# 3. DISCUSSION

This project has successfully collated a substantial base of knowledge of the physical environment of the seabed and water column, and of the basic seabed habitat types of Torres Strait. Nevertheless, the coverage of each dataset was either incomplete in space and/or time, or in the case of modelled datasets uncertain due to gaps in underlying data, or in the case of remote sensed data ambiguous due to confounding sources of radiance. Thus, there are notable data gaps and key information is needed to provide the knowledge required to deliver the broad objectives of the CRC Torres Strait and to assist Regional Marine Planning and evaluation of management in the region.

## 3.1. STATE OF KNOWLEDGE

Specific details of available data and maps are provided in section 2; the main facts of knowledge are summarized here.

### 3.1.1. Oceanographic Data

Tides and currents are known to dominate the physical oceanography of Torres Strait. The friction of the complex bathymetry of the region severely limits the net flow through the region and causes tidal elevations to be out of phase across the main reef tracks and strong tidal currents particularly in channel areas. Knowledge of tides and currents in the Torres Strait comes largely from the output of models, which have progressed from highly simplified channel models through 2- and 3-dimensional models that show good agreement with the (spatially limited) observations of sea levels and currents.

A spatial and seasonal mapping of basic hydrographic conditions (temperature, salinity, oxygen and nutrients — CARS) is available for Torres Strait, though the spatial and temporal coverage of the source data is sparse and seasonally biased. Nevertheless, temperature peaks broadly over the summer monsoon period and during winter, a cold-water anomaly forms over the shallow parts of Torres Strait. Salinities fall under the influence of the monsoon rains, when a freshwater feature also occurs along the PNG coastline, then salinity gradually increases again after the monsoon. The trade-winds can occasionally introduce freshwater from the Fly River plume to the northeast. Strong tidal mixing within Torres Strait generally prevents the development of vertical stratification and dissolved oxygen levels in the well-mixed waters tend to be relatively high, though the data coverage is extremely sparse. Nutrients (nitrate, phosphate, and silicate) appear to increase during the monsoon and decrease during the trade wind season, consistent with riverine inputs, but the existing data coverage is insufficient. A single hydrographic station, monitored from 1977 to 1983 near Booby Island in southwestern Torres Strait, showed temperature and salinity follow a very regular annual cycle and provided localised insight into interannual patterns suggesting variability in annual monsoonal low-salinity anomalies and nitrate peaks, and higher levels of interannual variability in dissolved oxygen due to trade winds.

Suspension of sediments is enhanced by strong spring tide cycles and wind stress, particularly in shallow areas and where riverine input occurs, such as the PNG coastline, leading to localised turbidity maxima. Turbidity estimates have also been derived from SeaWiFS satellite data but can be confounded in shallow areas like Torres Strait. Very few direct measurements have been made.

The phytoplankton (chlorophyll) in Torres Strait is not known from any direct measurements and estimates based on satellite ocean colour are likely to be confounded by turbidity and shallow water. Nevertheless, there are indications that chlorophyll levels in Torres Strait are higher during the monsoon season and decrease towards winter — a pattern opposite to that in the Gulf of Carpentaria and Coral Sea. The factors controlling primary production in Torres Strait are not known adequately, but may be related to seasonal nutrient levels and light availability.

### 3.1.2. Physical seabed data

Torres Strait is a shallow area of continental shelf of complex topography with numerous reefs and islands. The eastern area includes deeper water but is more complex; the northwestern area is very shallow and limits navigation. The bathymetry of the main shipping channels is well known and perhaps as much as half of the region has been mapped at low resolution, but there is very little high resolution data. The available data has been collated from a variety of sources including the Hydrographic Office, Geoscience Australia and CSIRO Marine Research.

The seabed sediment composition of Torres Strait covers the full spectrum from fine terrestrial muds near riverine inputs to coarse biogenic carbonate sands and gravels among coral reefs further from land. Overlaid on that pattern is the influence of the strong tidal currents that scour the fine sediment from narrow channels, leaving coarse gravels and rocks, and deposit them in calmer areas. The currents also create and move sizeable dunes or bedforms. These patterns in sediments and substratum have been shown to influence patterns in biological assemblages. The sediment data available with broad coverage includes mud, sand, gravel, and rock fractions, grain size and sorting, and carbonate content. The data has been collated principally by OSI, University of Sydney and CSIRO Marine Research.

