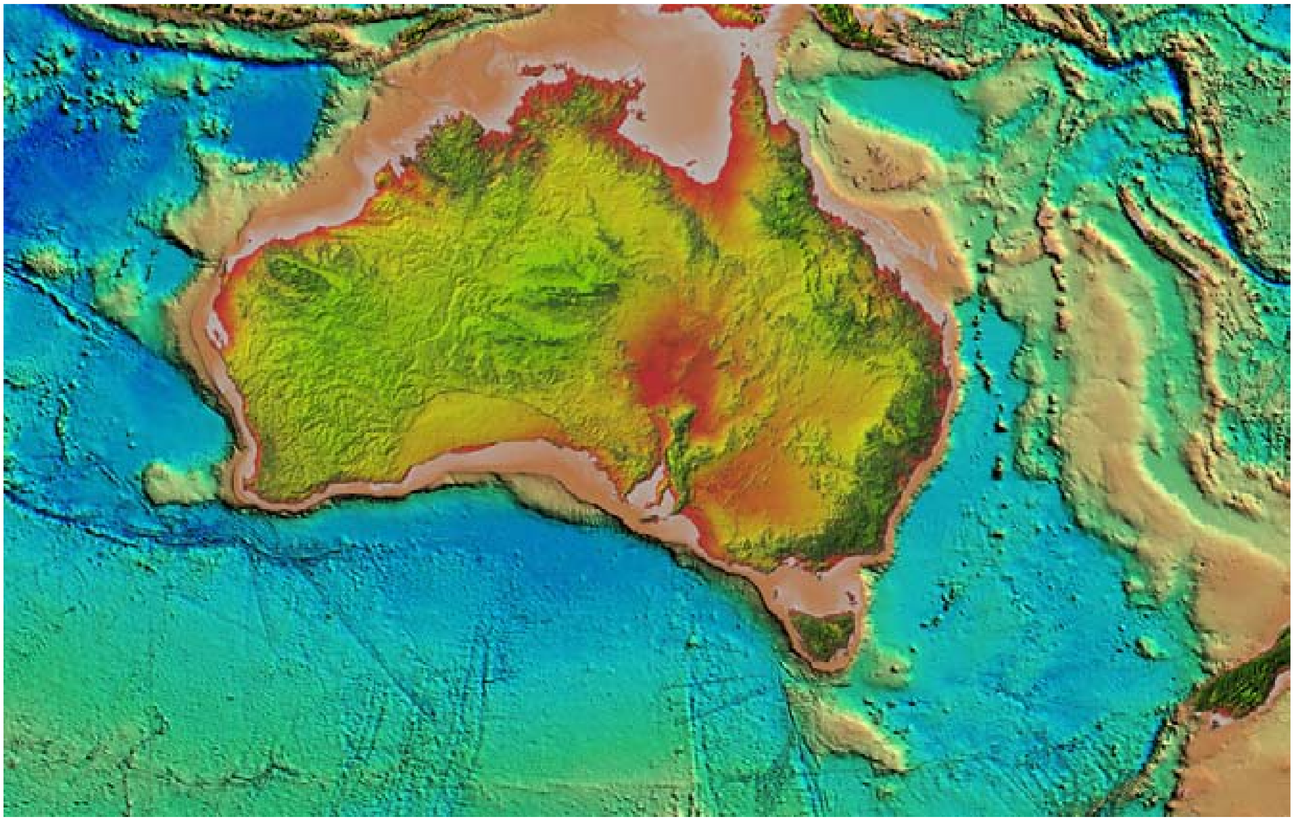
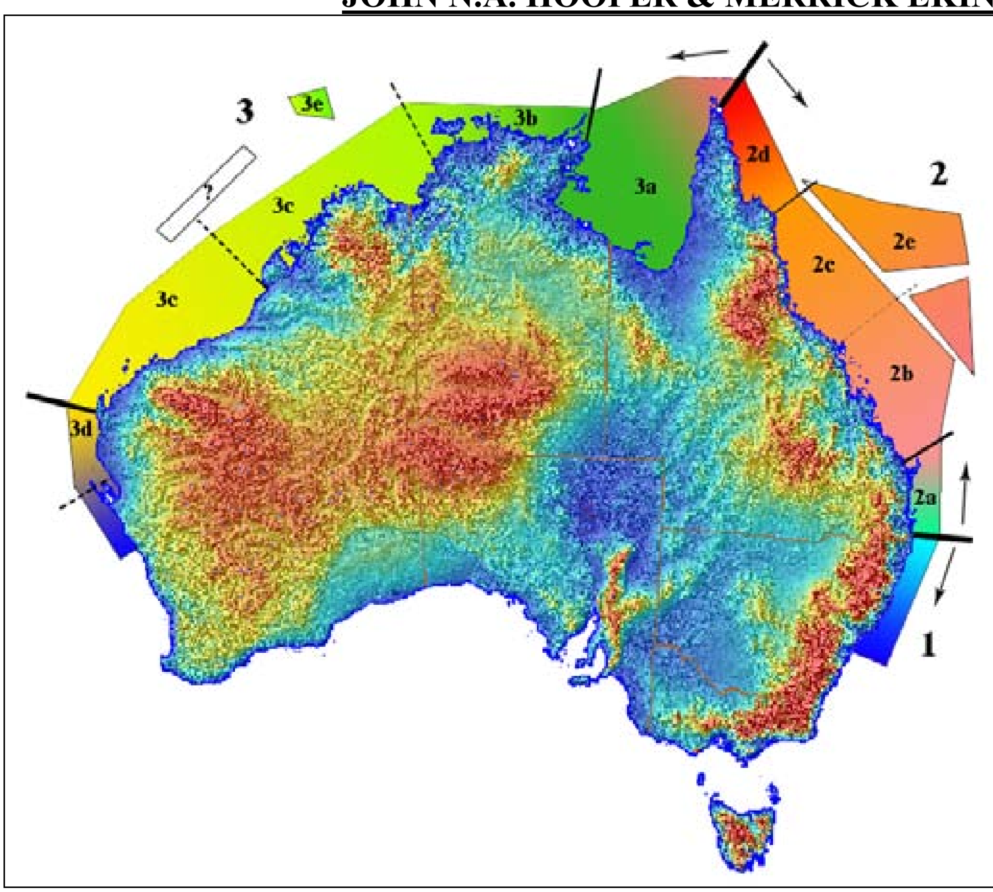


COLLATION AND VALIDATION OF MUSEUM COLLECTION DATABASES RELATED TO THE DISTRIBUTION OF MARINE SPONGES IN NORTHERN AUSTRALIA.

JOHN N.A. HOOPER & MERRICK EKINS



Collation and validation of museum collection databases related to the distribution of marine sponges in Northern Australia (Contract National Oceans Office C2004/020)

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CONTENTS

SUMMARY

Australian museums and other marine collections agencies now hold extensive collections of sponges (Phylum Porifera) and associated digital data that have demonstrated utility towards recognising and defining areas of high biodiversity value ('hotspots'). Amalgamation of the Queensland Museum sponge database (c.30,000 records) with recent collections (of a subset of 721 'surrogate' species) from the tropical fauna by the Australian Institute of Marine Science, Museums and Art Galleries of the Northern Territory and Western Australian Museum has produced a significant database of c.3,800 'species' (OTUs) from c.4,000 localities, representing 425 genera, 120 families, 26 orders and 3 classes of Porifera, with 2,248 species living in tropical waters and analysed in this study. This dataset is to be made available online through a nationally distributed database OZCAM (www.ozcam.gov.au). Point specimen data of the 'surrogate' species are accompanied by modelled geographic and depth distributions using the CSIRO CAAB system, together with digital descriptions of species to ensure compliance with taxonomic identifications across all agencies, with the intention that all 3,800 or so currently known (collected) species will eventually have similar digital information available on-line, irrespective of whether or not they have yet been formally described in the scientific literature (a painfully slow and exacting, but ultimately essential process). This amalgamated tropical sponge dataset was analysed descriptively using GIS, and numerically using statistical tools, to identify, test and define major changes (β-diversity) in species richness, species composition and community structure of marine sponges across the Australian tropics. It is anticipated that these data will eventually contribute to an integrative project for bioregionalisation of the tropical fauna based on numerous biotic and abiotic datasets.

Descriptive GIS analysis of sponge specimen point data, amalgamated into logical taxonomic groups (species-groups, genera, families), produced spatial maps of taxonomic distributions across the tropics from central eastern to central western coasts. These maps enabled visual interpretation of species' ranges and prevalence within the tropical fauna, and also provided descriptive data to help define localities and bioregions. Numerous lists of species (unique to particular IMCRA demersal bioregions) are provided as a contribution to characterising these bioregions using biotic data.

Numerical data were analysed at two spatial scales. (1) Localities (γ-scale diversity, or within-region diversity). Specimen point data were amalgamated into 34 localities across tropical Australia, in a transect from Sydney on the east coast to the Houtman Abrolhos on the west coast, based on similarity analyses (cluster, MDS) analyses, and each of these localities was

examined for taxonomic richness, diversity, similarity in species composition and community structure. Of 2248 species in 34 localities, only one species (*Clathria (Thalysias) vulpina*) was found in 22 localities and 19 in 13-19 localities (0.01% of species), with the remaining 2228 species found in 12 or less localities: 138 species (6%) occurred in 6-12 localities, 713 (32%) in 2-5 localities, and 1377 species (61%) were rare, found in only a single locality. Species rarefaction curve approached but did not reach the asymptote, indicating incomplete sampling of some localities. Six peaks in species richness (biodiversity 'hotspots') were recorded across the tropical-subtropical transect: (1) SE Queensland – N New South Wales biogeographic transition zone (peak in the Moreton Bay region); (2) S GBR (peak at Capricorn-Bunker Group); (3) Central GBR (peak in the Townsville region mid-lagoon reefs); (4) N GBR (peak in the Lizard Island region); (5) W margin of the Northern Province (peak in the Darwin to Cobourg Peninsula regions); and (6) NW Shelf (peak in the Dampier to Port Hedland region). Several different types data analyses (species richness, composition, taxonomic distinctness) support the existence of these 'biodiversity hotspots' as biological phenomena rather than sampling artifacts. Nevertheless, data were deficient in some respects, with the number of unique species in each locality partially related to the total species richness, but not necessarily correlated with collection effort, although species accumulation curves were skewed by considerable heterogeneity in species richness and collection effort between localities, and by some localities having abnormally high richness but without significantly correspondingly high uniqueness or collection effort. Similarity analysis (cluster, MDS) showed a number of trends in β–diversity across the tropical Australian transect, some reflecting major (historical) biogeographic patterns and other possibly more ecological or present-day environmental influences. Three major sponge provinces were indicated, with smaller transitions occurring within these: (1) Temperate-subtropical east coast fauna with a south-north gradient extending from temperate to tropical influence and hard boundary in the vicinity of the Tweed River (historical boundary between Solanderian and Peronian Provinces). (2) Tropical east coast fauna, containing (2a) a southern component, with moderately hard boundary somewhere north of Hervey Bay-Fraser Island; (2b) a central component, with soft boundary somewhere between Mackay and Townsville; (2c) a northern component, with one or more minor transitions in the Far Northern GBR leading to (2d) a major transition on the eastern edge (GBR side) of Cape York (historical boundary between Damperian and Solanderian Provinces); and (2e) the Coral Sea Territories on the Queensland Plateau with affinities to the western Pacific islands faunas but also containing many elements of the north-central and southern GBR faunas. (3) Tropical northern and western fauna, with several transitions that are not completely resolved by our data: (3a) the Gulf of Carpentaria, differing from either Torres Strait and the Wessel Islands (probably an ecological rather than biogeographic pattern); (3b) a moderately hard boundary at the Wessel Islands, differing moderately from Cobourg Peninsula and Darwin faunas (and probably representing a major species turnover point rather than a 'biodiversity hotspot' from previous analyses); (3c) one or more probable transitions west of the Darwin region to the North West Cape region, but these are not well indicated from our data and appear to be less dramatic than on the east coast; and (3d) a significant boundary in the vicinity of Northwest Cape, with the Shark Bay and Houtman Abrolhos faunas markedly different from the northwestern coastal and shelf faunas, but at this time it is uncertain whether this is a gradual (soft) or abrupt (hard) transition given the relative paucity of sponge data from this region. Hypothesis testing showed that latitudinal gradients in ß-diversity were not strong, moving in a transect from temperate to tropical faunas, irrespective of whether faunas were on the east or west coasts, although high latitude temperate faunas differed markedly from low latitude tropical faunas. By comparison, longitudinal gradients in ß-diversity were markedly stronger, underlining the significant faunal changes across a tropical transect from east to west coasts. Species- and genus-level taxonomic distinctness analyses produced similar trends in community structure, whereas family-level taxonomic analysis was far less informative and is a poor surrogate for species-level biodiversity studies. Several localities were significantly undersampled and are recommended as priority areas for future studies: Southern Sahul Shelf, Joseph Bonaparte Gulf and Bonaparte Archipelago.

(2) Bioregions (ε-scale diversity, or provincial diversity). Sites were amalgamated into nine larger-scale tropical/ subtropical provinces defined *a priori* by the IMCRA demersal bioregions (with the Northern Province (NP) subdivided into eastern (E.NP) and western (W.NP) components based on knowledge of changes in community structure of sponges across this province), to provide material to assist with the characterisation of the IMCRA bioregionalisation process. Provinces included in analyses extended from the Central Eastern Biotome (CEB) in northern New South Wales to the Central Western Province (CWP) in southwest Western Australia. Only one species (*Clathria (Thalysias) vulpina*) occurs in all nine bioregions, two in eight (*Echinodictyum mesenterinum*, *Spheciospongia papillosa*), 16 in seven, 18 in six, 35 in five, 63 in four, 188 in three, 403 in two, with most species (1516 or 68%) rare and found in only a single bioregion. In general, the three east coast bioregions contain substantially higher species richness and greater proportions of unique species than do the six northern and western bioregions, and species composition is also more similar between them than with north or west coast bioregions, with about 10% of species widely distributed

throughout the tropical east coast, but only 1-4% of these also found on north and west coast bioregions. Cape York is a significant species turnover point, with only 3.5% similarity between the North Eastern Biotone (NEB) and E.NP. The two northern bioregions (E.NP, W.NP) were more similar in species composition to the four west coast bioregions (CWP, CWB, NWP, NWB) than to those on the east coast. Hypothesis tests showed that there were no significant changes in β-diversity that could be attributed solely (or predominantly) to latitudinal gradients, but there was a significant change across the longitudinal gradient that reflects the faunistic changes from east to west coasts. Two bioregions on the south west coast (CWP, CWB) differ to a greater or lesser extent from the tropical fauna community structure in general (at species-, genus- and family-level taxonomic analyses), moreso than other bioregions, but these results are treated with caution as both these bioregions were undersampled, having relatively lower species richness and species diversity, than most others.

Comparisons between smaller-scale localities and larger-scale (IMCRA demersal) bioregions produced patterns of species richness and community structure that were not fully congruent, suggesting that sponge data do not fully conform to the current IMCRA demersal bioregional model, although there is no proposal to emend the existing bioregional boundaries based on sponge data until (unless) similar patterns are discovered in analyses of other benthic marine phyla, with a diversity of recruitment and dispersal mechanisms (oviparous vs. viviparous, demersal vs. pelagic larvae, etc.). Both smaller- and larger-scale datasets also show that localities/ bioregions are relatively heterogeneous in terms of both species diversity and community structure, and are at best working hypotheses that incorporate some biogeographic, physical and other data into a model useful for planning and management.

1. INTRODUCTION

1.1. General Introduction

For many marine phyla we are still uncertain of the magnitude of their diversity (Kohn, 1997), let alone their dynamics and interdependencies, their interactions and responses to environmental factors, their historical and modern day biogeographic distributions, special areas of richness (biodiversity 'hotspots') and endemism, or even the appropriate spatial scales needed to study them in order to develop appropriate marine conservation and management strategies. For many years sponges (Phylum Porifera) have been firmly included in this category (Hooper & Wiedenmayer, 1994), possibly based on their perceived high morphological plasticity (i.e. difficulty in assigning individuals to a species taxon), their paucity of useful or informative morphometric characters and consequent unstable higher systematics, and the inadequate pool of expertise needed to resolve these shortcomings (see various chapters in Hooper & Van Soest, 2002). Consequently, sponges have been usually omitted from marine biodiversity analyses and biogeographic models even though they are frequently dominant components of many benthic communities, from ephemeral (quasi-terrestrial) ones to the more stable marine abyssal zones. The renewed interest in the phylum and the accelerated discovery of species over the past few decades, largely driven by their huge potential as sources of therapeutic drugs (e.g., Munro *et al.* 1999), has had the consequence that there are now some large and significantly well sorted collections of marine sponges, and a number of competent research groups residing within museums and other marine research agencies in Australia and New Zealand. Prior to 1981 there had been no Australian-based sponge researchers since the early 1900s whereas there are now four 'independent' groups of taxonomic researchers working primarily on the tropical and subtropical Australian faunas. This substantially enlarged taxonomic capability and their associated collection efforts now enable us to productively analyse and interpret sponges as potential biodiversity models for Australian marine bioregionalisation.

This current project is one of a series of projects that comprise Phase 2 of the Invertebrate Datasets project under the National Bioregionalisation program, National Oceans Office. This project is focused on collation, validation, analysis and description of information on sponges from Northern Australia, which were identified in Phase 1 as a priority group for National Bioregionalisation. Outputs from this project will feed into the Integration projects for Bioregionalisation which will define and describe bioregions for the Australian Marine Jurisdiction (National Oceans Office Contract, 2004 (contract number C2004/020)).

The aims of this project are to:

- Identify sources of useful sponge distribution datasets held by Australian research groups, develop an achievable data management strategy and appropriate software tools within resources allocated to the project to collate, store and maintain data, and validate data associated with the sponge collections held by the Queensland Museum (QM), including: conversion of the existing (DOS-based) relational database to a GIS capable platform; transforming global position coodinates into decimal degrees; checking for obvious errors in coordinates using GIS analysis of all data points; updating the higher taxonomy of the whole database in line with a recent revision of the phylum; verifying the identifications of some key taxa used in the proposed bioregionalisation analyses; digitising 'mudmaps' of key taxa to allow (verifiable) input of data points by other agencies (Australian Institute of Marine Science (AIMS), Northern Territory Museum (MAGNT) and Western Australian Museum (WAM)) for key taxa ensuring that the data structure complies with Darwin Core standards; collate these amalgamated datasets into a single system; applying a confidence scaling system for all specimen point data for certain key fields; prioritize and select subsets of the whole database to focus on the tropical Australian faunas, with some special emphasis on the Northern Planning Area (Gulf of Carpentaria region), and within these subsets identify and select key taxa as potential representatives ('surrogates') of the entire fauna based on several criteria.
- Produce geographic distribution maps from the sponge database records using logical groups of taxa (grouping by taxonomic similarity, such as species-group, genus and family units); produce modelled distributions of geographic and depth distributions for key ('surrogate') taxa using the CSIRO CAAB system (www.marine.csiro.au/caab); and incorporate ABIF sponge data (pertaining to the published Australian sponge literature) into the distribution maps (www.deh.gov.au/biodiversity/abrs/online-resources/abif/fauna/afd/PORIFERA/) if possible within the time frame of the project.
- Disseminate sponge point data via the web (www.ozcam.gov.au), together with associated ANZLIC Metadata, mudmaps and CAAB distributions, to form the basis of a national marine sponge dataset.
- Review and outline existing knowledge of sponge distributions in the Australian marine territories, particularly the tropical faunas, and apply descriptive (GIS) and numerical analyses to the data in order to interpret sponge distributions in tropical Australia that will contribute to the Integration projects for Bioregionalisation.

The outputs from this project are to provide:

- Validated datasets for tropical Australian sponges containing (among other data) information on geographic distribution, depth distribution, reliability of information (OZCAM database).
- Summarised geographic and depth distribution data for selected ('surrogate') sponge species in a useful format for national and regional bioregionalisation data layer integration projects (OZCAM database and this report).
- Construction of a national capacity for data integration through a distributed national sponge database (OZCAM database)
- Analysis of distributional data providing a better understanding of the distribution of sponges in the marine environment (this report).
- Development of data and information on the seafloor, including expertise, to describe and inform decisions on bioregions (this report, OZCAM database, consortium of sponge taxonomists in Australia (QM, AIMS, MAGNT & WAM)).
- Improved information on the structure and function of marine ecosystems, leading to the development of more effective plans for marine protection and sustainable development (use of the sponge datasets in an integrated GIS Bioregionalisation analysis by Geosciences Australia (GA) in the construction of a Fundamental Marine Dataset); and
- Improved access to data on the nature of marine ecosystems by enhanced population of the marine invertebrates database which is a Fundamental Marine Dataset (OZCAM and GA databases).

These outputs will contribute towards informed decision making relating to the management of bioregions for Australia's Marine Jurisdiction through the provision of expert advice on the distribution of sponges, and also increase our knowledge of sustainable management of oceans through expert advice on the ecological significance of sponges for bioregionalisation.

1.2. Definitions of Australia's marine bioregions

Australia's marine demersal bioregions are defined by the Interim Marine and Coastal Regionalisation of Australia (IMCRA) version 3.3, the current national bioregional planning framework endorsed by ANZECC in 1998 (**Fig. 1**). These bioregions incorporate some of the concepts of, but should not be confused with, Australia's marine biogeographic provinces as they were first defined (**Fig. 2**), with only two tropical biogeographic provinces, or the now more widely accepted model where transition or overlap zones are considered to be as pivotal as the 'core' biogeographic provinces themselves (**Fig. 3**). The analyses conducted in this present project concern bioregionalisation moreso than biogeography. For sponges several attempts have been made at marine biogeographic reconstruction, with varying degrees of success, whereas this is the first attempt to undertake bioregional analysis.

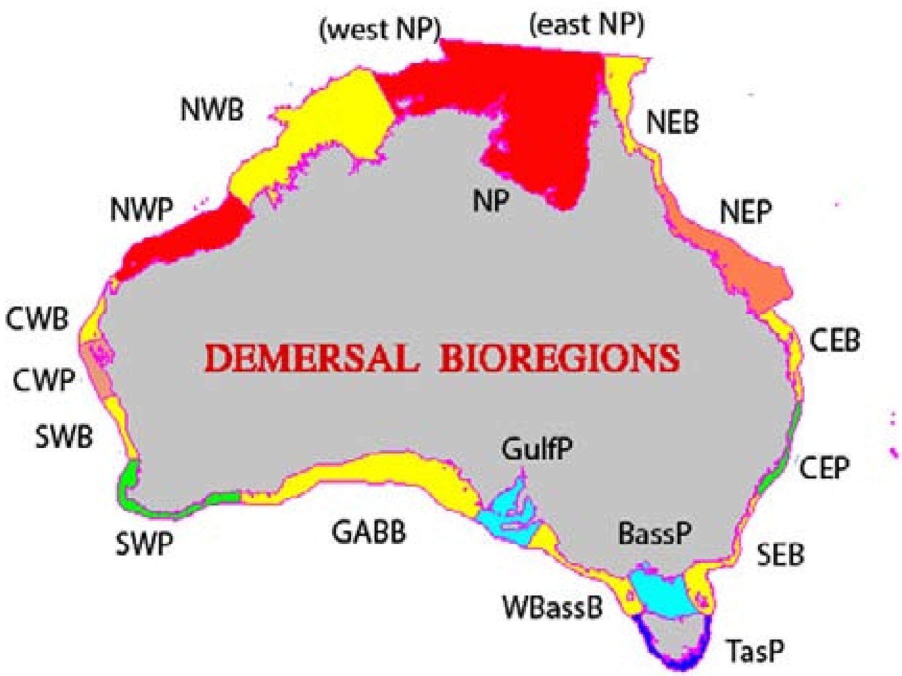

FIG. 1. IMCRA Marine and Coastal Regionalisation for Australia – Demersal Provinces. Provincial codes used in the text are as follows:
NP - Northern Province. **NEB** - North Eastern Biotone. **NEP** - North Eastern Province. **CEB** - Central Eastern Biotone. **CEP** - Central Eastern Province. **SEB** - South Eastern Biotone. **BassP** - Bassian Province. **TasP** - Tasmanian Province. **WBassB** - Western Bassian Biotone. **GulfP** - Gulf Province. **GABB** - Great Australian Bight Biotone. **SWP** - South Western Province. **SWB** - South Western Biotone. **CWP** - Central Western Province. **CWB** - Central Western Biotone. **NWP**- North Western Province. **NWB** - North Western Biotone. (Image kindly supplied by Geosciences Australia).

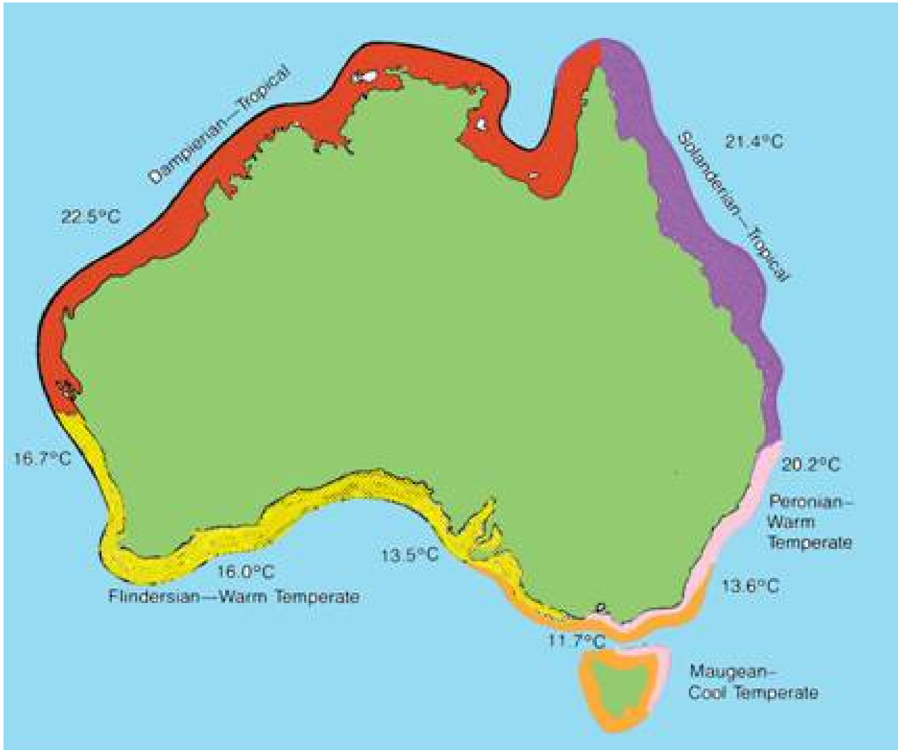

FIG. 2. Australian marine biogeographic zones (from Wilson & Allen, 1987)

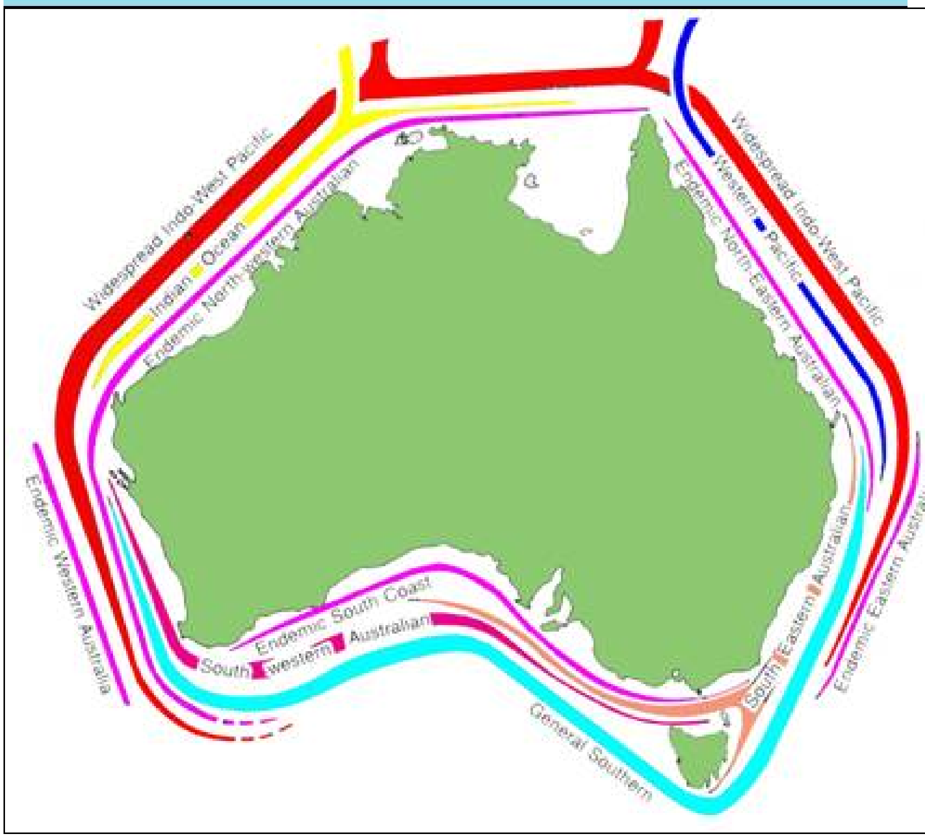

FIG. 3. More recent interpretations of Australian marine biogeography (from Wilson & Allen, 1987)

Place names mentioned in the text are depicted in **Fig. 4**.

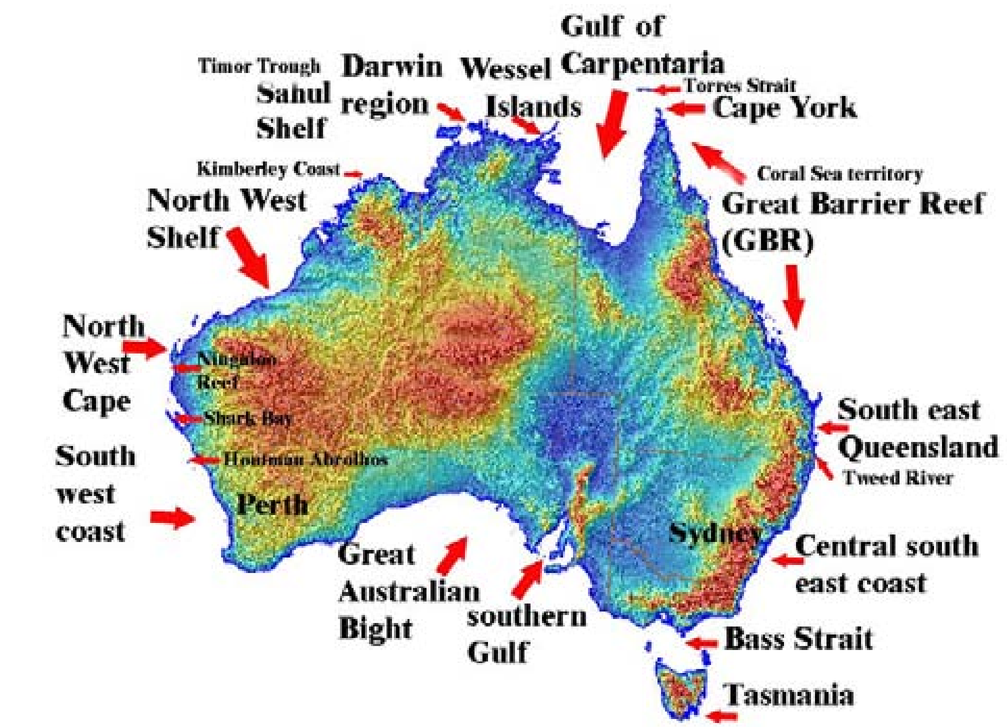

FIG. 4. Names for Australian coastal regions mentioned in the text

2. MATERIALS & METHODS

2.1. Specimen point-data conversion. The Queensland Museum and Northern Territory Museum sponge datasets were converted from 'R:Base' relational database format (1991-present) and 'Notebook' flat database format (1982-1991) to Biolink, a GIS compatible relational specimen database developed by CSIRO. This was achieved by transferring the data via ASCII delimited text files into excel where the data was rectified into distinct fields and formats (see below). For instance latitude and longitude coordinates were transformed from degrees, minutes and seconds or degrees and decimal minutes into decimal degrees. The Queensland Museum sponge datasets comprised 30,728 records pertaining to about 3,769 species, and was combined with the pre-1991 Northern Territory Museum database with an additional 4083 records, and the NCI collections within the Australian Institute of Marine Science database adding a further 4061 records. The excel spreadsheet was then imported into the relational database Biolink. The database was also transferred to Microsoft Access for other data transfer capabilities.

Specimen point database included the following fields, based on the Darwin Core data standards (**Table 1**), although not all records had information for all of these fields given that they were derived from different institutional databases. Fields specific to the previous Queensland Museum's R:Base database are labelled in the list below with '[QM]'. Fields only included in Northern Territory Museum database are marked with '[NT]' (those marked '*' will be suppressed on the basis of confidentiality with commercial agreements or institution policies; those marked '^' have confidence interval codes as outlined in **Table 2** below).

Table 1. List of data fields included in the QM Biolink sponge specimen database

Genus (taxon genera)
Species (taxon species)
Family (taxon family)
Order (taxon order)
Suborder (taxon suborder)
Class (taxon class)
Phylum (taxon phylum)
Species Authority (species author)
Taxon Year (year of species description)
Species Number (species identifier number for the those species not yet named
Material.Accession number)
Taxabs (taxonomic reference code) [QM]

TaxNo (taxonomic reference number) QM
Tax rem (taxonomic remarks) QM
Taxa date (date of taxonomic proof)
Taxa Proof (taxonomy proofed by)
Record Number (number of all individual records)
Registration number (material registration number)
Part Number (material reference number) QM
Otaxabs (previous taxon) QM
Identified by (who identified the material)
Identification Accuracy (confidence levels taxonomy) ^
Identified by number (code for identifier) QM
Identified on (when the material was identified)
Site name (where the material was collected from)
Macrohabitat (habitat description)
Microhabitat (microhabitat description)
Collection method (how the material was collected)
Elevation depth (average depth at which the material was collected)
Elevation lower (Maximum depth of collection)
Elevation upper (Minimum depth of collection)
Elevation source (Instrument for measuring depth)
Elevation error (Depth error) ^
Cross reference (site cross reference) *
Station (site station reference) *
Donor number (where material was donated from) *
Collector(s) (who collected the material) *
Collector number (collectors code) *
Start date (date of start of collection)
End date (date of end of collection)
Casual date (approximate date of collection)
Types,T (name of type ie holotype, paratype etc.)
Institution (Holding Institution)
Storage method (how the material is stored)
RegRem (registration remarks) QM
RegDate (creation date of original record) QM
Reference number (linking code; author, title, journal linking code, year of publication, page, remarks)
Curation status (status of material in collection)
Field number (site location number)
Locality (locality)
Country (country)
State (state)
Latitude (latitude as decimal degrees)
Longitude (longitude as decimal degree)
Position source (how the location was determined)
Position error (location confidence level) ^
Colour (colour description) NT
Morphology (morphological description) NT
Remarks (remarks) NT
Material number of species (number of species collected) NT
Material Photos (photos taken duirng collections) NT

Material slides (microscope slides produced) [NT]
Material disposal (status disposal of material) [NT]
Material sources (other sources of material) [NT]
Collection temperature (water temperature) [NT]
Collection salinity (water salinity) [NT]
Collection number of specimens (number of specimens collected) [NT]
Generated by (source of locality, who)

After importation and conversion of specimen data, validity and accuracy checking was carried out and a confidence scaling system for all specimen point data (i.e. method and accuracy of locality data, and taxonomic accuracy) was also incorporated into the database (**Table 2**).

Table 2. Confidence limits scaling for the QM Biolink sponge specimen point data

Confidence scale for geographic / depth ranges		Confidence scale for taxonomic identification	
0	Not yet entered	0	Not yet entered
1	Excellent (GPS to 2 or 3 decimals and depth from dive computer)	1	Highly reliable identification (e.g. includes published material, including types)
2	Good (GPS to 1 decimal and depth from dive computer or sounder)	2	Identification made with high degree of confidence at all levels (e.g. IDs made by international authority but remain unpublished)
3	Satisfactory (locality determined from map, depth from dive computer or sounder)	3	Identification made with high confidence to genus, less so to species (e.g. IDs made by research assistants of an international authority under supervision; or taxonomic placement still nebulous due to unstable nature of classification)
4	Poor (locality and depth determined from anecdotal evidence from collector or gazetteer)	4	Identification made with limited confidence (e.g. IDs made by a trained 3rd party but so far without corroboration by an international authority or comparison of material to a reliable collection)
5	Doubtful (anecdotal evidence questionable, or antiquated record from Museum register)	5	Identification superficial (e.g. IDs made by a 3rd party with limited sponge taxonomic skills)

2.2. Geographic coverage and scales of analysis. All sponge data points that fell within the Australian continental marine territory jurisdication were included in analyses (i.e. Antarctic and subantarctic data were not included), but with a major focus on tropical sponges. In the QM, AIMS and WAM collection databases there are many temperate species data points (e.g. Australian Antarctic Division's survey collections of Antarctica, and Aquenal Pty. Ltd.'s Tasmanian and Bass Strait sponge surveys, both now in QM collections; south west Australian coastal surveys in the WAM), and extra-limital species data points (e.g. surveys of western Pacific islands and Indo-Malay archipelago by the QM). Some of these data were also included in analyses for comparative purposes in order to: (1) analyse the extent of tropical species distributions, (2) determine the uniqueness or otherwise of particular species within tropical Australian bioregions, and (3) further refine bioregional boundaries at tropical-temperate zone margins.

Within the tropical data sets special attention was given to the Northern Planning Area (NPA), which includes the area bounded by Cape York in the east (10°14'S, 142°32'E) and approximately Maningrida in the west (12°03'S, 134°13'E) (see **Fig. 4** in Results section), i.e. the eastern portion of the NP bioregion. This area was of special significance given (1) that it was a National Oceans Office priority during the initial stages of this project, and (2) it represents a unique bioregional and biogeographical transitional zone due to the land barrier in place during several glacial low sea levels (150-200m below present), the most recent during the Pleistocene (~18,000 years ago), and subsequent remixing of eastern and western faunas during sea level rises (Larcombe *et al*., 1995). Species turnover at this (and other) boundaries are of particular biological interest (e.g. capacity for hybridization, recolonization and dispersal potential etc.) and management interest (particularly for Introduced Marine Pests assessments – knowing what is native and has evolved in the region and what has migrated or been introduced over human history).

In this context the term 'species turnover' is equivalent to β-diversity (Gray, 2001), referring to the spatial turnover of species along an environmental gradient, such as from site to site, or the number of species whose ranges end between adjacent sampling regions (e.g. O'Hara & Poore, 2004), with sampling regions vaying in size depending on the spatial scale of the particular analysis. Terminology used to define these spatial scales (after Gray, 2001) are: **point-diversity** (a single sample within a habitat, represented by individual database records), **α-scale diversity** (within-habitat diversity, or a number of samples within a habitat, where species are presumed to interact and compete for similar limiting resources), **γ-scale diversity** (within-region or landscape/ seascape diversity, where evolutionary processes becomes increasingly important, termed here **localities**), **ε-scale diversity** (regional or biogeographic provincial diversity, or the total species richness of a group of large areas, termed here **bioregions**).

2.3. Species distributions. The distribution maps for any or all species in any combination can be immediately produced from the 'Distribution Map' function in CSIRO's Biolink software. This produced a GIS shapefile, with maps of Australia and or the world, with separate layers showing the distribution points of the specimens. The layers and maps can be exported from Biolink into ArcINFO or ArcView for use in other GIS applications. Geographic distribution data for all the 721 surrogate sponges were produced using CSIRO's Biolink software. These distribution maps were analysed for accuracy, compared to modelled distribution's and used for identifying gaps in data, biodiversity, bioregionalisation and biogeographic modelling studies. Unfortunately it was not possible to incorporate the Geosciences Australia bathymetric shape file into the Biolink GIS mapping function, and consequently this overlay was not possible to achieve during the life of the current project.

2.4. Modelled distribution datasets and historical sponge data. The surrogate species used in this study were modelled using CSIRO Marine Research CAAB modelling system (www.marine.csiro.au/caab) to produce modelled distribution datasets for all the priority surrogate taxa to be used by the National Oceans Office Northern Australian Bioregionalisation. These models used the species point-data records and locked them to a datum point (0-281) on specific depth contours. These datasets and modelled distributions are compatible with the current fish bioregionalisation project. Modelled datasets include only sample point-data (from these databases). It is not currently possible to include historical data from the ABIF sponge catalogue (Hooper & Wiedenmayer, 1994, 1999) because these data do not presently include geographic coordinates (latitude, longitude, depth ranges) for all named Australian sponge taxa. This latter task requires intensive gazetteer searching for type locality (and other published locality) place names for each taxon, and manual data entry of geographic coordinates to allow incorporation into GIS modelled data. The Australian Biological Resources Study has awarded a contract to the senior author (2004-2005) to update the sponge ABIF database in line with recent revisions of the Phylum Porifera (Hooper & Van Soest, 2002) and Australian sponge records published since 1999, and for which we also hope to include incorporation of geographic coordinates for each taxon should resources permit.

2.5. Identification of useful datasets and gaps in data, prioritised by geographic location and acceptable data standards. Of the currently 3,769 species contained with the QM database, a proportion (721 or 19%) were chosen as environmental surrogates based on (a) their occurrence in the tropics in general and vicinity of the Northern Planning Area in particular, (b) completeness/ taxonomic validity of records, (c) their intrinsic value as environmental surrogates, such as habitat- or depth-specific taxa, highly endemic taxa, etc. These species are listed in **Appendix 1**.

Specimen point data of these priority surrogate species was linked to descriptive species database (see below) that enables the non-specialist to identify these species, thus allowing other agencies to input additional (verified) data on the geographical and temporal occurrence of these species into the 'master database'. These descriptive data also allow the inclusion of unnamed species into databases. The agencies contracted to supply data were:

Western Australian Museum (Dr Jane Fromont)
Northern Territory Museum (Dr Belinda Alvarez de Glasby; datasets post 1991)
Australian Institute of Marine Science (Dr Chris Battershill, datasets post 1991)

2.6. Species database. The entire species description database was digitised from mainly handwritten 'mudmaps' for all the key taxa and some other unique taxa pivotal to this project, forming the basis for a subsequent larger project whereby all sponge researchers, in all Australian museums and other biodiversity agencies, will be able to identify sponges on-line through comparison of their material with descriptions and illustrations provided in this database. The 'mudmap' database (perhaps to be reincarnated as the '*Australian sponge biology network*'), will also allow accredited researchers to add species records and descriptions directly (under password control), thus expanding the species coverage across the entire Australian tropics. This is an integral step in the database conversion and taxonomic validation of specimen point-data databases. A list of database fields descriptions is provided below (**Table 3**). In addition to the digital description of the individual species, digititization of the underwater photos, deck photos, microscope section and spicule photos, drawings and scanning electron microscope pictures were carried out for the 721 surrogate species.

Table 3. Data fields included in the QM Biolink species database

Scientific Name (genera and species)
Authority (who described the species originally)
Citation (reference to the species)
Class (class)
Order (order)

Family (family)
Species Number (species identifier number for all species especially those species not yet named)
Growth Form (description of sponge habitat in-situ)
Colour (colour of sponge in water and ethanol storage)
Oscules (description of presence, size and number of oscular structures)
Texture (description of sponge textural characteristics)
Surface Ornamentation (description of viable outer layer surface characteristics)
Ectosomal Skeleton (description of microscopic ectosomal (outer cortex layer) skeletal structure)
Choanosomal Skeleton (description of choanosomal skeletal structure)
Megascleres (description of presence, location, structure and geometric forms of megascleres)
Microscleres (description of presence, location, structure and geometric forms of microscleres)
Specimen (Accession numbers and locations of the specimens, including their global position coordinates)

2.7. Numerical analysis of sponge data. Clustering, ordination and biodiversity statistical analyses were applied to presence-absence data and similarity matrix data to test hypotheses concerning area relationships and connectivity between bioregions. Software packages Primer 5.0 (Plymouth Routines In Multivariate Ecological Research; Primer-E Ltd, Plymouth Marine Laboratory, 2001), Systat 9.0 (SPSS Inc., Chicago, 1999) and EstimateS (Version 7, R. K. Colwell, http://purl.oclc.org/estimates; Colwell, 2004) were used to perform analyses.

