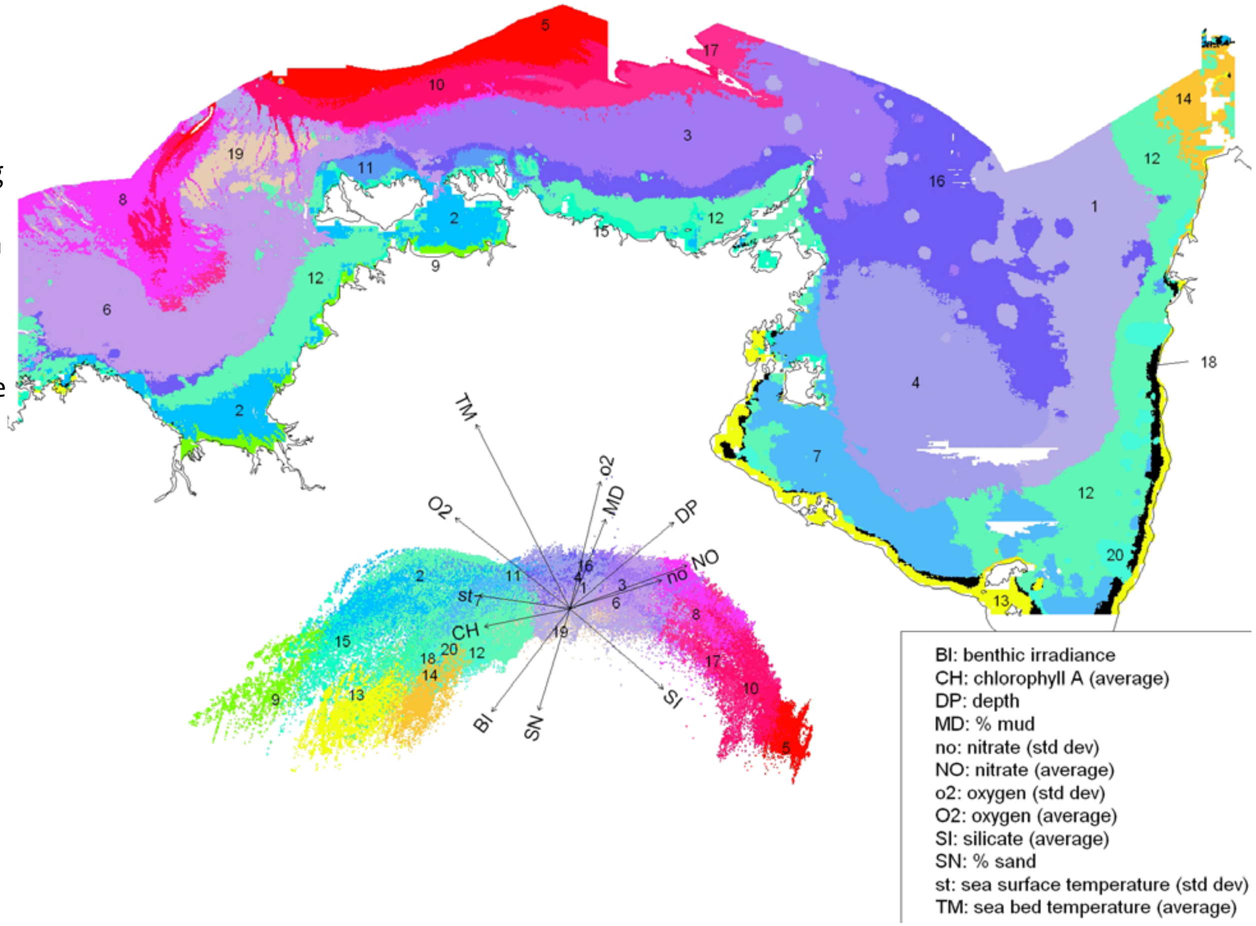
1. Four maps for a quick view of the each of the cluster sets (i.e. 20, 40, 60 and 80 clusters) predicting seabed assemblage patterns of marine fauna in the North Marine Region.
2. A map of the 20-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the NMR.
3. Maps identifying the spatial limits of each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the North Marine Region.
4. Description of physical attributes for each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the North Marine Region
5. Metadata record for database of seabed assemblage patterns of marine fauna in the North Marine Region.

Attachment 1: Four maps for a quick view of the each of the cluster sets (i.e. 20, 40, 60 and 80 clusters) predicting seabed assemblage patterns of marine fauna in the North Marine Region.