Acoustic remote sensed data was available from selected CSIRO Marine Research surveys with substantial coverage in central and east/southeast Torres Strait and has provided a useful surrogate for sediment where it had not yet been collected, and continuously along the vessel track. The acoustics data was also an indicative surrogate for basic epibenthic habitat.

Prawn trawl effort data, collated from the QDPI logbooks and summarized at a fairly coarse 0.1 degree resolution, showed that trawling was largely confined to a relatively narrow strip in central eastern Torres Strait and that extremely intense effort was confined to an area of about 200 km². From studies elsewhere, it is known that trawling activities are often even more aggregated at finer scales. Knowledge of spatial and temporal patterns of trawl effort is required for evaluations and management of the environmental sustainability of trawling.

### 3.1.3. Biological seabed data

Compared with most other areas of seabed within Australia, the Torres Strait is relatively well known. However, the biological survey data having good coverage of Torres Strait provide only a relatively coarse level of habitat information. This broad characterisation of the Torres Strait seabed is available for about two-thirds of the region, at a spatial resolution in the vicinity of about 10 km, and includes a 5-point ordinal scale for substratum type, a 4-point rank scale for megabenthos gardens, and presence and absence of algae and seagrass. Higher resolution knowledge is available for some of these seabed biotic components, but with much more limited spatial coverage. For example, seagrass percent cover; seagrass species cover or biomass; percent cover of some algal genera; megabenthos biomass; seabed fish species biomass; and abundance of a few specific species eg. lobster, pearl shell and some holothurians.

Seabed current stress appears to be very important in structuring patterns in the major biological habitats of the seabed, as has been known for some time (eg. Long *et al*. 1997). This study has confirmed its importance, as well as the importance of a range of other physical covariates, including: chlorophyll (from SeaWiFS), turbidity, oxygen, phosphate, salinity, silicate, nitrate, sediment grain size, and depth.

The sediments are known to be dynamic, having been scoured from inter-reef channels they can be deposited in large dunes that move and have been observed smothering sessile megabenthos or exposing bare rocky substratum. Seagrass diebacks are known to occur in north west Torres Strait coincident with changes in sediment dynamics, but the cause and effect is uncertain in relation to sediment.

Seabed fish species assemblages in vicinity of the trawl fishery in north east Torres Strait have been shown herein to differ between areas open and closed to trawling, most likely due to environmental differences rather that effects of trawl effort. From previous work (Harris *et al*. 1994), it is known that the trawl bycatch fish assemblage overlaps little with the fish assemblages on coral reefs in the same vicinity.

## 3.2. KNOWLEDGE GAPS

Specific details of data gaps are provided and mapped in section 2. The major deficiencies causing critical knowledge gaps are summarized here.

### 3.2.1. Oceanographic Data

There are few tidal and current monitoring stations in Torres Strait to provide data to validate models. Those available have been positioned in key navigation areas or to examine the Fly river plume results. The vast majority of Torres Strait is an observation gap with respect to these measurement stations, leading to model uncertainty and lack of knowledge of the broader the low frequency circulation, or dispersion and connectivity patterns. Gaps in bathymetry also affect the reliability of hydro-dynamic models.

The CARS mapping of basic hydrographic conditions is limited by the extreme spatial and temporal sparsity of the underlying hydrographic data in the region — ie. these parameters are more unknown than known — and there is a critical need to supplement these data to gain any knowledge of basic productivity processes in Torres Strait. Time series hydrographic data was available from only a single station and ceased ~20 years ago. Other key locations and contemporary data are gaps limiting knowledge of interannual variability and environmental change in the region.

Suspended sediments have been measured in only a very few locations and knowledge of their spring-neap and seasonal cycles is inadequate, as is knowledge of the role of suspended sediments in the biogeochemical cycles of Torres Strait. Knowledge of phyto-plankton biomass is limited to confounded estimates of chlorophyll inferred from satellite ocean colour and there is no knowledge of primary production and plankton community structure in Torres Strait.

### 3.2.2. Physical seabed data

Apart from the major shipping channels and low resolution mapping from research voyages, the bathymetry of most of Torres Strait has not be surveyed and is poorly known. Thus, for the majority of Torres Strait, bathymetry is potentially unreliable for circulation modelling and bio-physical mapping. Knowledge gap areas of particular concern include: NE Torres Strait, which is very complex with large reef and shoal formations, deep areas and channels; and NW Torres Strait, which is very shallow with large sand ridges and shoals, mostly uncharted and difficult to navigate. High resolution bathymetry is extremely limited in spatial coverage. Thus, there is very limited knowledge of fine scale topographic complexity.