Data were analysed at two spatial scales: **γ-scale (smaller-scale localities) and ε-scale diversity (larger-scale bioregions)**. Collection sites (dives, trawl stations etc.) were grouped into 34 smaller-scale localities based on similarities analyses (cluster, MDS) from earlier analysis (Hooper *et al.*, 2002). Conclusions concerning patterns of tropical sponge biodiversity, and development of a tropical sponge biodiversity model, were base on analyses of richness, diversity, similarity and community structure at this spatial scale, as described below. Similarly, collection sites were amalgamated into 9 larger-scale bioregions based on *a priori* boundaries determined by the IMCRA demersal bioregion model, to compare trends with smaller-scale analyses, but more importantly, to contribute data to characterising these existing IMCRA bioregions.

Pairwise comparisons in similarity between faunas were calculated using the Jaccard coefficient or similarity index (*a/(a+b+c)*, where *b* and *c* are the total number of species occurring in each region and *a* is the number of species shared by both regions; e.g. Clifford & Stephenson, 1975). This index was used in preference to the many other similarity indices for reasons explained in Hooper & Kennedy (2002). Similarity analysis (hierarchical clustering using unweighted group average linkage) and ordination analysis (2-D MDS) were performed on the Jaccard similarity matrix to investigate faunistic relationships amongst the different sponge communities.

Sample-based rarefaction (species accumulation curve) was computed using EstimateS, yielding an expected richness function (Mao Tau) with 95% confidence intervals. Rarefaction curves estimate sample species richness (i.e. species occurring in each of the localities sampled) from the pooled total species richness (i.e. species from all localities), based on all species actually discovered. They provide an estimate of sampling completeness based on saturation (an asymptote) of the species accumulation curve. Species richness was also computed using functional extrapolation, based on the Michaelis-Menten (MM) function in the EstimateS package that estimates the asymptotic curvilinear function that might fit the species accumulation curve (Colwell & Coddington, 1994). MM computes estimates for values for each pooling level, for each randomization run, averaged over all randomization runs. MM has the ability to detect the contribution of abnormally high species-rich localities that may produce enormous estimates of richness skewing the accumulation curve away from an asymptote, and thus a defacto indicator of spatial heterogeneity in species richness.

Smaller scale localities and larger scale bioregions were grouped into latitudinal and longitudinal classes and tested using non-parametric two-way nested analyses of similarity (ANOSIM), roughly analogous to standard two-way ANOVA, providing a statistical test of the null hypothesis – that there are no assemblage differences between groups of samples (localities or bioregions) – and as they are permutation/ randomization tests they make a minimum of assumptions and focus on the ranks of the biotic similarity matrices that contain the primary information on assemblage relationships between samples (Clarke and Warwick, 2001). According to these authors the pairwise Global R value is the pivotal statistic as it gives an absolute measure of how separated the groups are, on a scale of 0 (indistinguishable) to 1 (all similarities within groups are less than any similarities between groups). These tests also identify which of the factors (groups of localities or bioregions) are significantly different from others. Summary statistics for diversity and phylogenetic distinctness used to compare each of the bioregions are: Margalef species richness $d = (S-1)/Log(N)$ where S is the total number of species in each site and N is the total number of individuals; Shannon-Wiener diversity index H'(log e), $H' = \Sigma^{k}(P_i * Log(P_i))$ where k is the number of categories and Pi is the proportion of the observations found in category i; Average Taxonomic Distinctness (*AvTD*); Variation in taxonomic distinctness (*VarTD*) (see explanation below); Phylogenetic diversity (a measure of taxonomic distinctiveness, which is the total path length constituting the full taxonomic tree), include Average Phylogenetic diversity (*Phi+* or ϕ+) averaged over number of species in sample, and Total Phylogenetic diversity ($s\phi$+).

Taxonomic Distinctness Analysis (Clarke & Warwick, 2001) was conducted on presence/ absence data for species in each locality and bioregion. Taxonomic distinctness, an average measure of the relatedness between any two species in a community sample (Izsak & Price, 2001), was measured using two indices: Average Taxonomic Distinctness (*AvTD*) and Variation in taxonomic distinctness (*VarTD*) (Clarke & Gorley, 2001). These indices incorporate taxonomic or phylogenetic information by computing a path length, or relative taxonomic distance, between any two species. They are independent of sampling effort and therefore less susceptible to possible biases from sampling than are species richness indices, including the Jaccard index of similarity (Clarke & Warwick, 1998; Warwick & Clarke, 1998; Clarke & Gorley, 2001; Izsak & Price, 2001), and provide effective comparisons of biodiversity between localities/ bioregions at various spatial scales, and various taxonomic hierarchies. These indices reflect both the richness in higher taxa and the evenness component of diversity, but are ultimately a function of pure taxonomic relatedness of individuals (Warwick & Clarke, 2001). AvTD (Δ+ or Delta+) is the average taxonomic path length (in a Linnean or a phylogenetic classification) between any two randomly chosen species. The index is most effective for comparing sets of data where there are a restricted number of higher taxa for a given number of species, but is less effective when there is an uneven distribution of species taxa amongst higher taxa, where some taxa are over-represented and others under-represented in comparison to the species pool for the geographic region (e.g. effects of habitat heterogeneity). VarTD (Λ+ or Lambda+) therefore measures the evenness of the distribution of taxa across the hierarchical taxonomic tree, and is also independent of sample size. The two indices used together are considered to be a statistically robust summary of taxonomic relatedness patterns across an assemblage and appropriate to historical data and simple species lists (Warwick & Clarke, 2001). The null hypothesis tested is that a species list from a particular locality or bioregion, which may be incomplete, nonetheless has the same taxonomic distinctness structure as the master list from which it is drawn (i.e. for all species from all sites in that geographic region) (Clarke & Gorley, 2001). Using a series of randomisation tests that sample the whole dataset from the geographic region, repeated for a range of random sample subsets (M=20-100), a 95% confidence range of possible ('expected') values of both AvTD and VarTD was calculated. 'M' is essentially a measure of the degree to which two samples are taxonomically related to each other, termed an 'optimum taxonomic mapping statistic' (Warwick & Clarke, 2001). These probability envelopes (ellipse functions) were plotted over the real dataset for each set of taxa (bioregions), the real data compared to the predicted probability intervals, with samples below or above these intervals representing biodiversity measures below or above expectation, respectively. These data were compared at species, genus and family taxon levels.

2.8. Dissemination of data via the web. Although ODBC compatible, 'Biolink' is not capable of displaying data, or being interrogated directly from the web (unless of course users have copies of this software on their local computers). Consequently, specimen point data was exported to other programs that can be browsed/interrogated directly from the web. The specimen point data is currently stored in multiple formats including Biolink, SQL, Microsoft Access, XML, RTF and delimited file formats. The specimen point data is currently being exported to OZCAM (www.ozcam.gov.au) as soon as some technical issues have been sorted out. The Queensland Museum is currently in the process of changing over the servers for hosting the OZCAM sponge data.

2.9. Abbreviations. The following abbreviations are used in the text (**see also Figure 1 legend**): **ABIF**, Australian Biodiversity Information Facility (www.deh.gov.au/biodiversity/abrs/online-resources/abif/fauna/); **AIMS**, Australian Institute of Marine Science (Townsville); **AMS**, Australian Museum (Sydney); **Biolink**, Proprietry database developed by CSIRO Entomology (Canberra), available free on-line at www.ento.csiro.au/biolink; **CAAB**, Codes for Australian Aquatic Biota (www.marine.csiro.au/caab/); **GA**, Geosciences Australia; **GBIF**, Global Biodiversity Information Facility (www.gbif.net/portal/index.jsp); **GBR**, Great Barrier Reef; **MAGNT**, Museums and Art Galleries of the Northern Territory (Northern Territory Museum, Darwin); **NCI**, United States National Cancer Institute (Frederick, Maryland); **NMV**, Museum Victoria (Melbourne); **NPA**, Northern Planning Area (Gulf of Carpentaria region, Cape York to west of the Wessel Islands, NT); **NSW**, New South Wales; **NT,** Northern Territory; **NWS**, North West Shelf, WA; **OTU**, operational taxonomic unit, or 'morphospecies'; **QM**, Queensland Museum (Brisbane and Townsville); **SAM**, South Australian Museum (Adelaide); **Tas**, Tasmania; **Vic**, Victoria; **WA**, Western Australia; **WAM**, Western Australian Museum (Perth).

2.10. Background to GIS analysis of the sponge dataset

The QM Biolink database (incorporating QM collections (1990-present), NTM collections (1982-1991) and AIMS NCI collections (1985-1990)) contains 30,728 datapoints all underpinned by verifiable objects. These combined datasets consist of over 5,000 OTUs (although only 3,769 species have associated 'mudmaps' and can be used in a reliable way), from ~4,000 localities **(Fig. 5)**, the majority of which occur throughout Australian continental and tropical territorial waters (including some freshwater sponge records) **(Fig. 6)**. This QM database was supplemented by several hundreds of other specimen data points of selected surrogate species (see criteria for selection in Methods section), supplied by AIMS, WAM and MAGNT during the course of this project (the combined dataset will appear online at OZCAM: www.ozcam.gov.au). It is anticipated that eventually all sponge data points from these institutions' databases will be incorporated into the OZCAM database and form the basis of a national sponge database, but this ultimately depends on (1) adequate expertise and resources being made available within each of these institutions to identify sponges using a universal species-level classification (e.g. the 'mudmap' method and OTU numbering system), given that most Australian sponges currently lack species names and probably will do so for a long time to come; and (2) the ability of respective curatorial/ scientific staff within each of these institutions to enter all their species-level data points using a minimally acceptable standard (based on the Darwin Core standards, and defined in the Materials & Methods section).

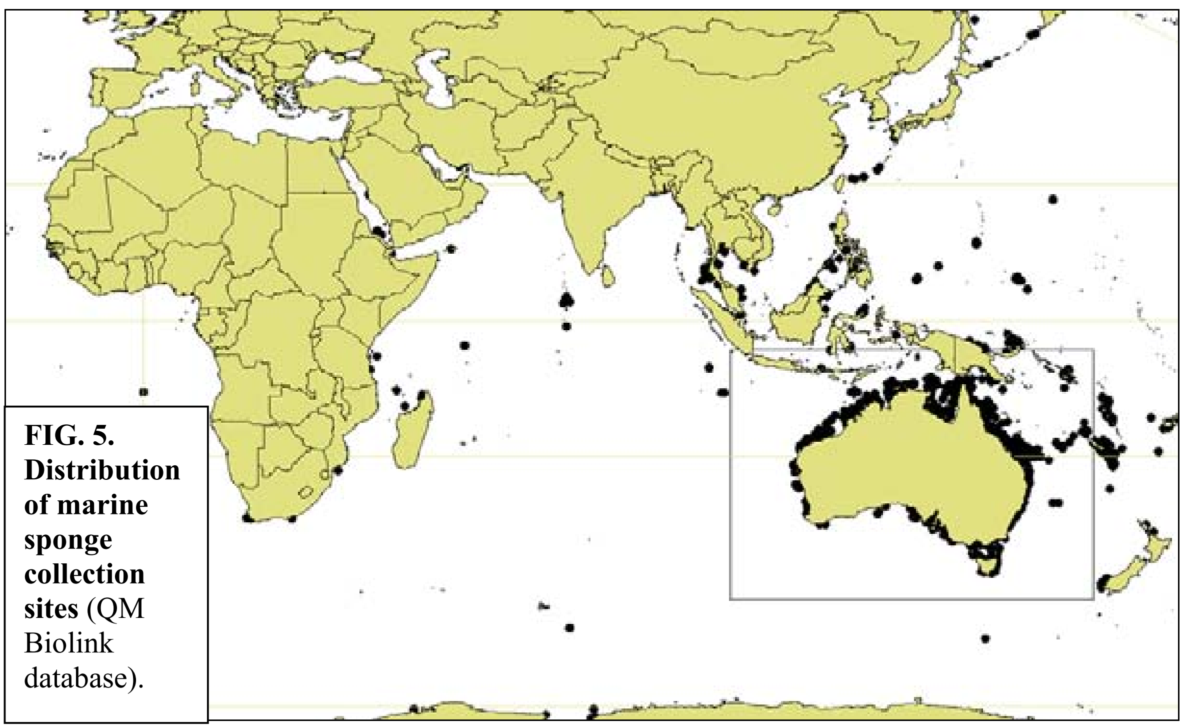

FIG. 5. Distribution of marine sponge collection sites (QM Biolink database).

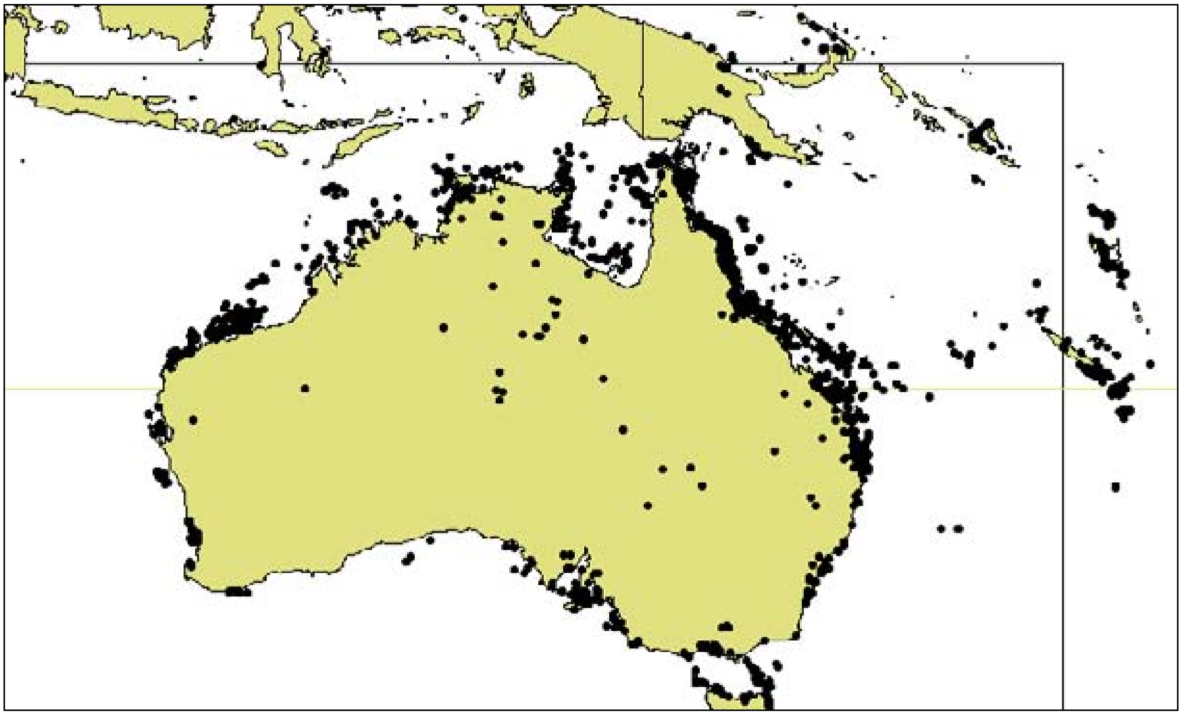

FIG. 6. Distribution of marine and freshwater sponge collection sites for Australian waters (QM Biolink database).

Sponge collections are relatively comprehensive for some of the transitional zones of special interest to this project: (1) The Cape York to Wessel Islands region **(Fig. 7)**, lying in the eastern portion of the NP bioregion (referred to as the Northern Planning Area or NPA), which despite its remote and difficult access has very good specimen coverage (e.g. numerous CSIRO Marine Research survey data of the Gulf of Carpentaria, QM & CSIRO benthic trawl surveys of Torres Strait, AIMS NCI and MAGNT diving surveys of the Wessel Islands). (2) The Sahul Shelf and northwest island territories (Ashmore and Hibernia Reefs, Cartier Island; **Fig. 8**), lying at the edge of the Timor Trough and thus containing an essentially Indonesian marine biota, lying in the NWP-NWB offshore boundary. (3) The Coral Sea island and reef territories lying off the GBR (**Fig. 9**), containing mixtures of GBR and western Pacific island faunas. (4) The eastern subtropical-temperate boundary at the Tweed River (NSW-Queensland border), an overlap of northern Solanderian and southern Peronian provinces (**Fig. 10**), which incompasses the southern portion of the CEB bioregion. All these data points are underpinned by verifiable objects, making the sponge database an invaluable objective scientific tool. Conversely, several important marine biogeographic regions are <u>not</u> yet well sampled for sponges (or at least if collections exist they have not yet had rigorous taxonomic investigation applied to them). These include: (1) The NP-NWB boundary lying west of the Darwin region, for which few surveys have yet been undertaken. (2) The boundary between the far north coastal regions in proximity to the Kimberley Coast, and the North West Shelf of Western Australia, encompassed within the NWB and NWP overlap zone. (3) The sponge fauna south of North West Cape, including Ningaloo Reef, on the central west coast, which is the important tropical-temperate overlap zone and narrowly defined as the CWB bioregion. Some collections of these west coast regions do exist (WAM collections) but have not yet been substantially worked up.

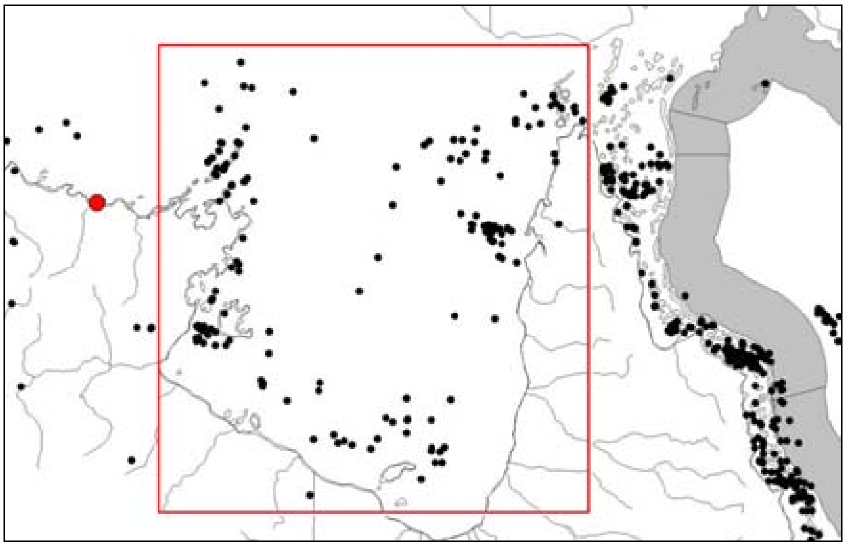

FIG. 7. Distribution of marine (and freshwater) sponge collection sites in the Northern Planning Area (red square) (QM Biolink database). (Maningrida, 12°04'S, 134°16'E, shown by red dot)

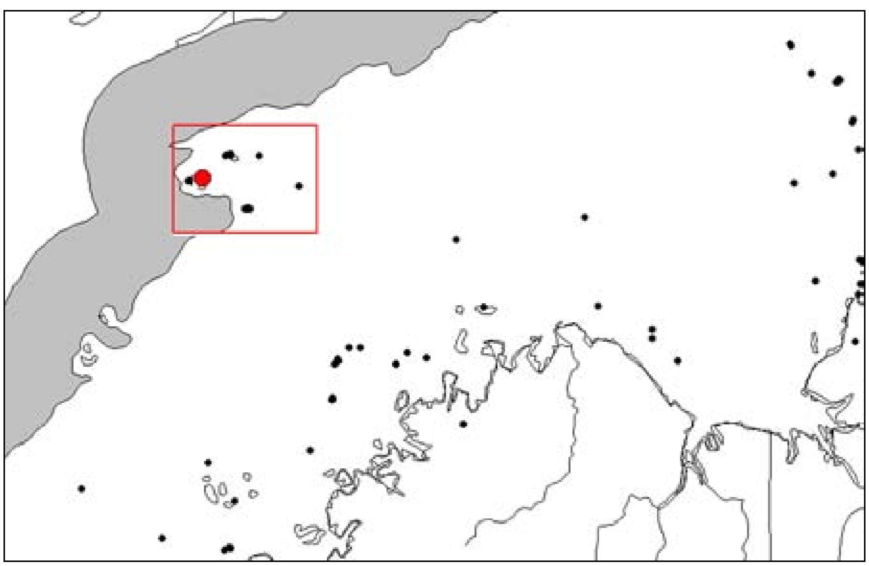

FIG. 8. Distribution of marine sponge collection sites (black dots) on the northwest coast and shelf, with Sahul Shelf indicated (red square) (QM Biolink database). (Ashmore Reef , 12°15.5'S, 123°04.5'E, shown by red dot)

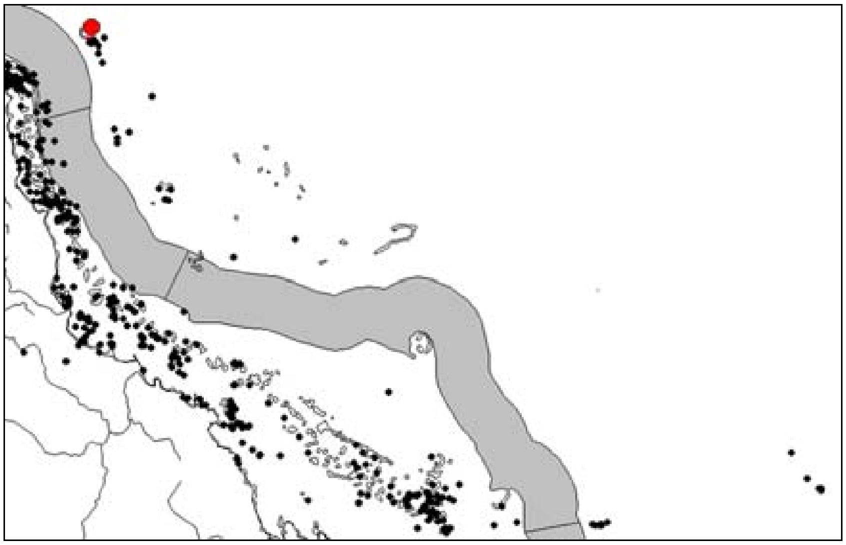

FIG. 9. Distribution of marine sponge collection sites (black dots) on the Coral Sea territories (QM Biolink database). (Osprey Reef , 13°55'S, 146°38'E, shown by red dot)

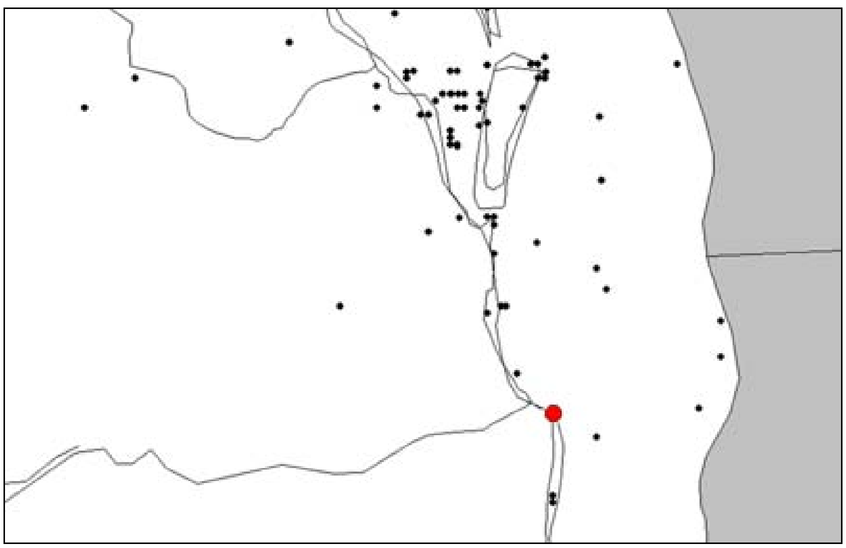

FIG. 10. Distribution of marine sponge collection sites (black dots) on the Tweed River region (QM Biolink database). (Tweed River bar, 28°11'S, 153°34'E, shown by red dot)

The combined sponge database records of 3,769 OTUs (henceforth refered to as 'species') are distributed amongst 425 genera, 120 families, 26 orders and 3 classes of Porifera, all documented and described using the comprehensive 'mudmap' method (an example is provided in **Figs 11-12**), and which form the pool of species available for analysis. Only two of the three sponge classes are included in present analyses, with the deep-sea Hexactinellida, or glass sponges, not yet substantially identified nor collected from within the continental juridiction. Similarly, another ~1,000 species were excluded from analyses because they are currently of unknown or uncertain identity (although largely sorted to genus) given that they were not identified using the 'mudmap' process and cannot yet be reconciled with these better-defined OTUs. These mostly concern the AIMS NCI collections (1985-1990) donated to the QM but not yet reconciled with the other collections in terms of their identity (a potentially huge task). This is a major challenge facing all Australian sponge collections, especially those in southern Museums (AMS, NMV, SAM) for which many have been sorted to genus but few to a unique OTU level. More recent AIMS data (post-1991 NCI contract) are included only for those surrogate species mentioned above.

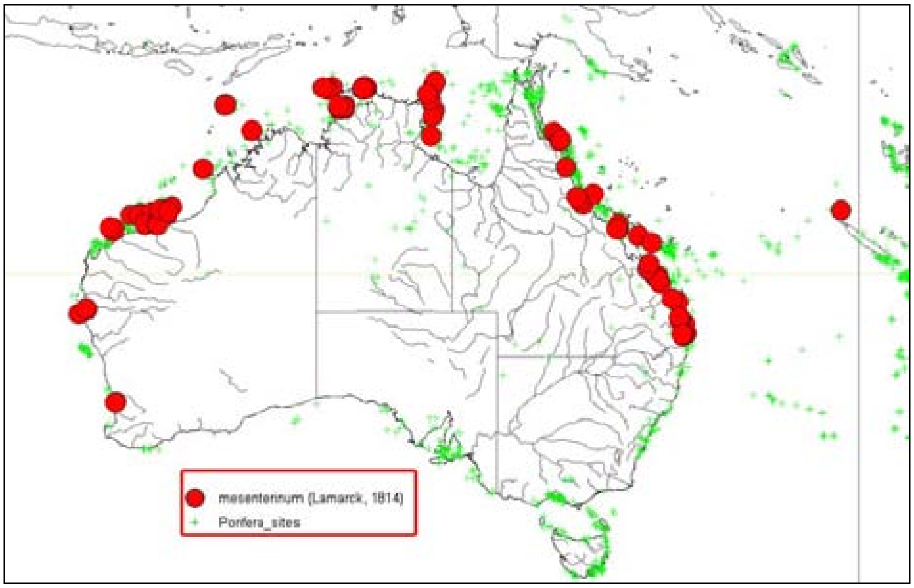

FIG. 11. Distribution of *Echinodictyum mesenterinum* in Australia (QM Biolink database) (red dots are species records, green crosses represent sampling sites)

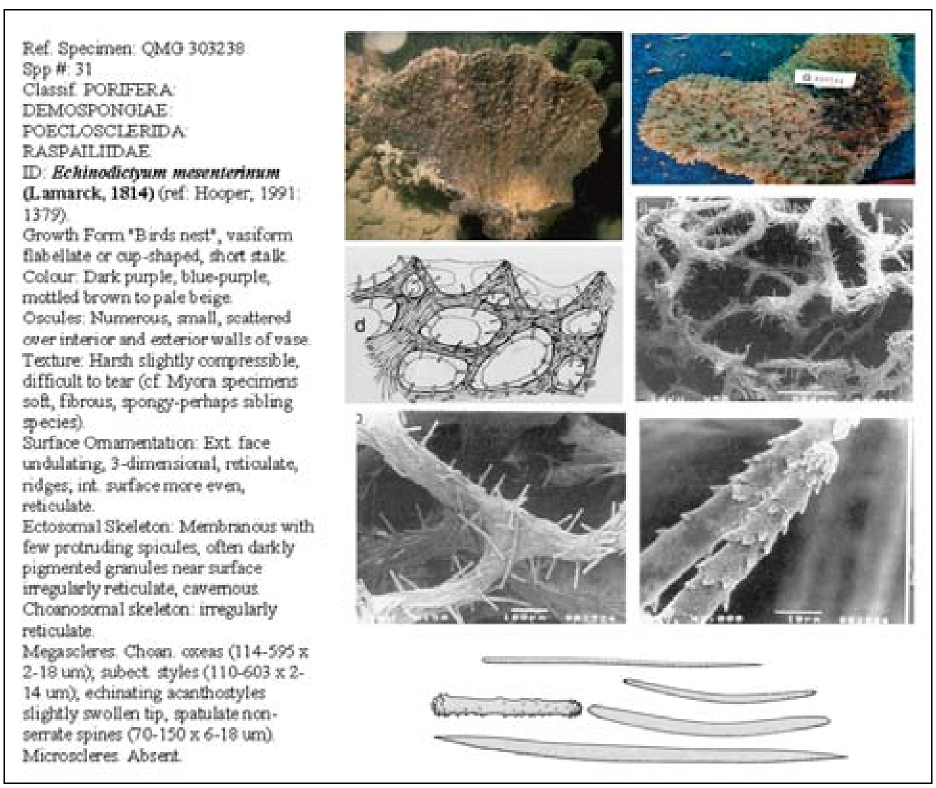

FIG. 12. Example of a digitized 'mudmap' of *Echinodictyum mesenterinum* (Lamarck) accompanying distribution map and modelled distribution.

3. RESULTS AND DISCUSSION

3.1. Introduction to existing knowledge of Australian sponge biodiversity and bioregionalisation.

As this is a first attempt to use sponge data for the purposes of bioregionalisation, it is appropriate to firstly summarise existing knowledge on the biodiversity of Australian sponges, as a context for subsequent analysis of the sponge dataset.

Worldwide there are currently about 7,000 described ('valid') species of sponges, whereas collections held by various museums, and the detection of cryptic sibling species by molecular studies, suggest that this diversity might be twice as large (e.g. Hooper & Lévi, 1994), representing a considerable body of taxonomic work still awaiting to be done. Several regional faunas are comparatively well known, including the Mediterranean, Caribbean and Australian faunas (e.g. Van Soest, 1994) (**Fig. 13**).

Knowledge of the Australian regional sponge fauna commenced with the pivotal works of Lamarck in the early 1800s and continues in a greatly escalated way up to the present day. The described fauna consists of approximately 1400 'valid' species in 313 genera and 83 families (Hooper & Wiedenmayer, 1994; ABIF-Fauna, 2004), although c.4,000 species have already been collected and documented ('sorted' to an operational taxonomic unit; OTU) indicating that significant taxonomic effort remains. The temperate faunas are best known (from the early 1800s), and about 800 species have been described from tropics (from the 1860s).

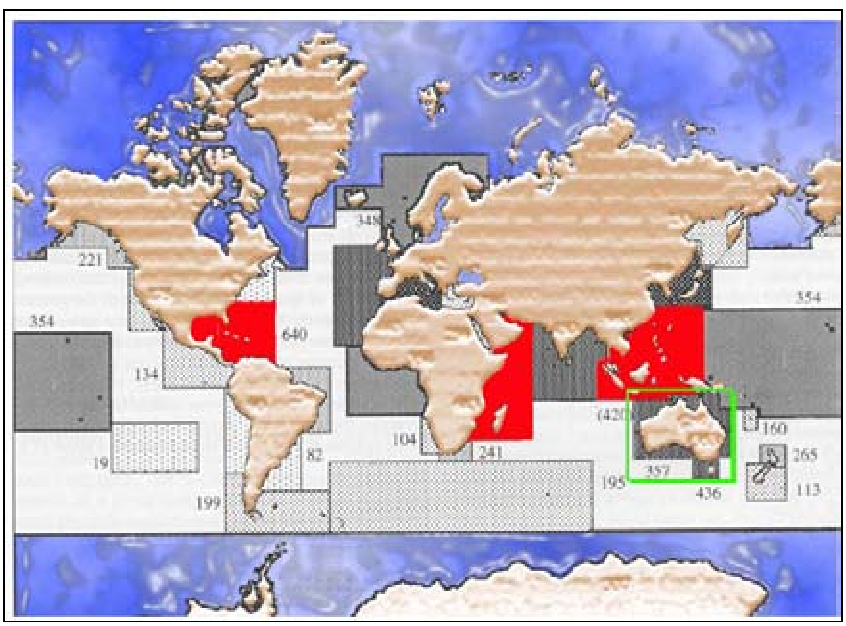

FIG. 13. Analysis of worldwide trends in sponge species richness, with highest diversity in 3 regions (in red), some due to historical legacies, such as early European exploration, some with a real biological basis, such as the Indo-Malay archipelago biodiversity 'hotspot' (modified from Van Soest, 1984)

Thus, an estimate of 5,000 species proposed for the entire regional Australian sponge fauna (Hooper & Lévi, 1994), might be conservative and a gross underestimate in so far as it largely ignores the potentially very many cryptic and sciaphilic species that await discovery. Over the last two decades knowledge of this sponge fauna has received substantial attention owing to their potential as commercial sources of novel therapeutic compounds (e.g. Munro et al., 1999; Faulkner, 2002), but the majority of species are still unnamed and there remain significant challenges to reconcile living populations with (often ancient) published taxonomic descriptions. Nevertheless, Australian sponge distributional data have been used with some success as an analytical tool for bioregional marine conservation planning and management (e.g. Great Barrier Reef Marine Park Authority Representative Areas Program; http://www.reefed.edu.au/rap/), and several biodiversity analyses, based on species presence/absence data, have revealed some interesting spatial trends that are not universally reflected in distributions of other marine phyla in the Indo-west Pacific.

Only a brief summary of these major trends is provided here. For more details refer to the bibliography. At the smaller (intra-regional) spatial scales sponges frequently form spatially heterogeneous, relatively highly 'apparently endemic' communities (e.g. Hooper & Kennedy, 2002), sometimes with as little as 15% similarity in species composition between geographically adjacent reef sites (Hooper, 1994) (**Figs 14-15**).

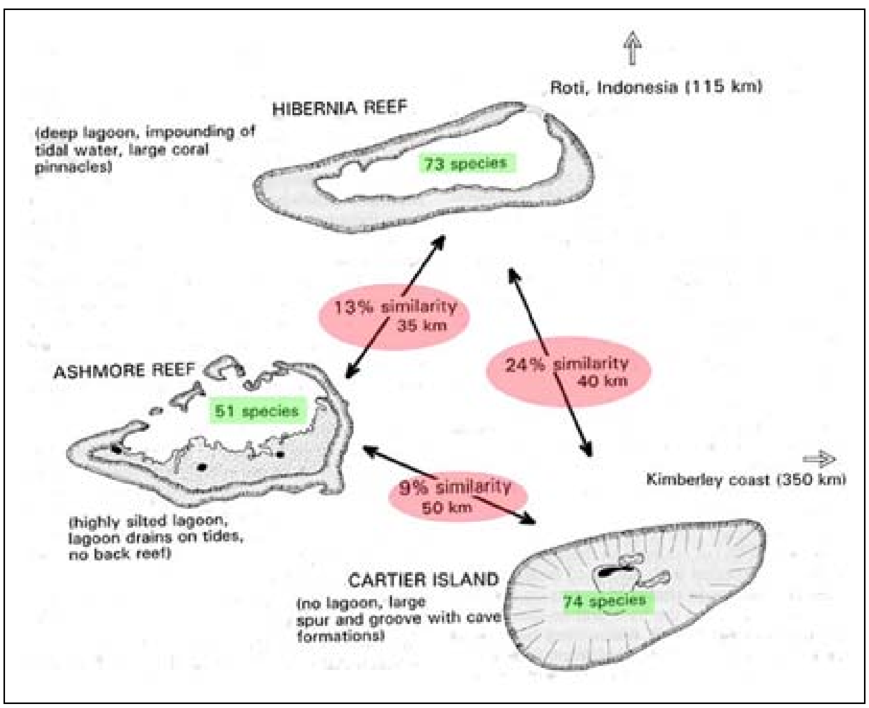

FIG. 14. Species richness and similarities in species composition of sponges living on adjacent reef systems on the Sahul Shelf, north Western Australia, analysed from a pool of 132 species (modified from Hooper, 1994)

The potential connectivity between adjacent communities is hampered by their reportedly very limited sexual reproductive dispersal capabilities and alleged preponderance of clonal dispersal and recruitment (Battershill & Bergquist, 1990; Zea, 1993; but see Davis *et al*., 1996; Zea, 2002). From studies on cross-shelf distributions certain environmental variables have been linked to community heterogeneity, most notably light, depth, substrate quality and nature (e.g. coralline vs. non-coralline, hard vs. soft substrata), local reef geomorphology (presence or absence of specialised niches), water quality and flow regimes, food particle size availability, larval recruitment and survival (Wilkinson & Cheshire, 1989; Hooper, 1994; Roberts & Davis, 1996).

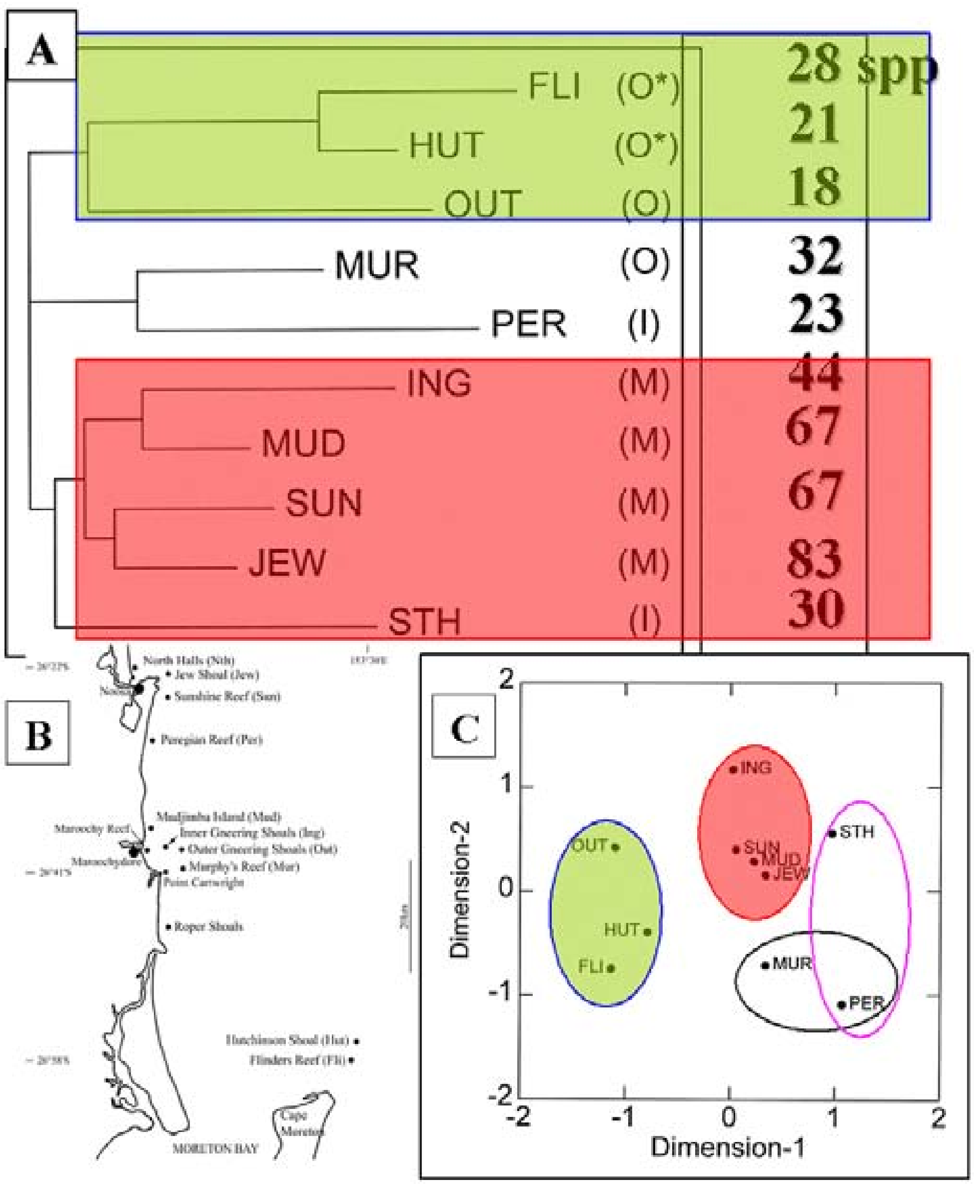

FIG. 15A-C. **Biodiversity (cluster, MDS) analysis of adjacent small-scale sponge populations off the Sunshine Coast of SE Queensland, from a pool of 226 species, showing distinct cross-shelf gradients in species richness, local ('apparent') endemism and taxonomic affinities; mid-reefs richest and most diverse (cf. inner and outer reefs); and all reefs highly heterogeneous (mean 34% 'apparent endemism'** (modified from Hooper & Kennedy, 2002)

At larger ('landscape') spatial scales there do not appear to be any trends in latitudinal gradients of species richness along the tropical to warm temperate coastal and shelf faunas (Hooper *et al.*, 1999, 2002), with the exception of the Great Barrier Reef which has a not-surprisingly higher overall coastal species richness than areas to the north and south (**Fig. 16**). Nevertheless, there are significant taxonomic differences (species diversity) between the major Australian marine bioregions on the NE, NW, SE and S coasts and shelf faunas, the Coral Sea and subantarctic territories (e.g. Hooper & Lévi, 1994; Hooper & Wiedenmayer, 1994; Roberts & Davis, 1996; Fromont, 1999; Hooper *et al.*, 2002). Those differences indicate large scale community patterns that might be linked to factors such as historic and modern day current patterns (connectivity, sea level changes), presence or absence of major carbonate platforms, historical biogeography, etc. It has been suggested that between 5% (New Caledonia fauna, Hooper & Lévi, 1994) and 15% of species in regional faunas (Sahul Shelf fauna, Hooper, 1994) may have extensive geographic distributions, ranging from the Red Sea to the central western Pacific islands. The remainder probably has more specific or restricted habitat requirements than generally acknowledged, possibly reflecting the mix of ecological specialists vs. generalists in these communities. However, already some of these so-called widely distributed or cosmopolitan species (e.g. *Astrosclera willeyana*, Wörheide *et al.*, 2002a; *Chondrilla* spp. Usher *et al.*, 2004) have been shown to consist of several cryptic sibling species that show high genetic diversity that is not clearly manifested at the morphological level across their wide geographic range, making their 'practical' species determination difficult.

Based on analysis of 2329 species of sponges from 1343 localities, differentiated into 37 regional faunas based on gradients of species richness and taxonomic affinities, five discontiguous 'hotspots' of biodiversity were detected (>250 spp/ region) within northern Australia (encompassing tropical to warm temperate waters on coastal and continental shelf waters) (Hooper *et al.*, 2002) (**Fig. 17**), with these gradients varying across all marine faunas and generally deviating from biodiversity models derived from analyses of other marine taxa. These 'hotspots' included two within the NPA bioregion: Darwin region and the Wessels/ Gove/ Groote Eylandt region, two within the GBR corresponding to the northern NEB and southern NEP, and one one the mid north west coast of Western Australia, corresponding to the southern part of the NWP bioregion (indicated as red circles in **Fig. 17**).

