May 2002

GBR Seabed Biodiversity Mapping Project: Phase 1

DRAFT Report to CRC-Reef

Roland Pitcher, CSIRO Marine Research (Task Leader)

Bill Venables, CSIRO Maths & Information Sciences

Francis Pantus, CSIRO Marine Research

Nick Ellis, CSIRO Marine Research

Ian McLeod, CSIRO Marine Research

Malcolm Austin, CSIRO Marine Research

Neil Gribble, QDPI Northern Fisheries Centre

Peter Doherty, AIMS, CRC Reef (Task Supervisor)

CSIRO Marine Research
233 Middle Street
CLEVELAND, Qld. 41
Australia

Australian Institute of
Marine Science
PMB 3, Townsville MC
TOWNSVILLE, Qld. 4810
Australia

Queensland Department of
Primary Industries
Northern Fisheries Centre
Tingara Street
CAIRNS, Qld. 4870
Australia

Contents:

Task Supervisor's commentary on Outcomes

The Great Barrier Reef World Heritage Area (GBRWHA) includes the largest multiple-use marine park on the planet (GBRMP). Under recent Commonwealth legislation (EPBC Act, 1999), major fisheries in the Park (prawn and line) must be assessed and demonstrated to be sustainable. For trawling, the issue is bycatch, despite current requirements to trawl only with bycatch excluding devices. For line fishing, the issue is stock size with major uncertainty about how fish use inter-reefal habitats. Independent of fishing, the managing agency (GBRMPA) is rezoning the marine park and, increasing the amount of no-take areas, through its Representative Areas Program. These initiatives are just three of the reasons why managers might wish to know more about seafloor habitats and biodiversity with the GBRMP.

In 2000, CRC Reef endorsed a proposal to sample the GBRMP seabed in support of sustainable industries and the management of biodiversity. Stakeholder consultation over this proposal raised several issues; primarily about the type of sampling gear to be used in different zones of the Park but also about the adequacy of existing data. Between 1994-99, Queensland Department of Primary Industries (QDPI) collected video records from 1300 stations looking for deep-water seagrasses. Some in the community felt that these records should provide an adequate basis for management of trawling and biodiversity within the GBRWHA. In response, the Board of CRC Reef requested a preliminary report into these and other sampling issues.

This report represents contributions from three research providers. QDPI staff provided access to their historical survey data, including videos and biological samples. CSIRO staff from two Divisions reanalysed some of this material and combined it with their own historical data into the effects of trawling. The latter included contemporaneous sampling with a full suite of possible techniques (trawl, dredge, video, acoustics), allowing direct tests of the power of alternative sampling strategies. AIMS staff compared the performance of baited videos with trawls.

Two key results have emerged from this analysis.

First, the comparison of gear types revealed huge differences in performance. For example, a small dredge collected around 1200 taxa (plants and invertebrates) of which more than 500 were also collected by prawn trawling on the same bottom; indicating the potential for impact through incidental catch. Simultaneous deployment of a towed video over the same ground captured just 5% of the biodiversity collected by the dredge, and just 7% of the biodiversity collected by the trawl; indicating the insensitivity of tests based on video. While videos performed better for fish, the low overlap between them and trawls shows that they are complementary rather than alternative sampling devices.

Second, the main reason for the poor performance of video tools is the poor resolution of taxonomic identity. For example, when species were resolved at the level of Class, two thirds of the spatial information was lost compared with patterns established from species level data. One clear reason for this rapid erosion of information content is that related species often have complementary distributions (e.g. an inshore species associated with mud and an offshore relative associated with carbonate sand). When resolved as separate species, the habitat preferences are clear and can be used to predict occurrence elsewhere. When pooled, however, the biophysical relationships are obscured and predictive power is lost.

Most of the information collected by the QDPI surveys was based upon presence and absence of high taxonomic units; mostly identified at Class level. A reduced and weighted set of biophysical variables was used to predict spatial pattern in assemblages across the whole GBRMP based on the QDPI data. Cross-validation, however, revealed that these predictions were highly unreliable. This result was not unexpected (see above) but it does show that the historical surveys do not contain enough information to manage biodiversity within the GBRWHA.

Further work on biophysical relationships from the CSIRO data (resolved at species level) showed that only half of all species have strong relationships useful for prediction based upon surrogates. While generalists may show weak and inconsistent relationships, other reasons for such failure including measuring the wrong proxy, and low or patchy abundance. This is compounded by problems of autocorrelation, where knowledge of the local state is only effective at predicting assemblages within relatively short distances, and uncertainty in many of the environmental descriptors. For about half of the biodiversity, there is no adequate substitute for direct sampling.

The report concludes with a cost-benefit analysis of alternative sampling strategies compared against an unconstrained one. While all parties are agreed that there will be no extraction from highly protected zones (yellow, green & pink), the cost-benefit analysis makes it clear that this would be a small penalty because of the size and distribution of these areas. Conversely, an inability to deploy dredge and/or trawl within General Use B (GUB – dark blue) would seriously undermine the risk assessments required by the fishing industry, because this zone represents a large proportion of the total shelf space.