Extensive gaps in surface sediment grain size attributes include most of east/southeastern and northwestern Torres Strait, which are largely unsampled. Given the importance of sediment for biota, the use of physical surrogates for assemblage prediction in these areas is questionable. Nevertheless, the remainder of Torres Strait has been only patchily and inadequately sampled, except for the main shipping channels and an area west of the southern warrior reefs. The gaps for surface sediment carbonate data are similarly distributed but even more extensive. There is very little knowledge of the spatial distribution of surface sediment organic content, and very restricted sampling of sediment depth profiles or sediment cores.

The trawl logbook effort data coverage is relatively complete, however the resolution is coarse compared with actual trawling activities. Thus, there is a gap in knowledge of fine scale trawl effort patterns needed to assess and manage the environmental sustainability of trawling.

The overall gaps in the physical seabed data, weighted by relative importance in the stratification are shown in Figure 3.2-1. Across all the physical seabed covariates, the sampling has been inadequate (significantly greater than the spatial auto-correlation distance for these attributes) for bio-physical mapping over the majority of Torres Strait. Since the current stress model and the SeaWiFS data have relatively high resolution, these gaps are largely due to the sediment, bathymetry, and CARS data respectively, which lead to uncertainty in the existing bio-physical maps. For reliable mapping of biological assemblages from bio-physical modelling, the required spatial resolution of the physical data is finer than that needed for the assemblages themselves (at ~0.1°) — that is, the physical data need to be available at a resolution finer than ~0.05° (see section 2.6.1) to reduce uncertainty in maps that attempt to predict biological assemblages where they have not been sampled.

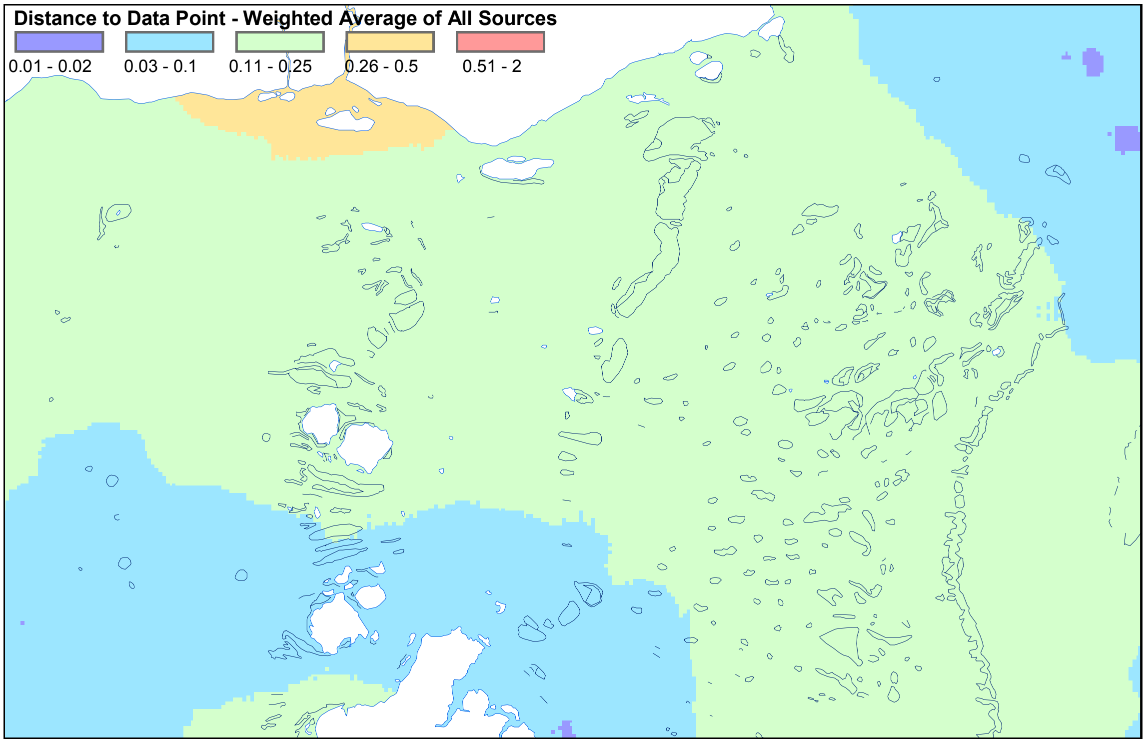


**Figure 3.2-1** Map of overall gaps averaged across all seabed physical covariates, weighted by co-variate importance (section 2.8.1.2). That is, the distance-to-data of more the important co-variates has greater influence in the calculation of the average for each point.