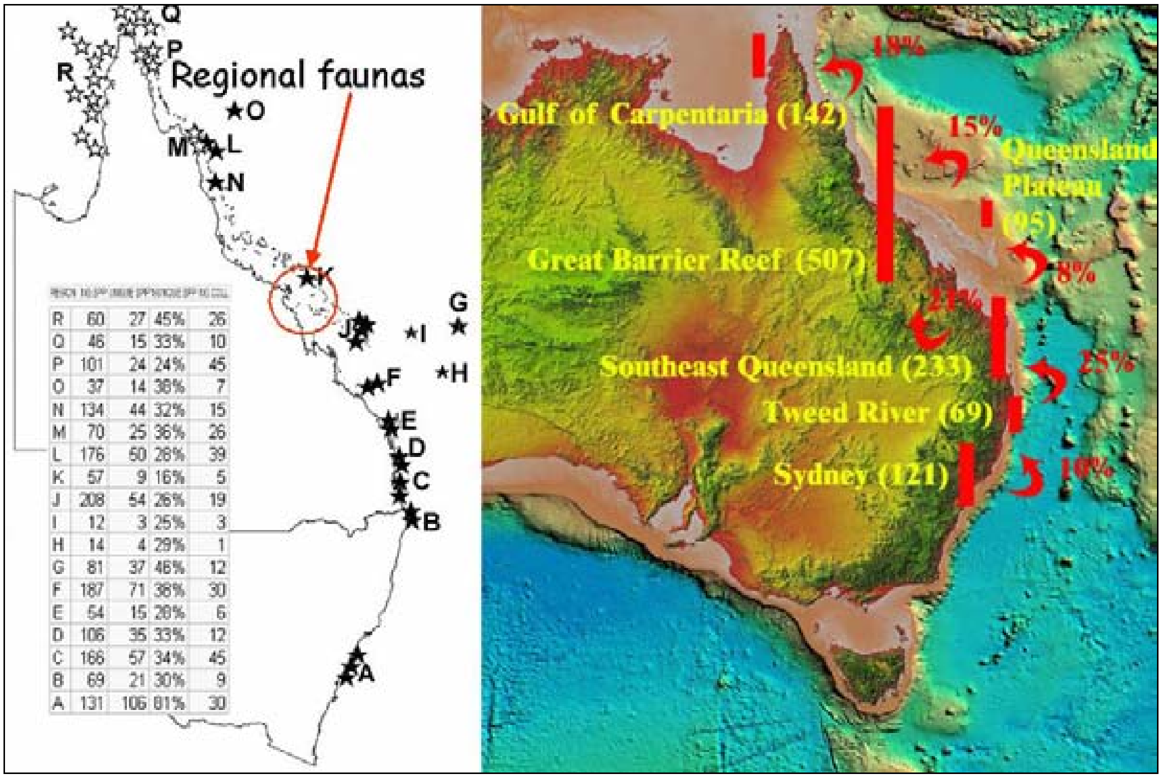

FIG. 16. Species richness (bars) and taxonomic affinities (percentages) between regional sponge populations along the central to northeastern Australian coasts (modified from Hooper *et al*., 1999)

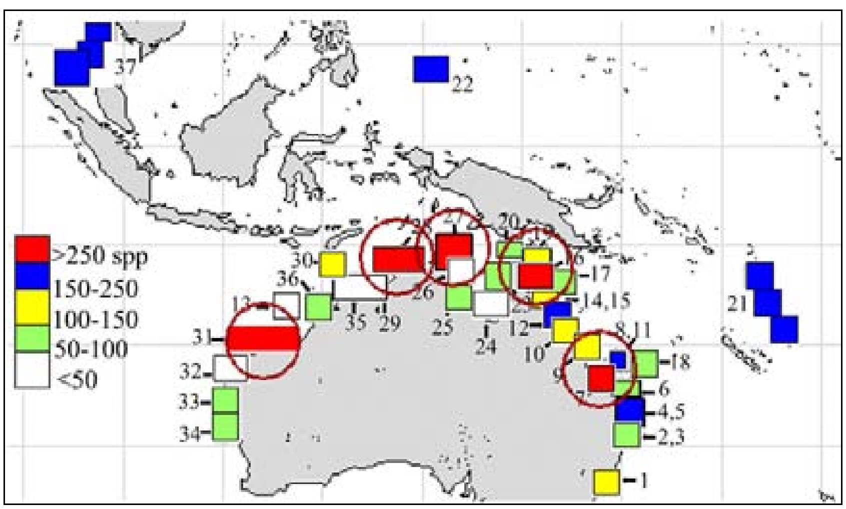

FIG. 17. Species richness of regional sponge faunas in tropical Australia (and some comparative outlining regions). Red circles indicate tropical 'hotspots' mentioned in the text (modified from Hooper *et al*., 2002)

Analysis of phylogenetic affinities between these species also showed that there were distinct differences (in species composition) between the sponge faunas of the east and west coasts, with major species turnover occurring at Cape York, such that sponges in the Gulf of Carpentaria, the Wessel Islands, and further to the west were more closely related to those of the Western

Australian coast and shelf than they were to the geographically adjacent Cape York and northern GBR faunas (**Fig. 18**). These data support an hypothesis that biogeographic factors and connectivity are more obvious in determining large-scale (provincial) marine sponge faunas than is geographic proximity, with few obvious physical gradients defining these provincial faunas (e.g. carbonate vs. terrigenous sediments, tidal regimes, etc.).

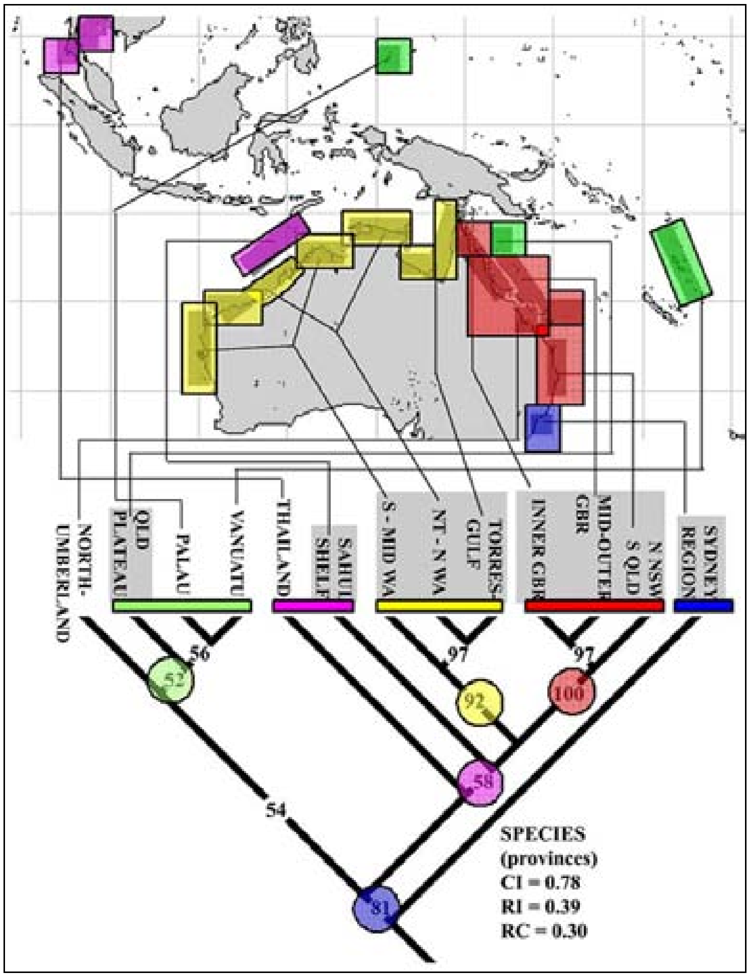

FIG. 18. Phylogenetic analysis of large-scale (provincial) sponge faunas based on parsimony analysis (PAUP) showing major trends in taxonomic affinities between provincial regions (modified from Hooper *et al.*, 2002)

Of major significance from these analyses was the recognition of high heterogeneity (at larger spatial scales) of the sponges living on the Great Barrier Reef, with two distinct ‘hotspots’ detected in the southern (corresponding to the NEP+CEB bioregions) and far northern regions (corresponding to NEB bioregion), and a variable mosaic of diversity and species richness elsewhere (**Fig. 17**). This pattern has been subsequently confirmed by a phylogeographic study of the calcareous sponge *Leucetta ‘chagosensis’* (Wörheide *et al.*, 2002b) (**Fig. 19**) based on rDNA analysis, and these results question the rigor or even validity of some traditional Australian marine biogeographic boundaries (reviewed by Wilson & Allen, 1987) to encompass all marine phyla. Although historically better known, and believed to contain much higher proportions of endemic species than the tropical faunas, the southern Australian sponge faunas (Flindersian, Peronian and Maugean provinces, believed to have Gondwanan origins) have not been studied in a contemporary or comparable manner to the tropics (Dampierian, Solanderian provinces considered to have Tethyan affinities). Consequently, numerical analyses provided here are restricted to the tropical bioregions.

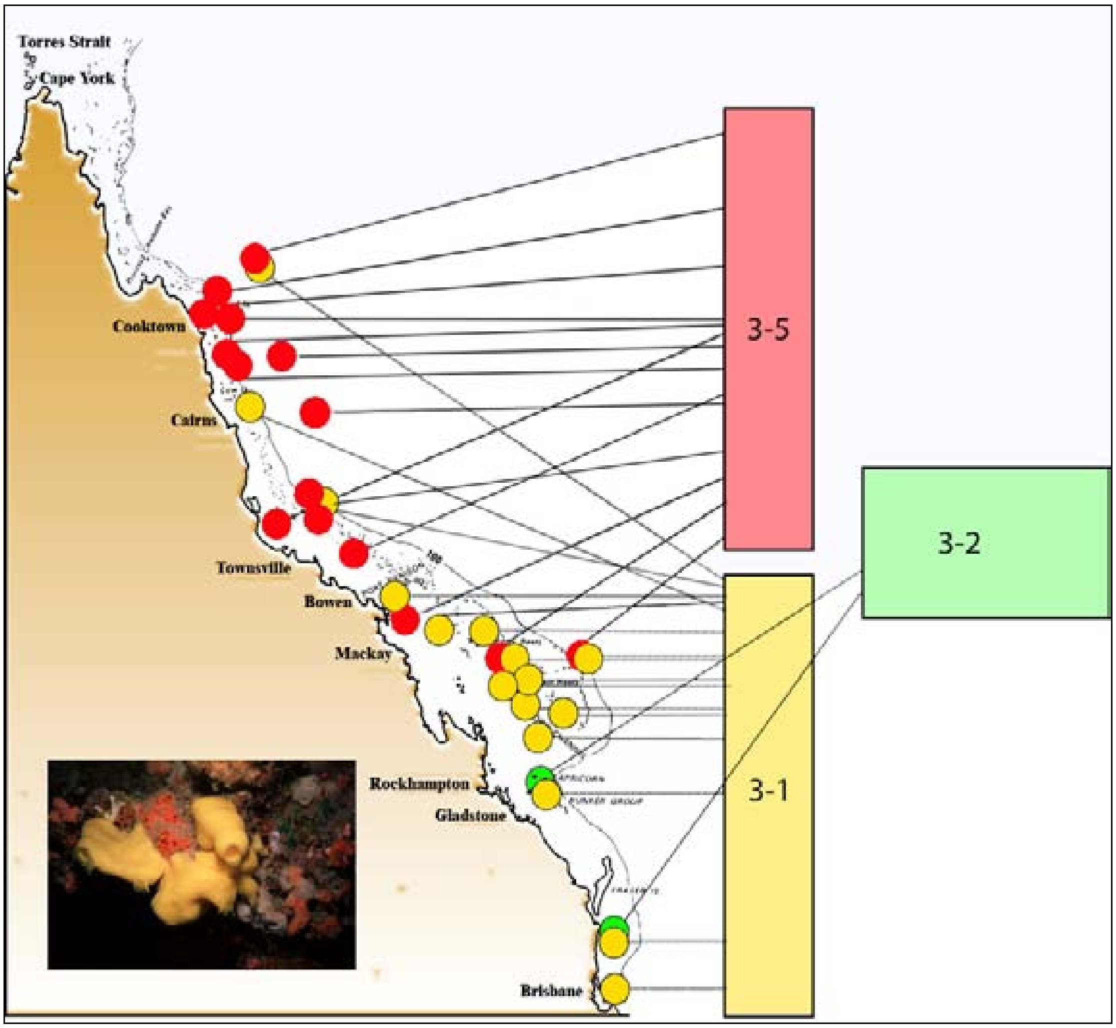

FIG. 19. rDNA ITS Sequence type distribution of *Leucetta 'chagosensis'* on the Great Barrier Reef. Each circle represents one sampling locality. Two distinct and deeply divergent clades were found to be present, corresponding to a southern clade (3-1) and a northern clade (3-5), the latter also containing sequence types found in Taiwan and Guam (3-2). The two clades only narrowly overlap in the central GBR, however, single specimens containing southern-clade sequence types were found at Osprey and Myrmidon Reefs (modified from Wörheide *et al.*, 2002b)**. This structure has subsequently been confirmed with an extended data set, covering more samples from the central GBR as well as from Reefs on the Queensland Plateau (Epp, 2003)** (modified from Wörheide *et al.*, in press)

3.2. Descriptive GIS analysis of bioregionalisation trends for sponge groups

GIS analysis of the sponge dataset is presented in **Appendix 6**. Although the primary focus is on the tropical faunas, distributions of temperate species in the collections are also presented to highlight differences between taxonomic groups in terms of their tropical versus temperate components, widely distributed (ubiquitous) species versus narrow-range endemics, and so on. GIS maps are presented in varying formats, ranging from species-groups to family-groups, depending on the diversity of a particular taxon and aiming for clarity of presentation. These GIS analyses are accompanied by an interpretation of the taxonomic grouping in terms of their bioregional trends (how they might contribute as surrogates for tropical bioregionalisation), summary detail (the scope and diversity of the taxa, geographic details on distributional peaks (richness, diversity)), and lists of species within genera and families that are unique to particular bioregions, and therefore which might be used to help define those bioregions.

Modeled CAAB distributions (incorporating geographic and depth distributions) of species chosen as environmental surrogates are presented in **Appendix 7** (attached PDF file). It is anticipated that these data will be eventually available on OZCAM, linked to the raw species distributions themselves.

3.3. Numerical analysis of Australian tropical sponge biodiversity and bioregionalisation
3.3.1. Localities (γ-scale diversity)

A subset of 2,249 species found in tropical and subtropical faunas was analysed using numerical methods, from the pool of 3,769 species included in the descriptive analyses (section 4.3). Sponge specimen point data were amalgamated into 34 smaller-scale spatial regions (henceforth referred to as **localities**) based on similarity and MDS analyses as described in Hooper *et al.* (2002). These localities are defined in **Appendix 2,** including the number of sites investigated and the number of unique species found in each locality (i.e. species occurring only in that particular locality). Frequency distributions, species rarefaction and species richness were analysed for each locality in a transect running across the tropics from the central east coast (Sydney region) to the central west coast (Houtman Abrolhos). Only one species (*Clathria (Thalysias) vulpina*) was found in 22 localities, two species in 19 localities (*Rhabdastrella globostellata, Acanthella cavernosa*), three species in 18 localities (*Ianthella flabelliformis, Myrmekioderma granulata, Echinodictyum mesenterinum*), three species in 17 localities (*Cinachyrella (Rhaphidotethya) enigmatica, Reniochalina stalagmites, Xestospongia* *testudinaria*), three species in 16 localities (*Pericharax heterorhaphis, Hyattella intestinalis, Ianthella basta*), two species in 15 localities (*Stellatta sp.#1005, Dendrilla rosea*), three species in 14 localities (*Ircinia sp.#1255, Agelas mauritiana, Dysidea cf. avara*), and three species in 13 localities (*Ianthella quadrangulata, Spheciospongia papillosa, Cinachyrella australiensis*). These species represent less than 1% of the tropical fauna. The majority of species (1377 or 61%) were found only in a single locality; 713 species (32%) in 2-5 localities, and 138 species (6%) in 6-12 localities (**Fig. 20**).

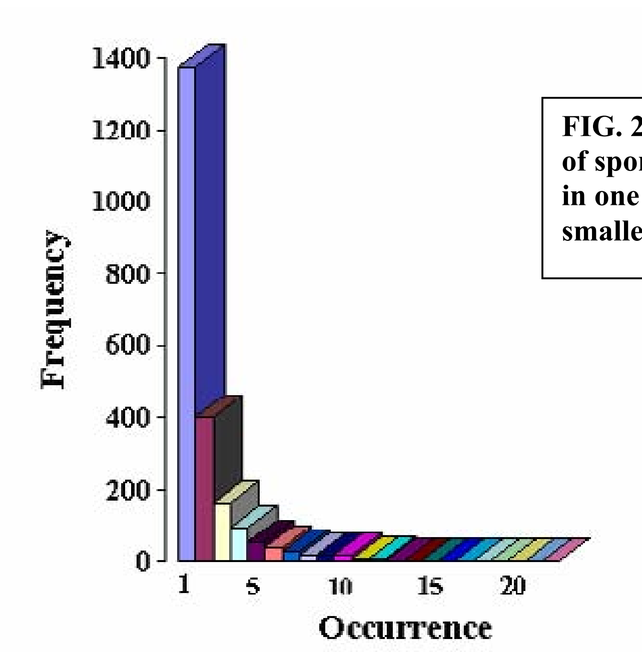

FIG. 20. Frequency distribution of sponge species co-occurring in one or more of the 34 smaller-scale localities.

The species rarefaction curve (**Fig. 21**) is approaching but has not yet reached a well-defined asymptote (R^2=0.9253), indicating that sampling of localities may not be statistically complete compared to an ideal (saturated) species accumulation curve.

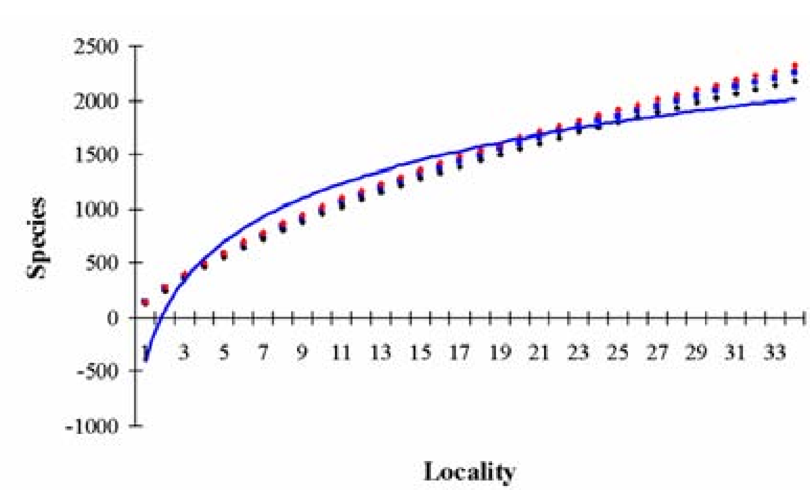

FIG. 21. Species rarefaction of accumulation curve showing estimates of species richness (Mau Tau function) (blue squares), upper and lower 95% confidence limits (red and black diamonds), and a logarithmic trendline of the Mau Tau function (blue curve) for the 34 smaller-scale localities.

Analysis of species richness along this tropical transect (**Fig. 22**) showed six peaks (possible biodiversity 'hotspots') in tropical or subtropical faunas: (1) Southeast Queensland – northern New South Wales biogeographic transition zone (with peak in the Moreton Bay region), an area significant as a biogeographic overlap zone between Solanderian and Peronian provinces); (2) Southern GBR (peak at Capricorn-Bunker Group); (3) Central GBR (peak in the vicinity of the Townsville region mid-lagoon reefs); (4) Northern GBR (peak in the vicinity of the Lizard Island region including outer barrier reefs); (5) Western margin of the Northern Province (peak in the Darwin to Cobourg Peninsula regions); and (6) North West Shelf (peak in the Dampier to Port Hedland region). In addition, sites investigated in the Far Northern GBR locality (Cape Melville up to the Torres Straits) have consistently moderate diversity, suggesting there may be a relatively homogeneous sponge fauna throughout this locality, but there is a dramatic turnover of species richness at the boundary between Cape York and the eastern Gulf of Carpentaria, which is supported further (below) by significant changes in species composition at this boundary.

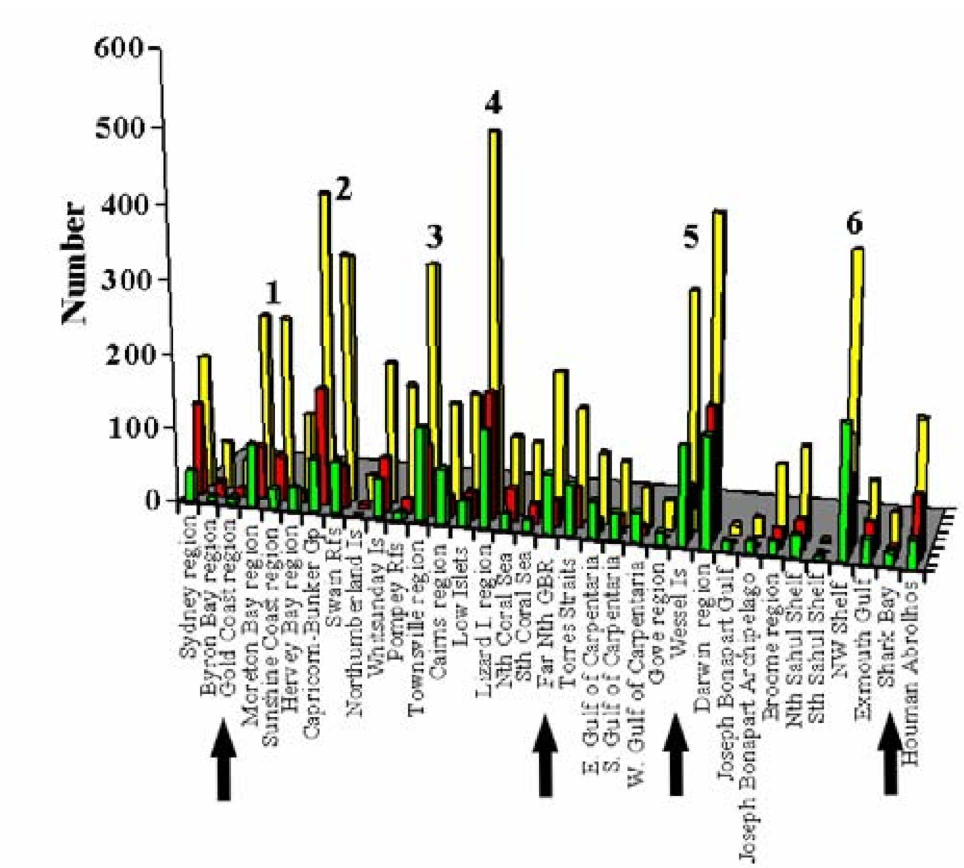

FIG. 22. Species richness (yellow area), number of unique species (red area) and number of localities investigated (green area) for sponges collected from smaller scale (γ-scale diversity) localities in northern Australia, running anticlockwise across the tropics from the south east coast (Sydney region) to the south west coast (Houtman Abrolhos Islands). Numbers and arrows refer to peaks in species richness and major species turnover points, repectively, mentioned in the text.

Visually, there appears to be a correlation between collection effort (number of sites collected for each locality) and the number of species and number of unique species in localities (**Fig. 22**), but these factors are significantly different (**Fig. 23**; F=20.662, Prob.=3.17E-08), with total numbers of species in localities not related to either collection effort (R^2=0.7226, F= 83.350, Prob.=2E-10) or proportions of unique species in these localities (R^2=0.8144, F=140.392, Prob.=3.06E-13). Conversely, collection effort and numbers of unique species are statistically related (F=0.0039, Prob.=0.9504) although there is no obvious biological explanation for this relationship. Nevertheless, these data suggest that other environmental variables are involved in determining the observed patterns of species richness/ proportions of unique species within localities, and these are not simply statistical artefacts of sampling effort. This conclusion is further supported by analysis of the Michaelis-Menten function (MM), which provides a more rigorous richness estimate based on computation of the asymptotic function in the species accumulation curve, depicting the effect of significant heterogeneity in species richness within a randomised dataset (**Fig. 24**) whereby abnormally high species-rich localities produce consequent enormous estimates of richness that skew MM estimates away from the asymptote (Colwell & Coddington, 1994).

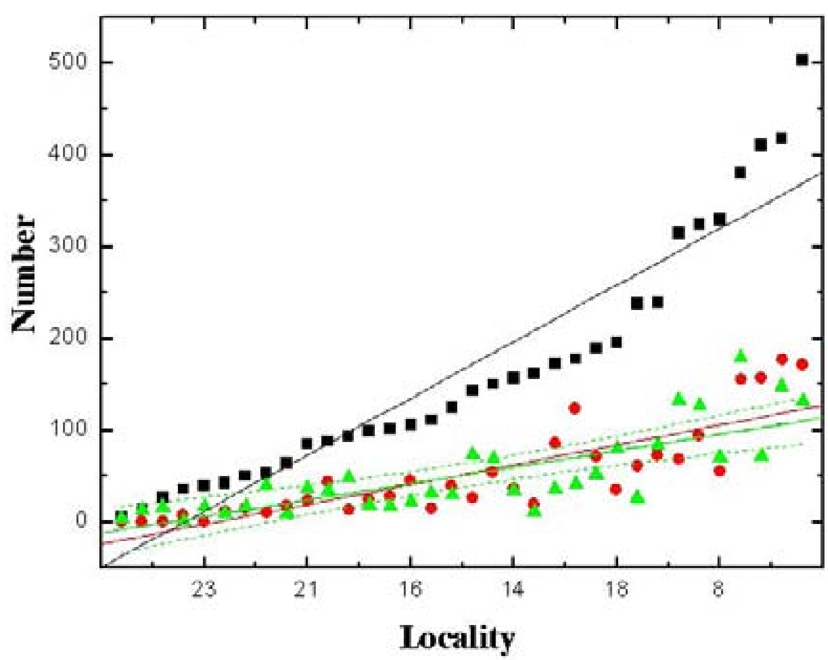

FIG. 23. Regression analysis of species richness (black), number of unique species (red) and collection effort (green ± 95% confidence limits) for sponge faunas in localities (γ--scale diversity) ordered by total species richness.

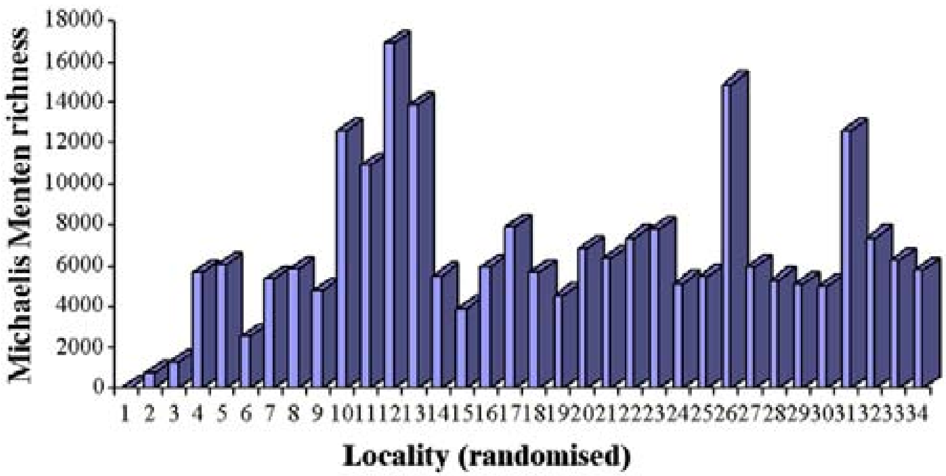

FIG. 24. Michaelis-Menten function (MM) for smaller scale (γ-scale diversity) species richness computed for a randomised locality dataset, illustrating the significant contribution of abnormally high heterogeneity in species richness between localities to the species accumulation curve.

MDS ordination (**Fig. 25**) of the Jaccard similarity matrix for γ-scale locality faunas shows several transition zones where community structure appears to change to a greater or lesser extent: (1) Major transition between temperate and tropical faunas at the Tweed River; (2) Minor transition between Southeast Queensland and Southern GBR faunas in the vicinity of Fraser Island-Hervey Bay; (3) Minor transition between the Far Northern GBR and Torres Strait; (4) Major transition between Torres Strait and the Eastern Gulf of Carpentaria – representing the most significant β-diversity recorded; (5) Major transition between the Gulf and Wessel Islands region (probably an ecological (habitat-related) rather than biogeographic transition); (6) Several minor transitions along the west coast between west of Darwin and Shark Bay (some of which remain undersampled, such as the Kimberley Coast and Northwest Cape), preventing any stronger conclusions on these areas of transition; (7) Minor transition between Exmouth-Shark Bay regions and the Houtman Abrolhos.

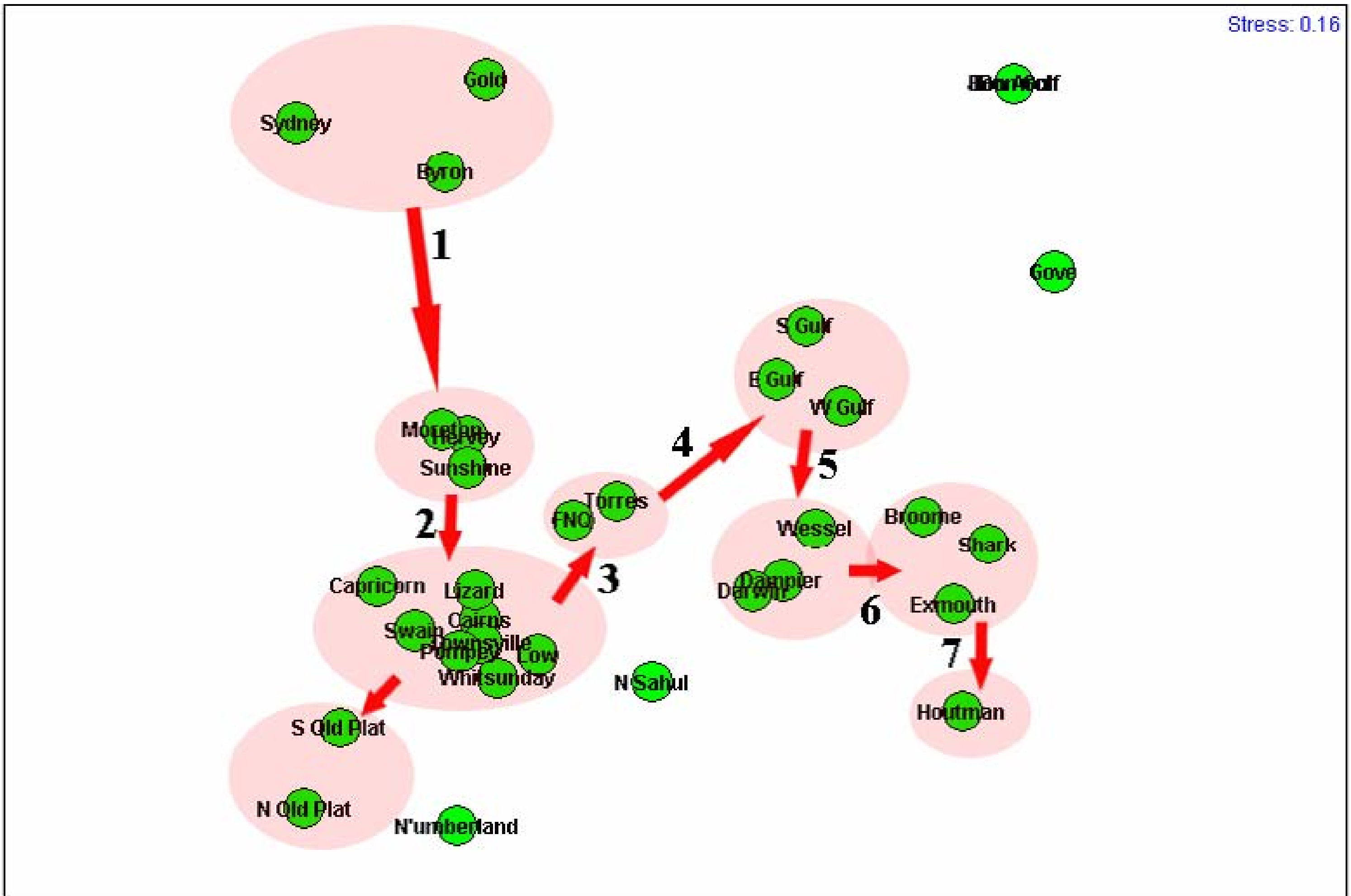

FIG. 25. MDS ordination of Jaccard Similarity matrix data for the 34 smaller scale localities (γ-scale diversity) (South Sahul Shelf not included owing to zero similarity to other sites). Numbers refer to transition zones mentioned in the text.

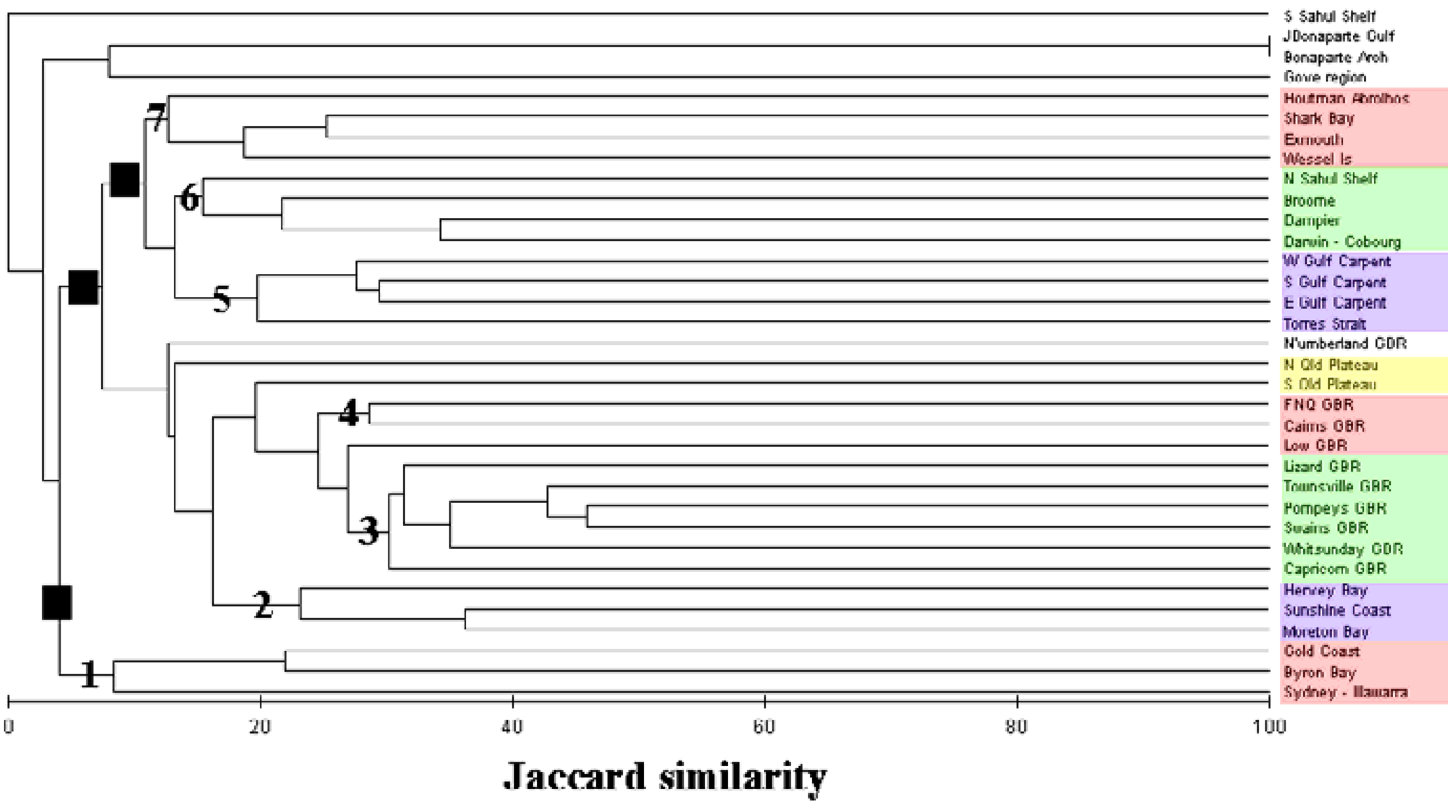

FIG. 26. Cluster analysis of Jaccard Similarity matrix data for the 34 smaller scale localities (γ-scale diversity). Numbers refer to cluster groups and black squares refer to major transitions zones mentioned in the text.

Cluster analysis (**Fig. 26**; see **Appendix 4** for data similarity matrix) showed a number of trends in β–diversity across the tropical Australian transect. Three major dichotomies are evident. Groups 5, 6 and 7 contain tropical west and north coast faunas, Groups 2, 3 and 4 contain tropical east coast faunas, and Group 1 contains a temperate-subtropical east coast fauna. These groups reflect major biogeographic trends discovered in other analyses (Hooper *et al.*, 2002).

Group 7 contains a mix of contiguous (Exmouth Gulf, Shark Bay, Houtman Abrolhos, all from Western Australia) and non-contiguous (Wessel Islands, Northern Territory) faunas, which as a group is more closely related to Groups 5 and 6 (consisting of western coast and north coast faunas, extending from the Dampier region, Western Australia, to the eastern Gulf of Carpentaria, Queensland). Of interest here is the inclusion of Torres Strait sampling sites in Group 5 together with the Gulf of Carpentaria localities under cluster analysis (**Fig. 26**), whereas under MDS analysis the Torres Strait fauna is more closely related to the Far Northern Queensland reefs of the Great Barrier Reef (**Fig. 25**), with faunal transition between them (transition point 3 in **Fig. 25**) less marked than between Torres Strait and the Gulf faunas (transition point 4). This suggests that species turnover at the Cape York boundary may occur moreso at the eastern edge (i.e. on the GBR side) than on the western edge (i.e. on the Gulf of Carpentaria side) of Cape York. Similarly, the fauna of the Wessel Islands region (11°30'S 136°25'E) in northern Australia appears to be more closely related to several west coast faunas (Group 7 in the cluster analysis, **Fig. 26**) than to the adjacent Darwin region (Group 6; 12°25'S 130°48'E), with species turnover less marked than other transition points (transition points 5-6 in **Fig. 25**). The conclusion from cluster and MDS analyses of west and north coast faunas, at the smaller locality (γ-scale) diversity, is that transition zones become progressively less obvious/ less marked as one moves westwards/ southwestwards along the transect from Cape York, with the exception of the Gulf of Carpentaria fauna (probably due to major ecological/habitat differences with adjacent localities; transition point 5 in **Fig. 25**), and the abrupt change at the Houtman Abrolhos (transition point 6, approximately 28°43'S 113°48'E; see also Fromont, 1999). Northern and Central GBR faunas form separate but closely related clusters (Groups 3-4 in **Fig. 25**). Limited genetic data on sponges (Wörheide *et al.*, 2002b; see **Fig. 19**) indicate a transition zone in the Central GBR region, somewhere between Mackay (21°09'S 149°12'E) and Townsville (19°15'S 146°50'E), but this transition is not clear from our faunal analyses, nor is it precise from the data presented by Wörheide *et al.* (2002b), who indicate some genetic mixing over several hundreds of kilometres within this region of the GBR. Nevertheless, the Northern and Central GBR reefs (with the northern boundary in the vicinity of Lizard Island and Ribbon Reefs, 14°40'S 145°28'E) are more-or-less distinct from the Far Northern GBR reefs (i.e. Cockburn Reef (11°50'S 143°18'E), Flinders Reefs, Howick Reefs, Turtle Group, and Shelburne Bay region). This relationship is stronger in ordination (MDS analysis, transition point 3 in **Fig. 25**) than cluster analysis (both localities grouped together in Group 4 in **Fig. 26**), indicating a more gradual transition occurring somewhere in the vicinity of the Far Northern GBR, but our data are not robust enough to accurately define any strong turnover point(s). Conversely, there is a much stronger divergence between faunas in the Southern GBR (Group 3 in **Fig. 26**) and the southern coastal reefs in Southeast Queensland (Group 2 in **Fig. 26**) with species turnover occurring in the vicinity of Fraser Island-Hervey Bay region (approximately 25°00'S 153°00'E, transition point 2, in **Fig. 25**). Of further interest here is the distinct break between these south east Queensland localities (Group 2 in **Fig. 26**) and more southern localities, from the Gold Coast extending down to Sydney (Group 1 in **Fig. 26**), with major transition between the Gold Coast and Moreton Bay regions (transition point 1 in **Fig. 25**). These data support an hypothesis of a sharp species turnover in the vicinity of the Tweed River (northern New South Wales – southern Queensland border; 28°11'S 153°34'E), based on *in situ* observations of tropical and temperate species co-occur at sampling sites but with different depth distributions (shallow and deeper, respectively; Davie & Hooper, 1998). Finally, irrespective of their amalgamation into a single faunistic group with the Byron Bay and Gold Coast faunas (under cluster analysis, Group 1 in **Fig. 26**), the Sydney region fauna differs more substantially from the other two localities (which have tropical elements), and is indicative of its nearly exclusive temperate origins.

Four offshore marine territories, the Queensland Plateau and Sahul Shelf off the northeast and northwest coasts respectively, show differing patterns of similarity (**Figs 25-26**). The Queensland Plateau fauna (with two localities, north and south), is more similar to the southern and central GBR faunas than to the far northern GBR and Torres Strait regions. Other studies have also shown them to have closer affinities to the western Pacific island faunas than do the GBR reefs, both in terms of species composition (Hooper *et al*., 2002) and genetic connectivity (Wörheide *et al*., 2002b). Conversely, the affinities of the Sahul Shelf faunas (with two localities, north and south) is not clear, falling between west and east coast faunas in both MDS and cluster analyses (**Figs 25-26**). South Sahul reefs (Clarke Reef and Rowley Shoals), were excluded from MDS analysis due to zero similarity with any other locality, skewing the other data trends, whereas North Sahul reefs (Ashmore and Hibernia Reefs and Cartier I.), show greater similarity to the northwest coast (present analysis) and Indo-Malay archipelago fauna (Hooper *et al*, 2002).

Localities of Northumberland Reefs, Rowley Shoals, Joseph Bonaparte Archipelago and Joseph Bonaparte Gulf are not resolved in terms of clear affinities with other faunas, either in cluster or MDS analyses, probably because all have low sample size and collection efforts applied to them (see **Appendix 4**). Nevertheless, the latter two localities are pivotal to the detection of delineating transition zones between north and west coast faunas, and should be considered a priority in future collection effort.

In summary, cluster groups depicted in ordinal space (MDS analysis; **Fig. 25**) illustrate the major faunal transition zones better than cluster analysis (**Fig. 26**). Three major sponge provinces are indicated, with smaller transitions occurring within these. **(1) *Temperate-subtropical east coast fauna***, with a south-north gradient extending from temperate to tropical influence and hard boundary in the vicinity of the Tweed River. This is a well-recognised biogeographic transition zone between Solanderian and Peronian Provinces. **(2) *Tropical east coast fauna***, containing (2a) a southern component, with moderately hard boundary somewhere north of Hervey Bay-Fraser Island; (2b) a central component, with soft boundary somewhere between Mackay and Townsville; (2c) a northern component, with one or more minor transitions in the Far Northern GBR leading to (2d) a major transition on the eastern edge (GBR side) of Cape York; and (2e) the Coral Sea Territories on the Queensland Plateau with affinities to the western Pacific islands faunas, such as Vanuatu, Papua New Guinea, Solomon Islands (Hooper, unpublished data), but also containing many elements of the north-central and southern GBR faunas. All of these transitions are undoubtedly related to genetic connectivity and modern-day current patterns (both endogenous and exogenous) that impact on the GBR and Coral Sea regions (see discussion in Wörheide *et al.*, 2002). A major hard boundary at Cape York is a recognised biogeographic boundary between the Dampierian and Solanderian Provinces. **(3) *Tropical northern and western fauna***, with several transitions that are not completely resolved by our data: (3a) the Gulf of Carpentaria which is markedly different from either adjacent eastern (Torres Strait) and western regions (Wessel Islands), and likely an ecological rather than biogeographic pattern; (3b) a moderately hard boundary at the Wessel Islands, differing moderately from Cobourg Peninsula and Darwin faunas (and probably representing a major species turnover point rather than a 'biodiversity hotspot' as indicated in previous analyses: Hooper *et al.*, 2002); (3c) one or more probable transitions west of the Darwin region to the North West Cape region, but these transitions are not well indicated by our data and appear to be less dramatic than on the east coast; and (3d) a significant boundary in the vicinity of Northwest Cape, with the Shark Bay and

Houtman Abrolhos faunas markedly different from the northwestern coastal and shelf faunas, but at this time it is uncertain whether this is a gradual (soft) or abrupt (hard) transition given the relative paucity of sponge data from the Exmouth and Ningaloo Reef regions. These patterns are illustrated in **Fig. 27**.