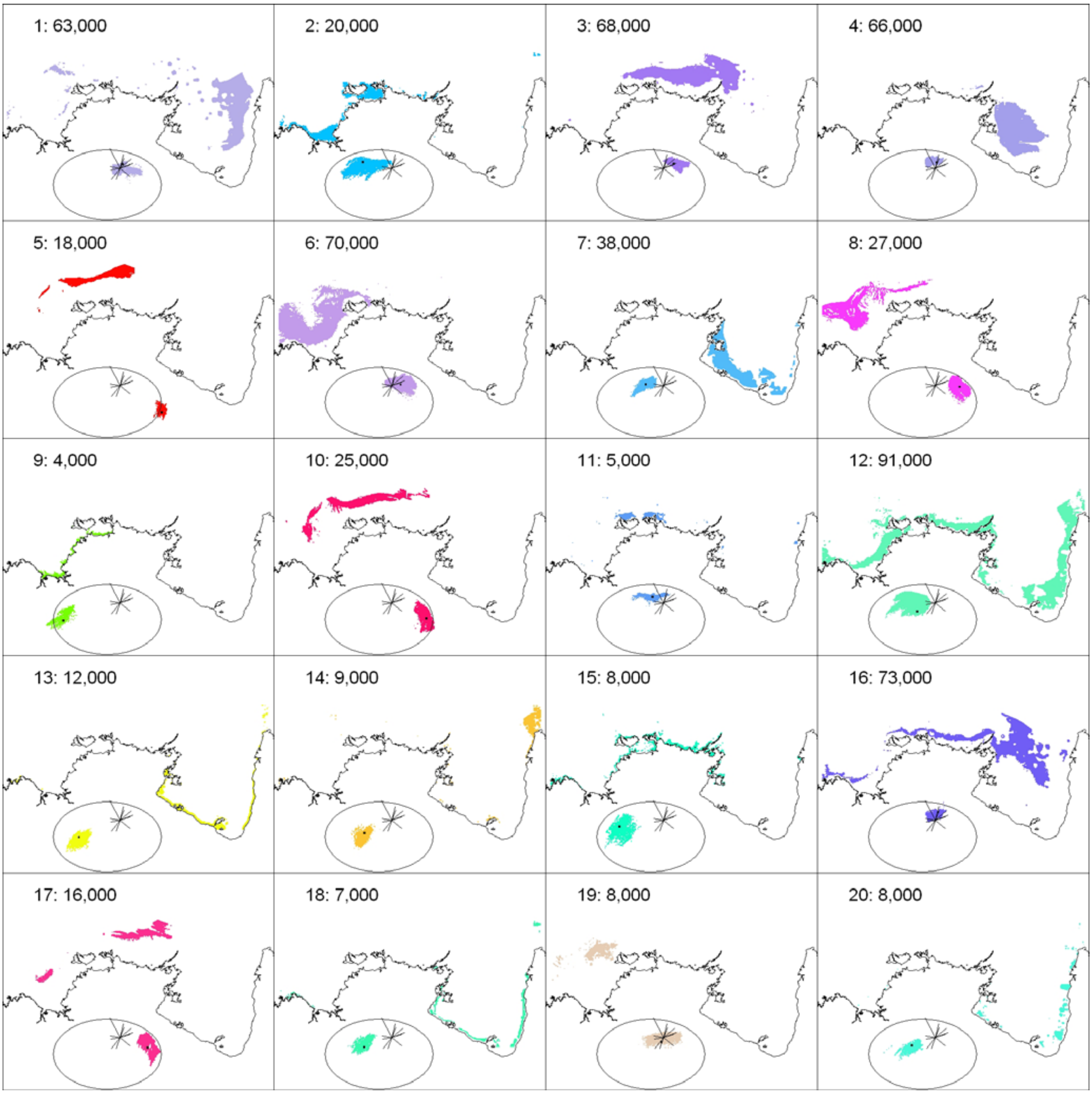


Attachment 2: A map of the 20-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the NMR. The interpretive colour key can be used to identify the physical variables having most influence on predicted patterns. For example, the colour green is associated with high chlorophyll A average, red with high silicate average, purple with high nitrate average. The gray area near the origin of the arrows corresponds to medium values of the physical variables. Cluster 18 has been rendered in black to make it easier to see. Also shown in the colour key are the centres (medoids) of each cluster in the 20-cluster set. Many clusters are disjointed (see Attachment 3 to identify their spatial limits). A brief description of the physical variables having most influence on predicted seabed assemblage patterns is provided in Attachment 4.

Note - The map and interpretive colour key account for 58% of the total variation; the remaining 42% is not shown as it cannot be displayed in 2 dimensions (if more information is required please phone the provided contact person)



Attachment 3: Maps identifying the spatial limits of each individual cluster in the 20 cluster set predicting seabed assemblage patterns of marine fauna in the North Marine Region. The number of 0.01° × 0.01° grids in the cluster is shown to the nearest thousand.



Attachment 4: Description of physical attributes for each individual cluster in the 20 cluster set prediction for seabed assemblage patterns of marine fauna in the North Marine Region

The physical attributes of each predicted assemblage of the 20 cluster output are distinguished by multiple variables used to characterise the region. Many clusters are distinguished on multi-variable combinations rather than individual variables. The following descriptions identify the most influential physical variables for each of the predicted seabed assemblages of marine fauna in the cluster set, clusters particularly distinctive on one variable are indicated by * (typical range shown in parentheses).

1. Eastern Carpentaria basin [~76K km^2]: moderately high variation in seabed oxygen (O2 SD: 0.58--0.65 mg l^{-1}), moderately low chlorophyll A (Chl A: 0.37--0.44 mg m^{-3}), moderately low turbidity (K490: 0.060--0.066 m^{-1}), primarily sandy (61--73%), deep mid-shelf (54–65 m)
2. Joseph Bonaparte Gulf / Beagle Gulf [~24K km^2]: high average water temperature at the seabed (CRS T: 28.1–28.3°C), low silicate average (Si: 3.22–4.38 µM), high turbidity (K490: 0.19–0.25 m^{-1}), high chlorophyll A (Chl A: 2.85–4.50 mg m^{-3}), sandy-muddy sediments with high gravel (16--36 %), high variation in bottom stress (BS IQR: 0--1 Nm^{-2}), inshore depth range (13–28 m),
3. Arafura mid-shelf [~82K km^2]: moderately high sediment mud content (49–70 %), low sediment sand content (26–45 %), high variation in seabed oxygen (O2 SD: 0.59--0.71 mg l^{-1}), low salinity average (S: 34.3--34.4 ‰), mid-shelf depth range (54–64 m),
4. Central Gulf of Carpentaria [~79K km^2]: high sediment mud content (49–72 %), low sediment sand content (25–45 %), low chlorophyll A (Chl A: 0.35–0.375 mg m^{-3}), low turbidity (K490: 0.058–0.06 m^{-1}), high salinity average (S: 34.9--35.1 ‰), high variation in seabed oxygen (O2 SD: 0.65--0.67 mg l^{-1}), mid-shelf depth (53–59 m),
5. Timor—Arafura slope [~22K km^2]: very low average water temperature at the seabed (CRS T: 16.3–20.4°C)*, low variation in sea surface temperature (SST SD: 1.2–1.2°C), very low benthic irradiance (BI: 0.000–0.001), upper slope depth range (129–185 m)*, very high silicate average (Si: 21.38–27.66 µM)*, very low chlorophyll A (Chl A: 0.240–0.272 mg m^{-3}), very low average seabed oxygen (O2: 2.45–2.58 mg/l)*, very low turbidity (K490: 0.048–0.052 m^{-1}), very high nutrients (NO3: 14.0--19.3 µM)*,
6. Timor mid-shelf [~84K km^2]: high sediment carbonate (48–75 %), high average sea surface temperature (SST: 28.6–28.8°C), low variation in water temperature at the seabed (CRS T SD: 1.0--1.3 °C), moderately high variation in bottom stress (BS IQR: 0.1--0.3 Nm^{-2}), mid-shelf depth range (65–84 m),
7. SW Carpentaria inner shelf [~46K km^2]: high variation in sea surface temperature (SST SD: 2.5–3.0°C), very high salinity average (S: 34.9--35.2 ‰), high variation in water temperature at the seabed (CRS T SD: 2.2--2.7 °C), inner-shelf depth range (21–35 m),
8. Timor outer-shelf [~32K km^2]: very high average sea surface temperature (SST: 28.8–28.9°C), low variation in sea surface temperature (SST SD: 1.1–1.2°C), low benthic irradiance (BI: 0.001–0.003), outer-shelf depth range (94–117 m), moderately low average seabed oxygen (O2: 3.01--3.45 mg l^{-1}), moderately high silicate average (Si: 10.9--13.9 µM), moderately high sediment mud content (42–70 %),
9. Bonaparte–Anson–Beagle coastal [~5K km^2]: very high average water temperature at the seabed (CRS T: 28.3–28.5°C), high benthic irradiance (BI: 0.271–0.728), very shallow depth (1–4 m), very low silicate average (Si: 2.85–3.18 µM), very high chlorophyll A (Chl A: 4.34–7.17 mg m^{-3}), very high turbidity (K490: 0.256–0.321 m^{-1})*, very high sediment gravel content (20--43 %), moderately high salinity average (S: 34.5--34.8 ‰),
10. Timor — Arafura shelf-break [~30K km^2]: low average water temperature at the seabed (CRS T: 22.6–24.3 °C), low benthic irradiance (BI: 0.002–0.008), shelf-break depth range (89–116 m), high silicate average (Si: 15.13–19.10 µM)*, low chlorophyll A (Chl A: 0.272–0.333 mg m^{-3}), low average seabed oxygen (O2: 2.71–3.06 mg/l), low turbidity (K490: 0.051–0.058 m^{-1}), high sediment mud (36--81 %),