### 3.2.3. Biological seabed data

The most basic of seabed habitat type information is unknown for north eastern Torres Strait and for extensive areas of western Torres Strait. While qualitatively helpful, this level of information has been shown to be inadequate for quantitative management applications where species biomass data are required. However, seabed species assemblages have not been sampled in Torres Strait, except for the trawl bycatch fish component in part of the prawn trawl grounds. Thus, other components of seabed assemblages are unknown, even in the sampled trawl grounds, and there are no species assemblage data available for the remainder of Torres Strait.

In addition to the lack of a static spatial description for seabed assemblages, there is very little knowledge of population or assemblage dynamics or of ecosystem processes. The dynamics of the lobster and prawn populations have been sampled for fisheries assessment purposes, and the annual lobster surveys over 15 years have recorded some changes in basic habitat type in a limited area. A few surveys of seagrass, mostly in central north-west Torres Strait, at irregular time intervals, have documented seagrass–dieback. Primary productivity, whether benthic or planktonic, has not been studied in Torres Strait nor have other ecosystem processes such as secondary productivity and higher trophic relationships, other inter-species inter-actions, or coupling between the benthic and pelagic ecosystems.

## 3.3. KEY INFORMATION NEEDS

The key information needed to advance critical knowledge of the Torres Strait marine environment, for sustainable management of the region, largely corresponds to the critical data gaps identified.

### 3.3.1. Oceanographic Data

Additional tidal and current monitoring stations need to be established at key locations distributed broadly across Torres Strait to provide data to validate circulation models and provide knowledge of the broader low frequency circulation, dispersion and connectivity patterns. Bathymetric data is also needed from gap areas because of its important to circulation. Hydrographic moorings are also needed at similar key locations to collect temperature, salinity, oxygen, nutrient and chlorophyll data to provide knowledge of interannual variability and environmental change in the region and to develop an understanding of productivity processes in Torres Strait. Measurements of suspended sediments are also required at critical locations across spring-neap tidal and seasonal cycles.

Complete studies are required of biogeochemical cycles, phyto-plankton and zoo-plankton assemblages and their primary and secondary productivity, again in a range of key sub-environments distributed broadly across Torres Strait.

The work program for the Torres Strait CRC will address a limited number of these data issues, and at varying levels of detail. Field measurements to be made by the "Bio-Physical" and "Seabed Mapping" Tasks and further hydrodynamic modelling will provide more detailed understanding of circulation and dispersion patterns, as well as some additional hydrographic data to improve CARS within the region. There will also be a substantial increase in the suspended sediment dataset, which will be complimented by sediment transport modelling. There may be opportunities to collect in situ chlorophyll data to assist with interpretation of ocean colour. However, the existing CRC-TS program does not include plankton sampling or studies of the biogeochemical cycles needed to understand the processes controlling primary and secondary production in Torres Strait.

### 3.3.2. Physical seabed data

Consistent coverage of bathymetric data over Torres Strait, at resolution less than the characteristic spatial auto-correlation distance (<<10 km), is required for circulation modelling and bio-physical mapping. Bathymetric data of sufficient resolution for navigation purposes is highly desirable, preferably acquired by airborne laser (LADS) and/or swathe mapping systems. High resolution bathymetric data is particularly important for areas like the Torres Strait where the topography is highly complex with many areas of reef intersected by narrow channels, and shallow shoaling areas.

Adequate sampling of surficial sediments, for grain size and composition attributes, is required in the extensive unsampled areas of Torres Strait, to provide a basis for understanding the important sediment processes, biogeochemical cycles and for use as surrogates for biotic assemblage prediction. Again the required scale is less than the characteristic spatial auto-correlation distance (<10 km). Measurement of sediment organic content, depth profiles and sediment cores would also contribute greatly to this knowledge.

Fine scale trawl effort data needs to be acquired from Vessel Monitoring Systems installed on Torres Strait trawlers and would provide the effort data at a resolution compatible with that needed to assess and manage the environmental sustainability of trawling.