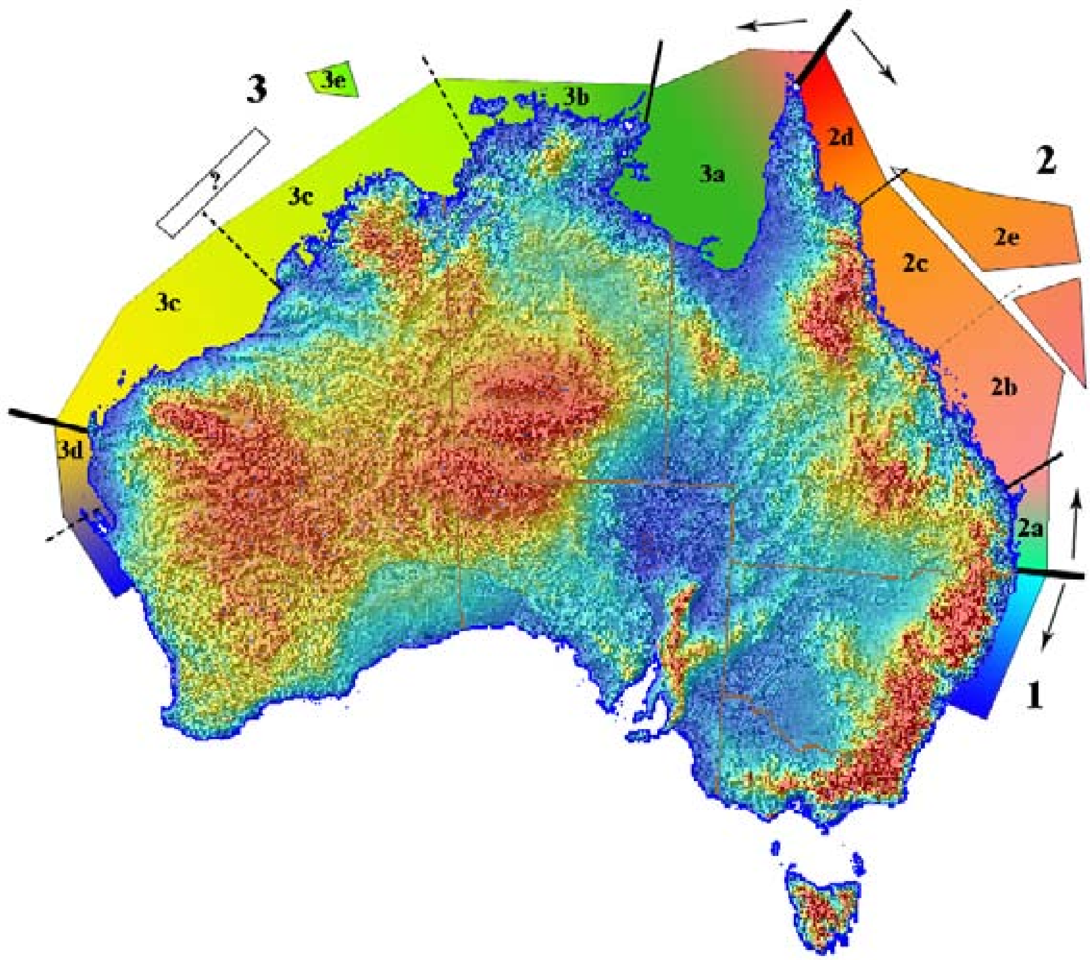

FIG. 27. Patterns of sponge distributions across tropical Australia based on similarities in species richness and taxonomic distributions for 34 smaller scale localities (γ-scale diversity). Numbers refer to major sponge provinces; letters refer to regional subdivisions within each province mentioned in the text; thickness of lines delimiting regions reflects confidence assessments applied to transition zones, mentioned in the text.

To test the strength of observed species turnover between temperate east, tropical east and tropical north and western faunas non-parametric 2-way nested Analyses of Similarity (ANOSIM) hypothesis tests were applied to the Jaccard similarity matrix data to determine the variation in biodiversity relationships, as an indicator of potential dispersal and connectivity between locality sponge assemblages (at the γ-scale diversity). Localities were grouped into classes according to *a priori* criteria: (A) five latitudinal clusters, and (B) six longitudinal clusters (**Table 4**), with the null hypothesis that there are no assemblage differences between groups of localities across latitudinal or longitudal gradients. ANOSIM analyses were also able to discriminate which of the factors (groups of localities) were significantly more different from others via pairwise comparisons (**Table 4, Fig. 28A-D**). There were no significant differences between latitude groups using longitude groups as samples (R=-0.436, Prob.= 0.999) (i.e. between-group similarities were not significantly greater than within-group similarities), and slightly more significance where latitude groups were averaged across all longitude groups (R=0.217, Prob.=0.074), with significance levels in pairwise tests between groups of localities varying from 73-100%. Conversely, there were significant differences between longitude groups using latitude groups as samples (R=0.609, Prob.=0.001), which was even more significantly different where longitude groups were averaged across all latitude groups (R=0.655, Prob.=0.0001), and significance levels from pairwise comparisons between groups ranging from 10-67%. These trends are illustrated in the histogram plots of factors (**Fig. 28**). In other words, latitudinal gradients in ß-diversity were not strong (or significantly different), moving from the temperate to tropical faunas, irrespective of whether east or west coast faunas, although differences between some groups of localities were greater than others, such as comparison of high latitude temperate faunas (Group 1) versus low latitude tropical faunas (Groups 4 and 5; **Table 4**). By comparison, longitudinal gradients in ß-diversity were markedly stronger (or significantly different), underlining the faunal changes across the transect from east to west (as depicted in **Fig. 27**).

Table 4A. Tests of significance between global R-values from analysis of similarity (2-way nested ANOSIM tests), comparing localities (γ-scale diversity) grouped *a priori* along geographic gradients: A, Latitude groups; B, Longitude groups. Refer to Table 4B for definition of locality groups.

Groups	**Global R statistic**	**Significance level %**	**Possible permutations**	**Actual permutations**
A. Latitude (nested within longitude groups)				
Global test: differences between **latitude groups** using longitude groups as samples: R = -0.436, Prob. = 99.9% (from 23648625 possible permutations, 999 actual permutations)				
Global test: differences between **longitude groups** averaged across all latutide groups: R = 0.655, Prob. = 0.01% (from a ‘large number’ of possible permutations, 999 actual permutations)				
Pairwise tests between latitude groups				
1,2	-0.75	100%	3	3
1,3	-0.167	90%	10	10
1,4	-0.071	73.3%	15	15

1,5	-0.25	80%	15	15
2,3	-0.667	100%	10	10
2,4	-0.536	100%	15	15
2,5	-0.536	100%	15	15
3,4	-0.204	77.1%	35	35
3,5	-0.315	100%	35	35
4,5	-0.677	100%	35	35
B. Longitude (nested within Latitude groups)				
Global test: differences between **longitude** groups using latitude groups as samples: R = 0.609, Prob. = 0.1% (from 21021000 possible permutations, 999 actual permutations)				
Global test: differences between **latitude** groups averaged across all longitude groups: R = 0.217, Prob. = 7.4% (from 42865200 possible permutations, 999 actual permutations)				
Pairwise tests between groups of **Longitude** classes				
1,2	0.074	20%	10	10
1,3	0.833	10%	10	10
1,4	0.875	10%	10	10
1,5	0.5	20%	10	10
1,6	0.815	10%	10	10
2,3	1	10%	10	10
2,4	0.75	10%	10	10
2,5	0.667	10%	10	10
2,6	1	10%	10	10
3,4	0	66.7%	3	3
3,5	0.75	33.3%	3	3
3,6	1	10%	10	10
4,5	0.25	33.3%	3	3
4,6	0.583	10%	10	10
5,6	0.833	10%	10	10

Table 4B. List of locality groups used in ANOSIM analyses.

Latitude groups	**Localities (refer to Appendix 2A for extent of locality boundaries)**
Group1 (35º-27ºS)	Sydney region, Byron Bay, Gold Coast, Moreton Bay region, Houtman Abrolhos
Group 2 (27º-23ºS)	Sunshine Coast, Hervey Bay region, Capricorn Bunkers, Shark Bay
Group 3 (23º-20ºS)	Swains, Northumberlands, Whitsundays, Pompeys, Sth Queensland Plateau, Exmouth region
Group 4 (20º-14ºS)	Townsville region, Cairns region, Low Is, Lizard Is region, Nth Queensland Plateau, Sth Gulf Carpentaria, Broome region, Sth Sahul Shelf, Dampier region
Group 5 (14º-9ºS)	Far Nth Queensland, Torres Straits, East Gulf Carpentaria, West Gulf Carpentaria, Gove region, Wessel Is, Darwin-Cobourg region, Joseph Bonaparte Gulf, Bonaparte Arch., Nth Sahul Shelf
Longitude groups	
Group 1 (157º-151ºE)	Sydney region, Byron Bay, Gold Coast, Moreton Bay region, Sunshine Coast, Hervey Bay region, Capricorn Bunkers, Swains, Northumberlands, Sth Queensland Plateau
Group 2 (151º-142ºE)	Whitsundays, Pompeys, Townsville region, Cairns region, Low Is, Lizard Is region, Nth Queensland Plateau, Far Nth Queensland, Torres Straits
Group 3 (142º-130ºE)	East Gulf Carpentaria, West Gulf Carpentaria, Sth Gulf Carpentaria, Gove region, Wessel Is, Darwin-Cobourg region
Group 4 (130º-122ºE)	Joseph Bonaparte Gulf, Bonaparte Arch., Broome region
Group 5 (122º-118ºE)	Nth Sahul Shelf, Sth Sahul Shelf, Dampier region
Group 6 (118º-112ºE)	Exmouth region, Shark Bay, Houtman Abrolhos

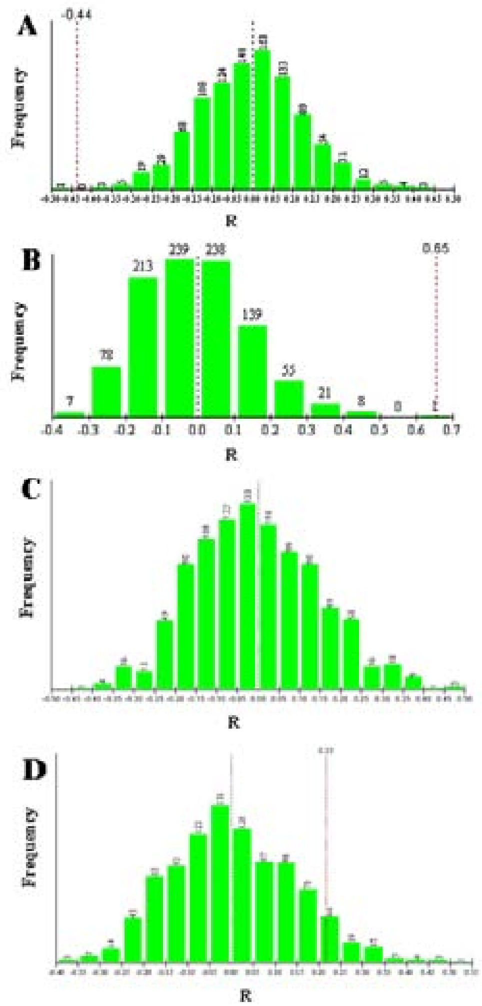

FIG. 28A-D. Frequency histograms of analysis of similarity (2-way nested ANOSIM tests), comparing localities (γ-scale diversity) grouped *a priori* along geographic gradients. A, Differences between Longitude groups (averaged across all Latitude groups). B, Differences between Latitude groups (using Longitude groups as samples). C, Differences between Latitude groups (averaged across all Longitude groups). D, Differences between Longitude groups (using Latitude groups as samples).

Taxonomic Distinctness Analysis was conducted on different taxonomic hierarchies (species, genus and family level taxa), for species presence/ absence data within each of the 34 localities (ß-scale diversity). This procedure measured the relatedness between any two taxa in a community sample, with the null hypothesis that a species/ genus/ family list from any particular site has the same taxonomic distinctness structure as the master list from which it was drawn (i.e. the list containing all species from all sites in tropical Australia). These results are presented as two-dimensional plots of 95% probability ellipses based on simulated distributions using sampling subsets from M=20 to M=100 (where M is an 'optimum taxonomic mapping statistic' based on the number of taxa in the single selected sample; Warwick & Clarke, 2001). Pairs of Average Taxonomic Distinctness (AvTD or delta+) and Variation in Taxonomic Distinctness (VarTD or lambda+) datapoints were calculated from the real sponge dataset, for each of the 34 localities, and superimposed within these probability ellipses (**Fig. 29A-C**), with summary diversity indices statistics presented (**Table 5,7,9**), and regression analyses conducted on each of datasets for the three taxonomic hierarchies (**Tables 6,8,10**) as a statistical test for contribution to overall community heterogeneity.

For species-level taxa (**Fig. 29A**), most sites fall within the M=60 simulated probability envelope of the 95% predicted range for Average Taxonomic Distinctness (delta+). Eight localities deviate most from general community structure, falling outside the M=40 95% simulated probability envelope. Three localities are undersampled (Southern Sahul Shelf, Joseph Bonaparte Gulf and Bonaparte Archipelago), all with relatively lower species richness (d) and species diversity (H'), and relatively high Average Taxonomic Distinctness (delta+) of all localities sampled, deviating the most from the general geographic regional community pattern (**Table 5**). Similarly, these three localities are also significantly under-represented in terms of their habitat heterogeneity (or unevenness), as measured by relatively low Variation in Taxonomic Distinctness (or lambda+), representing least heterogeneity of all localities in terms of community structure. Conversely, five localities have relatively high taxonomic distinctness and greatest heterogeneity in community structure (Wessel Islands, Gove region, Gold Coast, Southern and Western Gulf of Carpentaria). The contribution to overall community heterogeneity by these eight groups of localities is statistically highly significant (F=10.988, Prob.=0.002) (**Table 6**).

Table 5. Species level of taxonomy: Taxonomic Distinctness analyses statistics for localities (γ-scale diversity): species richness (S), Margalef species richness (d), Shannon-Wiener diversity index (*H'*(log_e)), Average taxonomic distinctness (*AvTD or Δ*+[*Delta*+]), Variation in taxonomic distinctness (*VarTD or Λ*+ [*Lambda*+]), Average Phylogenetic diversity (*Phi*+ or *ϕ*+), and Total Phylogenetic diversity (*sϕ*+), based on species presence/ absence data for each of the 34 localities.

Locality	No. species (S)	Margalef species richness (d)	Shannon-Wiener diversity index (H'(loge))	Average taxonomic distinctness (Delta+)	Variation in taxonomic distinctness (Lambda+)	Average phylogenetic diversity (Phi+)	Total phylogenetic diversity (sPhi+)
Sydney region	153	30.21606	5.030438	63.99495	125.0142	30.93682	4733.333
Byron Bay	60	14.41012	4.094345	63.46516	122.8326	40	2400
Gold Coast	40	10.57232	3.688879	63.09829	176.3693	40.41667	1616.667
Moreton Bay	214	39.69455	5.365976	64.41505	99.44271	29.43925	6300
Sunshine Coast	233	42.5607	5.451038	64.52568	105.1583	28.96996	6750
Hervey Bay	110	23.18912	4.70048	63.6169	106.4899	33.63636	3700
Capricorn-Bunkers	387	64.78222	5.958425	65.87808	129.425	26.27046	10166.67
Swains	304	52.99957	5.717028	64.64413	119.0867	27.30263	8300
Northumberlands	36	9.766936	3.583519	63.4127	81.56337	44.44444	1600
Whitsundays	135	27.31753	4.905275	63.2412	99.40801	31.85185	4300
Pompeys	162	31.64559	5.087596	63.53424	122.3565	30.04115	4866.667
Townsville	239	43.4587	5.476464	63.88899	110.0136	28.45188	6800

region							
Cairns region	99	21.32697	4.59512	64.24105	100.3946	36.36364	3600
Low Isles region	131	26.66559	4.875197	63.57213	93.02055	32.31552	4233.333
Lizard I. region	464	75.40858	6.139885	64.39745	120.3622	24.56897	11400
N Qld Plateau	106	22.51557	4.663439	64.27673	128.0608	32.86164	3483.333
S Qld Plateau	97	20.98493	4.574711	66.45905	119.8738	37.45704	3633.333
Far N Qld region	146	29.09539	4.983607	63.38844	113.958	32.07763	4683.333
Torres Strait	135	27.31753	4.905275	63.17487	115.9014	30.74074	4150
E Gulf Carpentaria	92	20.12478	4.521789	62.62542	105.3039	35.68841	3283.333
S Gulf Carpentaria	85	18.90763	4.442651	62.2409	130.7394	35.09804	2983.333
W Gulf Carpentaria	53	13.09727	3.970292	62.25206	132.7044	35.22013	1866.667
Gove region	13	4.678455	2.564949	61.96581	155.9646	50	650
Wessel Is	55	13.4753	4.007333	60.93154	142.7536	39.09091	2150
Darwin-Cobourg	395	65.89857	5.978886	63.31791	88.47028	25.23207	9966.667
Joseph Bonaparte Gulf	12	4.426726	2.484907	65.15152	31.37435	62.5	750
Bonaparte Arch	12	4.426726	2.484907	65.15152	31.37435	62.5	750
Broome region	84	18.73244	4.430817	63.29126	97.13599	35.51587	2983.333
N Sahul Shelf	124	25.51718	4.820282	63.69656	80.8935	35.61828	4416.667
S Sahul Shelf	2	1.442695	0.693147	66.66667	0	83.33333	166.6667
Dampier region	347	59.15213	5.849325	63.7776	87.87212	26.08069	9050
Exmouth region	45	11.55868	3.806662	62.62626	89.73574	41.11111	1850
Shark Bay	50	12.52549	3.912023	63.12925	100.8654	43.33333	2166.667
Houtman Abrolhos	130	26.50212	4.867534	62.80859	96.85576	34.10256	4433.333

Table 6. Regression analysis of Average Taxonomic Distinctness (AvTD, Delta+) and Variation in Taxonomic Distinctness (VarTD, Lambda+) for species-level taxonomic presence-absence data for the 34 localities (γ-scale diversity).

Regression Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.512	.262	.238	1.0643
A Predictors: (Constant), Lambda+				

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	12.446	1	12.446	10.988	.002
	Residual	35.113	31	1.133		
	Total	47.559	32			
a Predictors: (Constant), Lambda+. b Dependent Variable: Delta+						

At the genus level of taxonomy (**Fig. 29B, Table 7**), taxonomic distinctness statistics are less robust, with most sites falling within only the M=40 95% simulated probability envelope, but species-level patterns are preserved. The same three localities detected in species-level taxonomic analyses were undersampled and least heterogenous in terms of community structure (Southern Sahul Shelf, Joseph Bonaparte Gulf and Bonaparte Archipelago), and two (Wessel

Islands and Houtman Abrolhos) had relatively high taxonomic distinctness and greatest heterogeneity in community structure, with differences statistically significant (F=9.097, P=0.005) (**Table 8**). The genus-level taxonomic dataset was analysed further, below.

Table 7. Genus level of taxonomy: Taxonomic Distinctness analyses statistics for localities (γ-scale diversity): species richness (S), Margalef species richness (d), Shannon-Wiener diversity index (*H'(log$_e$)*), Average taxonomic distinctness (*AvTD or Δ*+[*Delta*+]), Variation in taxonomic distinctness (*VarTD or Λ*+ [*Lambda*+]), Average Phylogenetic diversity (*Phi*+ or *ϕ*+), and Total Phylogenetic diversity (*sϕ*+), based on species presence/ absence data for each of the 34 localities.

Locality	S	d	H'(loge)	Delta+	Lambda+	Phi+	sPhi+
Sydney region	153	30.21606	5.030438	66.37341	168.8048	36.47449	2917.959
Byron Bay	60	14.41012	4.094345	65.22333	184.3252	43.65255	1877.06
Gold Coast	40	10.57232	3.688879	67.58469	179.3134	45.43541	1272.192
Moreton Bay	214	39.69455	5.365976	67.34139	139.7277	36.95086	3658.135
Sunshine Coast	233	42.5607	5.451038	67.29588	130.2552	36.20798	3838.046
Hervey Bay	110	23.18912	4.70048	66.54843	115.8386	41.0771	2505.703
Capricorn-Bunkers	387	64.78222	5.958425	69.05471	141.704	34.98369	4967.684
Swains	304	52.99957	5.717028	68.36576	154.807	35.57261	4339.859
Northumberlands	36	9.766936	3.583519	66.14856	108.8984	48.25453	1351.127
Whitsundays	135	27.31753	4.905275	65.28377	144.8033	37.88066	2765.288
Pompeys	162	31.64559	5.087596	67.4281	162.8984	36.21415	2897.132
Townsville region	239	43.4587	5.476464	66.51706	145.9713	35.49754	3762.739
Cairns region	99	21.32697	4.59512	66.25553	147.7386	38.38687	2610.307
Low Isles region	131	26.66559	4.875197	66.1042	141.725	37.50751	2738.048
Lizard I. region	464	75.40858	6.139885	67.43204	154.5545	34.32229	4942.41
N Qld Plateau	106	22.51557	4.663439	67.81942	142.9325	41.92632	2305.948
S Qld Plateau	97	20.98493	4.574711	69.89082	147.4661	42.27022	2705.294
Far N Qld region	146	29.09539	4.983607	66.57267	143.9991	37.11761	3006.526
Torres Strait	135	27.31753	4.905275	65.44996	138.1695	38.85681	2564.55
E Gulf Carpentaria	92	20.12478	4.521789	65.92453	110.695	39.80932	2348.75
S Gulf Carpentaria	85	18.90763	4.442651	66.1022	96.16932	43.93413	2108.838
W Gulf Carpentaria	53	13.09727	3.970292	66.00477	113.6612	49.15479	1327.179
Gove region	13	4.678455	2.564949	64.99932	172.2436	58.25568	582.5568
Wessel Is	55	13.4753	4.007333	62.99222	216.526	41.21844	1648.738
Darwin-Cobourg	395	65.89857	5.978886	66.10731	131.4451	33.83685	4669.485
Joseph Bonaparte Gulf	12	4.426726	2.484907	67.62764	68.13522	62.10635	745.2762
Bonaparte Arch	12	4.426726	2.484907	67.62764	68.13522	62.10635	745.2762
Broome region	84	18.73244	4.430817	65.87729	147.0907	41.61908	2122.573
N Sahul Shelf	124	25.51718	4.820282	66.85324	110.1048	38.43549	3151.71
S Sahul Shelf	2	1.442695	0.693147	69.87728	0	84.93864	169.8773
Dampier region	347	59.15213	5.849325	66.33564	135.8022	34.27649	4490.221
Exmouth region	45	11.55868	3.806662	64.96368	132.593	42.12632	1474.421
Shark Bay	50	12.52549	3.912023	65.02653	159.6153	44.71661	1788.664
Houtman	130	26.50212	4.867534	63.96675	153.29	40.02827	3082.177

Abrolhos							

Table 8. Regression analysis of Average Taxonomic Distinctness (AvTD, Delta+) and Variation in Taxonomic Distinctness (VarTD, Lambda+) for genus-level taxonomic presence-absence data for the 34 localities (γ-scale diversity).

Regression Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.470	.221	.197	1.3313
a Predictors: (Constant), Lambda+				

ANOVA						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.123	1	16.123	9.097	.005
	Residual	56.715	32	1.772		
	Total	72.838	33			
A Predictors: (Constant), Lambda+. b Dependent Variable: Delta+						

Family level taxonomic distinctness analysis (**Fig. 29C**) was far less informative, with few of the 34 localities lying within the 95% probability envelope at the M=40 level or above, with the west and north coast localities appearing to deviate more from general community patterns (showing lower taxonomic distinctness and heterogeneity in community structure) than east coast localities (**Table 9**), although these differences are not statistically significant (F=0.666, Prob.=0.420) (**Table 10**), and possibly indicate that most localities are undersampled and homogeneous in terms of taxonomic distinctness at the family level of taxonomy. These results indicate that with several exceptions noted above the modelled 95% probability contour is a reasonable fit for all localities at the species- and genus-levels, but not at the family-level demonstrating that the latter is an inadequate surrogate for true (species-level) sponge biodiversity estimates, as concluded previously by Hooper *et al.* (2002).

Table 9. Family level of taxonomy: Taxonomic Distinctness analyses statistics for localities (γ-scale diversity): species richness (S), Margalef species richness (d), Shannon-Wiener diversity index (*H'(log$_e$)*), Average taxonomic distinctness (*AvTD or Δ*+[*Delta*+]), Variation in taxonomic distinctness (*VarTD or Λ*+ [*Lambda*+]), Average Phylogenetic diversity (*Phi*+ or *ϕ*+), and Total Phylogenetic diversity (*sϕ*+), based on species presence/ absence data for each of the 34 localities.

Locality	S	d	H'(loge)	Delta+	Lambda+	Phi+	sPhi+
Sydney region	153	30.21606	5.030438	61.4647	201.3595	41.67726	1500.381
Byron Bay	60	14.41012	4.094345	59.11378	206.3424	42.90028	1201.208
Gold Coast	40	10.57232	3.688879	63.12731	162.482	49.76628	846.0267
Moreton Bay	214	39.69455	5.365976	60.92274	171.8047	39.93828	1917.038
Sunshine Coast	233	42.5607	5.451038	61.21354	129.1437	41.52926	1951.875
Hervey Bay	110	23.18912	4.70048	59.28425	122.0704	42.94614	1503.115
Capricorn-	387	64.78222	5.958425	63.8687	189.5054	38.58766	2392.435

Bunkers							
Swains	304	52.99957	5.717028	63.52975	193.3277	40.51626	2147.362
Northumberlands	36	9.766936	3.583519	58.43343	88.39324	47.34901	946.9803
Whitsundays	135	27.31753	4.905275	57.29624	171.6611	41.67726	1500.381
Pompeys	162	31.64559	5.087596	62.04716	192.9486	43.34542	1473.744
Townsville region	239	43.4587	5.476464	59.52072	179.7401	39.48006	1855.563
Cairns region	99	21.32697	4.59512	58.14429	154.0369	42.40118	1441.64
Low Isles region	131	26.66559	4.875197	57.93667	154.557	39.60929	1465.544
Lizard I. region	464	75.40858	6.139885	62.13911	188.7323	39.05632	2304.323
N Qld Plateau	106	22.51557	4.663439	61.28071	125.8885	44.21885	1415.003
S Qld Plateau	97	20.98493	4.574711	64.77208	160.5474	44.071	1674.698
Far N Qld region	146	29.09539	4.983607	58.98887	170.0401	39.64399	1585.76
Torres Strait	135	27.31753	4.905275	57.61159	165.6437	41.11162	1438.907
E Gulf Carpentaria	92	20.12478	4.521789	57.92682	101.3192	39.94615	1358.169
S Gulf Carpentaria	85	18.90763	4.442651	56.78229	128.632	39.94615	1358.169
W Gulf Carpentaria	53	13.09727	3.970292	58.11159	96.66455	44.96413	944.2467
Gove region	13	4.678455	2.564949	58.03515	98.59855	58.26446	466.1157
Wessel Is	55	13.4753	4.007333	57.94481	190.8197	45.1309	992.8798
Darwin-Cobourg	395	65.89857	5.978886	58.8071	182.4731	38.59331	2122.632
Joseph Bonaparte Gulf	12	4.426726	2.484907	59.14003	69.50725	56.22146	618.4361
Bonaparte Arch	12	4.426726	2.484907	59.14003	69.50725	56.22146	618.4361
Broome region	84	18.73244	4.430817	59.29032	131.3253	43.06845	1292.053
N Sahul Shelf	124	25.51718	4.820282	59.55646	106.1754	42.52555	1743.547
S Sahul Shelf	2	1.442695	0.693147	61.47489	0	80.73744	161.4749
Dampier region	347	59.15213	5.849325	60.4828	144.1683	40.95334	2088.62
Exmouth region	45	11.55868	3.806662	56.47163	135.5934	41.33676	909.4088
Shark Bay	50	12.52549	3.912023	58.96874	147.4702	43.40138	1171.837
Houtman Abrolhos	130	26.50212	4.867534	55.45728	199.9991	39.00191	1794.088

Table 10. Regression analysis of Average Taxonomic Distinctness (AvTD, Delta+) and Variation in Taxonomic Distinctness (VarTD, Lambda+) for family-level taxonomic presence-absence data for the 34 localities (γ-scale diversity).

Regression Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.143	.020	-.010	2.2338
a Predictors: (Constant), Lambda+				

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	3.325	1	3.325	.666	.420
	Residual	159.676	32	4.990		
	Total	163.001	33			
a Predictors: (Constant), Lambda+. b Dependent Variable: Delta+						

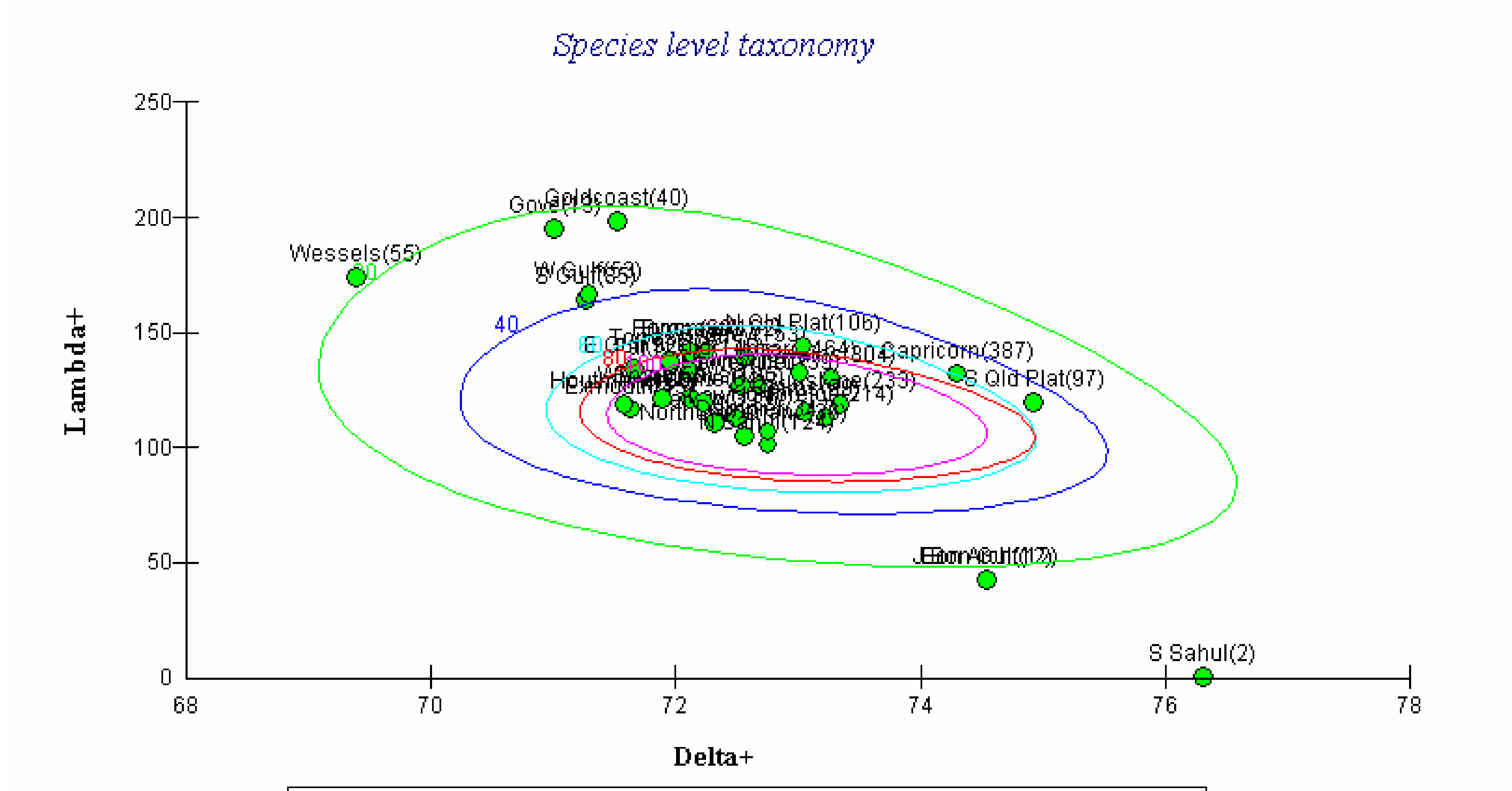

Fig. 29A. Average Taxonomic Distinctness (*AvTD or delta* +) and Variation in Taxonomic Distinctness (*VarTD or lambda* +) plots of species level taxa for presence-absence data, superimposed on 95% probability ellipses from simulated data for each sublist (M=20-100). Number of species in each locality (γ-scale diversity) is indicated in brackets.

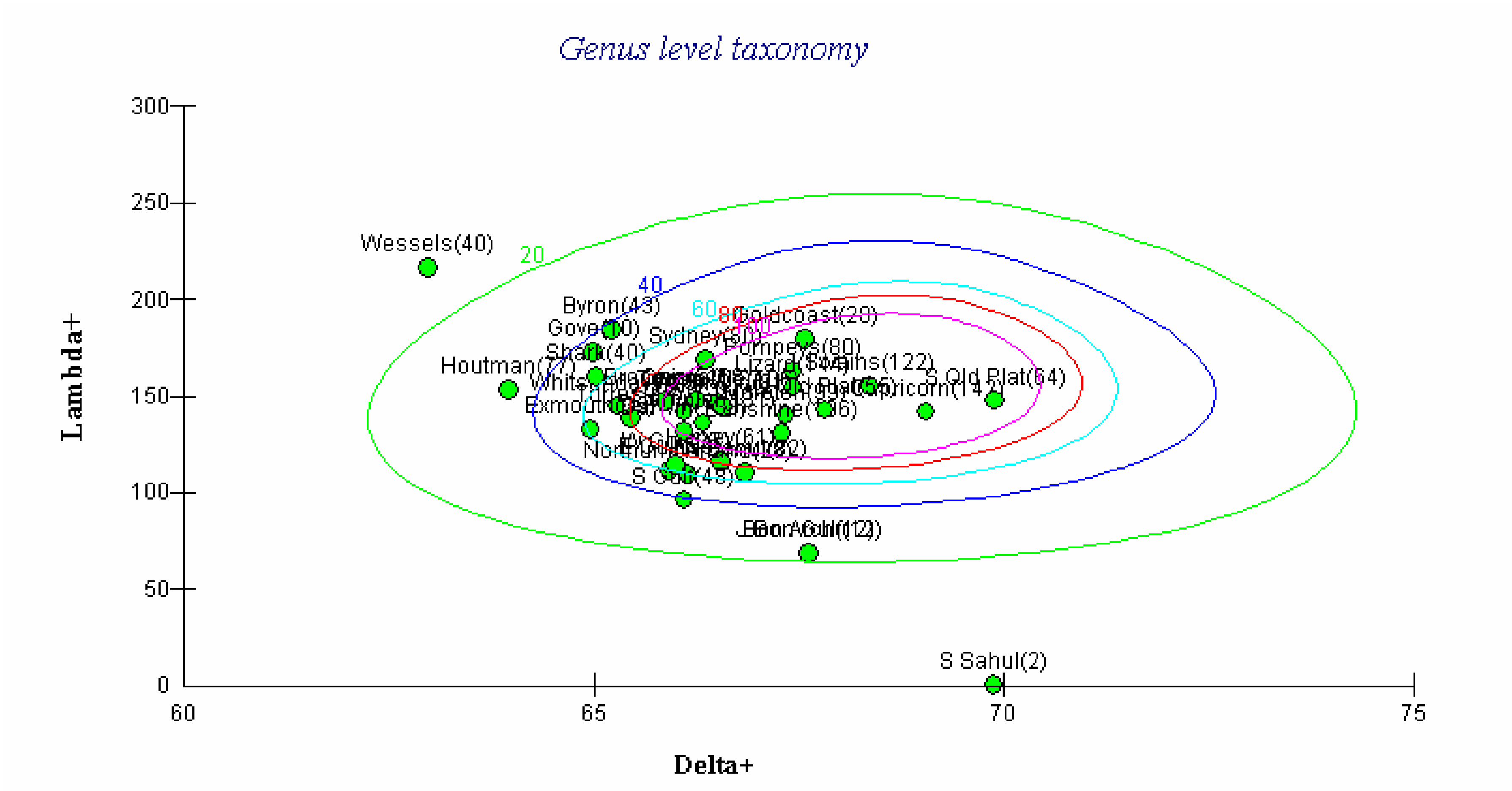

Fig. 29B. Average Taxonomic Distinctness (*AvTD or delta* +) and Variation in Taxonomic Distinctness (*VarTD or lambda* +) plots of genus level taxa for presence-absence data, superimposed on 95% probability ellipses from simulated data for each sublist (M=20-100). Number of species in each locality (γ-scale diversity) is indicated in brackets.

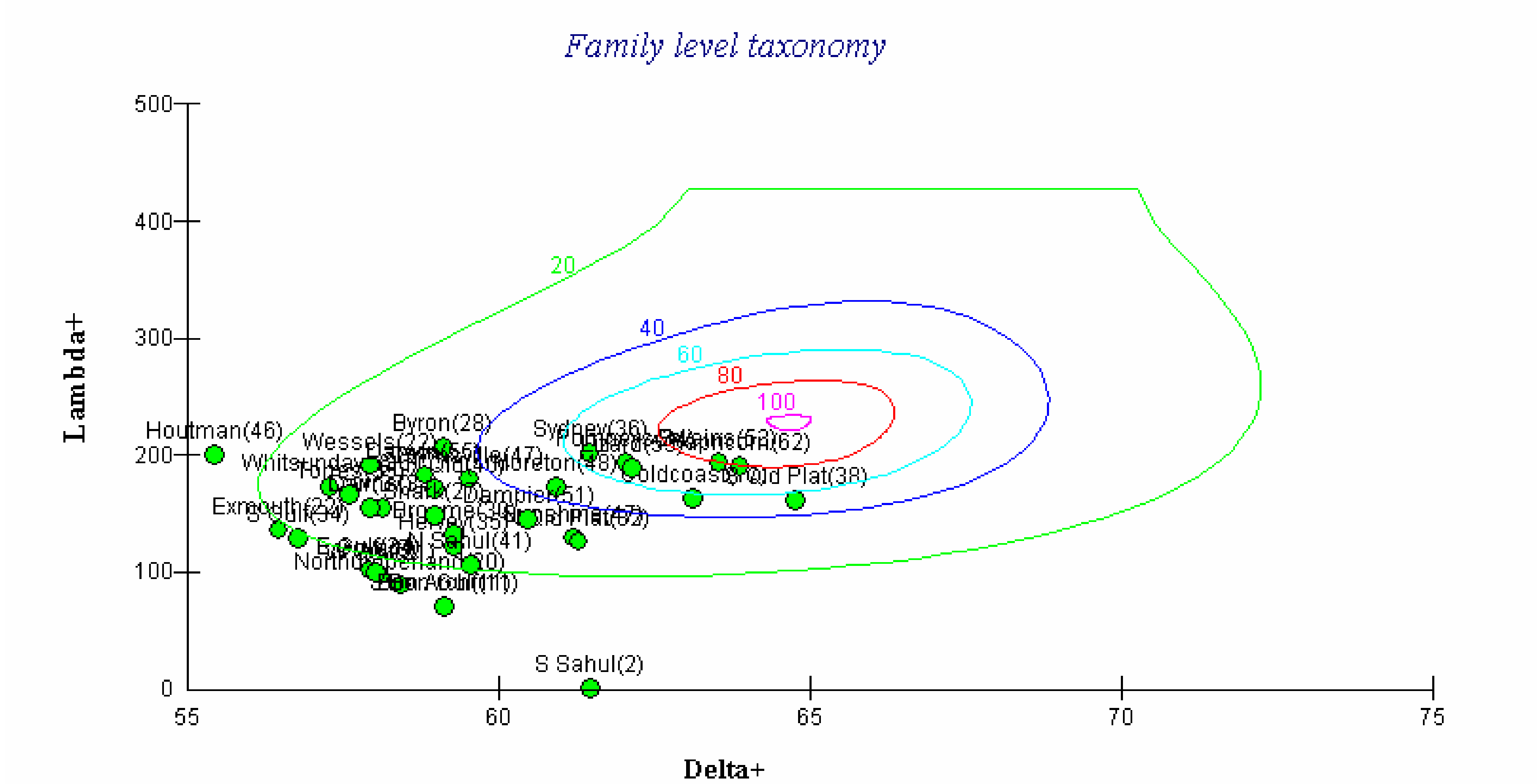

Fig. 29C. Average Taxonomic Distinctness (*AvTD or delta* +) and Variation in Taxonomic Distinctness (*VarTD or lambda* +) plots of family level taxa for presence-absence data, superimposed on 95% probability ellipses from simulated data for each sublist (M=20-100). Number of species in each locality (γ-scale diversity) is indicated in brackets.

Due to the large size of the dataset it was not possible to analyse the species-level dataset further using probability funnels in the Taxonomic Distinctness Analysis (presumably there are data size limitations in the Primer software program). However, as the genus-level data were shown to be potentially useful surrogates of the species-level dataset, at the smaller locality spatial scale (γ-scale diversity) at least, this dataset was analysed for Average Taxonomic Distinctness (Delta+) and Variation in Taxonomic Distinctness (Lambda+) separately, to examine the effects of heterogeneity in taxonomic richness and uniqueness on the Taxonomic Distinctness Analysis statistics (**Table 11, Figs 30A-B)**. Localities falling within the 95% probability funnel are not statistically significant from the general community structure for the whole dataset, whereas those falling outside the probability funnel deviate significantly from this general model.

In the case of Average Taxonomic Distinctness (**Fig. 30A**), there is a clear sequence of localities with relatively high richness (e.g. Lizard Island region, Capricorn Bunker Group, Swain Reefs, Darwin-Cobourg Peninsula region, Dampier region) to relatively low richness (e.g. Gold Coast region, Gulf of Carpentaria, Gove region) which nevertheless contain similar taxonomic community structure, and suggesting that samples are a true (or adequate) reflection of community structure for these particular localities. These data support the notion of several 'biodiversity hotspots' across the tropical faunas, detected in earlier analysis, supporting their recognition as biological phenomena rather than sampling artifacts. The exception is the locality of the Wessel Islands, delineated as a 'hotspot' by Hooper *et al.* (2002), which appears to differ substantially in community structure with relatively low taxonomic richness, and as such should probably be recognized as a species turnover / transition point, rather than a 'biodiversity hotspot'. Conversely, there are several taxa that fall close to or outside of the probability funnel (e.g. Byron Bay, South Queensland Plateau, Whitsunday Islands, Torres Strait, Wessel Islands, Exmouth, Shark Bay, Houtman Abrolhos), with a range taxonomic richness values, but differing significantly from general community structure. These latter localities, not surprisingly, correspond to the species turnover points, or transition zones, detected in similarity/ MDS analyses and depicted in **Fig. 27**. Analysis Variation in Taxonomic Distinctness in relation to taxonomic richness (**Fig. 30B**) shows the Wessel Islands with significantly higher community heterogeneity, and several localities (Hervey Bay, Eastern and Southern Gulf of Carpentaria, North Sahul Shelf) with significantly lower heterogeneity than general community structure. One significant conclusion from this analysis, therefore, was the strengthening of the confidence limit for a transition zone at the Wessel Islands (**Fig. 27**).