11. Melville/Coburg nearshore [~6K km^2]: low sediment carbonate (30–34 %), very high sediment mud content (72–90 %), very low sediment sand content (12–27 %), very low sediment gravel content (0--1 %), low sediment carbonate (: 30--35 %), low salinity average (S: 34.3--34.3 ‰), moderately high average water temperature at the seabed (CRS T: 27.9--28.2 °C), depth (25–39 m),
12. north region inner-shelf [~110K km^2]: low sediment mud content (10–27 %), moderately high sediment sand content (59--78 %), inner-shelf depth range (20–36 m),
13. SW & East Carpentaria coast [~14K km^2]: very high variation in sea surface temperature (SST SD: 2.9–3.5°C), very high benthic irradiance (BI: 0.521–0.772), very shallow (1–3 m), high sediment sand content (63–82 %), very high average seabed oxygen (O2: 4.60–4.73 mg/l), high chlorophyll A (Chl A: 2.746–4.198 mg m^{-3}), low sediment carbonate (29–46 %), relatively low average sea surface temperature (SST: 27.2–27.9°C), high turbidity (K490: 0.192–0.254 m^{-1}),
14. Western Torres Strait [~10K km^2]: very low sediment mud content (4–9 %), high sediment sand content (72–83 %), high sediment gravel content (11--20 %), high sediment carbonate (66–86 %), relatively low average sea surface temperature (SST: 27.5–27.7°C), very high variation in salinity (S SD: 1.4--1.6 ‰)*, very high variation in bottom stress (BS IQR: 0.2--2.3 Nm^{-2}), very high bottom stress (BS: 0.1--0.6 Nm^{-2}), moderately shallow (Depth: 6–12 m),
15. Arnhem land / Kimberley coast [~10K km^2]: high average water temperature at the seabed (CRS T: 28.1–28.5°C), high benthic irradiance (BI: 0.362–0.793), low silicate average (Si: 2.87–3.28 μM), very low salinity average (S: 34.2--34.3 ‰), shallow depth (1–6 m),
16. Northern Carpentaria—Arnhem inner-shelf [~89K km^2]: moderately high salinity average (S: 34.6--34.9 ‰), moderately high variation in seabed oxygen (O2 SD: 0.63--0.68 mg l^{-1}), depth range (52–61 m),
17. Arnhem / Bonaparte outer-shelf [~19K km^2]: low average water temperature at the seabed (CRS T: 23.8–24.8°C), high silicate average (Si: 12.42–13.92 μM), low average seabed oxygen (O2: 2.79–3.04 mg/l) and very high variation in seabed oxygen (O2 SD: 0.66--0.75 mg l^{-1}), high nutrients (NO3: 6.8--8.4 μM) and very high variation in nitrate (NO3 SD: 4.6--4.8 μM), outer-shelf depth range (69–79 m),
18. SW & East Carpentaria nearshore [~8K km^2]: very low average sea surface temperature relatively (SST: 27.2–27.7°C) and high variation in sea surface temperature (SST SD: 2.4–3.4°C), high average seabed oxygen (O2: 4.52–4.65 mg/l), moderately high chlorophyll A (Chl A: 2.093--3.548 mg m^{-3}) with very high variation (Chl A SD: 0.630--1.205 mg m^{-3}), moderately high turbidity (K490: 0.161--0.226 m^{-1}) with very high variation in turbidity (K490 SD: 0.024--0.043 m^{-1}), nearshore depth range (7–12 m),
19. Cootamundra Shoals area [~10K km^2]: high average sea surface temperature (SST: 28.5–28.6°C), very low variation in sea surface temperature (SST SD: 1.1–1.1°C), very high sediment carbonate (76–93 %), high bottom stress (BS: 0.1--0.1 Nm^{-2}) with high variation (BS IQR: 0.2--0.3 Nm^{-2}), typical depth range (36–56 m) with shoals to ~20 m,
20. Carpentaria sand patches [~9K km^2]: very high sediment sand content (88–93 %)*, low sediment mud content (5–11 %), low sediment gravel content (0--3 %), relatively low sediment carbonate (22–45 %), high average seabed oxygen (O2: 4.45–4.59 mg/l), depth range (12–23 m),

Attachment 5: Metadata record for benthic habitat database for NMR.

Database for benthic habitat prediction in the North Marine Region (NMR). Version 1.0

Short title : **MarLIN record number** : 8519 **Anzlic Identifier** : ANZCW0306008519 **ISO Topic**

Category/s Oceans

Data Type Aggregated/Derived Data

Area of Interest Northern Bioreg Data

Custodian Organisation : CSIRO Division of Marine and Atmospheric Research - Cleveland
PO Box 120
Cleveland
QLD Australia
4163
http://www.cmar.csiro.au/

Jurisdiction : Australia

Contributors : Nick Ellis

Acknowledgements : Geoscience Australia for sediment, bathymetry and benthic stress, CSIRO Marine and Atmospheric Research for CARS data SeaWifs for turbidity data. Funding: CERF Marine Biodiversity Hub

References :

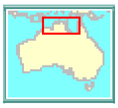
Abstract : This product (i.e. an Access database and csv files) contains data (longitude, latitude and attribute variables) that describe the predicted spatial patterns of seabed biodiversity composition for demersal fish and benthic invertebrates in the NMR. The predicted patterns are represented as point data on a 0.01 degree grid (~1.2 km^2) covering most of the NMR (approximately 400,000 km^2). Four separate meso-scale (10's-100's km) predictions have been provided that subdivide the NMR into 20, 40, 60, 80 sub-units (i.e. cluster sets).