Again, the work program for the Torres Strait CRC will address several of these data issues at varying resolution. Field sampling and measurements of physical attributes to be made by the "Seabed Mapping" Task include soundings of bathymetry along the vessel track, site samples of surface sediment for grain size and composition, and site measurements of hydrographic data (profiles of temperature, salinity, oxygen, turbidity and fluorescence) to improve CARS within the region. The resolution of the site-based sampling will be about 10-12 km — close to the upper limit of the spatial auto-correlation distance (<10 km). However, due to resource constraints, the coverage of Torres Strait at this scale will be incomplete, and gaps totalling about one third of the region will remain. In addition, the "Bio-Physical" Task will collect high-resolution swathe bathymetry and sediment data at number of small scale study sites.

### 3.3.3. Biological seabed data

Fundamental biological information is needed as a basis for regional marine planning in Torres Strait to contribute to the development of conservation, management and monitoring requirements. Information on the seabed habitat type is a basic need for unknown areas in north-eastern and western Torres Strait. However, it has been shown that knowledge of a broad spectrum of biota, at the species level, within seabed assemblages is required to properly characterize assemblage patterns, to develop bio-physical models and for quantitative management applications (Pitcher *et al*. 2002). For these purposes, seabed species assemblages need to be sampled in Torres Strait with multiple sampling devices, accurately identified with detailed taxonomic skill, and quantified and mapped. Careful identification of species is required because Torres Strait is significant biogeographically due to the periodic separation of east & west faunas due to changes in sea level. This biogeographic information is also essential for regional marine planning.

Successful management of multiple uses of the Torres Strait marine ecosystems also needs to take into account possible interactions between sectors and complex effects on the ecosystem that cannot be accommodated by single-sector management approaches. This requires dynamic modeling of the important components of the ecosystem, the human uses and the management (Management Strategy Evaluation — MSE), which has data-needs beyond static maps of seabed biological assemblages. The level and detail of data input required for such approaches varies substantially, but in general includes knowledge of population and assemblage dynamics and of ecosystem processes such as primary productivity (both benthic: seagrass, macro/micro-algae, and planktonic: phyto-plankton), secondary productivity (herbivory: includes dugong, turtle, fishes) and higher level trophic relationships (predation), other inter-species inter-actions (eg. competition), as well as coupling between the benthic and pelagic ecosystems. To be successful, ecosystem-based management requires this kind of ecosystem-level knowledge.

As with oceanographic and physical seabed information needs, the work program for the Torres Strait CRC will address several of these data issues to varying extents. The Torres Strait Seabed Mapping Project will provide data on seabed habitat and megabenthos from video, specimens of fauna and flora from epibenthic sled sampling and specimens of fishes, crustaceans and other bycatch species from trawl sampling. These specimens will be identified and quantified and their bio-physical relationships analysed to produce maps of assemblage composition and abundance, and develop attributes to assist planning (eg. biomass, species richness, rarity, uniqueness, condition, vulnerability). This information will be provided to another CRC TS project that will develop an MSE approach to evaluate management strategies for trawling that reduce environmental impacts. However, as noted above, the resolution of the site-based sampling will be close to the upper limit of the spatial auto-correlation distance and, due to resource constraints, the coverage of Torres Strait at this scale will not be complete. Further, the existing CRC TS program does not include studies of the biological assemblage dynamics, trophic relationships or other ecosystem processes needed to develop ecosystem-based management. The CRC TS program will, nevertheless, make considerable progress toward ecosystem-based management in the Torres Strait.

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# 5. PROJECT STAFF

| Name | % time |
|---|---|
| Roland Pitcher, Project leader: co-ordination, analyses, design, reporting | 25% |
| Scott Condie, Biological Oceanographer: water column characterisation, analyses, reporting | 10% |
| Jeff Dunn, Oceanographic data analyst: water column database & mapping | 15% |
| Ian McLeod, Spatial modeller: physical database, modelling & gridding physical data | 35% |
| Mick Haywood, Seabed biologist, characterisation analyses, reporting | 10% |
| Scott Gordon, Acoustics engineer: analysis & mapping of existing acoustics data | 20% |
| Tim Skewes, Seabed biologist: integration of disparate seabed habitat & biological data | 10% |
| Darren Dennis, Seabed biologist: integration of disparate seabed habitat & biological data | 5% |
| Malcolm Austin, Database programmer: management & integration of habitat/biological data | 20% |
| Bill Venables, Spatial statisitician: biophysical characterisation & modelling | 5% |
| Nick Ellis, Mathematical modeller: biophysical modelling | 20% |
| Tom Taranto, GIS modeller: mapping habitat & biological data | 5% |
| Liz Cotterell, data entry, assist in the integration of disparate data | 10% |