Table 11. Average Taxonomic Distinctness (AvTD, Delta+) and Variation in Taxonomic Distinctness (Lambda+) for genus-level taxonomic presence-absence data for the 34 localities (γ-scale diversity), and significance levels based on comparisons to the general community structure.

Locality	M	Delta+ value	Delta+ signif. %	Lambda+ value	Lambda+ signif. %
Sydney region	80	66.37	8.4	168.80	29.6
Byron Bay	43	65.22	6.0	184.33	18.2
Gold Coast	28	67.58	73.5	179.31	31.6
Moreton Bay	99	67.34	37.2	139.73	47.0
Sunshine Coast	106	67.30	33.2	130.26	15.8
Hervey Bay	61	66.55	17.0	115.84	9.6
Capricorn-Bunkers	142	69.05	27.2	141.70	46.2
Swains	122	68.37	89.9	154.81	70.9
Northumberlands	28	66.15	35.2	108.90	24.2
Whitsundays	73	65.28	0.8	144.80	84.7
Pompeys	80	67.43	52.1	162.90	42.6
Townsville region	106	66.52	6.8	145.97	86.1
Cairns region	68	66.26	11.6	147.74	96.3
Low Isles	73	66.10	7.6	141.72	72.3
Lizard I. region	144	67.43	31.2	154.55	68.3
N Qld Plateau	55	67.82	75.9	142.93	88.5
S Qld Plateau	64	69.89	17.0	147.47	97.5
Far N Qld	81	66.57	14.8	144.00	80.7
Torres Strait	66	65.45	3.0	138.17	65.9
E Gulf Carpentaria	59	65.92	8.0	110.70	4.4
S Gulf Carpentaria	48	66.10	14.6	96.17	1.8
W Gulf Carpentaria	27	66.00	28.6	113.66	27.0
Gove region	10	65.00	37.6	172.24	46.2
Wessels	40	62.99	0.6	216.53	2.0
Darwin-Cobourg	138	66.11	0.4	131.45	13.8
J Bonaparte Gulf	12	67.63	86.9	68.14	15.8
Bonaparte Arch	12	67.63	91.3	68.14	14.8
Broome region	51	65.88	11.8	147.09	98.1
N Sahul Shelf	82	66.85	22.6	110.10	0.8
S Sahul Shelf	2	69.88	100.0	0.00	100.0
Dampier region	131	66.34	1.2	135.80	22.6
Exmouth region	35	64.96	7.6	132.59	65.9
Shark Bay	40	65.03	6.2	159.62	60.5
Houtman Abrolhos	77	63.97	0.2	153.29	79.1

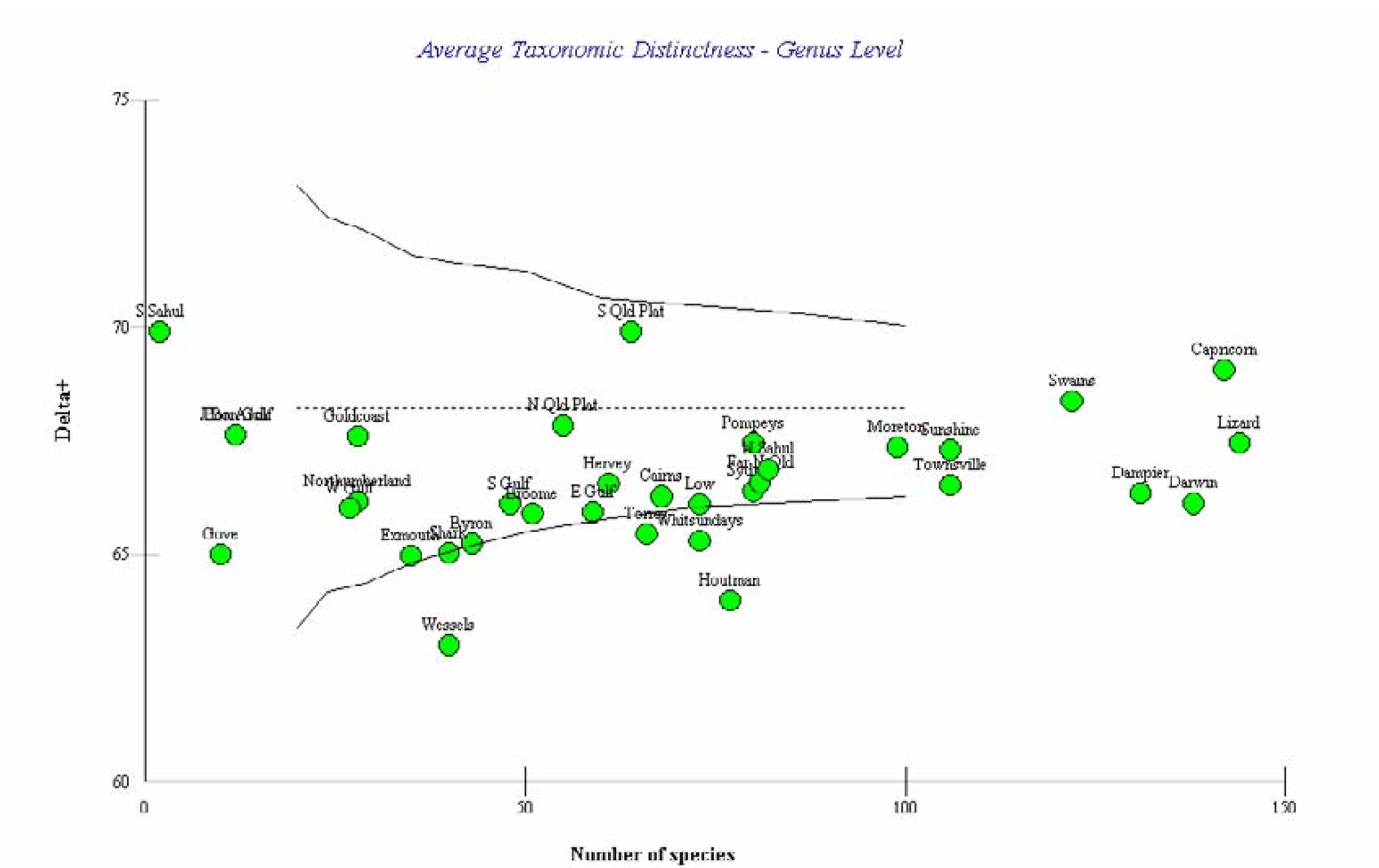

Fig. 30A. Average Taxonomic Distinctness (*AvTD or delta* +) related to generic diversity, superimposed on 95% probability funnels from the simulated dataset, for 34 smaller-scale locality data (γ-scale diversity).

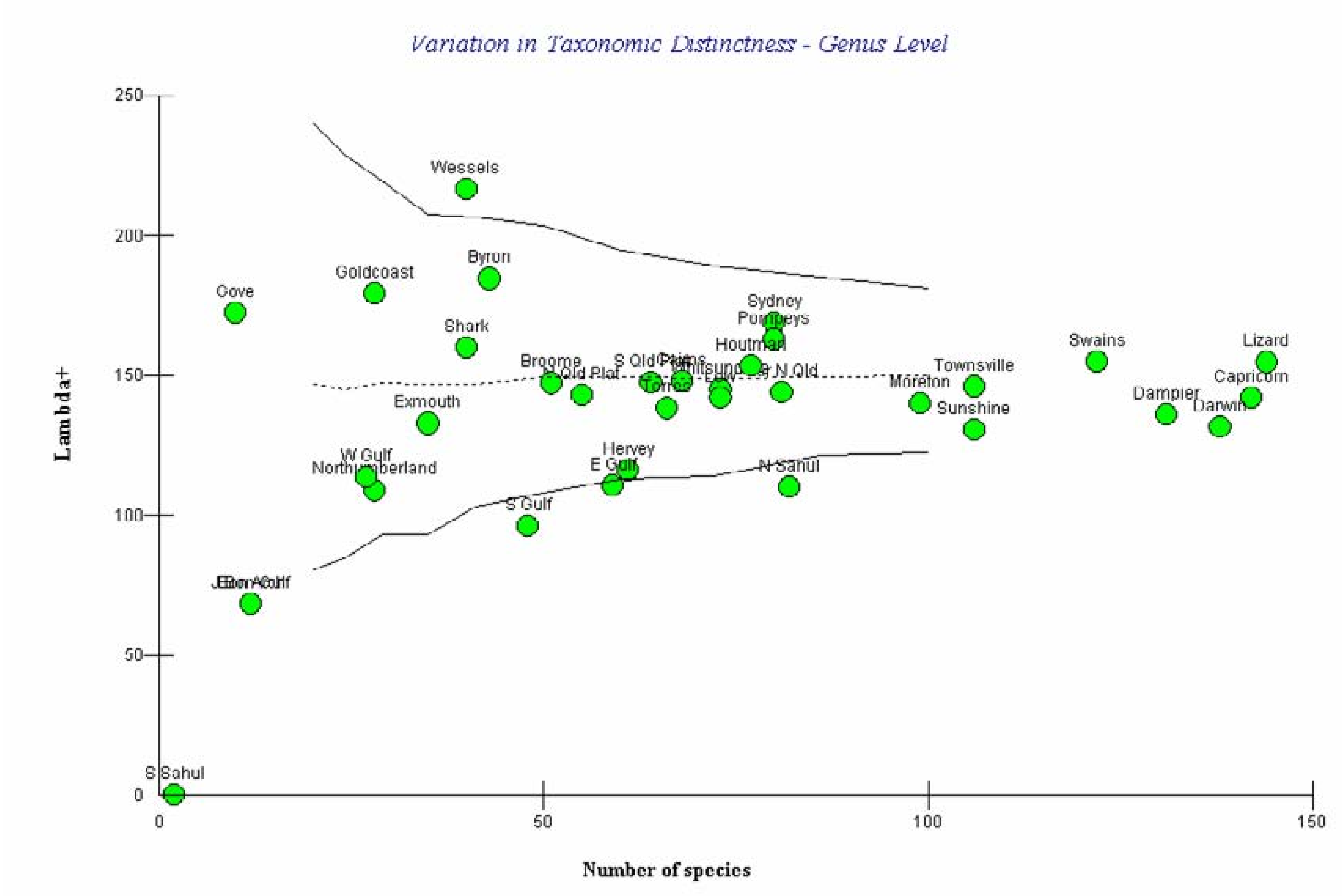

Fig. 30B. Variation in Taxonomic Distinctness (*VarTD or lambda* +) related to generic diversity, superimposed on 95% probability funnels from the simulated dataset, for 34 smaller-scale locality data (γ-scale diversity).

3.3.2. Bioregions (ε-scale diversity)

Species presence-absence data were amalgamated into larger-scale spatial units (ε-scale diversity) defined *a priori* by the IMCRA demersal bioregions (provinces and biotones) (**Fig. 1**) (henceforth referred to as **bioregions**). Here we analyse only the tropical and subtropical components our datasets, excluding the southeastern temperate fauna of Sydney-Illawarra-Newcastle area (CEP bioregion), which has been dealt with in the smaller-scale (locality) analysis. Analysis of the larger scale bioregions is provided here in an attempt to provide material to assist with the characterisation of the existing IMCRA demersal bioregions, which should be used in conjunction with the subjective lists of species we have provided that are unique components of these bioregions.

Within the tropical transect from the Byron Bay–Tweed River region to the Houtman Abrolhos (both recognised as tropical-temperate overlap zones: Wilson & Allen, 1987; including their sponge faunas: Davie & Hooper, 1998; Fromont, 1999), there are eight defined IMCRA demersal bioregions (**Fig. 1**), extending from the Central Eastern Biotome (CEB) to the Central Western Province (CWP), respectively. In this analysis we split the Northern Province (NP) into two regions, ENP and WNP, based on our knowledge of the sponge fauna which changes substantially between Cape York and Darwin, which provides us with a convenient vehicle to differentiate between eastern and western components of this province, although we do not necessarily advocate their recognition as separate bioregional provinces based solely on sponge data. Thus, **nine tropical bioregions** are delineated in this present study, with the term 'tropical' also encompassing subtropical faunas.

Of the 2,249 species included in analyses, one (*Clathria (Thalysias) vulpina* (Lamarck, 1814)) occurs in all nine bioregions, two occur in eight (*Echinodictyum mesenterinum* (Lamarck, 1814), *Spheciospongia papillosa* (Ridley & Dendy, 1886)), 16 occur in seven, 18 occur in six, 35 occur in five, 63 occur in four, 188 occur in three and 403 occur in two bioregions (**Fig. 31**; a list of species occurring in four or more bioregions are included in **Appendix 3**). Most species (1516 or 68%) are rare, occurring in only a single bioregion.

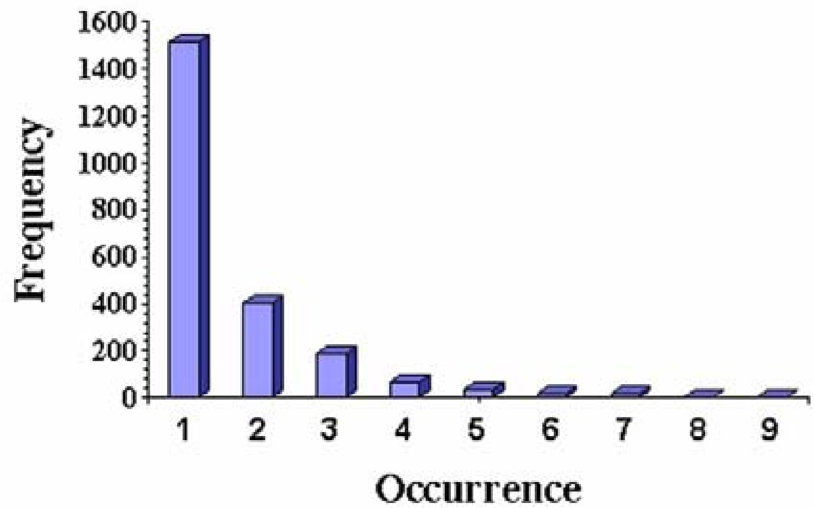

FIG. 31. Frequency distribution of sponge species co-occurring in one or more of the nine tropical bioregions.

Species richness and the number of unique species in each bioregion (**Fig. 32, Table 12**) appear to be substantially higher in east coast (including the CEB tropical-temperate transition zone), than in northern and west coast bioregions, with the major species turnover at Cape York indicated by an arrow in **Fig. 32**. Detecting gradients in species richness between east and west coast faunas, especially at this larger spatial scale, is partly exacerbated by differential collection efforts applied to each of the bioregions, and the patterns we present here ultimately require more rigorous testing by more complete taxonomic evaluation of the rich WAM collections, especially those from the north west coast (CWB and NWB bioregions in particular). From **Fig. 32** it is indicated that the number of unique species in each bioregion may be related to the total number of species collected and the collection effort (number of sites colleted within each region). Regression analysis of amalgamated larger-scale spatial data, however, shows significant differences in curves (**Fig. 33**; R^2=0.9599, F=167.658, Prob.=3.81E-06), although individual ANOVA of factors are less significant: the number of unique species versus the total number of species collected (F=3.2353, Prob.=0.057); total number of species versus the number of sites collected (F=4.5769, Prob.=0.048); and with the strong positive relationship between the number of unique species and collection effort (F=0.0873, Prob.=0.7715), as discovered in earlier analyses and which has no immediately obvious biological basis. These analyses demonstrate the likelihood that some of these species rich bioregions represent real biological phenomena and are not simply statistical artifacts.

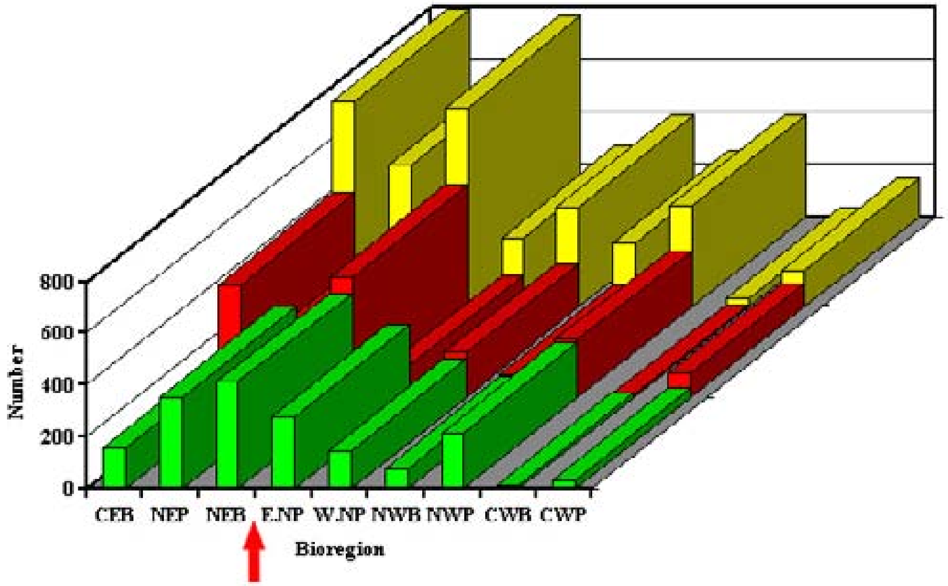

FIG. 32. Species richness (yellow area), number of unique species (red area) and number of sites collected in each bioregion (green area) for sponges from each major bioregion in a transect running across the tropics from the south east Queensland transition zone to the mid west coast transition zone. Arrow indicates major faunal transition.

Table 12. Large scale bioregions sampled for sponges (including temperate transitional bioregions). 'Unique' species refer to taxa found only within a particular bioregion.

Bioregion	Total no. of spp	Total no. of unique spp	% of unique spp	No. sites collected
CEB	791	442	55.88	159
NEP	548	253	46.17	350
NEB	766	472	61.62	409
Eastern NP	271	124	45.76	276
Western NP	387	171	44.19	148
NWB	250	86	34.40	78
NWP	391	220	56.27	213
CWB	33	10	30.3	17
CWP	145	94	64.83	36
Total	*3582*			
Mean	*398*	*208*	*48.82*	*1686*

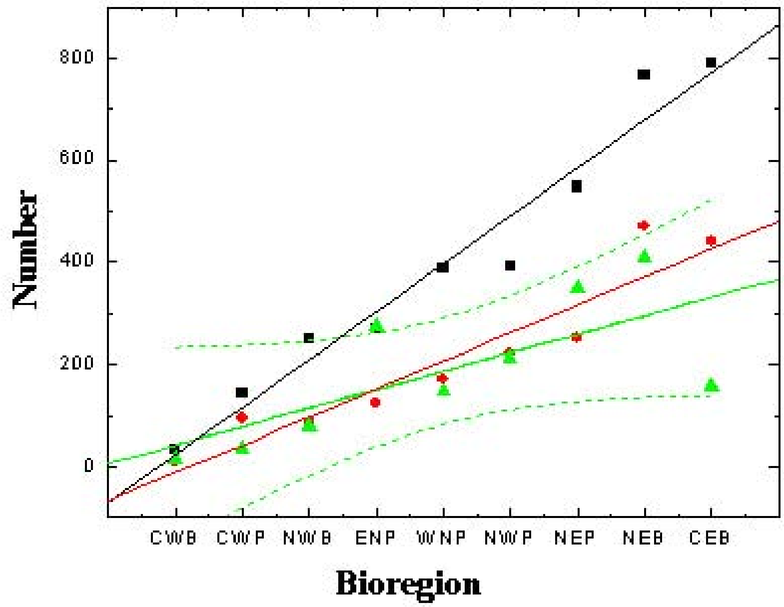

FIG. 33. Regression analysis of species richness (black), number of unique species (red) and number of sites collected in each bioregion (green ± 95% confidence limits on the mean) for sponges from each major bioregion, ordered by bioregions of increasing species richness.

Similarities in species composition between bioregional faunas revealed highest percentage of similarity between the three tropical east coast bioregions (CEB, NEP, NEB: mean 10.32% similarity; upper part of **Table 13** and lower part of **Appendix 2B**), without any apparent difference whether they were geographically contiguous or disjunct. In other words, about 10% of GBR species are widely distributed between all three bioregions, but with between only 1-4% similarity between GBR bioregions and those of the north and west coasts. By comparison, the four tropical bioregions on the west coast (NWB, NWP, CWB, CWP) had substantially lower levels of similarity between their faunas (mean 1.8% similarity; **Appendix 2B**), indicating fewer shared species between adjacent west coast bioregions. Areas where species turnover was greatest had equivalent low levels of similarity in species composition: northern GBR (NEB) and the Gulf of Carpentaria (E.NP) with 3.54% similarity; Gulf of Carpentaria (E.NP) and the Wessel Islands-Darwin regions (W.NP) with 4.05% similarity; and the Darwin-Cobourg region (W.NP) and Joseph Bonaparte Gulf (NWB) with 4.05% similarity.

Table 13. Similarities between larger (ε-scale diversity) bioregions, indicating pairwise comparisons in the number of species co-occurring in both sites (upper part of matrix), the total number of species co-occurring in both sites (diagonal, bold font), and Jaccard Similarity index (%) (lower part of matrix, italic font).

Number of shared species									
Bioregion	**CEB**	**NEP**	**NEB**	**E.NP**	**W.NP**	**NWB**	**NWP**	**CWB**	**CWP**
CEB	**791**	264	280	66	67	62	66	5	32
NEP	*24.56*	**548**	296	58	65	58	54	5	27
NEB	*21.93*	*29.08*	**766**	96	90	79	83	5	36
E.NP	*6.63*	*7.62*	*10.20*	**271**	110	84	97	7	31
W.NP	*6.03*	*7.47*	*8.47*	*20.07*	**387**	110	138	10	33
NWB	*6.33*	*7.84*	*8.43*	*19.22*	*20.87*	**250**	112	10	29
NWP	*5.91*	*6.10*	*7.73*	*17.17*	*21.56*	*21.17*	**391**	16	58
CWB	*0.61*	*0.87*	*0.63*	*2.36*	*2.44*	*3.66*	*3.92*	**33**	11
CWP	*3.54*	*4.05*	*4.11*	*8.05*	*6.61*	*7.92*	*12.13*	*6.59*	**145**
Jaccard Similarity index (%)									

Cluster analysis (using ranked similarities; **Fig. 34A**) and MDS ordination (**Fig. 34B**) performed on the Jaccard Similarity matrix of larger scale (ε-scale diversity) bioregion data (lower part of **Table 13**), further illustrates the major dichotomy in faunal relationships between east and west coast bioregions. The mid southwestern temperate transition zone (CWB) is not as strong as the other transitions, possibly due to comparatively low sample sizes and thus with low potential to have co-occurring species with any other bioregions (**Table 13**). Both MDS ordination and cluster analyses demonstrate the faunal relationships between the south west coast bioregion CWP (pink circle in **Fig. 34B**) and the other west coast bioregions (blue circle). It emphases the closer relationship between west and north coast faunas than with any of the east coast faunas (red dot on **Fig. 34A**), emphasising the major faunistic changeover at the eastern NP-NEB boundary (i.e. Cape York).

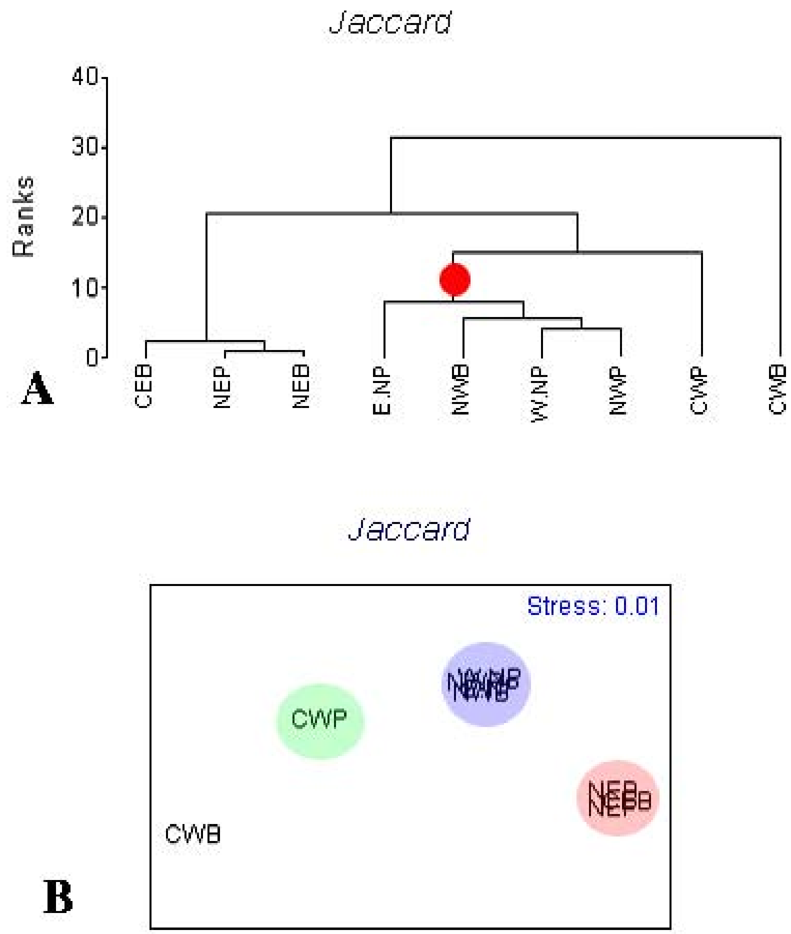

FIG. 34A-B. Cluster analysis and MDS ordination of Jaccard Similarity matrix data for the nine (ε-scale diversity) bioregions.

Two-way nested Analyses of Similarity (ANOSIM) hypothesis tests were applied to the Jaccard similarity matrix to test the strength of this observed turnover between east and west coast faunas, examining the variation in biodiversity relationships as an indicator of potential dispersal and connectivity between these larger (ε-scale diversity) bioregional sponge communities (**Table 14, Figs 35A-D**). Bioregions were grouped into two sets of classes according to *a priori* criteria: (A) four latitudinal clusters, and (B) four longitudinal clusters, with the null hypothesis that there are no assemblage differences between groups of bioregions across these environmental gradients. The number and composition of these groups differs slightly from those assembled for the smaller-scale ANOSIM analysis because membership of the latter was based on arbitrary latitude and longitude quadrants, whereas membership of the nine bioregional units was determined *a priori* by the IMCRA demersal bioregionalisation process (compare **Tables 4B**

and 14B). There were no significant differences between latitude groups using longitude groups as samples (R=-0.625, Prob.=1.00) (i.e. between-group similarities were not significantly greater than within-group similarities), or where latitude groups were averaged across all longitude groups (R=0, Prob.=0.667), with significance levels in pairwise tests between groups of bioregions consistent at 100%. Conversely, there were significant differences between longitude groups using latitude groups as samples (R=0.479, Prob.=0.019), although not statistically significant where longitude groups were averaged across all latitude groups (R=1, Prob.=0.333) probably due to crosstabulation of latitude and longitudinal factors, and significance levels from pairwise comparisons between groups ranging from 33.3-66.7%. These trends are illustrated in the histogram plots of factors, particularly the bimodal distribution of latitude groups averaged across longitude groups (**Fig. 35**). In other words, there were no significant faunistic changes (ß-diversity) that could be attributed solely (or predominantly) to the latitudinal gradient (similar to results from smaller-scale locality analyses), whereas there is a significant change across the longitudinal gradient (although not as strong as detected in the smaller-scale analyses) that reflects the faunistic changes from east to west coasts.

Table 14A. Tests of significance between global R-values from analysis of similarity (2-way nested ANOSIM tests), comparing bioregions (ε-scale diversity) grouped *a priori* along geographic gradients: A, Latitude groups; B, Longitude groups. Refer to Table 14B for locality membership of groups of bioregions.

Groups	Global R statistic	Significance level %	Possible permutations	Actual permutations
A. Latitude (nested within longitude groups)				
Global test: differences between **latitude groups** using longitude groups as samples: R = -0.625, Prob. = 100% (from 105 possible permutations, 105 actual permutations)				
Global test: differences between **longitude groups** averaged across all latutide groups: R = 1, Prob. = 33.3% (from 3 possible permutations, 3 actual permutations)				
Pairwise tests between latitude groups				
1,2	-0.75	100	3	3
1,3	-0.75	100	3	3
1,4	-0.5	100	3	3
2,3	-0.75	100	3	3
2,4	-0.5	100	3	3
3,4	-0.5	100	3	3
B. Longitude (nested within Latitude groups)				
Global test: differences between **longitude** groups using latitude groups as samples: R = 0.479, Prob. = 1.9% (from 105 possible permutations, 105 actual permutations)				
Global test: differences between **latitude** groups averaged across all longitude groups: R = 0, Prob. = 66.7% (from 3 possible permutations, 3 actual permutations)				
Pairwise tests between groups of **Longitude** classes				
1,2	0.25	33.3	3	3
1,3	1	33.3	3	3
1,4	0.75	33.3	3	3
2,3	0.5	33.3	3	3
2,4	0.375	33.3	3	3
3,4	0	66.7	3	3

Table 14B. List of bioregion groups used in ANOSIM analyses.

Latitude groups	**Bioregion and localities membership (refer to Appendix 2A for extent of locality boundaries)**
Group1 (CEB, CWP, CWB)	CEB (Byron, Gold Coast, Moreton Bay, Sunshine Coast, Hervey Bay), CWP (Houtman Abrolhos), CWB (Shark Bay)
Group 2 (NEP, NWP)	NEP (Capricorns, Swains, Northumberland, Whitsundays, Pompeys, Townsville, Sth Qld Plateau), NWP (Exmouth, Dampier, Port Hedland)
Group 3 (NEB, NWB)	NEB (Cairns, Low, Lizard, Far Nth Qld, Torres Straits, Nth Qld Plateau), NWB (Broome, Bonaparte Arch, J. Bonaparte Gulf, Sth Sahul, Nth Sahul Shelf)
Group 4 (E.NP, W.NP)	E.NP (E Gulf, S Gulf, W Gulf, Gove, Wessels), W.NP (Darwin, Cobourg)
Longitude groups	
Group 1 (CEB, NEP)	CEB (Byron, Gold Coast, Moreton Bay, Sunshine Coast, Hervey Bay), NEP (Capricorns, Swains, Northumberland, Whitsundays, Pompeys, Townsville, Sth Qld Plateau)
Group 2 (NEB, E.NP)	NEB (Cairns, Low, Lizard, Far Nth Qld, Torres Straits, Nth Qld Plateau), E.NP (E Gulf, S Gulf, W Gulf, Gove, Wessels)
Group 3 (W.NP, NWB)	W.NP (Darwin, Cobourg), NWB (Broome, Bonaparte Arch, J. Bonaparte Gulf, Sth Sahul, Nth Sahul Shelf)
Group 4 (NWP, CWB, CWP)	NWP (Exmouth, Dampier, Port Hedland), CWP (Houtman Abrolhos), CWB (Shark Bay)

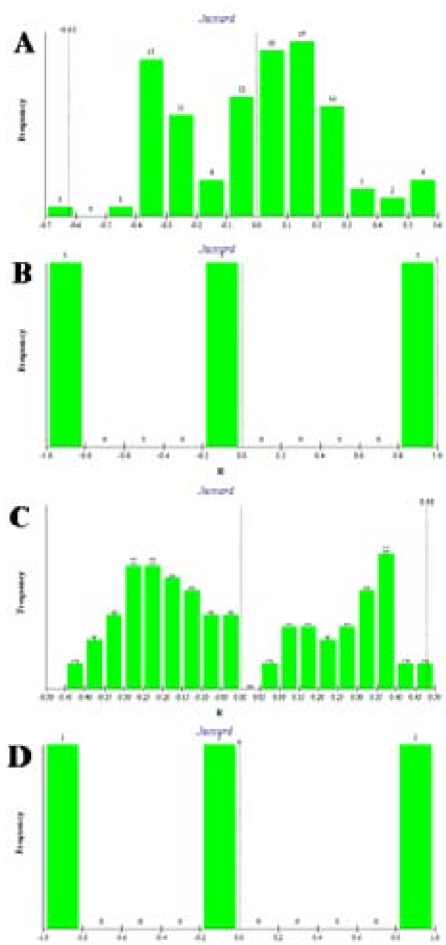

FIG. 35A-D. Frequency histograms of analysis of similarity (2-way nested ANOSIM tests), comparing localities (ε-scale diversity) grouped *a priori* along geographic gradients. A, Differences between Longitude groups (averaged across all Latitude groups). B, Differences between Latitude groups (using Longitude groups as samples). C, Differences between Latitude groups (averaged across all Longitude groups). D, Differences between Longitude groups (using Latitude groups as samples).

Taxonomic Distinctness Analysis was conducted on species, genus and family level taxonomic hierarchies for presence-absence data, amalgamated into larger (ε-scale diversity) bioregions, to test for levels of heterogeneity in taxonomic composition across the IMCRA demersal bioregions (with the null hypothesis being that all bioregions contain a uniform or homogeneous taxonomic composition with respect to the entire dataset). For species-level data (**Fig. 36A**), most sites fall within the 95% predicted range for AvTD (delta+), with only the two undersampled bioregions on the south west coast (CWP, CWB), both falling outside the M=100 simulated probability envelope but within an M=60 simulated range. Both these bioregions have relatively lower species richness (d), species diversity (H'), and AvTD (delta+) of all bioregions included in analyses, deviating the most from the general geographic regional community pattern (**Table 15**). Similarly, both bioregions are marginally over-represented in terms of their habitat heterogeneity (or unevenness), as measured by relatively high VarTD (or lambda+) values (**Fig. 36A**), representing greater heterogeneous of all bioregions in terms of community structure. However, the contribution to overall community heterogeneity by the CWP and CWB bioregions is not statistically significant (**Table 16**).

Table 15. Species-level taxonomic data: Taxonomic Distinctness analyses statistics for bioregional diversity (ε-scale diversity): species richness (S), Margalef species richness (*d*), Shannon-Wiener diversity index (*H'(log$_e$)*), Average taxonomic distinctness (*AvTD or Δ*+[*Delta*+]), Variation in taxonomic distinctness (*VarTD or Λ*+ [*Lambda*+]), Average Phylogenetic diversity (*Phi*+ or *ϕ*+), and Total Phylogenetic diversity (*sϕ*+), based on species presence/ absence data for each of the nine bioregions.

Bioregion	No. species (S)	Margalef species richness (d)	Shannon-Wiener diversity index (H'(loge))	Average taxonomic distinct-ness (Delta+)	Variation in taxonomic distinctness (Lambda+)	Average phylogenetic diversity (Phi+)	Total phylogenetic diversity (sPhi+)
CEB	793	118.6371	6.6758	65.0471	121.2264	27.4408	21760.5199
NEP	549	86.8725	6.3081	64.1745	115.5379	29.1319	15993.4223
NEB	765	115.0624	6.6399	64.2736	108.8366	27.7776	21249.8855
E.NP	266	47.4613	5.5834	63.2340	100.5812	32.9586	8766.9899
W.NP	383	64.2229	5.9480	63.3282	88.8545	30.856	11817.8494
NWB	252	45.3935	5.5294	63.6691	82.4129	34.2155	8622.3089
NWP	386	64.6425	5.9558	63.9654	90.1432	31.1063	12007.0388
CWB	32	8.9447	3.4657	62.1976	106.0353	50.0577	1601.8461
CWP	144	28.7737	4.9698	62.8351	101.7881	39.6702	5712.5080

Table 16. Regression analysis of Average Taxonomic Distinctness (AvTD) and Variation in Taxonomic Distinctness (VarTD) for species-level taxonomic presence-absence data at the bioregional (ε-scale diversity) spatial scale.

Regression Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.248	.062	-.072	.7963
a. Predictors: (Constant), Lambda+. b. Dependent Variable: Delta+				

ANOVA						
Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	.292	1	.292	.460	.519
	Residual	4.439	7	.634		
	Total	4.731	8			
a. Predictors: (Constant), Lambda+. b. Dependent Variable: Delta+						

These patterns are repeated for genus-level taxonomic analysis (**Fig. 36B**, data in **Table 17**), with CWP and CWB bioregions again deviating most from general community patterns, with all other bioregions falling within, or close to, the M=80 95% probability envelope, but again these differences (community heterogeneity for these two bioregions) are not statistically significant (**Table 18**). At family-level taxonomic analysis (**Table 19**), however, only the east coast bioregions (NEB, NEP and CEB) and one west coast bioregion (NWP) fall within the 95% probability envelope at the M=40 level or above, with the remainder (all north coast and most west coast bioregions) deviating significantly (P=0.195; **Table 20**) from general community patterns, and with CWB and CWP being the most heterogenious with respect to other bioregions (**Fig. 36C**). These results indicated that the distribution of samples within species-, genus- and family-groups in the two west coast bioregions (CWB+CWP) differ to a greater or lesser extent from the tropical geographic region in general, although this heterogeneity is only markedly different (i.e. statistically significant) when data are analysed at the family-level. These results simply reflect the lower taxonomic distinctness (AvTD) and higher unevenness (VarTD) of these two bioregions from the tropical fauna. Thus, with the exception of the southern west coast bioregions CWB and CWP at the species- and genus-levels, and all but the east coast tropical bioregions at the family-level, the modelled 95% probability contour is a reasonable fit for all these sponge faunal distributions.

Table 17. Genus-level taxonomic data: Taxonomic Distinctness analyses statistics for bioregional (ε-scale diversity) spatial scale based on presence/ absence data for each of the nine bioregions. Refer to Table 7 for key to diversity indices.

Bioregion	S	H'(loge)	Delta+	Lambda+	Phi+	sPhi+
CEB	793	6.675823	68.51379	145.6771	33.00778	6106.439
NEP	549	6.308098	68.18301	149.3755	33.75269	5400.431
NEB	765	6.639876	67.12695	148.6735	32.72435	6217.627
E.NP	266	5.583496	65.26415	135.5306	35.66499	3923.149
W.NP	383	5.948035	66.06909	134.3292	33.75701	4624.71
NWB	252	5.529429	66.20178	118.7929	34.61715	4119.441
NWP	386	5.955837	66.98651	137.8045	34.41584	4783.801
CWB	32	3.465736	65.19433	119.6194	48.65634	1167.752
CWP	144	4.969813	63.97436	166.5055	39.44462	3352.793

Table 18. Regression analysis of Average Taxonomic Distinctness (AvTD) and Variation in Taxonomic Distinctness (VarTD) for genus-level taxonomic presence-absence data at the bioregional (ε-scale diversity) spatial scale.

Regression Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.029	.001	-.142	1.5712
a. Predictors: (Constant), Lambda+. b. Dependent Variable: Delta+				

ANOVA						
Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	1.450E-02	1	1.450E-02	.006	.941
	Residual	17.281	7	2.469		
	Total	17.295	8			
a. Predictors: (Constant), Lambda+. b. Dependent Variable: Delta+						

Table 19. Family-level taxonomic data: Taxonomic Distinctness analyses statistics for bioregional (ε-scale diversity) spatial scale based on presence/ absence data for each of the nine bioregions. Refer to Table 7 for key to diversity indices.

Bioregion	S	H'(loge)	Delta+	Lambda+	Phi+	sPhi+
CEB	793	6.675823	63.62065	199.8102	38.39704	2649.396
NEP	549	6.308098	63.58688	204.5322	39.41616	2443.802
NEB	765	6.639876	61.97097	195.3575	39.00191	2652.13
E.NP	266	5.583496	57.97985	141.2177	40.60712	1949.142
W.NP	383	5.948035	58.77822	185.0934	38.7641	2093.261
NWB	252	5.529429	58.63446	124.3492	40.60712	1949.142
NWP	386	5.955837	61.98192	157.0176	41.49891	2240.941
CWB	32	3.465736	56.85859	126.8926	45.77947	824.0305
CWP	144	4.969813	56.75602	209.9284	39.93828	1917.038

Table 20. Regression analysis of Average Taxonomic Distinctness (AvTD) and Variation in Taxonomic Distinctness (VarTD) for family-level taxonomic presence-absence data at the bioregional (ε-scale diversity) spatial scale.

Regression Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.476	.227	.116	2.60864951517554
a. Predictors: (Constant), Lambda+				

ANOVA						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	13.979	1	13.979	2.054	.195
	Residual	47.635	7	6.805		
	Total	61.615	8			
a. Predictors: (Constant), Lambda+. b. Dependent Variable: Delta+						

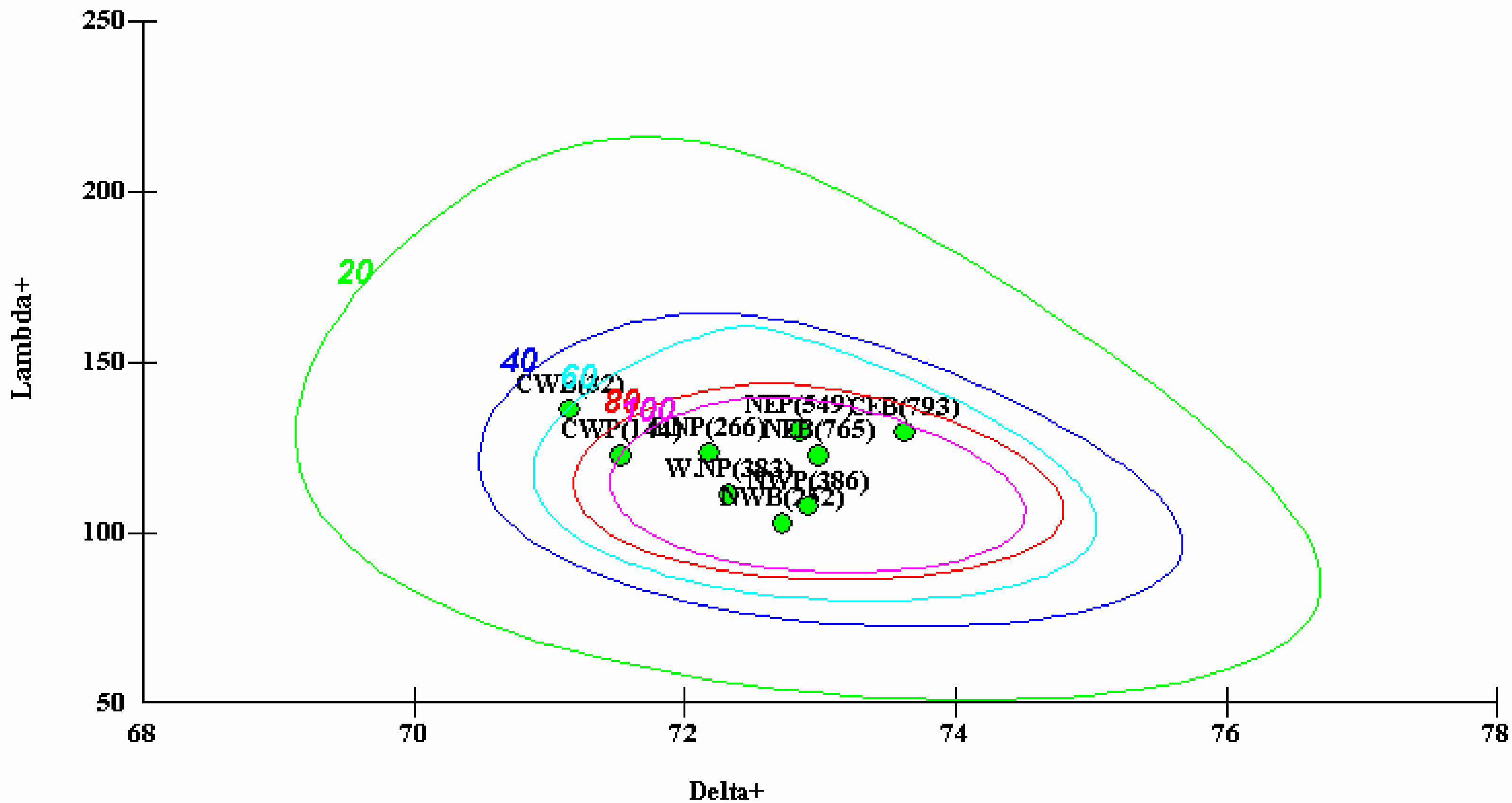

Fig. 36A. Average Taxonomic Distinctness (*AvTD or delta* +) and Variation in Taxonomic Distinctness (*VarTD or lambda* +) plots of species-level taxa for bioregional presence-absence data, superimposed on 95% probability ellipses from simulated data for each sublist (M=20-100). Number of species in each (ε-scale diversity) bioregion is indicated in brackets.