Attributes Overview : CERF_ID: a primary key
LON: longitude
LAT: latitude
component01-13: the 13-dimensional principal component data that was clustered
probweight: cell weighting used in two-stage CLARA/PAM clustering
cluster20: the 20-cluster clustering
cluster40: the 40-cluster clustering

cluster60: the 60-cluster clustering
cluster80: the 80-cluster clustering

Geographic Extent

8.89 S

126.06 E  142.5 E

17.12 S

Dataset contains GIS spatial data in format Geocentric Australia (New Standard GDA).

Subject Categories and Search Word(s)

MarLIN Subject Categories

1383. Biogeography and biogeographic regions

Habitat Keywords

EARTH SCIENCE > Biosphere > Aquatic Habitat > Benthic Habitat

GCMD Keywords

EARTH SCIENCE > Land Surface > Landscape > Landscape Ecology
EARTH SCIENCE > Oceans > Marine Biology > Marine Habitat

ANZLIC Search Words

ECOLOGY
ECOLOGY Habitat
ECOLOGY Landscape
MARINE Biology
Northern Bioreg Data
Oceans

Originating Research Project

Not Entered

Beginning date : Not Known
Ending date : Not Known
Progress : Complete
Maintenance and Update Frequency : As required
Stored Data Format(s) DIGITAL - Database Files - MS Access
Stored Data Volume 113 MB of digital data
Specific Software Requirements Requires Msoft Access

Stored Data Documentation
Stored Data Location
Available Format Type(s) Same As Stored
Access constraint
The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.
Lineage This is an original derivation.
Positional accuracy
Data are based on interpolated values from a variety of sources. E.g. see CARS (Anzlic Identifier : ANZCW0306005960)
Parameter accuracy
Logical consistency report
Completeness There are some cells for which predictor data are missing in mid Gulf of Carpentaria
Contact
Nick Ellis
CSIRO Division of Marine and Atmospheric Research - Cleveland
PO Box 120
Cleveland
QLD Australia
4163
nick.ellis@csiro.au

Metadata Access Public
Metadata Entry Created 16-Jun-2009 by Nick Ellis
Metadata Last Updated 18-Jun-2009 by Nick Ellis
Metadata Export
Show ANZLIC core metadata in ANZLIC XML format
Show full metadata in MarLIN (extended ANZLIC) XML format
Metadata Updateable By
Nick Ellis
Edit this MarLIN record (authorisation required)

Product title: Predicted seabed assemblage patterns of marine fauna in the East Marine Region (EMR).

Relevance of product to marine planning and management

This product provides planners and managers with the most recent and complete information about the predicted seabed assemblage patterns of marine fauna, at a range of scales, in the EMR, based on extensive analyses of species responses to the physical environment. It can be used as follows:

1. To produce maps of predicted patterns of seabed assemblage of marine fauna (i.e. benthic invertebrates and demersal fish combined) in the EMR;
2. To provide the results of scientific analysis of extensive biological data to planners and managers with the responsibility to conserve and manage seabed biodiversity in the EMR (e.g. MPA planning and management);
3. As a biologically informed data input to models of the marine environment in the EMR, where appropriate (e.g. Marxan); and
4. To identify areas of highest priority for future seabed biodiversity surveys, the findings of which can be compared with these predictions of seabed assemblage patterns of marine fauna in the EMR.

Product description

This product (i.e. an Access database and csv files) contains data (longitude, latitude and attribute variables) that describe the predicted spatial patterns of the seabed assemblages of demersal fish and benthic invertebrates in the EMR. The predicted patterns are represented as point data on a 0.01 degree grid (~1.2 km^2) covering the continental shelf & upper slope of the EMR (approximately 87,000 km^2). Four separate meso-scale (10's-100's km) predictions have been provided that subdivide the EMR into 10, 15, 20 and 40 sub-units (i.e. the 20 prediction divides the region into 20 sub-units called clusters, collectively they form a cluster set). The predictions were limited to the mainland shelf & upper slope due to the lack of suitable data for the remainder of the EMR, and restricted to south of 24.5°S because the GBR is managed by the GBRMPA.

Interpretation of product

The product represents the predicted spatial patterns of seabed assemblages of marine fauna (i.e. demersal fish and benthic invertebrates) in the EMR. Each predicted assemblage is represented as a cluster in the data-product that should be interpreted as areas of seabed where the mixture of demersal fish and benthic invertebrate species and their abundances are characteristic of a particular physical environment, reasonably homogeneous and, to varying extents, distinct from other assemblages in the cluster set. Some clusters will be more distinct compared to others, and the boundaries between them will have varying levels of fuzziness; some are gradual, some are steep. For example, there is some geographical overlap between clusters 1 and 3. The accompanying colour maps, and in particular the colour key (Attachment 2) provide insight into this.

The different scales of clusters (i.e. cluster sets of 10, 15, 20 and 40) provide progressively finer scale information. The individual clusters of finer-scale cluster sets are expected to represent more homogeneous assemblages, compared to those in coarser scale cluster sets, but at finer scales the differences between individual clusters are smaller and less certain. In coarser scale cluster sets, individual clusters may not be as homogenous, but are expected to have greater and more certain differences compared to their neighbouring clusters. For more information on certainty please phone or email the contact.

Brief description of methods/data used develop output

The following provides a basic description of methods/data used to develop this product:

1. All suitable available biological data (i.e. demersal fish and benthic invertebrate species) for the EMR were collated from four different sources: the Great Barrier Reef seabed biodiversity survey, the Queensland East Coast Trawl Fishery scallop and prawn surveys, the South East Fishery fish trawl and benthic sled surveys, and various surveys from the vessel Kapala off the NSW coast.
2. All suitable available physical data, comprising 29 physical variables (e.g. bathymetry, mud content of sediment, dissolved oxygen, temperature, light availability, etc.) were collated by the CERF Marine Biodiversity Hub, to provide full coverages of the region.
3. Analyses of presence/absence data were conducted on over 700 seabed fish and invertebrate species to identify thresholds along each of the 29 physical gradients (e.g. percentage of mud content in sediment) that correspond to observed changes in the spatial patterns of benthic species;
4. Thresholds of each of physical gradient (i.e. within a single physical variable such as percentage of mud content in sediment) were then used to transform that physical variable to a biologically-informed variable. Thresholds that corresponded to relatively large changes in benthic assemblages were more influential in transforming the variable than those corresponding to small changes;
5. Each of the 29 biologically informed variables was weighted based on the importance of that variable in determining seabed assemblages. Physical variables that corresponded to relatively large changes in benthic assemblages were considered more important than those corresponding to small changes; and
6. The 29 biologically informed variables were then used to populate each 0.01° × 0.01° grid cell in the EMR. The data were used to produce maps to display predicted spatial patterns in seabed assemblages (see attachments).