In summary, the major lessons from this report are:

(a) it is highly desirable to identify species, which requires collecting,
(b) without collections, there can be no estimate of biomass,
(c) without biomass, there can be no quantitative risk assessment of trawl,
(d) without access to GUB, there can be no formal analysis of sustainability.

The analytical and authorship team is to be congratulated for its rigorous approach, which has provided clear answers to these important questions, and for the production of an excellent report.

Peter Doherty
November 2002

Summary:

The main aims of the proposed GBR Seabed Biodiversity Mapping Project are to develop inventory and mapping of seabed habitat and benthic fish & invertebrate assemblages, at scales of 10s-100s km, throughout the continental shelf of the WHA for management purposes and post-hoc accounting with respect to the representative areas program. The same data are also readily applicable to the important task of risk assessment for trawling within the Marine Park area, for Strategic Assessment and related environmental policy processes. Issues addressed would include effects of trawl on habitat, benthic assemblages and trawl bycatch.

The major clients & beneficiaries of the resulting information include the GBRMPA and GBR stakeholders and the QFS and Queensland fishing industry. Funding is proposed from the CRC-Reef, FRDC and the research agencies. The research providers include CSIRO, AIMS, QDPI & Qld Museum.

The milestones and deliverables of Phase 1 of the Project included: (1) collation and analysis of available data including that from the QDPI deep water seagrass surveys and the CSIRO/QDPI Effects of Trawling Study to assess the current state of knowledge and to design the most effective and representative sampling strategy for the Project. (2) analysis of sampling design options with respect to sampling devices and GBRMP Zones; clarify the information content of different sampling devices; and report on the sampling options.

Significant information on the physical environment was available from existing data. The Project collated 22 datasets of physical and biological data for the region. After quality checking and redundancy among some sources, 21 physical variables (+8 of variability) were identified and mapped as potentially useful for modelling & stratification. A 0.01 degree resolution (~1.1 km) grid was established for analyses and sampling design, and the physical variables were resampled to this grid, to provide a consistent set of full-coverage covariates for ~180,000 grid cells for the Project.

The Project sorted and identified a number of benthos samples from the QDPI Deepwater Seagrass Surveys (DWS). The QDPI DWS taxonomic Class-level Presence/Absence data was found to have the broadest coverage for analysis. This dataset was clustered into 28 Class P/A ‘assemblages’ and straightforward biophysical relationships were developed to attempt spatial prediction and mapping of these ‘assemblages’ for full coverage of the GBR Shelf. However the reliability of the mapping is low (~19%) due to poor biophysical relationships.

The species-biomass data available from the Effects of Trawling Study was analysed to assess the potential of species-biomass data for mapping and spatial prediction of seabed assemblages at spatial scales useful for management. Broad scale seabed biodiversity assemblages and communities were successfully classified & mapped, using a similar suite of pattern analysis techniques as applied to the DWS Survey data. Investigations of bio-physical relationships indicated that spatial prediction of assemblages has satisfactory reliability (~60%) and ~50-65% of species have predictable responses. The bio-physical modelling identified and ranked the importance of the range of collated physical variables for structuring assemblage patterns and thus their importance for stratification in sampling design.

The potential outputs and utility of Species Biomass data include: Inventories and maps of the distribution and abundance of seabed assemblages; Biodiversity attributes (eg. species richness, biomass, uniqueness) for assemblages; Estimates of inclusion of benthic assemblages & communities by GBR Zone; Maps of uncommon and/or vulnerable habitats and/or species

assemblages; Estimates of the large scale effects of trawling; and Quantitative risk indicators for benthos and fish species caught in bycatch.

Analyses of the Effects of Trawling dataset raised several issues to be considered in future sampling. Quantitative comparisons demonstrated that biodiversity information content is substantially eroded at coarser taxonomic resolution. Assemblage patterns at Class & Phylum level had little similarity to patterns at the species level. Presence/absence data was also found to have lower information content than biomass data at the same taxonomic level. Consequently, high taxonomic resolution & enumeration of biomass is necessary for optimum information content of seabed survey data.

Comparisons of the information content of different sampling devices deployed at the same sites showed that sampling devices differ greatly in their ability to detect species and the patterns of seabed assemblages inferred from them also differ greatly. Quantitative comparisons of patterns in seabed 'assemblages' from sled and trawl showed that patterns from these devices were only ~35% similar and the devices are complementary for obtaining a more complete quantification of assemblages. Detailed analysis of video detected only a fraction of the benthos species found by sampling at the same sites, and again, quantitative comparisons found that 'assemblage' patterns from seabed habitat video were only ~14% similar to detailed species assemblage patterns. The lower information content of video stems from the difficulty observing, identifying and quantifying benthos from video.