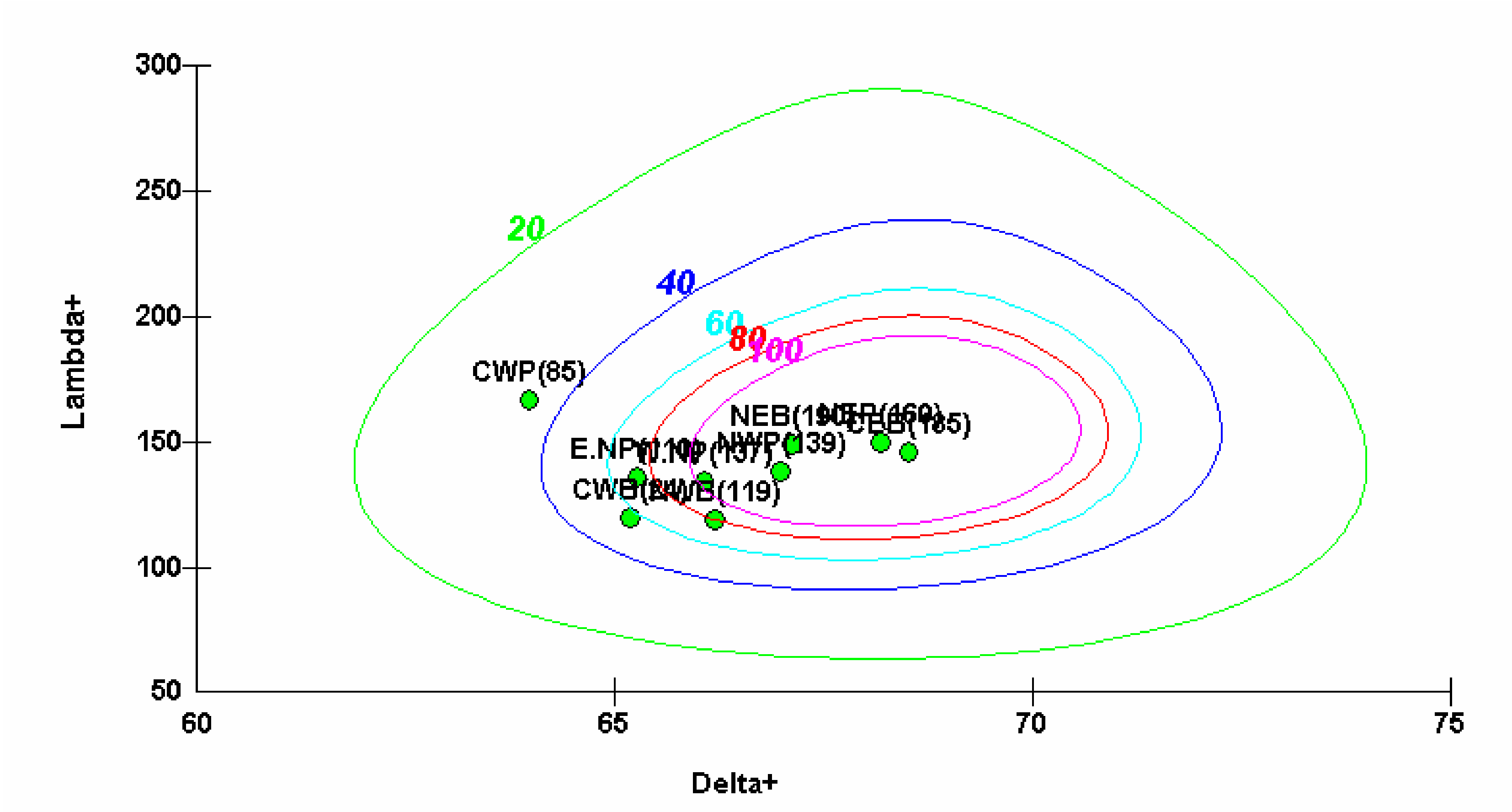

Fig. 36B. Average Taxonomic Distinctness (*AvTD or delta +*) and Variation in Taxonomic Distinctness (*VarTD or lambda +*) plots of genus-level taxa for bioregional presence-absence data, superimposed on 95% probability ellipses from simulated data for each sublist (M=20-100). Number of species in each (ε-scale diversity) bioregion is indicated in brackets.

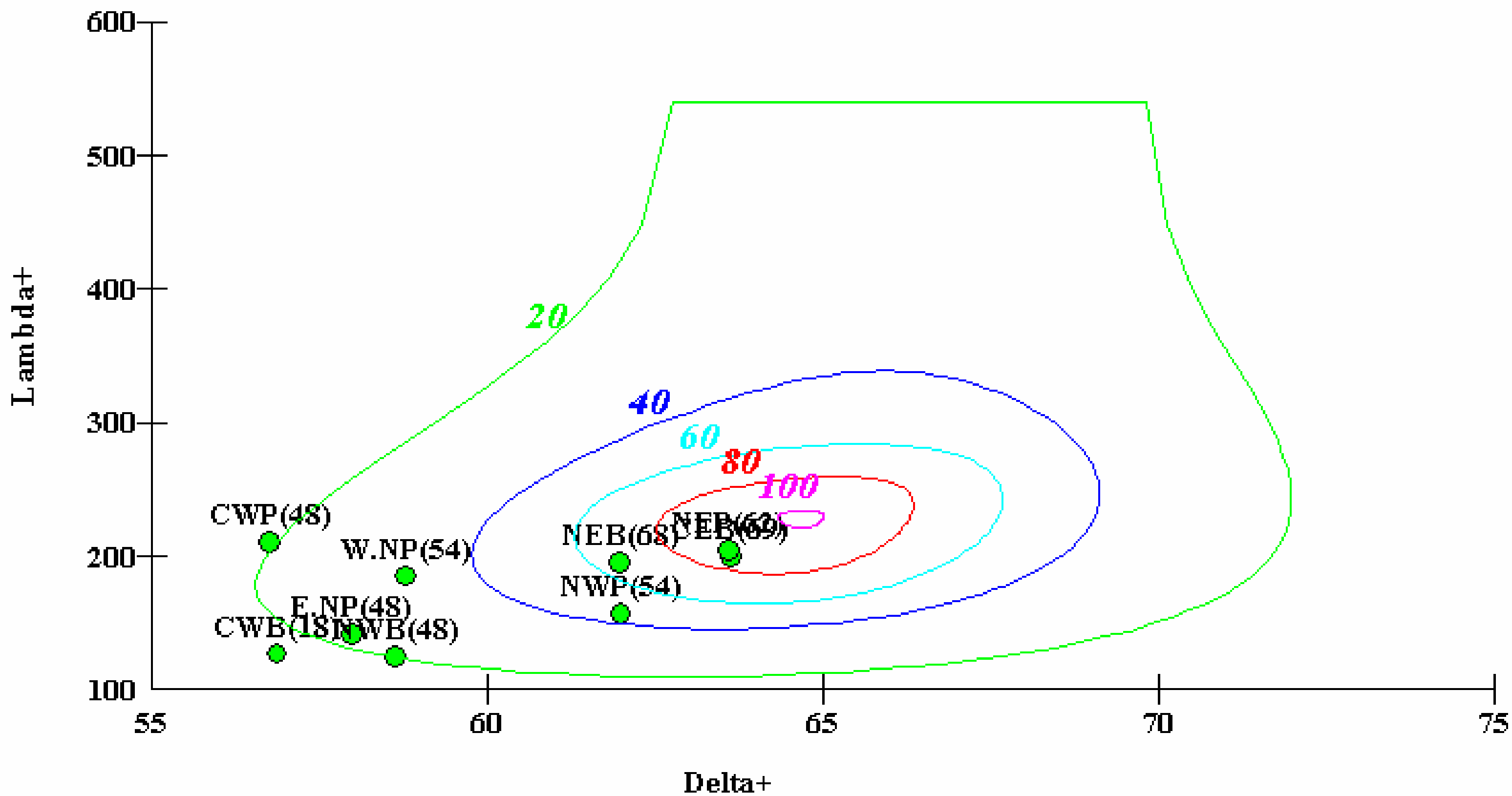

Fig. 36C. Average Taxonomic Distinctness (*AvTD or delta* +) and Variation in Taxonomic Distinctness (*VarTD or lambda* +) plots of family-level taxa for bioregional presence-absence data, superimposed on 95% probability ellipses from simulated data for each sublist (M=20-100). Number of species in each (ε-scale diversity) bioregion is indicated in brackets.

3.4. Consensus of datasets delineating bioregional transition zones.

Comparisons between amalgamating sponge species presence-absence data into smaller-scale locality groups (γ-scale diversity), and larger-scale IMCRA demersal bioregional groups (ε-scale diversity), produces patterns of richness and composition are not fully congruent, suggesting that sponge data do not fully conform to the current IMCRA demersal bioregional model. However, despite some level of incongruety between datasets, it is certainly not proposed that the IMCRA demersal bioregions be emended based on these sponge distribution patterns alone, but that additional data from other benthic marine phyla should be added to the matrix – although it is possible or even likely that different phyla will have different biodiversity patterns, particularly at the smaller-spatial scale (e.g. oviparous vs. viviparous dispersal, demersal vs. pelagic larvae, etc.).

Nevertheless, our results (at both smaller and larger spatial scales) clearly demonstrate that there are major changes in the fauna along a transect running from the central east to central west coasts that are more-or-less consistent across taxonomic groups; species turnover along the west and north coasts is less prominent than on the east coast; and boundaries between localities/ bioregions based on sponge data are not as clearly defined on the west coast as on the east coast. Smaller-scale analysis indicates three major sponge provinces, with smaller transitions occurring within two of these. **(1)** ***Temperate-subtropical east coast fauna***, with a strong boundary in the vicinity of the Tweed River marking a biogeographic transition between Solanderian and Peronian Provinces. **(2)** ***Tropical east coast fauna***, containing (a) a southern component, with moderately hard boundary north of Hervey Bay-Fraser Island; (b) a central component, with soft boundary between Mackay and Townsville; (c) a northern component, with one or more minor transitions in the Far Northern GBR, leading to (d) a major transition on the eastern edge (GBR side) of Cape York; and (e) the Coral Sea Territories on the Queensland Plateau with affinities to the western Pacific islands and north-central and southern GBR sponges. Transitions within the GBR are probably driven by endogenous and exogenous current patterns, with a major hard boundary at Cape York that marks the biogeographic boundary between Dampierian and Solanderian Provinces. **(3)** ***Tropical northern and western fauna***, with several transitions that are not completely resolved by our data: (a) the Gulf of Carpentaria which is markedly different from Torres Strait and Wessel Islands, and likely an ecological rather than biogeographic pattern; (b) a more diffuse species turnover zone in the vicinity of the Wessel Islands; (c) one or more probable transitions west of the Darwin region to the North West Cape region, not well defined by sponge data and certainly less dramatic than transitions on the east coast; (d) a significant boundary in the vicinity of Northwest Cape reflecting the differences between faunas to the north and south, but uncertain whether this is a soft or hard transition requiring significantly more data.

Both smaller- and larger-scale datasets also show that localities/ bioregions are relatively heterogeneous in terms of both species diversity and community structure, and are at best working hypotheses that incorporate some biogeographic, physical and other data into a model useful for planning and management. A striking example of this is the Great Barrier Reef province, which is presently recognised (at the larger bioregional spatial scale) to contain a single (central) bioregion (NEP) with two transitional ones north and south of it (NEB and CEB, respectively), whereas at the smaller spatial scale it clearly has the capacity to be further subdivided into more functional ecological units – although requiring testing from other phyla datasets and not solely based on sponge data. Thus, a major challenge remains to acquire a better knowledge of the distribution and relationships of a whole range of marine phyla in order to assign any confidence levels to the bioregions proposed or supported by this present study, and to test these sponge data with trends seen in other phyla.

4. CONCLUSIONS

- Sponge datasets from the QM collections, and augmented by some data of selected taxa ('surrogate species') from the NTM, WAM and AIMS collections, were databased, validated (including identifications), mapped (in GIS), and interpreted within a community structure for tropical Australia. 'Surrogate' species were originally selected from a set of criteria that focussed on the Northern Planning Area (Gulf of Carpentaria region), based on the bioregional priorities of the National Oceans Office at the outset of this project, but subsequently expanded to include the entire Australian tropical sponge faunas (including comparison with some contiguous faunas in the Indo-Malay Archipelago and the western Pacific islands). These data were unified in a single database (CSIRO 'Biolink') using a contemporary higher classification based on a recent major review of the phylum. Where data were unidentified to an Operational Taxonomic Unit (OTU) or species level, they were differentiated using a unique species number identifier with accompanying 'mudmaps' (i.e. brief digitized descriptions and illustrations of the major morphological diagnositic characters for each taxon). Although highly desirable, incorporation of the ABIF sponge records (i.e. an on-line database listing all published sponge species in the Australian fauna and their known distributions) was not possible because these database records are not yet accompanied by locality position coordinates, and therefore not compatible with GIS analysis used in this project (i.e. having only descriptors of type and other locality records). This was a major shortcoming of the current project because it excluded the potentially more extensive sponge distributional data from the published literature, given the stricter (numerical) data standards required for GIS database analyses, and well beyond the resources available for this project.

- Descriptive (i.e. more subjective) and numerical analyses of sponge distribution data showed significant heterogeneity within the Australian tropical coastal and shelf faunas, signifying environmental and/or historical distribution gradients influencing modern-day distributions. While small numbers of (morpho)species appeared to have extensive distributions across the tropics, or span several adjacent (IMCRA-defined) bioregions, the majority of species occurred in only one of few bioregions, and a number of these were determined to be useful indicators for characterising the regions themselves (i.e. repeating geographic patterns across many taxonomic groups), and thus useful for the processes of bioregionalisation. Some of these patterns are undoubtedly linked to biogeographic trends, including historical distributions such as east-west species pairs, but this aspect was not the focus of the present analysis which considered only the present-day distributions without seeking biotic or abiotic reasons for these observed patterns. It is possible that some of these distributions may serve as useful surrogates for more integrative bioregionalisation analyses in conjunction with other biotic and physical data in GIS analyses. Raw specimen data have been supplied to Geosciences Australia and the National Oceans Office, and periodically updated datasets will be made available upon request as new material is added to the database and taxonomic refinements are made to the sponge dataset.

- Geographic trends detected initially in the descriptive analyses of sponge distributions were subsequently generally well supported by numerical (biodiversity) analyses. These biodiversity analyses were able to identify a number of prominent sponge localities and transition zones, based on taxonomic richness, diversity and faunistic relationships between sites/ localities/ bioregions, and a bioregional model based on sponge data was presented. Data were analysed in smaller-scale spatial units (localities, groups of collection sites amalgamated into contiguous regions based on similarity and MDS analyses) and also larger scale (bioregions), the latter testing the IMCRA demersal bioregions and providing data to support (or refute) existing boundaries. Conversely, it was not possible within the timeframe of this project, or using the software available, to include the added dimension of depth into GIS or numerical analyses, although CAAB modelled distributions of surrogate 'key' species data were compiled and will be freely available on www.ozcam.gov.au. Although a highly desirable outcome of the project, to compare shallow coastal, continental shelf and deeper-water distribution patterns, most existing sponge datapoints comprise coastal or shelf species, most above 50m depth, some to 80m depth, but relatively few yet collected from the continental slope or deeper sea bed, and where these deeper-water collection do exist they are confined to one or few point samples. It was also not possible to include all these data (i.e. actual and CAAB modelled species distributions for individual species, and accompanying morphological 'mudmap' descriptions of them) into a single report – which would run into many thousands of figures and pages. This information will be made available on the web via OZCAM.

- Uncertainties (and/or errors) in the sponge database were assessed and qualified in the form of Confidence Limits for particular variables: global position coordinates, depth range distributions, and taxonomic identifications. It is this latter category which still presents the greatest challenges for sponge bioregionalisation and biogeography analyses. Despite recent major advances in the higher systematics of sponges the task of discriminating species-level relationships remains a major impediment in our attempts to combine all available sponge datasets (held in Australian museums and other marine collection agencies), into a single accessible (and meaningful) database. The further development and utilisation of 'mudmaps' (i.e. to allow non-specialists to participate in future sponge distributional mapping), and an arbitrary species numbering system (i.e. that would differentiate each (morpho)species as unique) will provide an interim mechanism to discriminate species-level taxa (OTUs) as the 'same or different' across all collections from the Australian tropical bioregions – irrespective of whether or not species yet have scientific names applied to them – while awaiting the arduous task of formally describing the very many species known to live in the Australian fauna. It is anticipated that this system (or something similar) will be adopted by current and future workers studying this fauna, once it is made available on-line via OZCAM, and thus progress the concept of a national sponge taxonomic database. Using this technique the distribution database for all sponge taxa has the potential ability to be expanded across all continental and territorial waters provided that adequate resources become available, and institutions make an appropriate commitment, to document existing collections (particularly southern Australian museums), and to capture their data in a digital format that complies with the present data standards (as a minimum). The other major limitation with respect to existing sponge datasets includes an incomplete geographical gap in our knowledge of several significant faunas: in particular the Great Australian Bight (GABB bioregion), the southern part of the south west coast of Western Australia (SWP bioregion), and most deeper water faunas (off the continental shelf). Existing data for these are patchy or nonexistent, or where collections of these do exist they have not yet been adequately worked up to an acceptable taxonomic level that would enable differentiation at the species (or OTU) level. A discussion of current strengths and weaknesses in our present sponge knowledge and the collections, analysed in the context of both taxonomic and geographic coverage, is provided in Hooper & Wiedenmayer (1994) and ABIF-Fauna (2004), although significant collections have been acquired of the northeast coast and adjacent western Pacific island faunas since 1994.

- The use of Australian sponge data as models for the bioregionalisation of coastal and shelf faunas, with some biogeographic interpretation applied to analyses, has been demonstrated in several earlier studies at small (point sample) and larger (continental) scales of diversity, identifying areas of heterogeneity and some environmental correlates. As noted in these earlier analyses, sponge distributions do not necessarily conform to those of other marine phyla – such as molluscs, echinoderms, scleractinian corals, tunicates – with possible reasons including their different dispersal and recruitment strategies, non temperature dependence for reproduction (cf. scleractinian corals), short larval mobility and longevity etc. In any case, inclusion of Phylum Porifera in marine bioregionalisation (and biogeographic) analysis provides an alternative perspective to traditional concepts of marine distributions. Sponge data have also been used during the initial phase of identifying representative areas in the Great Barrier Reef Marine Park Authority's Representative Areas Program (non-reef areas) for the GBR World Heritage Area bioregionalisation (http://www.gbrmpa.gov.au/), although the fundamental dataset was deficient and these deficiencies are now being addressed through the GBR Seabed Biodiversity Mapping Project (http://www.reef.crc.org.au/resprogram/programC/seabed/index.htm). In contrast, the present analysis applied a much larger dataset to the tropical Australian fauna (including subtropical and temperate overlap zones), using GIS mapping tools, and numerical (biodiversity) analysis that provided some level of biological interpretation beyond mere 'dots on maps'. Shortcomings in the present analysis, as noted above, include: the lack of analysis of depth-related distributions (although CAAB distributions for key surrogate species were modelled but not interpreted (in **Appendix 6**), and data for deeper-water faunas are generally poor in existing datasets); and omission of published species distributions due to the non-GIS compliant format of the existing ABIF database (http://www.deh.gov.au/biodiversity/abrs/online-resources/abif/fauna/afd/PORIFERA/), both of which were both beyond the scope of software and resources available for this particular project. In addition, some interpretation of the application of biodiversity/ bioregional data analyses at small spatial scales to marine management and reserve design was made by Hooper & Kennedy (2002) concerning critical marine reserve size as being inclusive of genetic diversity.

- Scope for the further interpretation of sponge data in future GIS analyses includes: (1) the differential depth distribution profiles across continental shelf and slope – although existing data are patchy at best; and (2) more comprehensive GIS and numerical analyses of species turnover across the tropical gradient, especially at the major transition zones identified here, and also for east-west species pairs identified in this study. This latter aspect will help define more precisely the boundaries between the major bioregions.

- One major anticipated outcome of the current project is the likelihood that the current database will develop into a national marine sponge dataset on the OZCAM web site, as part as Australia's commitment to the Global Biodiversity Information Facility (GBIF) as a partnership between the QM, AIMS, MAGNT and WAM. As noted, institutional commitment and some additional institutional (and other) resources will be required to complete this project, including incorporation of the ABIF data into a GIS database.

5. ACKNOWLEDGEMENTS

The authors are most grateful to the following for their invaluable assistance during the many facets of this project:

- Dr Belinda Alvarez de Glasby (Museums and Art Galleries of the Northern Territory, Darwin) for providing data points of key taxa from the MAGNT collections for the OZCAM database.
- Dr Chris Battershill, Mr Casten Wolff and Ms Libby Evans-Illidge (Australian Institute of Marine Science, Townsville) for providing data points of key taxa from the AIMS collections for the OZCAM database.
- Dr Jane Fromont (Western Australian Museum, Perth) for providing data points of key taxa from the WAM collections for the OZCAM database.
- Dr Tony Rees (CSIRO Marine Research, Hobart), for producing numerous CAAB modelled distribution maps of surrogate sponge species, that will be placed on-line with the sponge data on OZCAM.
- Staff of the National Oceans Office, Hobart (in particular Dr Sally Troy, Dr Vicki Nelson, Mr Adam Jagla, Ms Miranda Carver), for funding and assistance during the course of this project, and members of the National Bioregionalisation Working Group for useful comments and discussions on marine bioregionalisation.
- Staff of the Biodiversity Program, Queensland Museum, for assistance with updating and ground-truthing the sessile marine database and digitizing 'mudmaps' (Ms Andrea Crowther, Ms Michela Mitchell, Dr Monika Schlacher).
- Dr Rob Van Soest (University of Amsterdam) and Dr Gary Poore (Museum Victoria) for their most useful comments and suggestions during the referee process.

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APPENDIX 1.

List of sponge species chosen as a subset of the entire sponge database as surrogates for the present analysis, representing a collaborative study between Australian sponge collection and research institutions (QM, AIMS, MAGNT, WAM). Refer to Appendix 6 for PDF file of CAAB modelled species distributions for each of these surrogate species.

Family	Genus and Species	Author	Sp # (Mudmap #)
Petrosiidae	Neopetrosia exigua	(Kirkpatrick 1900)	2
Dysideidae	Dysidea herbacea	(Keller) 1889	3
Iotrochotidae	Iotrochota baculifera	Ridley 1884	4
Axinellidae	Cymbastela stipitata (Bergquist & Tizard, 1967)		5
Tetillidae	Cinachyrella australiensis	(Carter) 1886	6
Petrosiidae	Xestospongia testudinaria	(Lamarck) 1814	7
Ianthellidae	Ianthella basta	(Pallas) 1776	8
Microcionidae	Clathria (Thalysias) reinwardti Vosmaer, 1880		9
Aplysinidae	Aplysina ianthelliformis	(Lendenfeld) 1888	12
Isodictyidae	Coelocarteria singaporensis	(Carter) 1883	13
Raspailiidae	Trikentrion flabelliforme Hentschel, 1912		22
Axinellidae	Reniochalina stalagmitis Lendenfeld, 1888		23
Microcionidae	Clathria (Wilsonella) tuberosa (Bowerbank, 1875)		24
Microcionidae	Clathria (Thalysias) vulpina (Lamarck, 1814)		25
Axinellidae	Axinella 26		26
Thorectidae	Phyllospongia lamellosa	(Esper) 1794	28
Microcionidae	Clathria (Thalysias) lendenfeldi Ridley & Dendy, 1886		29
Chalinidae	Haliclona cymaeformis	(Esper) 1794	30
Raspailiidae	Echinodictyum mesenterinum (Lamarck, 1814)		31
Raspailiidae	Raspailia (Raspailia) vestigifera Dendy, 1896		34
Axinellidae	Axinella 35		35
Halichondriidae	Halichondria stalagmites	(Hentschel) 1912	39
Thorectidae	Thorectandra excavata	(Ridley) 1884	51
Niphatidae	Gelliodes fibulatus	(Carter) 1881	53
Raspailiidae	Raspailia (Raspaxilla) compressa Bergquist, 1970		54
Tedaniidae	Tedania anhelans	(Schmidt) 1862	56
Desmoxyidae	Myrmekioderma granulata	(Esper) 1830	63
Clionaidae	Speciospongia vagabunda	Ridley 1884	78
Clionaidae	Speciospongia cf. vagabunda	Ridley 1884	86
Microcionidae	Clathria (Isociella) eccentrica (Burton, 1934)		93
Clionaidae	Cliona orientalis		97
Microcionidae	Antho_(Acarnia) ridleyi (Hentschel, 1912)		99
Ianthellidae	Ianthella flabelliformis	(Pallas) 1766	104
Axinellidae	Phakellia carduus (Lamarck, 1814)		107
Axinellidae	Axinella 112		112
Raspailiidae	Echinodictyum nidulus Hentschel, 1911		120
Microcionidae	Clathria (Thalysias) abietina (Lamarck, 1814)		121
Axinellidae	Reniochalina 122		122
Axinellidae	Phakellia 129		129
Rhabderemiidae	Rhabderemia sorokinae	Hooper 1990	130
Axinellidae	Phakellia 131		131
Raspailiidae	Echinodictyum asperum (Ridley & Dendy, 1886)		133
Phloeodictyidae	Oceanapia 135		135
Spirastrellidae	Spirastrella 150		150
Raspailiidae	Echinodictyum cancellatum (Lamarck, 1814)		152
Axinellidae	Axinella aruensis Hentschel, 1912		153
Crellidae	Crella spinulata	(Hentschel) 1911	154
Axinellidae	Axinella 156		156
Axinellidae	Reniochalina 172		172

Druinellidae	Pseudoceratina 190		190
Ianthellidae	Ianthella cf. flabelliformis	(Pallas) 1776	196
Mycalidae	Mycale (Mycale) cf. ridleyi	(Lendenfeld) 1888	203
Microcionidae	Clathria (Thalysias) darwinensis Hooper, 1996		208
Raspailiidae	Ectyoplasia tabula (Lamarck, 1814)		210
Clionaidae	Pione hixoni	Lendenfeld 1886	213
Raspailiidae	Raspailia (Clathriodendron) arbuscula (Lendenfeld, 1888)		216
Axinellidae	Axinella 217		217
Raspailiidae	Raspailia (Clathriodendron) darwinensis Hooper, 1991		218
Darwinellidae	Dendrilla rosea	Lendenfeld, 1883	221
Darwinellidae	Aplysilla sulphurea	Schulze 1878	224
Dysideidae	Dysidea 229		229
Raspailiidae	Raspailia_(Parasyringella) nuda Hentschel, 1911		230
Desmacellidae	Neofibularia irata	Wilkinson 1978	243
Axinellidae	Phakellia 244		244
Dictyonellidae	Rhaphoxya cf. pallida		252
Axinellidae	Axinella 254		254
Microcionidae	Clathria (Thalysias) coppingeri Ridley, 1884		259
Spongiidae	Rhopaloeides odorabile	Thompson, Murphy, Bergquist & Evans, 1987	262
Thorectidae	Fascaplysinopsis reticulata	(Hentschel) 1912	264
Raspailiidae	Raspailia (Clathriodendron) melanorhopsa Hooper, 1991		265
Axinellidae	Axinella 267		267
Callyspongiidae	Callyspongia (Cladochalina) cf. mannus	(Lendenfeld) 1887	268
Desmacididae	Iotrochota coccinea	(Carter) 1886	269
Mycalidae	Mycale (Arenochalina) mirabilis	(Lendenfeld) 1887	270
Chondrosiidae	Psammoclema 271		271
Microcionidae	Echinochalina (Echinochalina) intermedia (Whitelegge, 1902)		272
Spongiidae	Hyattella intestinalis	(Lamarck) 1814	274
Axinellidae	Reniochalina 275		275
Theonellidae	Theonella swinhoei	Gray 1868	280
Axinellidae	Reniochalina 285		285
Axinellidae	Reniochalina 287		287
Raspailiidae	Thrinacophora cervicornis Ridley & Dendy, 1887		288
Microcionidae	Clathria (Thalysias) hesperia Hooper, 1996		292
Desmacididae	Phoriospongia 293		293
Raspailiidae	Raspailia (Clathriodendron) desmoxyiformis Hooper, 1991		298
Microcionidae	Clathria (Thalysias) cancellaria (Lamarck, 1814)		300
Raspailiidae	Endectyon thurstoni (Dendy, 1887)		304
Niphatidae	Niphates 307		307
Axinellidae	Axinella 308		308
Geodiidae	Pachymatisma 311		311
Ancorinidae	Stelletta clavosa	Sollas 1888	313
Axinellidae	Reniochalina 315		315
Plakinidae	Plakortis (Dercitopsis) cf. Mammillaris	(Lendenfeld) 1906	326
Microcionidae	Clathria (Thalysias) procera (Ridley, 1884)		329
Dictyonellidae	Stylissa Flabelliformis	(Hentschel) 1912	336
Axinellidae	Phakellia dendyi Bergquist, 1970		339
Raspailiidae	Raspailia (Raspaxilla) wardi Hooper, 1991		341
Desmoxyidae	Higginsia Scabra	Whitelegge 1907	343
Axinellidae	Axinella 346		346
Raspailiidae	Raspailia (Clathriodendron) kerontria Hooper, 1991		350
Axinellidae	Reniochalina 352		352
Axinellidae	Reniochalina 353		353
Microcionidae	Holopsamma laminaefavosa Carter, 1885		359
Pseudoceratinidae	Pseudoceratina 364		364
Microcionidae	Clathria (Thalysias) hallmanni Hooper, 1996		372
Desmoxyidae	Higginsia Mixta	(Hentschel) 1912	374
Iotrochotidae	Iotrochota 377		377

Petrosiidae	Xestospongia Bergquistia	Fromont 1991	383
Callyspongiidae	Callyspongia (Callyspongia) Carens	Pulitzer-Finali 1982	386
Callyspongiidae	Callyspongia (Euplacella) 387		387
Tetillidae	Cinachyrella enigmatica	(Burton 1934)	390
Microcionidae	Antho (Antho) tuberosa (Hentschel, 1911)		393
Suberitidae	Aaptos Aaptos	Schmidt 1864	406
Axinellidae	Axinella 412		412
Axinellidae	Phakellia Stelliderma	Levi & Levi 1989	413
Raspailiidae	Raspailia_(Parasyringella) australiensis Ridley, 1884		414
Tetillidae	Cinachyrella 415		415
Raspailiidae	Raspailia (Raspaxilla) reticulata Hooper, 1991		416
Axinellidae	Reniochalina cf.stalagmitis Lendenfeld, 1888		417
Axinellidae	Phakellia 418		418
Raspailiidae	Echinodictyum conulosum Kieschnick, 1900		419
Hymedesmiidae	Hamigera Strongylata	Burton 1934	426
Microcionidae	Clathria (Isociella) skia Hooper, 1996		427
Microcionidae	Clathria (Wilsonella) australiensis (Carter, 1885)		430
Microcionidae	Clathria (Clathria) rubens (Lendenfeld, 1888)		431
Clionaidae	Cliona patera	(Hardwicke) 1822	432
Tedaniidae	Tedania 433		433
Microcionidae	Echinochalina (Echinochalina) barba (Lamarck, 1814)		434
Raspailiidae	Raspailia (Raspailia) phakellopsis Hooper, 1991		437
Microcionidae	Clathria (Clathria) conectens (Hallmann, 1912)		440
Acarnidae	Acarnus bergquistae	Van Soest, Hooper and Hiemstra 1991	441
Chondropsidae	Psammoclema chaliniformis	(Lendenfeld) 1889	443
Axinellidae	Axinella 444		444
Axinellidae	Axinella flabellata (Ridley & Dendy, 1886)		445
Axinellidae	Phakellia 447		447
Microcionidae	Clathria (Thalysias) hirsuta Hooper & Levi, 1993		449
Microcionidae	Clathria (Axosuberites) canaliculata (Whitelegge, 1906)		453
Axinellidae	Ptilocaulis 454		454
Callyspongiidae	Callyspongia 456		456
Agelasidae	Agelas gracilis	Whitelegge 1897	459
Tedaniidae	Tedania 462		462
Axinellidae	Axinella 463		463
Dictyonellidae	Rhaphoxya cf. pallida	(Dendy) 1896	465
Axinellidae	Axinella 467		467
Microcionidae	Holopsamma pluritoxa (Pulitzer-Finali, 1982)		468
Callyspongiidae	Dactylia radix	(Lendenfeld) 1888	471
Microcionidae	Holopsamma crassa Carter, 1885		476
Microcionidae	Echinoclathria nodosa Carter, 1885		478
Raspailiidae	Echinodictyum austrinus Hooper, 1991		479
Spirastrellidae	Spirastrella papillosa	Ridley & Dendy 1886	480
Microcionidae	Echinochalina (Echinochalina) tubulosa (Hallmann, 1912)		482
Pseudoceratinidae	Pseudoceratina clavata	Pulitzer-Finali 1982	484
Microcionidae	Holopsamma macropora (Lendenfeld, 1888)		493
Axinellidae	Cymbastela notiaina Hooper & Bergquist, 1992		494
Trachycladidae	Trachycladus laevispirulifer	Carter 1879	496
Thorectidae	Phyllospongia papyracea	(Esper) 1806	500
Microcionidae	Clathria (Dendrocia) pyramida Lendenfeld, 1888		501
Microcionidae	Clathria (Clathria) noarlungae Hooper, 1996		503
Axinellidae	Phakellia 508		508
Halichondriidae	Hymeniacidon 509		509
Axinellidae	Cymbastela concentrica (Lendenfeld, 1887)		514
Clathrinidae	Clathrina 519		519
Spongiidae	Spongia hispida	Lamarck 1814	520
Axinellidae	Axinella 521		521
Dysideidae	Euryspongia cf. arenaria	Bergquist 1961	522
Axinellidae	Cymbastela 524		524

Mycalidae	Mycale (Arenochalina) flammula	(Lamarck) 1814	526
Crellidae	Crella incrustans	(Carter) 1886	537
Microcionidae	Holopsamma ramosa (Hallmann, 1912)		543
Microcionidae	Clathria (Thalysias) cactiformis (Lamarck, 1814)		545
Raspailiidae	Echinodictyum clathrioides Hentschel, 1911		546
Microcionidae	Clathria (Thalysias) major Hentschel, 1912		547
Microcionidae	Echinoclathria leporina (Lamarck, 1814)		549
Microcionidae	Clathria (Thalysias) styloprothesis Hooper, 1996		551
Microcionidae	Clathria (Thalysias) spinifera (Lindgren, 1897)		552
Raspailiidae	Amphinomia sulphurea Hooper, 1991		554
Axinellidae	Axinella 559		559
Axinellidae	Axinella 579		579
Thorectidae	Carteriospongia foliascens		580
Callyspongiidae	Siphonochalina deficiens	Pulitzer-Finali 1982	582
Niphatidae	Niphates 586		586
Thorectidae	Aplysinopsis reticulata	(Lendenfeld) 1889	589
Petrosiidae	Petrosia (Petrosia) cf crassa	(Carter) 1880	590
Thorectidae	Ledenfeldia plicata	Esper 1806	591
Microcionidae	Clathria (Thalysias) toxifera (Hentschel, 1912)		602
Raspailiidae	Echinodictyum rugosum Ridley and Dendy, 1886		603
Phloeodictyidae	Oceanapia ramsayi	(Lendenfeld) 1888	604
Microcionidae	Clathria (Thalysias) phorbasiformis Hooper, 1996		606
Microcionidae	Clathria (Thalysias) tingens Hooper, 1996		610
Axinellidae	Phakellia 611		611
Axinellidae	Axinella 612		612
Raspailiidae	Raspailia_(Parasyringella) elegans (Lendenfeld, 1887)		613
Axinellidae	Axinella 616		616
Axinellidae	Axinella 620		620
Dysideidae	Dysidea 630		630
Axinellidae	Phakellia 643		643
Axinellidae	Phakellia 646		646
Axinellidae	Phakellia 647		647
Microcionidae	Clathria (Clathria) transiens Hallmann, 1912		650
Thorectidae	Luffariella geometrica	Kirkpatrick 1900	653
Axinellidae	Phakellia 654		654
Verticillitidae	Vaceletia crypta	Vacelet 1979	655
Astroscleridae	Astrosclera willeyana	Lister 1900	656
Acanthochaetidae	Acanthochaetetes wellsi	Hartman & Goreau 1975	657
Axinellidae	Dragmacidon 659		659
Agelasiidae	Agelas cf. mauritianus	Carter 1883	660
Agelasiidae	Agelas axifera	Hentschel 1911	661
Axinellidae	Dragmacidon australis (Bergquist, 1970)		662
Axinellidae	Phakellia pulcherrima	(Ridley & Dendy) 1886	663
Axinellidae	Cymbastela coralliophila Hooper & Bergquist, 1992		664
Raspailiidae	Raspailia (Raspailia) wilkinsoni Hooper, 1991		665
Raspailiidae	Endectyon elyakovi Hooper, 1991		666
Dictyonellidae	Acanthella constricta	Pulitzer-Finali 1982	667
Leucettidae	Pericharax heterorhaphis	(Polejaeff) 1883	668
Microcionidae	Antho (Isopenectya) chartacea (Whitelegge, 1907)		670
Microcionidae	Clathria (Microciona) aceratoobtusa (Carter, 1887)		671
Raspailiidae	Ectyoplasia vannus Hooper, 1991		703
Axinellidae	Phakellia 705		705
Axinellidae	Axinella 706		706
Axinellidae	Phakellia 707		707
Raspailiidae	Ceratopsion palmata Hooper, 1991		709
Raspailiidae	Plocamione pachysclera	(Levi & Levi) 1983	711
Axinellidae	Dragmacidon 712		712
Microcionidae	Clathria (Microciona) grisea (Hentschel, 1911)		714
Axinellidae	Cymbastela marshae Hooper & Bergquist, 1992		725

Axinellidae	Axinella 728		728
Axinellidae	Axinella 730		730
Microcionidae	Holopsamma favus (Carter, 1885)		739
Microcionidae	Clathria (Axosuberites) 741		741
Microcionidae	Clathria (Axosuberites) patula Hooper, 1996		741
Mycalidae	Mycale (Mycale) pectinicola	Hentschel 1911	747
Microcionidae	Clathria (Isociella) selachia Hooper, 1996		754
Raspailiidae	Ceratopsion montebelloensis Hooper, 1991		761
Axinellidae	Axinella 766		766
Axinellidae	Axinella 770		770
Axinellidae	Axinella 774		774
Plakinidae	Plakortis nigra	Levi 1959	775
Ancorinidae	Stelletta splendans	(de Laubenfels, 1954)	779
Axinellidae	Axinella 780		780
Axinellidae	Reniochalina 781		781
Raspailiidae	Ceratopsion axifera (Hentschel, 1912)		782
Microcionidae	Clathria (Wilsonella) claviformis Hentschel, 1912		783
Microcionidae	Clathria (Thalysias) erecta (Thiele, 1899)		784
Axinellidae	Phakellia 785		785
Thorectidae	Carteriospongia flabellifera	(Bowerbank) 1877	788
Ancorinidae	Melophlus sarassinorum	Thiele 1899	794
Thorectidae	Hyrtios erecta	(Keller) 1889	796
Axinellidae	Reniochalina 798		798
Microcionidae	Clathria (Wilsonella) abrolhosensis Hooper, 1996		807
Axinellidae	Axinella 810		810
Axinellidae	Axinella 812		812
Aplysinellidae	Aplysinella 814		814
Microcionidae	Holopsamma sp._indeterminate_816		816
Microcionidae	Clathria (Thalysias) cf.hirsuta Hooper & Levi, 1993		821
Microcionidae	Clathria (Dendrocia) myxilloides Dendy, 1896		826
Desmacididae	Psammoclema 827		827
Microcionidae	Echinoclathria chalinoides	(Carter) 1885	828
Mycalidae	Mycale (Arenochalina) cf. mirabilis	(Lendenfeld) 1887	830
Callyspongiidae	Dactylia 833		833
Microcionidae	Clathria (Wilsonella) ensiae Hooper, 1996		838
Axinellidae	Phakellia 844		844
Raspailiidae	Raspailia (Clathriodendron) 850		850
Chalinidae	Haliclona (Haliclona) 854		854
Axinellidae	Axinella 859		859
Tethyidae	Tethya 862		862
Axinellidae	Phakellia 863		863
Axinellidae	Axinella 866		866
Axinellidae	Dragmacidon 867		867
Microcionidae	Clathria (Clathria) murphyi Hooper, 1996		868
Microcionidae	Echinoclathria subhispida Carter, 1885		880
Axinellidae	Axinella 882		882
Axinellidae	Cymbastela hooperi sp. Nov	Van Soest et al 1996	883
Microcionidae	Clathria (Wilsonella) cf.guettardi (Topsent, 1933)		885
Microcionidae	Echinoclathria riddlei Hooper, 1996		894
Raspailiidae	Raspailia (Clathriodendron) cacticutis (Carter, 1885)		895
Microcionidae	Clathria (Thalysias) costifera Hallmann, 1912		897
Microcionidae	Echinoclathria egena Wiedenmayer, 1989		901
Chondrosiidae	Phoriospongia cf. kirki	(Bowerbank) 1841	902
Axinellidae	Phakellia 903		903
Axinellidae	Axinella 905		905
Raspailiidae	Raspailia (Clathriodendron) 910		910
Desmoxyidae	Didiscus aceratus	(Ridley & Dendy) 1886	913
Axinellidae	Cymbastela cantharella	(Levi) 1983	914
Microcionidae	Echinochalina_(Protophlitapongia) laboutei Hooper & Levi, 1993		915