It should be noted that this method identifies the physical attributes that are associated with the predicted seabed assemblages of marine fauna; it does not identify the suite of species that typify the assemblages due to gaps in the available biological data. The method has been developed in collaboration with and reviewed by an international team of 10 scientists from Australia, Canada, USA (Maine and Texas) and is being applied in these regions also.

Advantages/improvements over existing products

The product is based on a novel technique that uses biological information to transform physical data and predict spatial patterns of seabed assemblages of marine fauna at a range of scales in the EMR. This product uses the most recently available and broadest collation of data on the physical environment and of biology (surveys of demersal fish and benthic invertebrates) in the EMR. The data sources have been newly collated to provide input to this product, and include additional data for some variables (e.g. bathymetry and sediments), as well as many new variables (eg. bottom water attributes) and new biological surveys that have not been used previously for this purpose.

Conditions of use

This product does not contain any confidential information. It is a preliminary product subject to further development by the CERF Marine Biodiversity Hub. Final product is due around May 2010 .The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.

Contact for further information
Nick Ellis 07 3826 7260 nick.ellis@csiro.au
Roland Pitcher 07 3826 7250 roland.pitcher@csiro.au

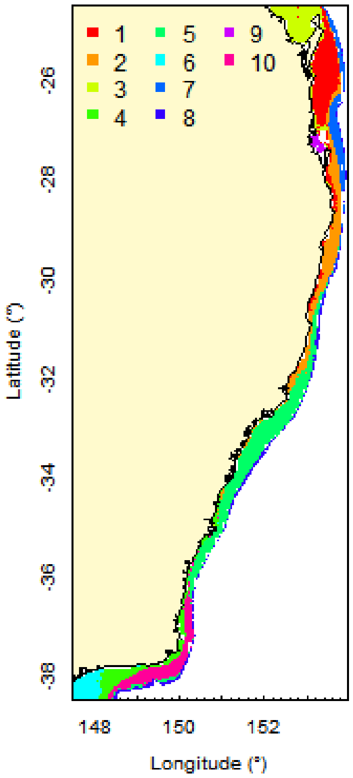
Attachments

1. Four maps for a quick view of the each of the cluster sets (i.e10, 15, 20 and 40 clusters) predicting seabed assemblage patterns of marine fauna in the East Marine Region.
2. A map of the 10-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the EMR.
3. Maps identifying the spatial limits of each individual cluster in the 10 cluster set predicting seabed assemblage patterns of marine fauna in the East Marine Region.
4. Description of physical attributes for each individual cluster in the 10 cluster set predicting seabed assemblage patterns of marine fauna in the East Marine Region
5. Metadata record for database of seabed assemblage patterns of marine fauna in the East Marine Region.

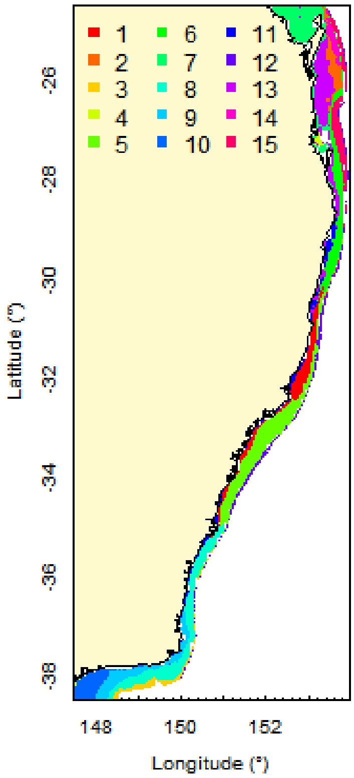
Acknowledgement of datasets
Great Barrier Reef Seabed Biodiversity Project:
Pitcher, C.R., Doherty, P., Arnold, P., Hooper, J., Gribble, N., and 50 others (2007). Seabed Biodiversity on the Continental Shelf of the Great Barrier Reef World Heritage Area. AIMS/CSIRO/QM/QDPI Final Report to CRC Reef Research. 320 pp.
South East Fishery Ecosystem Project:
Bax, N and Williams, A. (2000). Habitat and fisheries production in the South East Fishery ecosystem - Final report to the Fisheries Research and Development Corporation. CSIRO Marine Research, Hobart.
Queensland East Coast Trawl Fishery Bycatch Project: data provided by Dr. Tony Courtney QDPI&F
Courtney, A. J., Haddy, J. A., Campbell, M. J., Roy, D. P., Tonks, M. L., Gaddes, S. W., Chilcott, K. E., O'Neill, M. F., Brown, I. W., McLennan, M., Jebreen, E. J., van der Geest, C., Rose, C., Kistle, S., Turnbull, C. T., Kyne, P. M., Bennett, M. B. and Taylor, J. (2007). Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery. Fisheries Research and Development Corporation (FRDC) Project #2000/170 Final Report 307p.
NSW Fisheries Research Institute *FRV Kapala* surveys: data provided by Ken Graham NSW FRI.

Attachment 1: Four maps for a quick view of the each of the cluster sets (i.e. 10, 15, 20 and 40 clusters) predicting seabed assemblage patterns of marine fauna in the East Marine Region.