The level of taxonomic identification and the type of sampling device also have implications for the reliability of bio-physical relationships for spatial prediction and mapping. With coarser taxonomy and lower information content of video, the relationships between the physical environment and the biological assemblage patterns are progressively eroded. This is because different species within a family, class or phylum often live in different habitats, so identification at higher taxonomic levels obscures the biophysical responses. The lower information content of video may be regarded as an even coarser level of taxonomy and leads to high prediction error and poor reliability of biophysical mapping from video.

When quality species-abundance data are available, seabed assemblages can be mapped successfully with adequate reliability. However, not all species and/or species-groups ('communities') have reliable bio-physical relationships for prediction — for ~quarter of these, bio-physical models explained only 10-20% of the variation. For these, the only reliable method for mapping is well designed representative sampling of distribution and abundance.

The reliability of mapping and stratification is also dependent on the reliability of the physical covariates. While the covariates provided the broadest coverage available, they are largely based on previous sampling and their reliability is very dependent on where that sampling was done. There are substantial gaps in covariates that require direct sampling, and their reliability decreases with distance from the sampled location. Thus, the physical covariates are not reliable over the entire GBR and prediction and stratification is uncertain in such areas. Optimal sampling would ensure such uncertain areas are sampled.

A major consideration in determining the density of sampling in seabed surveys is the distance over which the seabed assemblage remains homogeneous, within any defined habitat type (spatial auto-correlation distance). While it is inefficient to place sample sites too close together, information on seabed patterns will be inadequate if sites are too far apart. Further, spatial prediction of assemblages cannot be reliably applied at great distances from sampled sites. The available data indicate that the spatial auto-correlation distance is relatively short (~5 km) generally, and even within habitat strata extends to only ~5-10 km (max 20 km). Thus, the optimal sampling density is ~5-20 km and the reliable prediction distance within strata is only ~5-10 km (max 20 km). Spatial prediction mapping that extrapolates beyond these distances will be highly unreliable and uncertain.

The Project compared the information content, for seabed fish, of data from baited remote underwater video stations (BRUVS) and from prawn trawls. This work showed that of all the fish species observed, 30% were observed by both devices (these were typically smaller mobile fish), 30% were observed only by BRUVS (typically larger mobile fish), and 40% were observed only in trawls (typically smaller more sedentary fish, 'bycatch'). Both techniques indicated very similar spatial patterns of seabed fish species assemblages. The fish assemblages identified from BRUVS were more precisely described and predicted. The trawl samples provided specimens for reliable identification, and the availability of these specimens assisted identification of fish in BRUVS. The trawl samples provided biomass per area by species that can be used for Risk Assessment of bycatch, whereas BRUVS provide relative abundance. BRUVS can be deployed over rough ground, whereas trawls cannot. The logistics of deploying BRUVS were more time-consuming, and there is some risk of loss. This assessment demonstrated that these devices complement each other, but cannot replace each other, for a comprehensive assessment of seabed fish biodiversity.

The strategy for designing the proposed future sampling was based on biologically informed stratification of the physical variables to achieve representative sampling of the environment space in the GBR, rather than the 2-dimensional space. This approach ensures that seabed assemblages of as many different habitats types as possible would be characterised. Biological information was included in the stratification by weighting the physical variables based on their relative importance in modelling bio-physical relationships — variables of greater biological importance had larger weighting and influence in the stratification. The stratification also considered the stated spatial resolution for management utility; the implications of the spatial auto-correlation distance; and the cost-benefit of logistics. In this approach, 180 primary strata with similar physical characteristics were defined, covering the GBR shelf. Each strata would be sampled at an average ~10 sites for benthos, and at a third of those for fish.

Five options for possible future sampling were assessed in relation to their capability of achieving the main aims of the project. The different options related to the availability of different zones of protection to the proposed extractive sampling devices. For each option, the availability of strata was accounted with respect to the GBR Zoning & Queensland State closures to trawling. The options assessed included: (1) no extractive sampling permitted anywhere in the GBRMP; (2) trawl & sled sampling not permitted within zones GU-B or highly protected areas (HPAs = MNP A&B, Buffers and Preservation) and trawl not permitted in State closures; (3) trawl & sled sampling not permitted within GU-B or HPAs; (4) trawl sampling not permitted within GUB or HPAs and sled not permitted within HPAs; (5) trawl and sled sampling not permitted within HPAs. The assessment showed that options from 5 down through 1 represented increasing compromise with respect to attainment of the aims of the Project and the utility and benefits of the outputs for management purposes. Option 1 represented a very severe compromise to the attainment Project aims and few of the proposed outputs could be delivered. Option 5 would allow almost all Project aims to be attained and almost all proposed outputs to be delivered; for this option the compromises primarily involved inability to directly characterise or measure the status of seabed assemblages in highly protected areas.