Callyspongiidae	Callyspongia 916		916
Dictyonellidae	Rhaphoxya systremma	Hooper & Levi 1993	919
Petrosiidae	Xestospongia nigricans	(Lindgren) 1897	921
Dictyonellidae	Stylissa carteri	(Dendy) 1889	922
Microcionidae	Clathria (Clathria) kylista Hooper & Levi, 1993		923
Microcionidae	Clathria (Thalysias) corneolia	Hooper & Levi 1993	924
Dictyonellidae	Stylissa massa	(Carter, 1887)	925
Microcionidae	Clathria (Thalysias) flabellifera	Hooper & Levi 1993	926
Microcionidae	Clathria (Thalysias) araiosa	Hooper & Levi 1993	927
Desmacellidae	Neofibularia hartmani	Hooper & Levi 1993	928
Suberitidae	Homaxinella domantayi	(Levi) 1961	930
Axinellidae	Axinella 931		931
Axinellidae	Ptilocaulis 932		932
Dysideidae	Dysidea arenaria	Bergquist 1965	940
Axinellidae	Phakellia conulosa Dendy, 1922		948
Raspailiidae	Raspailia (Parasyringella) 949		949
Chalinidae	Reniera chrysa	De Laubenfels, 1954	950
Axinellidae	Axinella 955		955
Axinellidae	Auletta 960		960
Axinellidae	Phakellia 961		961
Microcionidae	Clathria (Thalysias) 970		970
Phloeodictyidae	Oceanapia sagittaria	(Sollas) 1902	972
Raspailiidae	Raspailia (Clathriodendron) 973		973
Rhabderemiidae	Rhabderemia indica	Dendy 1905	976
Raspailiidae	Axechina raspailoides Hentschel, 1912		977
Desmacididae	Desmacidon 980		980
Callyspongiidae	Callyspongia 981		981
Microcionidae	Clathria (Thalysias) wesselensis	Hooper 1996	982
Coelosphaeridae	Coelocarteria 988		988
Ancorinidae	Ancorina 989		989
Ianthellidae	Ianthella quadrangulata	Bergquist 1993	993
Niphatidae	Amphimedon terpensis	Fromont 1993	996
Microcionidae	Clathria (Thalysias) craspedia Hooper, 1996		997
Coelosphaeridae	Lissodendoryx (Ectodoryx). 1001		1001
Axinellidae	Phakellia stipitata (Carter, 1881)		1004
Ancorinidae	Stelleta 1005		1005
Raspailiidae	Ceratopsion clavata Thiele, 1898		1008
Microcionidae	Echinochalina (Protophlitaspongia) bargibanti	Hooper & Levi 1993	1011
Microcionidae	Echinochalina_(Protophlitapongia) favulosa Hooper, 1996		1012
Axinellidae	Phakellia 1013		1013
Axinellidae	Phakellia 1014		1014
Axinellidae	Axinella 1015		1015
Axinellidae	Axinella 1016		1016
Petrosiidae	Petrosia 1021		1021
Niphatidae	Cribrochalina 1023		1023
Chalinidae	Haliclona 1031		1031
Microcionidae	Clathria (Thalysias) aphylla Hooper, 1996		1040
Chalinidae	Haliclona 1043		1043
Niphatidae	Gelliodes 1049		1049
Microcionidae	Clathria (Thalysias) coralliophila (Thiele, 1903)		1051
Raspailiidae	Raspailia_(Parasyringella) 1054		1054
Axinellidae	Cymbastela vespertina Hooper & Bergquist, 1992		1055
Niphatidae	Niphates 1056		1056
Axinellidae	Ptilocaulis epakros	Hooper & Levi 1993	1057
Microcionidae	Clathria (Clathria) menoui	Hooper & Levi 1993	1058
Axinellidae	Reniochalina condylia	Hooper & Levi 1993	1060
Microcionidae	Clathria (Clathria) bulbosa Hooper & Levi, 1993		1061
Microcionidae	Echinochalina_(Protophlitapongia) tuberosa Hooper, 1996		1064
Leucettidae	Leucetta microraphis	(Haeckel) 1872	1065

Halichondriidae	Hymeniacidon 1066		1066
Microcionidae	Clathria (Wilsonella) litos	Hooper & Levi 1993	1067
Axinellidae	Phakellia mauritiana	Dendy 1921	1068
Microcionidae	Clathria (Axosuberites) lambei	(Koltun) 1955	1069
Microcionidae	Clathria (Clathria) laevigata	Lambe 1893	1070
Microcionidae	Clathria (Clathria) chelifera	(Hentschel) 1911	1073
Microcionidae	Clathria (Clathria) 1074		1074
Microcionidae	Clathria (Thalysias) cervicornis (Thiele, 1903)		1075
Thorectidae	Strepsichordaia lendenfeldi	Bergquist, Ayling & Wilkinson 1988	1077
Chondropsidae	Phoriospongia 1080		1080
Raspailiidae	Raspailia (Raspaxilla) 1081		1081
Axinellidae	Ptilocaulis fusiformis Levi, 1967		1082
Raspailiidae	Raspailia (Raspaxilla) clathrioides (Levi, 1967)		1084
Axinellidae	Dragmacidon debitusae	Hooper & Levi 1993	1085
Raspailiidae	Ceratopsion clavata	Thiele 1898	1088
Axinellidae	Axinella 1089		1089
Agelasidae	Agelas mauritiana	Carter 1883	1094
Ancorinidae	Rhabdastrella globostellata	Carter 1883	1100
Dysideidae	Dysidea granulosa	Bergquist 1965	1106
Tethyidae	Tethya australis	Bergquist & Kelly-Borges 1991	1115
Callyspongiidae	Callyspongia 1116		1116
Spongiidae	Hippospongia elastica	(Lendenfeld) 1889	1121
Niphatidae	Niphates 1122		1122
Hymedesmiidae	Phorbas 1134		1134
Microcionidae	Echinoclathria waldoschmitti	de Laubenfels 1954	1141
Raspailiidae	Ectyoplasia frondosa	(Lendenfeld) 1887	1152
Raspailiidae	Raspailia (Raspailia) atropurpurea	(Carter) 1885	1153
Raspailiidae	Raspailia (Raspailia) echinata	Whitelegge 1907	1154
Raspailiidae	Raspailia (Raspailia) gracilis (Lendenfeld, 1888)		1155
Raspailiidae	Raspailia (Raspailia) pinnatifida	(Carter) 1885	1156
Raspailiidae	Raspailia (Raspailia) tenella	(Lendenfeld) 1888	1157
Raspailiidae	Raspailia (Raspaxilla) frondula	(Whitelegge) 1907	1159
Raspailiidae	Raspailia (Parasyringella) clathrata	Ridley 1884	1160
Raspailiidae	Raspailia (Hymeraphiopsis) irregularis	Hentschel 1914	1162
Raspailiidae	Endectyon fruticosa aruensis	(Carter) 1885	1163
Raspailiidae	Endectyon xerampelina	(Lamarck) 1814	1164
Raspailiidae	Eurypon graphidiophora	Hentschel 1911	1165
Raspailiidae	Ceratopsion dichotoma	(Whitelegge) 1907	1166
Raspailiidae	Cyamon aruense	Hentschel 1912	1167
Raspailiidae	Echinodictyum arenosum	Dendy 1896	1168
Raspailiidae	Echinodictyum carlinoides	(Lamarck) 1814	1169
Raspailiidae	Echinodictyum costiferum	Ridley 1884	1170
Raspailiidae	Echinodictyum lacunosum	Kieschnick 1898	1171
Irciniidae	Psammocinia 1175		1175
Callyspongiidae	Callyspongia (Euplacella) 1176		1176
Raspailiidae	Echinodictyum 1178		1178
Irciniidae	Psammocinia 1181		1181
Chondropsidae	Psammoclema 1183		1183
Leucettidae	Pericharax 1187		1187
Clionaidae	Cliona 1189		1189
Irciniidae	Psammocinia 1191		1191
Aplysinellidae	Aplysinella 1194		1194
Clionaidae	Spheciospongia areolata	(Dendy 1897)	1195
Aplysinidae	Aplysina 1198		1198
Microcionidae	Holopsamma 1202		1202
Chalinidae	Haliclona 1205		1205
Dysideidae	Dysidea 1211		1211
Microcionidae	Clathria (Wilsonella) 1212		1212
Phloeodictyidae	Oceanapia 1220		1220

Halichondriidae	Halichondria 1227		1227
Irciniidae	Ircinia 1228		1228
Axinellidae	Dragmacidon 1239		1239
Irciniidae	Ircinia 1242		1242
Raspailiidae	Raspailia (Clathriodendron) 1245		1245
Microcionidae	Clathria (Clathria) angulifera Dendy, 1896		1246
Irciniidae	Ircinia 1255		1255
Halichondriidae	Halichondria bergquistae	Hooper et al. 1995	1269
Axinellidae	Phakellia 1270		1270
Ancorinidae	Disyringa (Tribrachion) schmidtii	(Weltner 1882)	1274
Druinellidae	Pseudoceratina 1279		1279
Microcionidae	Clathria (Clathria) basilana	Levi 1961	1280
Axinellidae	Phakellia 1285		1285
Niphatidae	Cribrochalina 1293		1293
Irciniidae	Ircinia 1294		1294
Coelosphaeridae	Coelosphaera 1299		1299
Ancorinidae	Stelleta 1308		1308
Thorectidae	Fasciospongia 1318		1318
Raspailiidae	Ceratopsion aurantiaca (Lendenfeld, 1888)		1328
Axinellidae	Axinella 1333		1333
Axinellidae	Axinella 1341		1341
Microcionidae	Clathria (Axosuberites) thetidis (Hallmann, 1920)		1342
Microcionidae	Clathria (Clathria) striata Whitelegge, 1907		1343
Microcionidae	Holopsamma arborea (Lendenfeld, 1888)		1344
Microcionidae	Holopsamma rotunda (Hallmann, 1912)		1358
Petrosiidae	Neopetrosia pacifica	(Kelly-Borges & Bergquist 1988)	1362
Callyspongiidae	Arenosclera 1363		1363
Spongiidae	Hyattella 1366		1366
Callyspongiidae	Dactylia 1368		1368
Phloeodictyidae	Aka 1373		1373
Callyspongiidae	Siphonochalina 1374		1374
Callyspongiidae	Dactylia 1376		1376
Sycettidae	Sycon cf. gelatinosum	Blainville, 1834	1390
Leucettidae	Leucetta chagosensis	Dendy 1913	1402
Microcionidae	Echinochalina_(Protophlitapongia) bispiculata (Dendy, 1895)		1413
Raspailiidae	Aulospongus samariensis	Hooper et al, 1998	1422
Microcionidae	Clathria (Microciona) illawarrae Hooper, 1996		1474
Axinellidae	Axinella 1490		1490
Axinellidae	Axinella 1491		1491
Spongiidae	Coscinoderma mathewsi	(Lindenfeld) 1886	1493
Thorectidae	Dactylospongia elegans	(Thiele) 1899	1514
Desmacididae	Liosina paradoxa	Theile, 1899	1518
Dysideidae	Dysidea 1519		1519
Dysideidae	Dysidea 1524		1524
Crellidae	Crella 1525		1525
Crambeidae	Monanchora (Ectyobatzella) 1541		1541
Dysideidae	Dysidea 1547		1547
Levinellidae	Levinella prolifera		1554
Callyspongiidae	Euplacella 1559		1559
Microcionidae	Antho (Isopenectya) punicea Hooper, 1996		1571
Axinellidae	Reniochalina 1607		1607
Microcionidae	Echinochalina (Echinochalina) felixi Hooper, 1996		1610
Raspailiidae	Echinodictyum 1620		1620
Microcionidae	Echinoclathria 1628		1628
Microcionidae	Echinoclathria bergquistae Hooper, 1996		1629
Microcionidae	Echinoclathria digitata (Lendenfeld, 1888)		1630
Microcionidae	Clathria (Thalysias) fusterna Hooper, 1996		1631
Microcionidae	Clathria (Microciona) lizardensis Hooper, 1996		1632
Axinellidae	Auletta 1638		1638

Axinellidae	Phakellia 1639		1639
Axinellidae	Axinella 1640		1640
Raspailiidae	Endectyon 1641		1641
Axinellidae	Reniochalina 1642		1642
Axinellidae	Reniochalina 1643		1643
Raspailiidae	Raspailia (Parasyringella) 1644		1644
Microcionidae	Clathria (Axosuberites) 1645		1645
Microcionidae	Clathria (Microciona) 1646		1646
Microcionidae	Clathria (Microciona) mima (de Laubenfels, 1954)		1650
Axinellidae	Cymbastela 1655		1655
Axinellidae	Axinella 1659		1659
Microcionidae	Clathria (Microciona) 1665		1665
Microcionidae	Antho (Isopenectya) saintvincenti Hooper, 1996		1685
Raspailiidae	Raspailia (Raspailia) 1695		1695
Raspailiidae	Raspailia (Raspaxilla) 1696		1696
Microcionidae	Echinoclathria levii Hooper, 1996		1697
Microcionidae	Echinoclathria notialis Hooper, 1996		1698
Microcionidae	Echinoclathria parkeri Hooper, 1996		1699
Microcionidae	Echinoclathria inornata	(Hallmann) 1912	1700
Microcionidae	Echinoclathria confragosa	(Hallmann) 1912	1702
Microcionidae	Echinoclathria axinelloides (Dendy, 1896)		1703
Esperiopsidae	Ulosa spongia	(de Laubenfels, 1954)	1728
Phloeodictyidae	Aka 1738		1738
Microcionidae	Echinochalina_(Protophlitapongia) isaaci Hooper, 1996		1754
Microcionidae	Echinochalina_(Protophlitapongia) collata Hooper, 1996		1755
Microcionidae	Clathria (Isociella) 1758		1758
Raspailiidae	Raspailia (Raspailia) 1761		1761
Microcionidae	Clathria (Microciona) 1763		1763
Raspailiidae	Raspailia_(Parasyringella) 1765		1765
Axinellidae	Axinella 1769		1769
Axinellidae	Phakellia 1770		1770
Raspailiidae	Raspailia (Raspailia) 1772		1772
Halichondriidae	Amorphinopsis 1785		1785
Axinellidae	Reniochalina 1795		1795
Microcionidae	Clathria (Clathria) faviformis	van Soest	1820
Microcionidae	Holopsamma 1830		1830
Dysideidae	Eurospongia deliculata	Bergquist, 1995	1833
Microcionidae	Clathria (Microciona) 1839		1839
Dysideidae	Dysidea 1845		1845
Chalinidae	Haliclona 1853		1853
Microcionidae	Echinoclathria 1855		1855
Esperiopsidae	Ulosa 1856		1856
Tetillidae	Cinachyrella 1870		1870
Microcionidae	Clathria (Microciona) 1875		1875
Irciniidae	Ircinia 1876		1876
Raspailiidae	Eurypon 1877		1877
Halichondriidae	Axinyssa 1878		1878
Microcionidae	Clathria (Microciona) 1882		1882
Raspailiidae	Eurypon 1889		1889
Microcionidae	Clathria (Microciona) 1890		1890
Microcionidae	Clathria (Dendrocia) dura Whitelegge, 1901		1921
Microcionidae	Clathria (Microciona) 1940		1940
Niphatidae	Niphates 1943		1943
Irciniidae	Ircinia 1944		1944
Chalinidae	Halilclona 1954		1954
Microcionidae	Clathria (Microciona) 1957		1957
Thorectidae	Candidaspongia flabellata	Bergquist, Sorokin and Karusu, 1999	1958
Podospongiidae	Diacarnus levii	Kelly-Borges & Vacelet 1995	1960
Niphatidae	Niphates 1980		1980

Spongiidae	Spongia 1983		1983
Halichondriidae	Halichondria 1984		1984
Microcionidae	Echinochalina_(Protophlitapongia) 1991		1991
Raspailiidae	Thrinacophora 1993		1993
Raspailiidae	Echinodictyum 2001		2001
Callyspongiidae	Callyspongia 2022		2022
Druinellidae	Aplysinella rhax	(de Laubenfels, 1954)	2027
Microcionidae	Clathria (Microciona) 2033		2033
Axinellidae	Reniochalina 2036		2036
Microcionidae	Clathria (Microciona) richmondi	Hooper, Kelly-Borges and Kennedy	2055
Microcionidae	Echinochalina (Echinochalina) 2057		2057
Axinellidae	Axinella 2083		2083
Raspailiidae	Echinodictyum 2088		2088
Axinellidae	Axinella 2108		2108
Microcionidae	Clathria (Microciona) 2114		2114
Axinellidae	Auletta 2136		2136
Microcionidae	Clathria (Microciona) 2145		2145
Axinellidae	Axinella 2159		2159
Thorectidae	Fascaplysinopsis 2170		2170
Microcionidae	Clathria (Microciona) 2176		2176
Microcionidae	Clathria (Microciona) 2177		2177
Niphatiidae	Cribrochalina 2178		2178
Axinellidae	Axinella 2189		2189
Rhabderemiidae	Rhabderemia 2195		2195
Axinellidae	Phakellia 2202		2202
Axinellidae	Axinella 2205		2205
Microcionidae	Clathria (Thalysias) 2207		2207
Microcionidae	Clathria (Thalysias) 2211		2211
Raspailiidae	Raspailia (Raspaxilla) 2264		2264
Microcionidae	Clathria (Microciona) 2265		2265
Axinellidae	Axinella 2267		2267
Axinellidae	Axinella 2281		2281
Microcionidae	Clathria (Microciona) 2292		2292
Microcionidae	Clathria (Microciona) 2295		2295
Microcionidae	Clathria (Microciona) 2310		2310
Microcionidae	Clathria (Microciona) 2317		2317
Raspailiidae	Echinodictyum 2319		2319
Microcionidae	Clathria (Thalysias) 2322		2322
Raspailiidae	Aulospongus 2349		2349
Axinellidae	Phakellia 2356		2356
Raspailiidae	Raspailia (Parasyringella) 2357		2357
Microcionidae	Clathria (Thalysias) 2373		2373
Microcionidae	Clathria (Clathria) 2376		2376
Desmacididae	Iotrochota 2386		2386
Microcionidae	Clathria (Thalysias) 2413		2413
Raspailiidae	Eurypon hispida	de Laubenfels, 1954	2414
Microcionidae	Clathria (Microciona) 2431		2431
Microcionidae	Clathria (Thalysias) 2432		2432
Microcionidae	Clathria (Thalysias) 2433		2433
Microcionidae	Clathria (Thalysias) 2441		2441
Microcionidae	Clathria (Clathria) 2454		2454
Agelasidae	Agelas 2480		2480
Raspailiidae	Raspailia_(Parasyringella) 2482		2482
Microcionidae	Clathria (Microciona) 2489		2489
Microcionidae	Clathria (Thalysias) 2530		2530
Microcionidae	Clathria (Axosuberites) nidificata	Kirkpatrick, 1907	2574
Microcionidae	Clathria (Thalysias) 2583		2583
Axinellidae	Cymbastela 2606		2606
Axinellidae	Auletta 2613		2613

Raspailiidae	Echinodictyum 2627		2627
Axinellidae	Axinella 2635		2635
Axinellidae	Auletta 2636		2636
Tetillidae	Tetilla 2655		2655
Microcionidae	Echinochalina_(Protophlitapongia) 2688		2688
Microcionidae	Clathria (Thalysias) 2692		2692
Microcionidae	Clathria (Microciona) 2701		2701
Microcionidae	Clathria (Clathria) 2711		2711
Raspailiidae	Raspailia (Raspailia) 2714		2714
Microcionidae	Clathria (Microciona) 2723		2723
Microcionidae	Clathria (Axosuberites) 2731		2731
Raspailiidae	Ceratopsion cf. montebelloensis		2732
Axinellidae	Phakellia 2755		2755
Raspailiidae	Echinodictyum 2789		2789
Axinellidae	Ptilocaulis 2791		2791
Axinellidae	Ptilocaulis 2800		2800
Raspailiidae	Raspailia_(Parasyringella) 2803		2803
Raspailiidae	Ceratopsion 2806		2806
Microcionidae	Echinochalina (Echinochalina) 2819		2819
Microcionidae	Echinochalina (Echinochalina) 2822		2822
Axinellidae	Axinella 2823		2823
Raspailiidae	Ceratopsion 2825		2825
Microcionidae	Clathria (Microciona) 2844		2844
Raspailiidae	Ceratopsion 2846		2846
Axinellidae	Ptilocaulis 2856		2856
Axinellidae	Ptilocaulis 2866		2866
Raspailiidae	Aulospongus 2876		2876
Microcionidae	Echinochalina_(Protophlitapongia) oxeata (Burton, 1934)		2878
Microcionidae	Clathria (Isociella) 2897		2897
Axinellidae	Axinella 2938		2938
Axinellidae	Axinella 2950		2950
Raspailiidae	Raspailia (Raspailia) 2953		2953
Microcionidae	Echinochalina (Echinochalina) 2959		2959
Axinellidae	Axinella 2962		2962
Raspailiidae	Ceratopsion 2964		2964
Chondropsidae	Psammoclema 2980		2980
Raspailiidae	Raspailia (Raspailia) 3003		3003
Axinellidae	Phakellia 3004		3004
Microcionidae	Clathria (Clathria) hispidula (Ridley, 1884)		3005
Axinellidae	Cymbastela 3009		3009
Axinellidae	Phakellia columnata	Burton, 1928	3016
Axinellidae	Cymbastela 3052		3052
Raspailiidae	Raspailia (Raspailia) 3054		3054
Microcionidae	Echinochalina (Echinochalina) 3088		3088
Raspailiidae	Echinodictyum 3089		3089
Axinellidae	Reniochalina 3092		3092
Axinellidae	Phakellia 3096		3096
Axinellidae	Phakellia 3102		3102
Axinellidae	Axinella 3108		3108
Raspailiidae	Aulospongus calthrioides		3115
Raspailiidae	Raspailia (Raspailia) 3189		3189
Axinellidae	Auletta 3196		3196
Microcionidae	Clathria (Dendrocia) 3197		3197
Microcionidae	Clathria (Wilsonella) 3214		3214
Axinellidae	Axinella 3249		3249
Axinellidae	Auletta 3256		3256
Axinellidae	Cymbastela 3287		3287
Raspailiidae	Raspailia (Clathriodendron)) 3311		3311
Axinellidae	new genus? 3324		3324

Microcionidae	Echinochalina_(Protophlitapongia) 3333		3333
Axinellidae	Phakellia 3356		3356
Microcionidae	Echinochalina (Echinochalina) 3446		3446
Axinellidae	Phakellia 3459		3459
Axinellidae	Axinella 3461		3461
Raspailiidae	Raspailia (Raspailia) 3463		3463
Microcionidae	Echinochalina_(Protophlitapongia) 3482		3482
Microcionidae	Clathria (Clathria) 3488		3488
Axinellidae	Ptilocaulis 3490		3490
Axinellidae	Dragmacidon 3493		3493
Raspailiidae	Ceratopsion 3496		3496
Raspailiidae	Ceratopsion 3520		3520
Raspailiidae	Raspailia (Clathriodendron) 3554		3554
Raspailiidae	Raspailia (Raspailia) 3578		3578
Microcionidae	Echinoclathria 3587		3587
Microcionidae	Clathria (Microciona) 3589		3589
Axinellidae	Axinella 3611		3611
Axinellidae	Phakellia 3612		3612
Axinellidae	Cymbastela 3613		3613
Axinellidae	Cymbastela 3614		3614
Axinellidae	Axinella 3616		3616
Microcionidae	Echinoclathria 3617		3617
Microcionidae	Echinochalina (Echinochalina) 3643		3643
Raspailiidae	Raspailia (Hymeraphiopsis) 3644		3644
Microcionidae	Clathria (Axosuberites) 3678		3678
Microcionidae	Clathria (Clathria) biclathria	Hooper nom.nov.	3684
Microcionidae	Clathria (Clathria) basilana Levi, 1961		3689
Microcionidae	Clathria (Thalysias) distincta	Thiele 1903	3690
Microcionidae	Clathria (Clathria) echinonematissima	Carter 1881	3691
Microcionidae	Clathria (Dendrosia) elegantula		3692
Microcionidae	Clathria (Axosuberites) macropora	Ledenfeld 1888	3694
Microcionidae	Clathria (Clathria) inanchorata	Ridley and Dendy	3695
Microcionidae	Clathria (Clathria) meyeri	Bowerbank 1877	3696
Microcionidae	Clathria (Clathria) multipes	Hallman 1912	3697
Microcionidae	Clathria (Clathria) nexus	Koltun 1964	3698
Microcionidae	Clathria (Clathria) oxyphila	Hallman 1912	3699
Microcionidae	Clathria (Clathria) partita	Hallman 1912	3700
Microcionidae	Clathria (Clathria) perforata	Ledenfeld 1887	3701
Microcionidae	Clathria (Clathria) piniformis	Carter 1885	3702
Microcionidae	Clathria (Clathria) raphana	Lamark 1813	3703
Microcionidae	Clathria (Dendrocia) scabida	Carter 1885	3705
Microcionidae	Clathria (Clathria) squalorum	Wiedenmayer	3706
Microcionidae	Clathria (Clathria) wilsoni	Wiedenmayer 1989	3709
Microcionidae	Clathria (Dendrocia) imperfecta	Dendy 1896	3713
Microcionidae	Clathria (Axosuberites) cylindrica	Ridley and Dendy 1886	3714
Microcionidae	Clathria (Isociella) macropora	Lendenfeld, 1886	3715
Microcionidae	Clathria (Thalysias) arborescens	Ridley 1884	3716
Microcionidae	Clathria (Thalysias) aruensis	Hentschel 1912	3717
Microcionidae	Clathria (Thalysias) calochela	Hentschel 1913	3718
Microcionidae	Clathria (Thalysias) cratitia	Esper 1797	3719
Microcionidae	Clathria (Thalysias) dubia	Kirkpatrick 1900	3720
Microcionidae	Clathria (Thalysias) fasiculata	Wilson 1925	3721
Microcionidae	Clathria (Thalysias) juniperina	Lamark 1814	3723
Microcionidae	Clathria (Thalysias) longitoxa	Hentschel 1912	3725
Microcionidae	Clathria (Thalysias) nuda	Hentschel 1912	3728
Microcionidae	Clathria (Thalysias) paucispina	Ledenfeld 1888	3730
Microcionidae	Clathria (Thalysias) placenta	Lamarck 1814	3731
Microcionidae	Clathria (Thalysias) ramosa	Kieschnick 1896	3732
Microcionidae	Clathria (Thalysias) topsenti	Thiele 1899	3735

Microcionidae	Clathria (Thalysias) Burtons name not coralliophila		3736
Microcionidae	Clathria (Clathria) arcuophora	Whitelegge 1907	3737
Microcionidae	Clathria (Thalysias) nidificata	Kirkpatrick	3743
Microcionidae	Clathria (Thalysias) paucispiculus	Burton	3744
Microcionidae	Echinochalina (Echinochalina) australiensis Ridley, 1884		3747
Microcionidae	Holopsamma elegans	Ledenfeld 1888	3752
Microcionidae	Holopsamma simplex	Ledenfeld 1885	3753
Raspailiidae	Ceratopsion 3762	Burton	3762
Microcionidae	Echinochalina_(Protophlitapongia) 3763		3763
Axinellidae	Cymbastela 3767		3767
Axinellidae	Ptilocaulis 3816		3816
Axinellidae	Auletta 3817		3817
Axinellidae	Cymbastela 3818		3818
Axinellidae	Axinella 3832		3832
Axinellidae	Reniochalina 3833		3833
Rhabderemiidae	Rhabderemia 3834		3834
Rhabderemiidae	Rhabderemia 3835		3835
Microcionidae	Clathria (Dendrocia) 3837		3837
Raspailiidae	Raspailia (Raspailia) 3838		3838
Microcionidae	Clathria (Isociella) 3840		3840
Microcionidae	Echinochalina (Echinochalina) 3843		3843
Microcionidae	Echinochalina (Echinochalina) 3844		3844
Microcionidae	Clathria (Clathria) paucispicula	Burton 1932	3946
Microcionidae	Clathria (Thalysias) ruba	Ledenfeld 1888	3947

APPENDIX 2A-B. A. Small scale (γ-scale diversity) localities sampled for sponges in northern Australia extending into temperate/ transitional faunal zones. 'Unique' species and genera refer to taxa found only within a particular locality. B. Similarities between larger scale (ε-scale diversity) IMCRA bioregions, indicating pairwise comparisons in the number of species co-occurring in both bioregion (upper part of matrix), the total number of species co-occurring in both bioregion (diagonal, bold font), and percentage of species co-occurring in both bioregion (lower part of matrix).

A.

Local. No.	Latitude range	Longitude range	IMCRA Bio-region name	Locality Name	No sites sampled in this locality	No. species	No. unique species	% unique species	No. Genera	No. unique genera	% unique genera
1	33°00' - 35°00' S	150°00' - 154°00' E	CEP	Sydney, Illawarra, Newcastle regions, NSW	41	178	123	69	66	4	6
2	28°05' - 29°00' S	153°30' - 154°30' E	CEB	Northern NSW – Byron Bay region, NSW	9	64	18	28	33	1	3
3	27°50' - 28°05' S	153°00' - 154°30' E	CEB	Gold Coast – Tweed River to S. Stradbroke I., Qld	9	42	12	29	22	0	0
4	26°50' - 27°50' S	153°00' - 154°00' E	CEB	Moreton Bay, Stradbroke & Moreton Islands, Qld	84	239	73	31	78	3	4
5	26°00' - 26°50' S	153°00' - 154°00' E	CEB	Sunshine Coast (Mooloolaba to Noosa) , Qld	26	238	61	26	92	1	1
6	24°30' - 26°00' S	152°00' - 154°00' E	CEB	Hervey Bay – Fraser Island region, Qld	31	111	15	14	39	1	3
7	23°00' - 24°30' S	151°30' - 153°00' E	NEP	Capricorn-Bunkers to Keppel Is, Southern section GBR, Qld	72	410	157	38	118	5	4
8	21°30' - 23°00' S	151°00' - 153°00' E	NEP	Swain Reefs, outer Southern section GBR, Qld	70	329	55	17	93	1	1
9	21°30'-22°20' S	149°-151°00' E	NEP	Northumberland Islands Group, Southern section GBR, Qld	1	36	7	19	29	0	0
10	20°00' - 21°00' S	148°00' - 149°30' E	NEP	Whitsunday Is. , Central section GBR, Qld	52	189	71	38	69	0	0
11	20°30' - 21°30' S	149°50' - 151°50' E	NEP	Pompey Reefs, outer Southern section GBR, Qld	11	162	19	12	77	0	0
12	18°00' - 20°00' S	146°00' - 150°50' E	NEP	Townsville region (Orpheus, Palm, Slashers, Myrmedon, Broadhurst, Hook, Old, Stanley Rfs) – Central section GBR, Qld	127	325	95	29	77	0	0
13	16°30' - 18°00' S	145°30' - 147°00' E	NEB	Cairns region (Batt, Oyster, Sudbury, Opal Rfs) – Cairns section GBR, Qld	73	143	26	18	65	3	5
14	16°00' - 16°30' S	145°20' - 146°30' E	NEB	Low Islets – Cairns section GBR, Qld	34	157	36	23	62	1	2
15	14°00' - 16°00' S	144°30' - 146°00' E	NEB	Lizard, Direction Is, Ribbon, NoName, Yonge Rfs – Cairns section GBR, Qld	131	503	171	34	104	1	1
16	13°30' - 16°00' S	146°30' - 147°30' E	Coral Sea	Northern section Queensland Plateau, Coral Sea - Osprey, Bougainville Rfs	22	106	45	42	51	0	0
17	20°00' - 23°00' S	153°00' - 157°00' E	Coral Sea	Southern section Queensland Plateau, Coral Sea - Wreck, Cato, Saumarez Reefs	17	101	27	27	62	1	2
18	11°00' - 14°30' S	142°30' - 144°30' E	NEB	Far Northern section GBR (Cockburn, Flinders, Howick Rfs, Turtle Group, Shelburne Bay) , Qld	80	196	35	18	71	1	1
19	09°30' - 11°00' S	141°30' - 143°30' E	NEB	Torres Straits region, Qld	69	150	54	36	41	0	0

20	11°00' - 15°00' S	139°00' - 142°30' E	E.NP	East Gulf of Carpentaria, Qld	49	94	13	14	56	1	2
21	15°00' - 18°00' S	135°00' - 142°00' E	E.NP	South Gulf of Carpentaria, Qld/ NT	37	85	23	27	31	0	0
22	13°00' - 15°00' S	135°00' - 139°00' E	E.NP	West Gulf of Carpentaria, NT	40	53	11	21	27	0	0
23	12°00' - 13°00' S	135°00' - 138°00' E	E.NP	Gove region, NT	17	39	0	0	25	0	0
24	10°45' - 12°00' S	135°00' - 137°00' E	E.NP	Wessel Islands, NT	133	315	69	22	116	3	3
25	10°45' - 13°00' S	130°00' - 135°00' E	W.NP	Darwin and Cobourg Peninsula regions, NT	148	418	177	42	111	1	1
26	13°00' - 15°30' S	127°00' - 130°30' E	NWB	Joseph Bonaparte Gulf, NT/WA	13	13	0	0	17	0	0
27	13°00' - 15°30' S	124°10' - 127°00' E	NWB	Bonaparte Archipelago, WA	16	26	0	0	9	0	0
28	15°25 - 18°00' S	121°00' - 125°30' E	NWB	Broome region, Northwest Shelf, WA	19	99	25	25	48	3	6
29	11°00' - 13°30' S	122°00' - 124°10' E	Sahul Shelf	N Sahul Shelf (Ashmore, Cartier, Hibernia Reefs)	30	125	39	31	77	2	3
30	17°00' - 18°00' S	118°45' - 119°45' E	Sahul Shelf	S Sahul Shelf (Rowley Shoals)	4	5	0	0	20	2	10
31	18°00' - 22°30' S	115°00' - 120°00' E	NWP	Dampier and Port Headland regions, Northwest Shelf, WA	179	380	155	41	129	6	5
32	21°00' - 23°00' S	113°00' - 115°00' E	NWP	Exmouth Gulf region, WA	34	88	44	50	16	0	0
33	23°00' - 27°00' S	112°00' - 115°00' E	CWB	Shark Bay region, WA	17	50	15	30	38	3	8
34	27°00' - 29°00' S	112°00' - 115°00' E	CWP	Houtman Abrolhos, WA	36	173	85	49	49	2	4

B.

Bioregion	NEB	CEB	NEP	NWP	W.NP	E.NP	NWB	CWP	CWB
NEB	**766**	280	296	83	90	96	79	36	5
CEB	10.32	**791**	264	66	67	66	62	32	5
NEP	10.91	9.73	**548**	54	65	58	58	27	5
NWP	3.06	2.43	1.99	**391**	138	97	112	58	16
W.NP	3.32	2.47	2.39	5.08	**387**	110	110	33	10
E.NP	3.54	2.43	2.14	3.57	4.05	**271**	84	31	7
NWB	2.91	2.28	2.14	4.13	4.05	0.31	**250**	29	10
CWP	1.33	1.18	0.99	2.14	1.22	1.14	1.07	**145**	11
CWB	0.18	0.18	0.18	0.59	0.37	0.26	0.37	0.41	**33**

APPENDIX 3. List of species occurring in four or more tropical Australian bioregions.

SpeciesName	CEB	NEP	NEB	E.NP	W.NP	NWB	NWP	CWB	CWP	Total bioregions
Clathria (Thalysias) vulpina (Lamarck, 1814)	1	1	1	1	1	1	1	1	1	9
Echinodictyum mesenterinum (Lamarck, 1814)	1	1	1	1	1	1	1	0	1	8
Spheciospongia papillosa (Ridley & Dendy, 1886)	1	1	1	1	0	1	1	1	1	8
Acanthella cavernosa Dendy, 1922	1	1	1	1	1	1	1	0	0	7
Cinachyrella australiensis (Carter, 1886)	1	1	1	1	1	1	1	0	0	7
Dysidea cf.avara (Schmidt, 1862)	1	1	1	1	1	1	1	0	0	7
Echinodictyum asperum (Ridley & Dendy, 1886)	1	0	1	1	1	1	1	1	0	7
Higginsia mixta (Hentschel, 1912)	1	1	1	1	1	1	1	0	0	7
Hyattella intestinalis (Lamarck, 1814)	1	0	1	1	1	1	1	0	1	7
Ianthella basta (Pallas, 1776)	1	1	1	1	1	1	1	0	0	7
Ianthella cf.flabelliformis (Pallas, 1776)	1	1	1	1	1	1	1	0	0	7
Ianthella flabelliformis (Pallas, 1776)	1	1	1	1	1	1	1	0	0	7
Iotrochota baculifera Ridley, 1884	1	1	1	1	1	1	1	0	0	7
Ircinia 1	1	1	1	0	1	1	1	0	1	7
Ircinia 1255	1	1	1	1	1	1	1	0	0	7
Myrmekioderma granulata (Esper, 1830)	1	1	1	1	1	1	1	0	0	7
Oceanapia 135	1	0	1	1	1	1	1	0	1	7
Rhabdastrella globostellata (Carter, 1883)	1	1	1	1	1	1	1	0	0	7
Xestospongia testudinaria (Lamarck, 1813)	1	1	1	1	1	1	1	0	0	7
Agelas axifera Hentschel, 1911	1	1	1	0	0	1	1	0	1	6
Aka mucosa (Bergquist, 1965)	0	1	1	1	1	1	1	0	0	6
Aplysina ianthelliformis (Lendenfeld, 1888)	1	1	1	0	1	0	1	0	1	6
Callyspongia (Toxochalina) schulzei Kieschnick, 1900	1	1	0	1	1	1	1	0	0	6
Carteriospongia foliascens (Pallas, 1766)	1	1	1	1	0	1	1	0	0	6
Cinachyrella_(Raphidotethya) enigmatica (Burton, 1934)	1	1	1	0	1	1	1	0	0	6
Ciocalypta tyleri Bowerbank, 1873	1	1	1	0	1	1	1	0	0	6
Clathria (Thalysias) lendenfeldi Ridley & Dendy, 1886	0	0	1	1	1	1	1	1	0	6
Crella_(Crella) spinulata (Hentschel, 1911)	0	1	1	0	1	1	1	0	1	6
Dendrilla rosea Lendenfeld, 1883	1	1	1	1	1	0	0	0	1	6
Fascaplysinopsis reticulata (Hentschel, 1912)	1	1	1	1	1	1	0	0	0	6

Haliclona (Haliclona) cymaeformis (Esper, 1794)	0	1	1	0	1	1	1	0	1	6
Ianthella quadrangulata Bergquist & Kelly Borges, 1995	1	1	1	1	1	1	0	0	0	6
Lamellodysidea herbacea (Keller, 1889)	1	1	1	0	1	1	1	0	0	6
Oceanapia ramsayi (Lendenfeld, 1888)	1	0	0	1	1	1	1	0	1	6
Pachymatisma 311	1	0	1	1	1	0	1	0	1	6
Pericharax 58	1	0	0	1	1	1	1	0	1	6
Plakortis nigra Levi, 1959	1	1	1	0	0	1	1	0	1	6
Reniochalina stalagmitis Lendenfeld, 1888	1	0	1	1	1	1	1	0	0	6
Aaptos aaptos (Schmidt, 1864)	1	1	1	0	0	1	1	0	0	5
Agelas mauritiana (Carter, 1883)	1	1	1	0	1	1	0	0	0	5
Axinella aruensis Hentschel, 1912	0	0	1	1	1	1	1	0	0	5
Axinella flabellata (Ridley & Dendy, 1886)	1	1	1	0	0	1	0	1	0	5
Cinachyrella 333	0	0	0	1	1	1	1	0	1	5
Clathria (Thalysias) abietina (Lamarck, 1814)	0	0	1	1	1	1	1	0	0	5
Clathria (Thalysias) reinwardti Vosmaer, 1880	0	0	1	1	1	1	1	0	0	5
Craniella 402	0	0	0	1	1	1	1	1	0	5
Dactylospongia elegans (Thiele, 1899)	1	1	1	1	0	1	0	0	0	5
Dragmacidon australis (Bergquist, 1970)	1	1	1	0	1	1	0	0	0	5
Dysidea granulosa Bergquist, 1965	1	1	1	0	1	1	0	0	0	5
Echinochalina (Echinochalina) intermedia (Whitelegge, 1902)	1	1	1	1	0	0	1	0	0	5
Echinodictyum cancellatum (Lamarck, 1814)	0	0	0	1	1	1	1	1	0	5
Echinodictyum conulosum Kieschnick, 1900	1	0	1	1	1	0	1	0	0	5
Ectyoplasia tabula (Lamarck, 1814)	0	0	0	1	1	1	1	0	1	5
Halichondria (Halichondria) stalagmites (Hentschel, 1912)	1	1	1	0	1	1	0	0	0	5
Higginsia scabra Whitelegge, 1907	0	0	1	1	1	1	1	0	0	5
Hyrtios erecta (Keller, 1889)	1	1	1	0	1	1	0	0	0	5
Lendenfeldia plicata (Esper, 1806)	0	1	1	0	1	1	0	0	1	5
Mycale (Arenochalina) mirabilis (Lendenfeld, 1887)	1	1	1	1	0	0	1	0	0	5
Neopetrosia exigua (Kirkpatrick, 1900)	1	1	1	0	1	1	0	0	0	5
Niphates 307	0	0	0	1	1	1	1	0	1	5
Pericharax heteroraphis (Polejaeff, 1883)	1	1	1	1	0	1	0	0	0	5
Phakellia 646	0	0	1	1	1	1	1	0	0	5
Phyllospongia lamellosa (Esper, 1794)	1	1	1	0	1	0	0	0	1	5
Phyllospongia papyracea (Esper, 1806)	1	1	1	0	0	1	1	0	0	5
Pseudoceratina 190	0	0	0	1	1	1	1	0	1	5

Pseudoceratina 364	1	1	1	0	1	1	0	0	0	5
Raspailia (Raspailia) vestigifera Dendy, 1896	0	0	0	1	1	1	1	0	1	5
Reniochalina 122	0	1	0	1	1	1	1	0	0	5
Spheciospongia vagabunda (Ridley, 1884)	1	0	0	1	1	0	1	0	1	5
Stelletta 1005	1	1	1	0	0	1	1	0	0	5
Stelletta clavosa (Sollas, 1888)	0	1	1	1	1	0	1	0	0	5
Stylissa flabelliformis (Hentschel, 1912)	0	1	1	0	1	1	1	0	0	5
Thorectandra excavatus (Ridley, 1884)	0	0	0	1	1	1	1	0	1	5
Trikentrion flabelliforme Hentschel, 1912	0	0	0	1	1	1	1	1	0	5
Acanthella constricta Pulitzer-Finali, 1982	1	1	1	0	0	0	1	0	0	4
Agelas cf.mauritiana (Carter, 1883)	1	1	1	1	0	0	0	0	0	4
Aka 332	0	0	1	0	1	1	1	0	0	4
Amphimedon 167	0	0	1	1	0	0	1	0	1	4
Anomoianthella popeae Bergquist, 1980	0	0	0	0	1	1	1	0	1	4
Astrosclera willeyana Lister, 1900	1	1	1	0	0	1	0	0	0	4
Axechina raspailioides Hentschel, 1912	0	0	1	1	1	0	1	0	0	4
Axinella 26	0	0	0	1	1	1	1	0	0	4
Callyspongia (Callyspongia) 138	0	0	1	1	1	1	0	0	0	4
Callyspongia (Callyspongia) 369	0	1	0	1	1	0	0	0	1	4
Caulospongia perfoliata (Lamarck, 1813)	0	0	0	0	0	1	1	1	1	4
Ceratopsion palmata Hooper, 1991	0	0	0	1	1	1	1	0	0	4
Chondrilla 14	1	1	1	0	1	0	0	0	0	4
Cinachyrella 376	1	1	1	0	1	0	0	0	0	4
Cinachyrella schulzei Keller, 1880	0	0	1	0	1	1	1	0	0	4
Clathria (Thalysias) procera (Ridley, 1884)	0	0	1	1	1	0	1	0	0	4
Clathria (Thalysias) tingens Hooper, 1996	0	1	1	0	1	1	0	0	0	4
Cliona 17	1	1	0	0	1	1	0	0	0	4
Cliona 76	0	0	1	1	1	0	1	0	0	4
Cliona orientalis Thiele, 1900	1	1	1	0	1	0	0	0	0	4
Cliona patera (Hardwicke, 1822)	0	0	1	1	0	1	1	0	0	4
Coelocarteria singaporensis (Carter, 1883)	0	1	1	1	1	0	0	0	0	4
Crella_(Crella) 1525	1	1	1	1	0	0	0	0	0	4
Cymbastela coralliophila Hooper & Bergquist, 1992	1	1	1	1	0	0	0	0	0	4
Cymbastela vespertina Hooper & Bergquist, 1992	0	0	0	1	1	1	1	0	0	4
Desmapsamma 241	0	1	0	0	1	1	1	0	0	4

Dictyodendrilla 362	0	0	1	0	1	1	1	0	0	4
Disyringia dissimilis (Ridley, 1884)	0	0	0	1	1	1	1	0	0	4
Dysidea 16	0	1	1	0	1	1	0	0	0	4
Dysidea arenaria (Bergquist, 1965)	1	1	1	0	0	1	0	0	0	4
Echinodictyum nidulus Hentschel, 1911	0	1	0	0	1	0	0	1	1	4
Ectyoplasia vannus Hooper, 1991	0	0	0	1	1	1	1	0	0	4
Esperiopsis 48	0	0	1	0	1	0	1	0	1	4
Fasciospongia 290	0	0	1	1	0	0	1	0	1	4
Gelloides fibulatus Ridley, 1884	0	1	1	0	1	1	0	0	0	4
Halichondria (Halichondria) 1227	1	1	1	1	0	0	0	0	0	4
Halichondria (Halichondria) 179	0	0	1	1	0	1	1	0	0	4
Halichondria (Halichondria) bergquistae Hooper et al., 1997	1	1	1	0	1	0	0	0	0	4
Halichondria (Halichondria) phakellioides Dendy & Frederick, 1924	0	0	0	1	1	1	1	0	0	4
Haliclona (Haliclona) 1381	1	1	1	1	0	0	0	0	0	4
Haliclona (Haliclona) 36	0	0	0	1	1	1	1	0	0	4
Haliclona (Haliclona) 384	1	0	0	0	1	1	1	0	0	4
Hymeniacidon 1066	1	1	1	0	0	0	0	0	1	4
Iotrochota 377	0	0	1	1	1	0	1	0	0	4
Iotrochota coccinea (Carter, 1886)	1	1	1	0	0	1	0	0	0	4
Ircinia 1228	0	0	1	1	1	0	1	0	0	4
Ircinia 1944	1	1	1	1	0	0	0	0	0	4
Liosina paradoxa Theile, 1899	1	1	1	0	0	1	0	0	0	4
Mycale (Mycale) 80	1	1	0	0	1	0	1	0	0	4
Mycale (Mycale) pectinicola Hentschel, 1911	0	0	0	1	0	1	1	0	1	4
Oceanapia 1220	0	1	1	1	1	0	0	0	0	4
Phakellia 244	0	0	0	1	1	1	1	0	0	4
Phakellia stipitata (Carter, 1881)	1	1	1	1	0	0	0	0	0	4
Phoriospongia 293	0	1	0	1	1	0	1	0	0	4
Pseudoceratina 1279	1	1	1	1	0	0	0	0	0	4
Spirastrella 150	0	0	0	1	1	0	1	0	1	4
Spongia 1983	1	1	1	0	1	0	0	0	0	4
Spongia hispida Lamarck, 1813	1	1	1	0	0	0	1	0	0	4
Stelletta splendens (de Laubenfels, 1954)	1	1	1	0	0	0	1	0	0	4
Stylissa carteri (Dendy, 1889)	1	1	1	0	0	0	1	0	0	4

Tethya coccinea Bergquist & Kelly-Borges, 1991	0	0	1	1	0	0	1	0	1	4
Thrinacophora cervicornis Ridley & Dendy, 1887	0	0	0	1	1	1	1	0	0	4
Trachycladus laevispirulifer Carter, 1879	1	0	0	0	0	0	1	1	1	4
Xestospongia 158	0	0	1	1	1	0	1	0	0	4

APPENDIX 4. Jaccard Similarity index (%) for pairwise comparisons between small scale (γ-scale diversity) localities sampled for sponges in northern Australia (including temperate transitional zones).