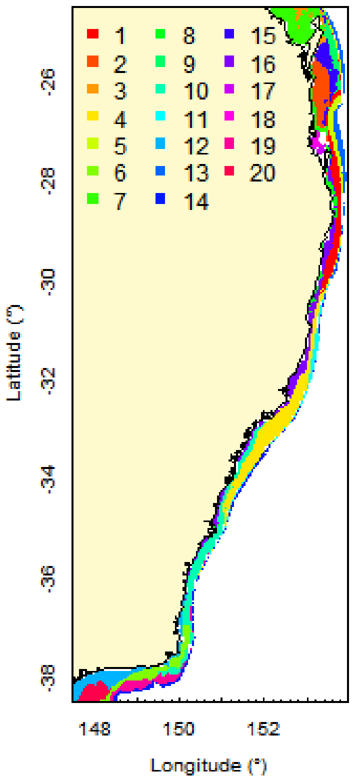
10 clusters



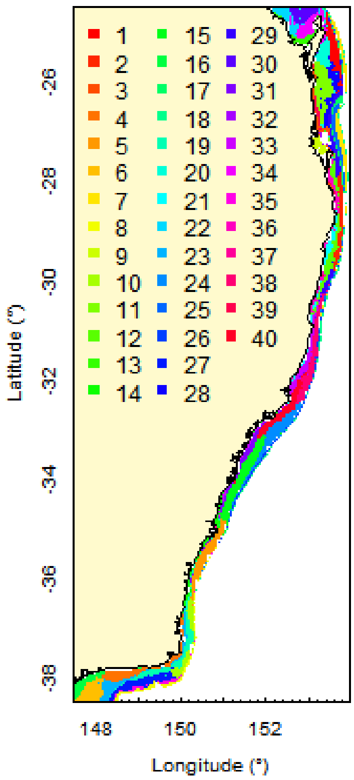
15 clusters



20 clusters



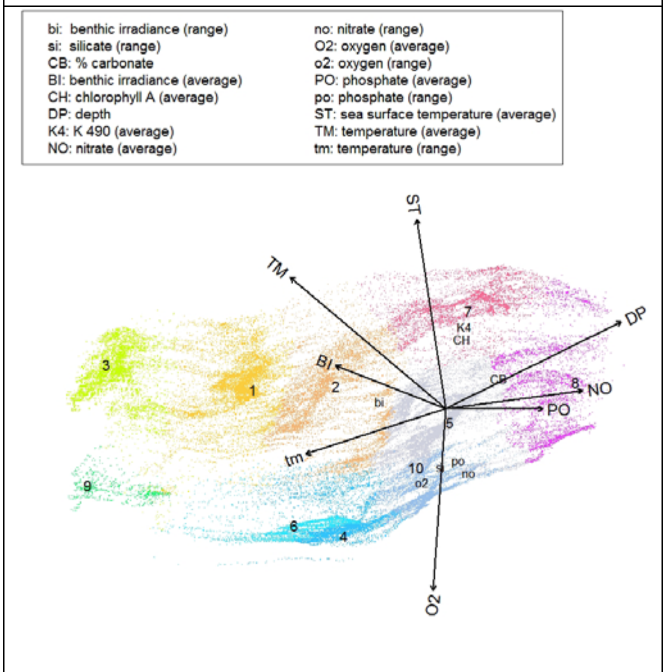
40 clusters

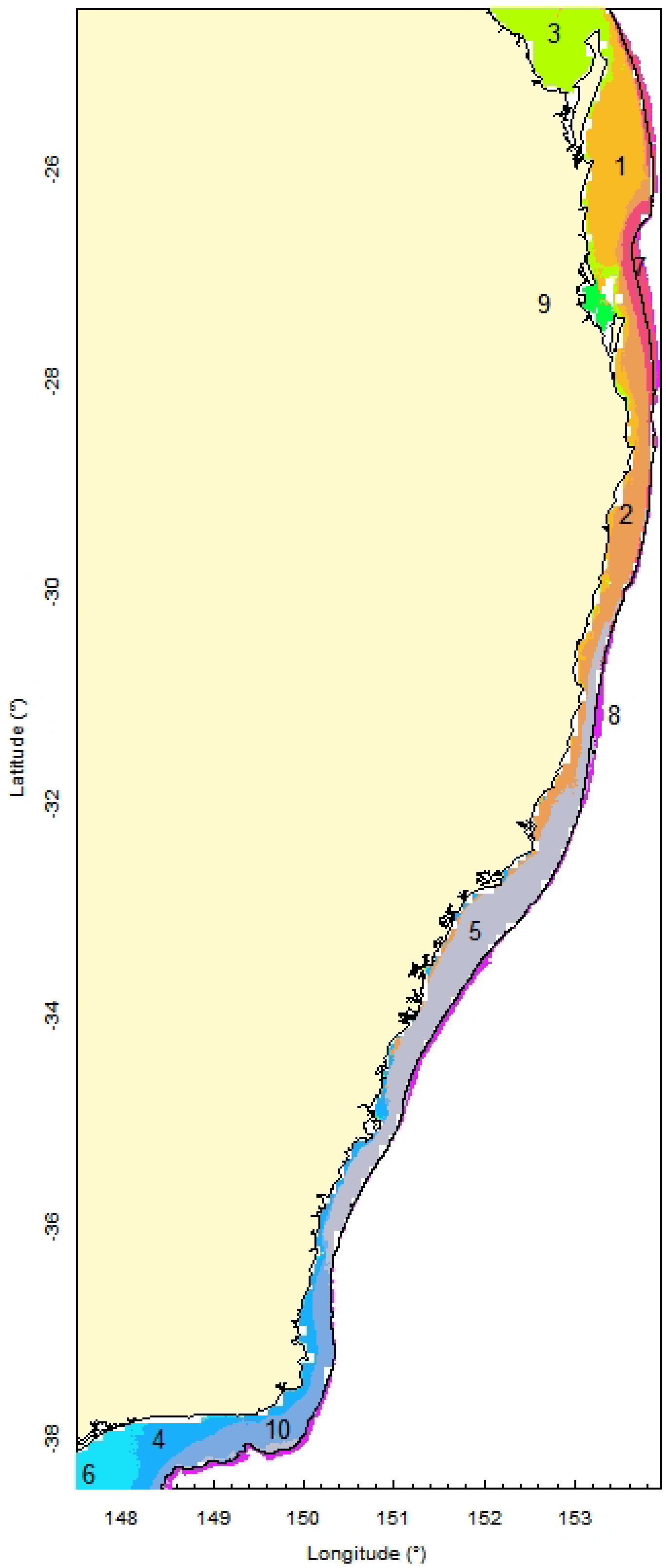


MARINE BIODIVERSITY RESEARCH
Prediction and Management of Australia's Marine Biodiversity

Attachment 2: A map of the 10-cluster set identifying the physical variables having most influence on the predicted seabed assemblages pattern of marine fauna in the EMR. The interpretive colour key can be used to identify the physical variables having most influence on predicted patterns. For example, the colour purple is associated with deeper areas, red with higher sea surface temperature, green with shallow areas with high benthic irradiance, blue with high oxygen. The gray area near the origin of the arrows corresponds to medium values of the physical variables. Also shown in the colour key are the centres (medoids) of each cluster in the 10-cluster set. Some clusters (e.g. 1, 3, 6) are disjointed (see Attachment 3 to identify their spatial limits). A brief description of the physical variables having most influence on predicted seabed assemblage patterns is provided in Attachment 4.

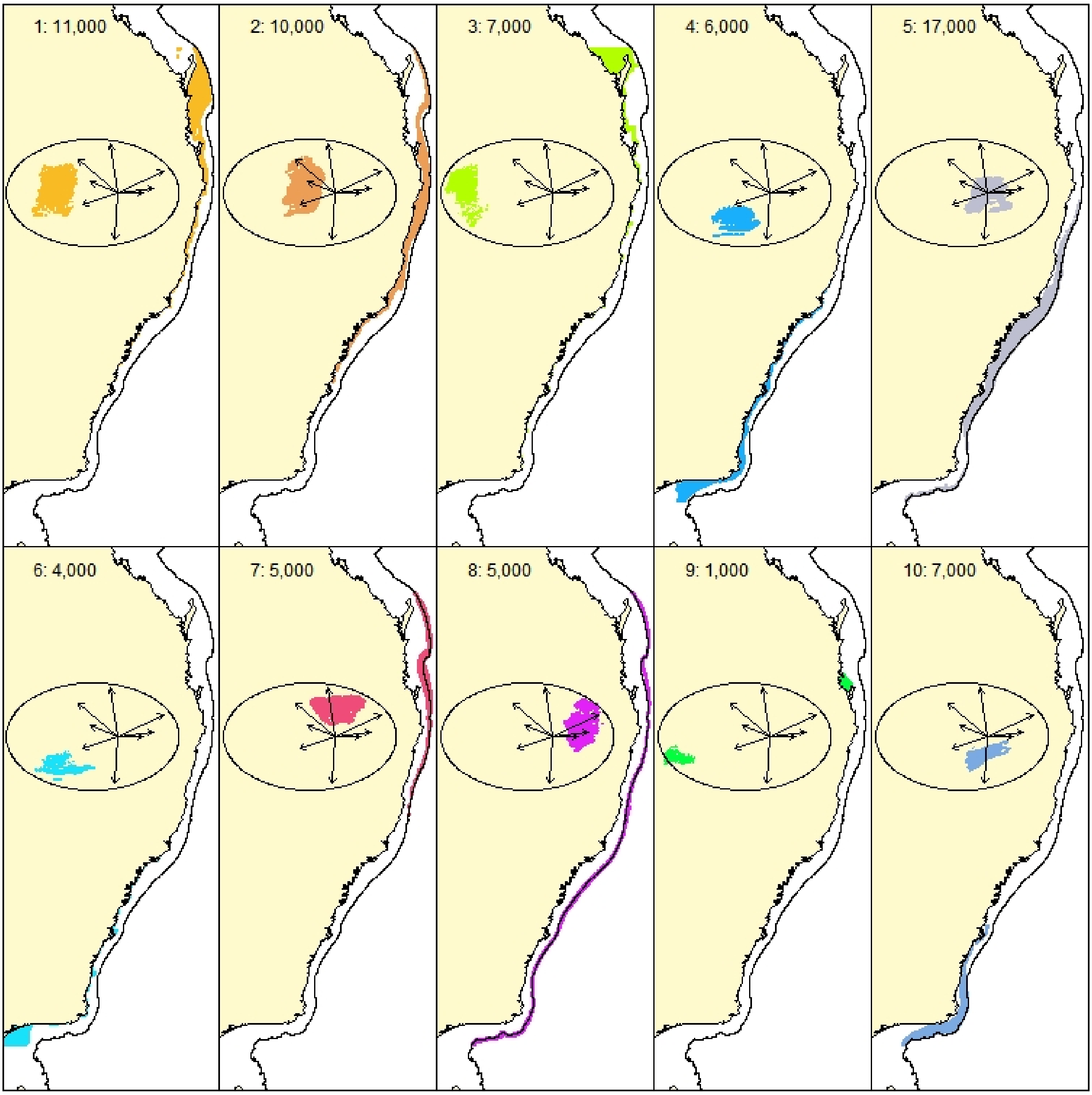
Note - The map and interpretive colour key account for 75% of the total variation; the remaining 25% is not shown as it cannot be displayed in 2 dimensions (if more information is required please phone the provided contact person)





10 March 2010

Attachment 3: Maps identifying the spatial limits of each individual cluster in the 10 cluster set predicting seabed assemblage patterns of marine fauna in the East Marine Region. The number of 0.01° × 0.01° grids in the cluster is shown to the nearest thousand. The 200m depth contour is also shown. The location of the grids in the colour key is also shown inside the ellipse (see Attachment 2).



Attachment 4: Description of physical attributes for each individual cluster in the 10 cluster set prediction for seabed assemblage patterns of marine fauna in the East Marine Region

The physical attributes of each predicted assemblage of the 10 cluster output are distinguished by multiple variables used to characterise the region. Many clusters are distinguished on multi-variable combinations rather than individual variables. The following descriptions identify the most influential physical variables for each of the predicted seabed assemblages of marine fauna in the cluster set, clusters particularly distinctive on one variable are indicated by * (typical range shown in parentheses).

1. Sunshine Coast inner shelf [~13K km^2]: moderately low depth (Depth: 44–59 m), low sediment carbonate (CRBNT: 22–52 %), low nitrate (NO3: 1.6–3.0 µM), low phosphate average (PO4: 0.24–0.34 µM), range of water temperature at the seabed (CRS T SD: 4.2–5.0 °C)*
2. East coast mid shelf [~12K km^2]: depth (Depth: 57–86 m), low average seabed oxygen (O2: 4.19–4.36 mg l^{-1}), low range of seabed oxygen (O2 SD: 0.37–0.45 mg l^{-1}), average water temperature at the seabed (CRS T: 18.5–19.8 °C)*, low silicate average (Si: 1.76–2.91 µM)
3. Hervey Bay/ Sunshine Coast nearshore [~9K km^2]: low depth (Depth: 12–25 m)*, very low sediment carbonate (CRBNT: 10–18 %), very low nitrate (NO3: 0.2–0.3 µM)*, very low phosphate average (PO4: 0.11–0.13 µM)*, average water temperature at the seabed (CRS T: 24.2–24.4 °C)*, range of water temperature at the seabed (CRS T SD: 5.1–5.7 °C)*, low silicate average (Si: 1.39–2.65 µM)
4. SE Victoria inner shelf [~7K km^2]: moderately low depth (Depth: 51–77 m), low sediment carbonate (CRBNT: 17–44 %), low average water temperature at the seabed (CRS T: 14.1–14.8 °C), low average sea surface temperature (SST: 16.0–18.3 °C)
5. Central Coast shelf [~20K km^2]: depth (Depth: 111–145 m), low average seabed oxygen (O2: 4.26–4.58 mg l^{-1}), low benthic irradiance (BI: 0.000–0.001)
6. North Bass Strait [~5K km^2]: low depth (Depth: 41–55 m), low phosphate average (PO4: 0.31–0.37 µM), average seabed oxygen (O2: 5.40–5.51 mg l^{-1})*, very low silicate average (Si: 1.32–1.80 µM), very low average sea surface temperature (SST: 15.6–15.7 °C)*
7. East Coast outer shelf [~7K km^2]: depth (Depth: 137–235 m), very low average seabed oxygen (O2: 4.04–4.11 mg l^{-1})*, low range of seabed oxygen (O2 SD: 0.14–0.34 mg l^{-1}), very low range of water temperature at the seabed (CRS T SD: 0.9–1.3 °C), low range of benthic irradiance (bi: 0.000–0.004)
8. East Coast slope [~5K km^2]: depth (Depth: 275–357 m)*, nitrate (NO3: 11.6–14.5 µM)*, phosphate average (PO4: 0.90–1.12 µM)*, very low range of seabed oxygen (O2 SD: 0.10–0.31 mg l^{-1}), very low average water temperature at the seabed (CRS T: 11.0–12.3 °C)*, low range of water temperature at the seabed (CRS T SD: 0.9–1.5 °C), very low benthic irradiance (BI: 0–0)*, very low range of benthic irradiance (bi: 0–0)*
9. Moreton Bay [~1K km^2]: very low depth (Depth: 2–11 m)*, low nitrate (NO3: 0.3–0.6 µM)*, range of water temperature at the seabed (CRS T SD: 8.8–9.4 °C)*, silicate average (Si: 7.79–12.15 µM)*
10. SE coast outer shelf [~8K km^2]: depth (Depth: 115–139 m), low average water temperature at the seabed (CRS T: 13.7–14.1 °C), low range of water temperature at the seabed (CRS T SD: 1.6–2.5 °C), low average sea surface temperature (SST: 16.9–18.5 °C), low benthic irradiance (BI: 0–0), low range of benthic irradiance (bi: 0.000–0.001)

Attachment 5: Metadata record for benthic habitat database for EMR.

Database for benthic habitat prediction in the East Marine Region (EMR). Version 1.0

Short title : **MarLIN record number** : 8631 **Anzlic Identifier** : ANZCW0306008631 **ISO Topic Category/s**

Oceans

Data Type

Aggregated/Derived Data

Custodian Organisation :

CSIRO Division of Marine and Atmospheric Research - Cleveland
PO Box 120
Cleveland
QLD Australia 4163
http://www.cmar.csiro.au/

Jurisdiction : Australia

Contributors : Nick Ellis

Acknowledgements : Geoscience Australia for sediment, bathymetry and benthic stress
CSIRO Marine and Atmospheric Research for CARS data
SeaWifs for turbidity data
Queensland Primary Industries and Fisheries for bycatch composition data
NSW Fisheries Research Institute for catch composition data gathered on FRV Kapala
Funding: CERF Marine Biodiversity Hub

References :

Great Barrier Reef Seabed Biodiversity Project:
Pitcher, C.R., Doherty, P., Arnold, P., Hooper, J., Gribble, N., and 50 others (2007). Seabed Biodiversity on the Continental Shelf of the Great Barrier Reef World Heritage Area. AIMS/CSIRO/QM/QDPI Final Report to CRC Reef Research. 320 pp.

South East Fishery Ecosystem Project:
Bax, N and Williams, A. (2000). Habitat and fisheries production in the South East Fishery ecosystem - Final report to the Fisheries Research and Development Corporation. CSIRO Marine Research, Hobart.

Queensland East Coast Trawl Fishery Bycatch Project: data provided by Dr. Tony Courtney QDPI&F
Courtney, A. J., Haddy, J. A., Campbell, M. J., Roy, D. P., Tonks, M. L., Gaddes, S. W., Chilcott, K. E., O'Neill, M. F., Brown, I. W., McLennan, M., Jebreen, E. J., van der Geest, C., Rose, C., Kistle, S., Turnbull, C. T., Kyne, P. M., Bennett, M. B. and Taylor, J. (2007). Bycatch weight, composition and preliminary estimates of the impact of bycatch reduction devices in Queensland's trawl fishery.

Fisheries Research and Development Corporation (FRDC) Project #2000/170 Final Report 307p.

NSW Fisheries Research Institute FRV Kapala surveys: data provided by Ken Graham NSW FRI.

Abstract : This product (i.e. an Access database and csv files) contains data (longitude, latitude and physical data) that explains the predicted spatial patterns of benthic habitats for demersal fish and benthic invertebrates in the EMR. Predicted patterns for habitats represent point data on a 0.01 decimal degree grid covering most of the EMR (approximately 78,000 square km).

Attributes Overview :

CERF_ID: a primary key
LON: longitude
LAT: latitude
component01-09: the 9-dimensional principal component data that was clustered
probweight: cell weighting used in two-stage CLARA/PAM clustering
cluster10: the 10-cluster clustering
cluster15: the 15-cluster clustering
cluster20: the 20-cluster clustering
cluster40: the 40-cluster clustering
r: red value for rendering on a map (scale 0-1)
g: green value for rendering on a map (scale 0-1)
b: blue value for rendering on a map (scale 0-1)

Location Keywords

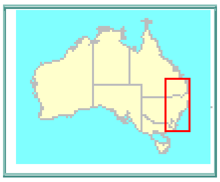
Australia > New South Wales Coast
Australia > Queensland Coast Southern
Australia > Victoria Coast

ANZLIC Geographic Extent Names (Category, [Jurisdiction], Name)

Ocean and Sea Regions, [Australia], New South Wales Coast
Ocean and Sea Regions, [Australia], Queensland Sub Tropical Coast
Ocean and Sea Regions, [Australia], Victoria Coast

Geographic Extent

24.5 S

147.5 E  153.95 E

38.75 S

Dataset contains GIS spatial data in format Geocentric Australia (New Standard GDA).

Maximum Depth

400

Subject Categories and Search Word(s)

MarLIN Subject Categories

1383. Biogeography and biogeographic regions

Habitat Keywords

EARTH SCIENCE > Biosphere > Aquatic Habitat > Benthic Habitat

GCMD Keywords

EARTH SCIENCE > Land Surface > Landscape > Landscape Ecology
EARTH SCIENCE > Oceans > Marine Biology > Marine Habitat

ANZLIC Search Words

ECOLOGY
ECOLOGY Habitat
ECOLOGY Landscape
MARINE Biology
Oceans

Originating Research Project

Not Entered

Beginning date : Not Known
Ending date : Not Known
Progress : Complete
Maintenance and Update Frequency : As required
Stored Data Format(s)

DIGITAL - Database Files - MS Access

Stored Data Volume

12 MB of digital data

Specific Software Requirements

Requires Microsoft Access

Stored Data Documentation

Stored Data Location

Available Format Type(s)

Same As Stored

Access constraint

The data may be copied for distribution within DEWHA for their internal business operations, but may not be provided to third parties. Enquiries from third parties should be directed to the CERF Hub.

Lineage

This is an original derivation.

Positional accuracy

Data are based on interpolated values from a variety of sources. E.g. see CARS (Anzlic Identifier : ANZCW0306005960)

Parameter accuracy
Logical consistency report
Completeness

Refer to the published literature.

Contact

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Metadata Access

Public

Metadata Entry Created

09-Mar-2010 by Nick Ellis

Metadata Export

Show ANZLIC core metadata in ANZLIC XML format
Show full metadata in MarLIN (extended ANZLIC) XML format

Metadata Updateable By

Nick Ellis