LOCALITY	Byron Bay	Gold Coast	Hervey Bay	Sunshine Coast	Moreton Bay	Sydney-Illawarra	N Qld Plateau	S Qld Plateau	Shark Bay	Gove region	E Gulf Carpent	S Gulf Carpent	W Gulf Carpent	Wessel Is	Cairns GBR	Far N Qld GBR	Lizard I GBR	Low Is GBR	Torres Straits	Capricorn GBR	Nth'land GBR	Swains GBR	Townsville GBR	Whitsundays GBR	Pompeys GBR	Broome	Bonaparte Arch	Joseph Bonaparte Gulf	Dampier	Exmouth	N Sahul Shelf	S Sahul Shelf	Houtman Abrolhos
Byron Bay																																	
Gold Coast	22.0																																
Hervey Bay	10.6	8.0																															
Sunshine Coast	14.3	15.4	23.9																														
Moreton Bay	22.6	11.8	22.2	36.2																													
Sydney-Illawarra	9.4	7.3	2.3	8.3	10.4																												
N Qld Plateau	0.0	0.0	7.4	11.8	6.9	0.8																											
S Qld Plateau	1.3	1.5	5.8	12.1	10.3	1.6	13.8																										
Shark Bay	5.5	6.7	3.8	4.9	4.5	2.0	1.3	1.4																									
Gove region	0.0	0.0	1.6	3.3	1.8	1.2	0.0	0.0	9.5																								
E Gulf Carpent.	7.9	6.1	8.9	8.6	8.5	1.6	2.0	1.1	8.5	5.7																							
S Gulf Carpent	4.1	1.6	5.1	6.9	5.4	2.5	1.0	6.6	5.9	8.2	29.4																						
W Gulf Carpent	5.3	2.2	7.4	6.3	6.0	1.0	0.0	2.7	13.6	12.1	26.2	29.0																					
Wessel Is	3.5	2.1	6.1	8.3	7.4	1.0	3.7	5.3	13.3	14.7	17.7	10.0	13.0																				
Cairns GBR	5.0	2.9	8.6	18.1	13.4	3.2	9.8	20.4	2.7	1.8	7.3	5.4	7.9	9.1																			
FarN Qld GBR	9.7	7.5	16.4	19.5	17.2	5.4	10.3	13.2	5.1	3.8	19.3	13.9	15.1	13.9	28.6																		
Lizard I GBR	4.6	2.8	12.2	22.1	16.8	3.2	15.8	16.8	3.9	1.3	9.4	6.6	6.2	7.3	22.7	29.5																	
Low Is GBR	1.0	2.3	12.4	16.5	13.3	1.4	16.0	20.2	5.5	4.2	9.0	6.5	9.8	14.0	25.2	24.5	25.2																
Torres Straits	6.2	4.6	16.3	13.6	14.3	2.8	5.0	8.6	6.5	2.7	20.3	20.9	18.1	11.6	17.1	27.0	17.0	13.5															
Capricorn GBR	5.8	3.7	16.9	23.5	18.6	3.7	12.2	17.8	3.2	1.0	4.6	5.1	3.2	4.5	18.1	19.1	27.7	17.4	11.9														
Northumberland GBR	4.2	2.6	9.6	11.2	9.6	0.0	8.5	13.5	2.3	0.0	4.7	0.0	9.0	6.6	17.8	9.9	8.0	16.8	8.2	8.5													
Swains GBR	4.4	4.1	15.9	22.7	19.3	3.5	18.0	21.9	2.8	2.5	4.0	3.6	5.0	6.1	24.8	22.2	35.7	25.3	13.7	37.9	12.9												
Townsville GBR	4.7	2.2	14.9	24.6	18.5	2.0	19.7	23.8	4.2	2.4	6.0	5.6	5.5	12.2	30.2	29.1	38.1	32.4	18.7	33.2	15.3	42.0											
Whitsundays GBR	4.1	2.3	14.7	17.4	14.9	2.8	13.3	17.2	5.4	2.7	2.6	10.0	5.3	10.5	24.8	21.4	23.7	30.1	17.8	20.3	18.7	26.9	38.0										
Pompeys GBR	3.6	3.0	13.2	20.3	15.4	2.5	17.2	25.5	4.7	3.4	4.7	8.1	6.5	9.2	28.4	23.4	27.8	31.4	17.5	32.1	17.2	45.9	43.4	40.4									
Broome region	1.4	0.0	5.2	6.3	3.4	0.8	0.0	2.2	14.9	8.2	19.3	10.7	14.6	21.6	4.4	7.8	6.6	7.4	11.0	3.0	1.7	2.6	5.6	6.4	4.9								
Bonaparte Arch	0.0	3.8	0.0	1.6	0.9	0.0	0.0	0.0	3.2	8.0	5.8	8.2	6.2	6.0	1.8	3.8	0.8	1.4	2.7	0.0	0.0	0.0	0.0	0.0	0.0	4.2							
Joseph Bonaparte Gulf	0.0	3.8	0.0	1.6	0.9	0.0	0.0	0.0	3.2	8.0	5.8	8.2	6.2	6.0	1.8	3.8	0.8	1.4	2.7	0.0	0.0	0.0	0.0	0.0	0.0	4.2	100.0						
Dampier region	2.9	2.1	8.8	10.3	10.3	3.2	2.6	3.6	11.1	3.3	20.0	12.5	11.5	16.9	8.1	18.3	12.1	9.6	15.4	7.9	3.7	8.9	11.6	7.9	7.5	23.7	3.9	3.9					
Exmouth region	3.8	2.4	3.9	6.5	5.4	1.0	1.3	1.4	25.3	3.4	10.2	4.6	12.2	24.0	6.9	8.4	3.9	6.8	5.6	2.8	7.4	2.9	4.2	5.6	3.9	12.4	7.0	7.0	14.3				
N Sahul Shelf	2.2	1.2	12.8	11.8	11.2	2.2	11.3	10.9	6.9	1.5	8.3	5.7	6.8	16.8	13.5	17.0	13.9	14.9	15.4	9.0	6.3	13.1	16.0	16.2	15.4	12.5	2.9	2.9	14.9	5.9			
S Sahul Shelf	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
Houtman Abrolhos	5.3	2.4	4.2	4.4	5.8	6.4	1.7	2.6	20.0	1.4	8.1	5.6	7.7	5.4	1.7	3.6	5.1	3.1	6.0	3.1	1.2	3.2	4.3	3.0	2.7	8.4	1.4	1.4	20.1	12.6	6.3	0.0	
Darwin-Cobourg	2.2	1.4	11.5	10.2	10.2	2.6	3.2	4.1	7.6	4.9	20.5	13.8	10.7	16.4	4.9	15.9	14.0	12.2	15.8	8.2	4.6	10.0	13.9	13.6	9.7	19.6	3.9	3.9	34.2	9.5	18.9	0.0	10.7

APPENDIX 5. Metadata for the sponge dataset to accompany NOO, GA and OZCAM databases.

Neptune DATA DIRECTORY

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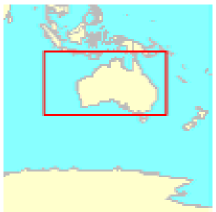

Sponge Specimen Point Database

Data Type

Biolink Relational Database

Marine Planning Region

Eastern-central Marine Region (ECMR)
North-east Marine Region (NEMR)
North-west Marine Region (NWMR)
Northern Marine Region (NMR)
South-east Marine Region (SEMR)
South-west Marine Region (SWMR)
Western-central Marine Region (WCMR)

Custodian

Queensland Museum

Jurisdiction

Australia

Originator Organisations (sources of the base data)

Queensland Museum

Contact

Queensland Museum
Queensland Centre for Biodiversity
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South Brisbane,
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Abstract

This is a dataset of sponge distributions in tropical and subtropical Australia collected by the Queensland Museum (1991- present); the US National Cancer Institute shallow water collection contract (sponges) undertaken by James Cook University and the Australian Institute of Marine Science (1988-1991) now housed at the Queensland Museum Brisbane campus; the Northern Territory Museum sponge dataset (1982-1991), with some additional records of selected (surrogate) species collected since 1991, and some Western Australian Museum records of selected species. Majority of records from tropical Australia but with additional material from the Indo-west Pacific islands and Antarctica.

Attributes

Taxonomic names, authorities, unique specimen and registration numbers, collection date, collector, collection method, locality, latitude, longitude, position source, position error, depth minimum, depth maximum, depth source, depth error, habitat, storage site, storage condition, identified by, date of identification, identification accuracy and collection notes.

Limitations

Variable taxonomic rigor applied across the collections (different identifiers), method of fixing locality records (GPS, gazetteer etc.) and depth recording (sounder, dive computer etc.), with coding applied for these variables within a defined confidence interval.

Documentation Links

www.Qmuseum.qld.gov.au

http://www.qmuseum.qld.gov.au/organisation/sections/sessilemarineinvertebrates/spong.pdf

Data Links

http://www.qmuseum.qld.gov.au/organisation/sections/sessilemarineinvertebrates/spong.pdf
http://www.marine.csiro.au/caab/
http://www.ozcam.gov.au/

Location Keywords

Australia

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

Australia, [Australia], Australia

Geographic Extent

7.24 S

97.29 E 156.5 E

41.14 S

Subject Categories and Search Word(s)

General Keywords

Porifera, Sponges, Biodiversity

ANZLIC Search Words

Beginning date: 1 Jan 1982 **Ending date**: 22 July 2004 **Progress**: Complete **Maintenance and Update Frequency**: Not specified **Stored Data Format(s)**

Biolink Relational Database

Stored Data Volume

220 MB

Available Format Type(s)

Biolink Export: ASCII text, RTF, Microsoft Excel, Microsoft Access, Microsoft Word, XML, Bitmap Distribution maps

Access constraint

Not all attributes available to the public

Lineage

The Sponge Dataset was created from conversion of R:Base databases from Queensland Museum and Northern Territory Museum Data. The specimens were reclassified under a revised classification published in Systema Porifera (2002). Data confidence levels were determined for location, depth and identifications. The creation of GIS distribution maps and Predictive distribution maps were then carried out on selected key taxa.

Numeric spatial scale denominator: **Projection Details**

Positional accuracy

The majority of locations and depths are recorded in precise latitudes and longitudes (decimal degrees), and metres respectively. The accuracies of the locations are split into 5 groups
(1) Excellent (GPS to 2 to 3 decimals and depth from dive computer)
(2) Good (GPS to 1 decimal place and depth from dive computer or depth sounder)
(3) Satisfactory (Locality determined from map, depth from dive computer or sounder)
(4) Poor (Locality and depth determined from anecdotal evidence from collector or gazetter)
(5) Doubtful (anecdotal evidence questionable, or antiquated record from museum register)
Those locations without precise latitudes and longitudes are given a rating (0) Unknown origin, as these collections locations were either not recorded or recorded as simply e.g. “Queensland”.

Attribute accuracy

Variable

Logical consistency report

.

Completeness

Complete

Metadata Access

Public

Metadata Entry Created

22 Jul 2004 by Merrick Ekins

Metadata Last Updated

APPENDIX 6. Descriptive analysis of GIS bioregionalisation trends for sponge groups

Taxa are ordered phylogenetically, corresponding to the structure of *Systema Porifera* (Hooper & Van Soest, 2002).

Phylum Porifera Grant, 1836
Class Demospongiae Sollas, 1885, Subclass Homoscleromorpha
Order Homosclerophorida Dendy, 1905
Family Plakinidae Schulze, 1880

1. *Plakortis*, *Corticium, Oscarella*, *Plakinastrella* and *Plakinolopha* spp (Demospongiae: Homosclerophorida: Plakinidae) (Fig. 37)

Bioregional trends: Predominantly tropical, peaks in diversity on GBR and with north and south GBR bioregions delineated by species composition; west coast fauna under-represented in Plakinidae samples.

Summary details: Database records of *Plakortis* (11 spp, 3 named), *Corticium* (5 spp, 2 named), *Plakinastrella* (3 spp, 1 named), *Oscarella* (3 unnamed spp) and *Plakinolopha* (1 unnamed sp.) are primarily tropical, with one species (*Plakortis nigra*) recorded from the south west coast (SWB) to the southern GBR (NEP), and another species (*Corticium simplex*) with a wide north west and north coast distribution (NWP-NP). Peaks of diversity in Plakinidae occur in the northern GBR (NEB: 5 spp) and southern GBR (NEP: 4 spp), with only two species overlapping in species composition and delineating northern and southern GBR bioregions. Several species are markers for specific bioregions:
-north GBR (NEB): *Oscarella* sp. #3270, *Plakortis* sp. #3200
-south GBR (NEP): *Oscarella* sp. #2182, *Plakortis* sp. #2788
-south east Queensland (CEB): *Plakortis* sp. #2674, *Plakinastrella* sp. #2677

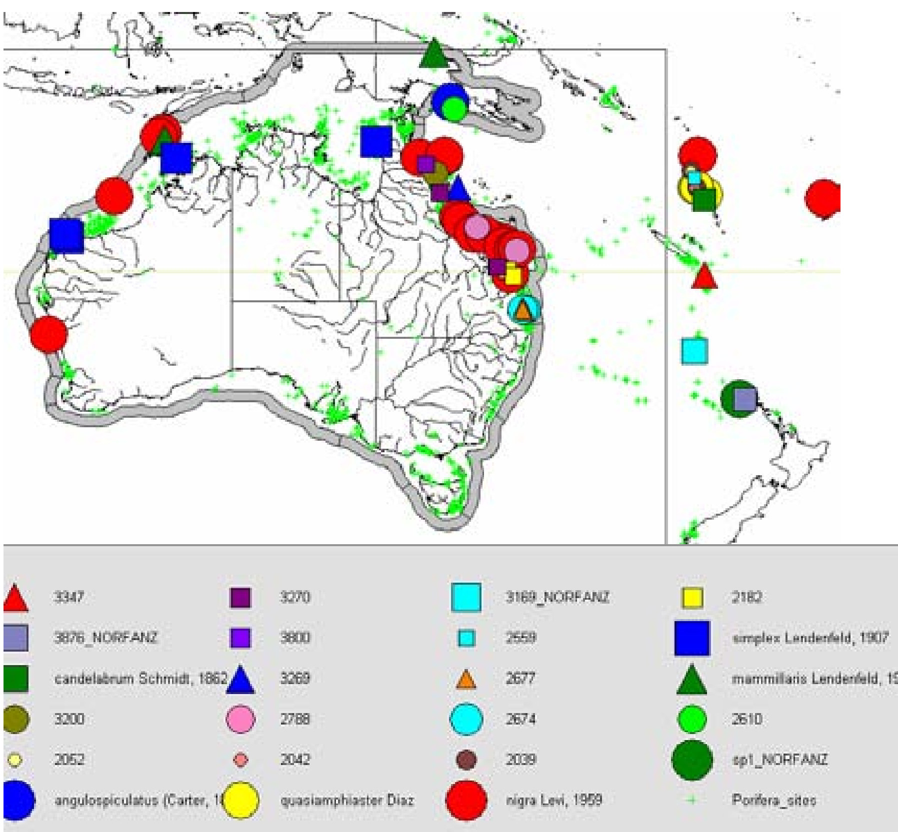


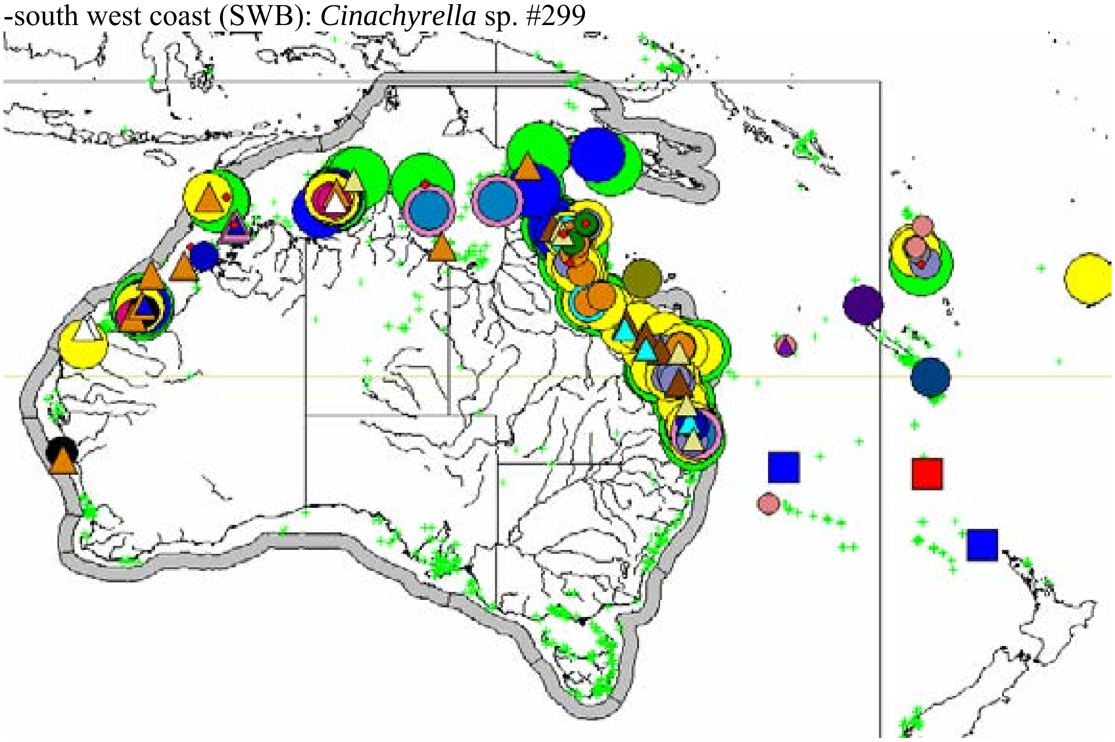
FIG. 37. *Plakortis* (circles), *Corticium, Oscarella* (squares), *Plakinastrella* and *Plakinolopha* spp (triangles) (QM Biolink database)

Subclass Tetractinomorpha
Order Spirophorida Bergquist & Hogg, 1969
Family Tetillidae Sollas, 1886

2. *Cinachyrella* spp (Demospongiae: Spirophorida: Tetillidae) (Fig. 38)

Bioregional trends: Predominantly tropical, dominated by three abundant and widely distributed species; east and west coast faunas differentiated at the eastern part of NP; peaks of diversity on the northern GBR and north west coast, with north and south GBR bioregions not well differentiated.

Summary details: *Cinachyrella* (37 spp, only 3 named so far) is dominated in database records by the three named species (*C. australiensis, C. schulzei and C. (Rhaphidotethya) enigmatica*), which extend across tropical Australia from the north west coast (NWP) to south east Queensland (CEB). Several or possibly many of the unnamed species being significantly variable forms ('morphospecies') of *C. australiensis*. Species with only single records are not differentiated on maps presented here. Peaks in diversity (for 'morphospecies') occur on the northern GBR (NEB: 13 spp), southern GBR (NEP: 9 spp), south east Queensland (CEB: 8 spp), north coast (NP: 10 spp), northwest coast (NWP: 13 spp). Each of these bioregions is differentiated mostly by rare species, but several broad groups of bioregions have shared species: north west coast to north coast (NWP-NP: *Cinachyrella* spp #205, #333), north and south GBR and south east Queensland (CEB-NEB: *Cinachyrella* spp #376, #1725, #1881, #1870), with a few species markers for specific bioregions. Northern and southern GBR bioregions not clearly differentiated, but east and west coast faunas distinctive and species turnover at the eastern NP.
-north GBR (NEB): *Cinachyrella* spp #1536, #1729
-south GBR (NEP): *Cinachyrella* sp. #1885
-south east Queensland (CEB): *Cinachyrella* sp. #180
-north west coast (NWP): *Cinachyrella* sp. #404
-south west coast (SWB): *Cinachyrella* sp. #299



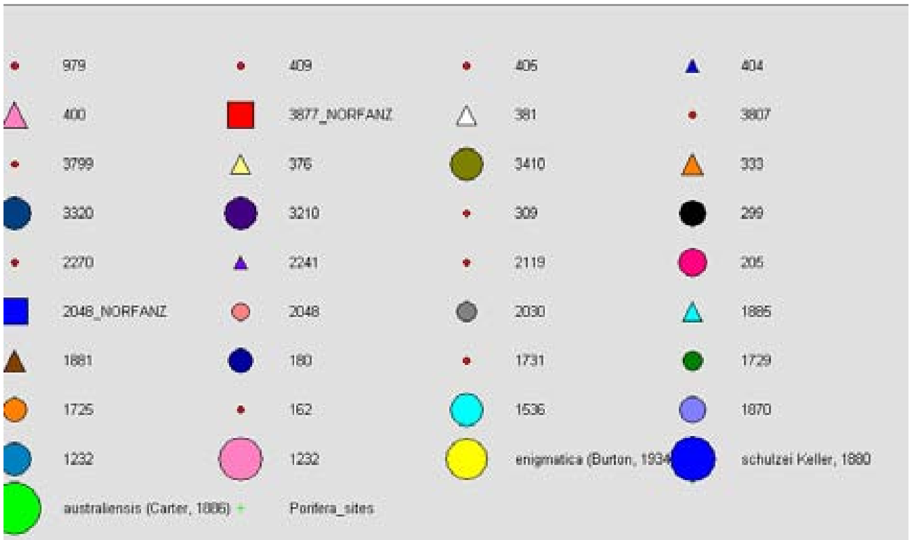


FIG. 38. *Cinachyrella* spp (QM Biolink database)

***Craniella, Cinachyra, Paratetilla* and *Tetilla* spp (Demospongiae: Spirophorida: Tetillidae) (Fig. 39)**

Bioregional trends: Predominantly tropical, with distinct east and west coast faunas, with species turnover at the eastern part of NP; northern GBR has distinct, highly abundant species not found in the southern GBR; west coast fauna more homogeneous in species distributions.

Summary details: *Craniella* (8 spp, 1 named), *Cinachyra* (1 named sp.), *Paratetilla* (1 unnamed sp.) and *Tetilla* (8 spp, 1 named) are represented in the database by predominantly tropical species, with distinctive east and west coast faunas (at eastern NP). Genera have relatively low diversity but populations of three species are abundant in particular bioregions: *Tetilla* sp. #2655 (north and south GBR: NEB-NEP), #3172 (northern GBR: NEB) and *Craniella* sp. #402 (north west and north coasts: NWP-NP). A few species are markers for bioregions:
-north GBR (NEB): *Craniella simillima*
-south GBR (NEP): *Tetilla* sp. #2485
-Darwin region (western part of NP): *T. dactyloidea*
-north west coast (southern part of NWP): *Cinachyra uteoides*

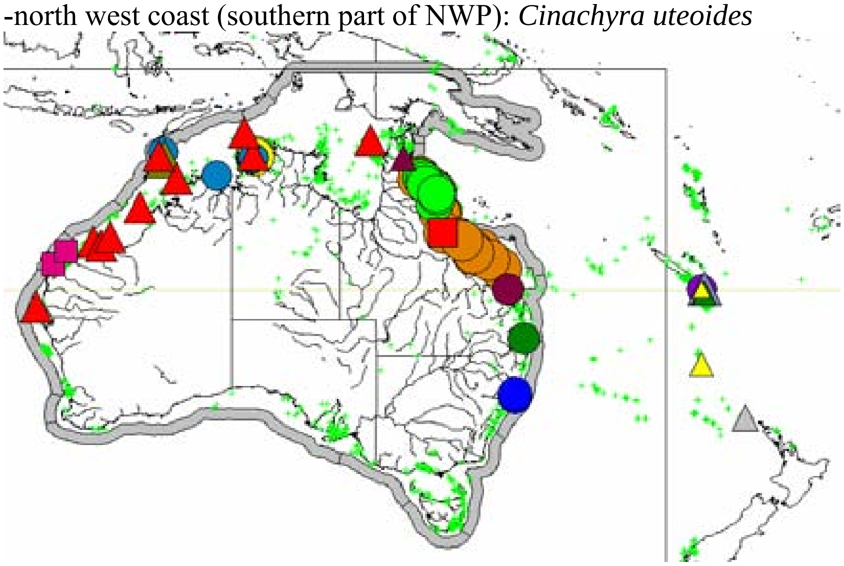
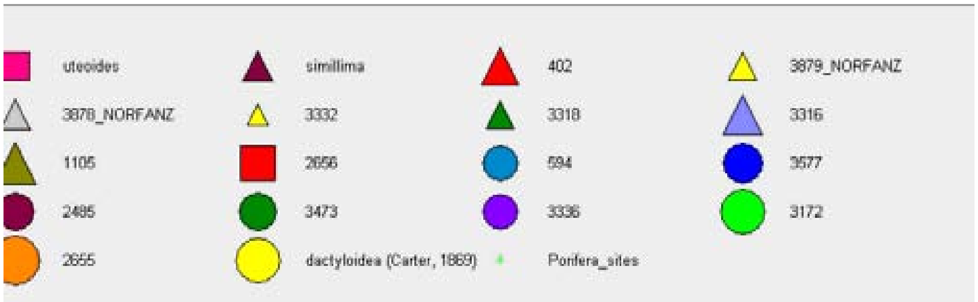


FIG 39. *Cinachyra* , *Paratetilla* (squares), *Craniella* (triangles) and *Tetilla* spp (circles) (QM Biolink database)



Order Astrophorida Sollas, 1888
Family Ancorinidae Schmidt, 1870

3. *Ancorina* spp (Demospongiae: Astrophorida: Ancorinidae) (Fig. 40)

Bioregional trends: Highest diversity in temperate waters (BassP & TasP); low diversity on GBR; distinctive bioregional distributions of species in north coast (NP), south west coast (SWB) and Tasmanian provinces (TasP).

Summary details: Thirteen species are recorded although only one can be presently assigned to a named taxon. Distinct regionalisation of species with little or no apparent sympatry. Highest species diversity (6 spp) in the TasP and BassP regions. Species indicative for NP (*Ancorina* sp.#989), SWP & SWB (*A. brevidens* and *Ancorina* sp. #746), GulfP (*Ancorina* sp. #835), and BassP & TasP regions (*Ancorina* sp. #3292). GBR with few records (record of the predominantly SWB species *A. brevidens* possibly a cryptic sibling (sister) species with conspecificity yet to be tested using genetic markers).

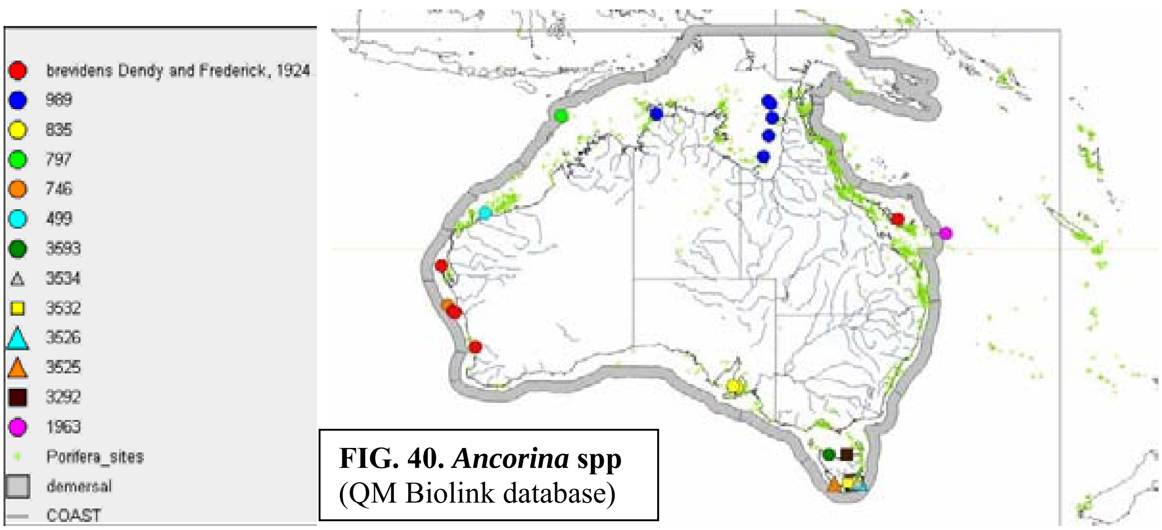


FIG. 40. *Ancorina* spp
(QM Biolink database)

***Disyringa* and *Ecionemia* spp (Demospongiae: Astrophorida: Ancorinidae) (Fig. 41)**

Bioregional trends: *Disyringa* and *Ecionemia* with distinctly different distributions, tropical and temperate, respectively; both genera indicative of NP-NWP and TasP and SWB-CWP bioregions.

Summary details: *Disyringa* exclusively tropical, represented by two geographically sympatric species (*D. dissimilis* and *D. schmidti*) characteristic of NP and NWP bioregions, usually at depths greater than 40m. *Ecionemia* exclusively temperate, predominantly shallow water (<30m depth), located on the SE coast (TasP: three species; *E. geodides*, *Ecionemia* spp #3622 & #3660) and SW coast (SWB & CWP: two species: *E. acervus* and *Ecionemia* sp. #768).

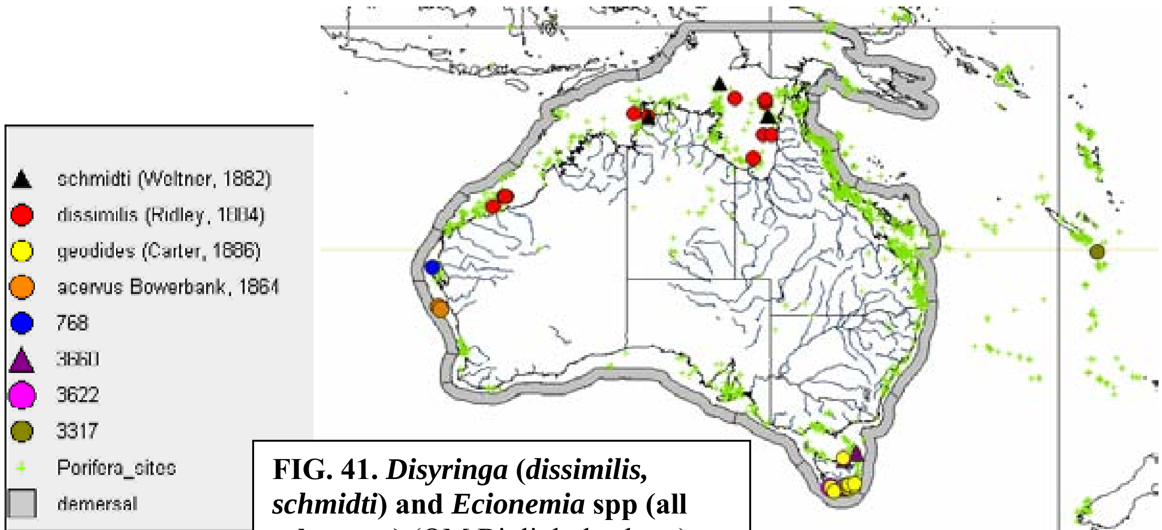


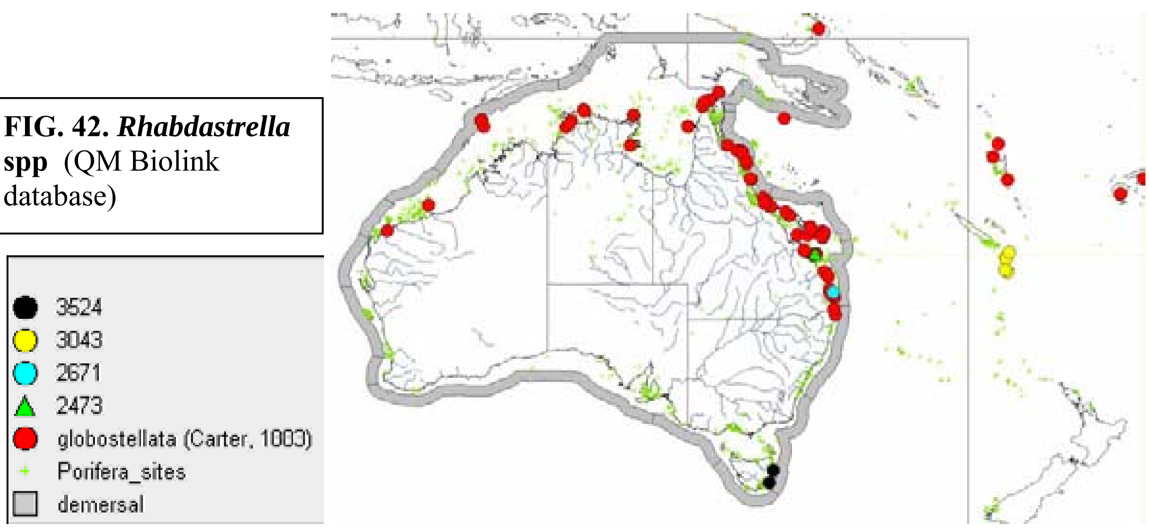
FIG. 41. ***Disyringa*** **(*dissimilis, schmidti*) and *Ecionemia* spp (all other spp)** (QM Biolink database)

Rhabdastrella **spp (Demospongiae: Astrophorida: Ancorinidae) (Fig. 42)**

Bioregional trends: *R. globostellata* indicative of tropical-temperate boundary; no differentiation of northern or southern GBR, or east coast – west coast faunas.

Summary details: Five species are represented in the database, three occurring in the southern GBR and south east Queensland bioregions (NEP-CEB), with only one currently assigned to a named taxon. One widespread tropical (CEB to NWP), *R. globostellata* (formerly widely misidentified in the literature as *Jaspis stellifera*), with an extensive Indo-west Pacific distribution; two rare species (*Rhabdastrella* spp #2473 and #2671) and one temperate species restricted to TasP (*Rhabdastrella* sp. #3524).

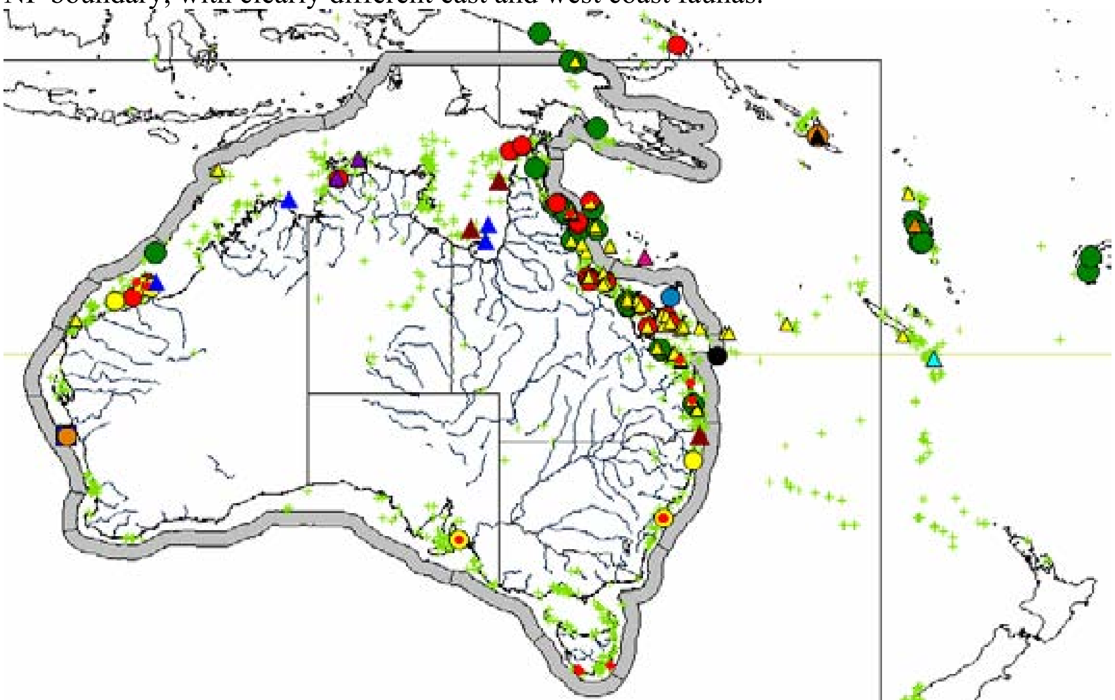
FIG. 42. ***Rhabdastrella*** **spp** (QM Biolink database)



7. ***Stelletta*** **spp (Demospongiae: Astrophorida: Ancorinidae) (Fig. 43)**

Bioregional trends: Several species indicative of the tropical – temperate boundaries, with one restricted to the GBR, Coral Sea and other western Pacific coral reefs; no clear differentiation of north and south GBR bioregions, but east and west coast faunas distinctive and species turnover at eastern NP boundary.

Summary details: Highly speciose family of sponges with 38 species recorded for Australia, of which only seven can be presently assigned reliably to a named taxon. Two species with widespread tropical distributions (*S. clavosa* and *Stelletta* sp. #1005) from NWP to CEB and extending further into the Indo-west Pacific, one warm and cool temperate (*S. purpurea*) from CEP to CWB, and one species (*S. splendens*, formerly incorrectly allocated in the literature to *Jaspis*) widely distributed on the north eastern coast (CEB to NEB) and throughout the tropical western Pacific islands. Highest diversity is on the GBR (13 spp), but with no apparent differentiation of northern and southern GBR bioregions. Distinctive species turnover at eastern NP boundary, with clearly different east and west coast faunas.



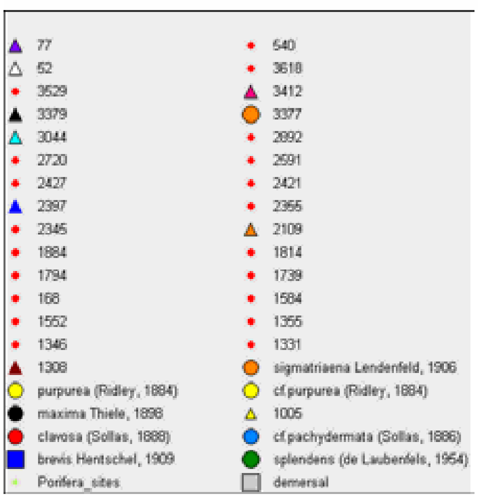


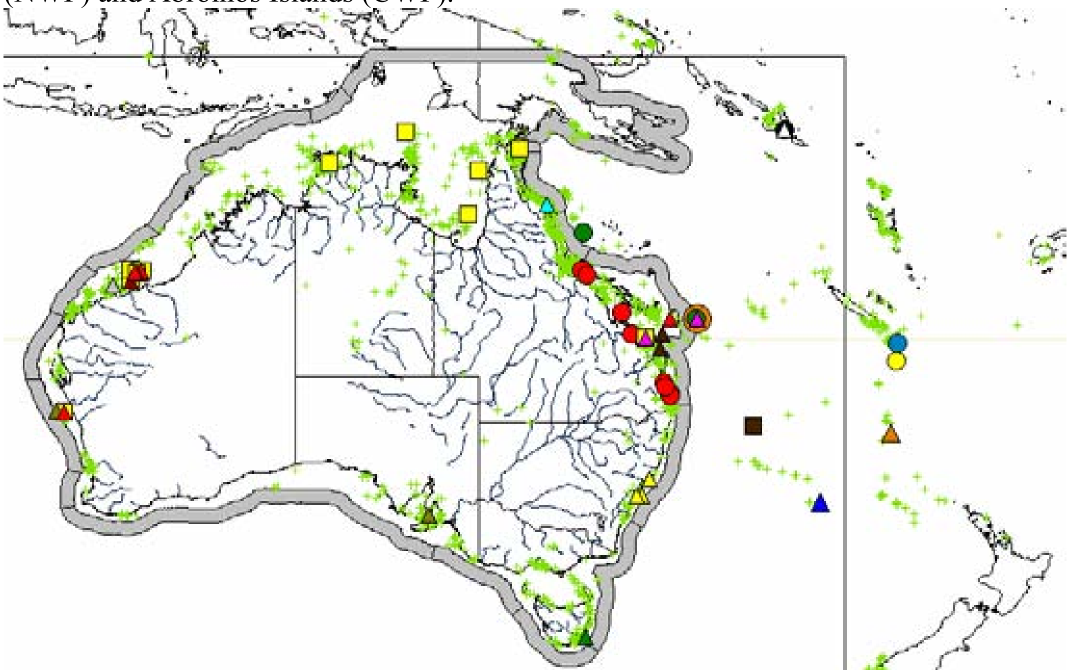
FIG. 43. *Stelletta* spp (QM Biolink database)

Family Geodiidae Gray, 1867

4. *Erylus*, *Geodia*, *Caminus* & *Pachymatisma* spp ((Demospongiae: Astrophorida: Geodiidae) (Fig. 44)

Bioregional trends: Southern GBR with highest diversity of *Erylus* and *Geodia* spp., and clearly differentiated from northern GBR; *Pachymatisma* found only from the northern and west coast regions (NP-CWP); clear east-west coast differentiation, with species turnover at eastern NP boundary; most species have relatively deeper water (>40m depth) distributions.

Summary details: Six species of *Erylus*, 12 species of *Geodia* and one species of *Caminus* are recorded in the database for the Australian and Coral Sea region. *Erylus* (4 species) and *Geodia* (4 species) are most diverse in the central and southern GBR region (NEP, CEB) and Coral Sea territories, with four species also known for the central western coast (CWP & CWB). Three species of *Geodia* (spp #535, #1329, #3528) occur exclusively in temperate western and eastern coastal regions (SWB, GulfP, SEB and TasP). *Pachymatisma* sp. #311 is found exclusively from Torres Straits, Wessel Islands and Darwin regions (NP), Northwest Shelf (NWP) and Abrolhos Islands (CWP).



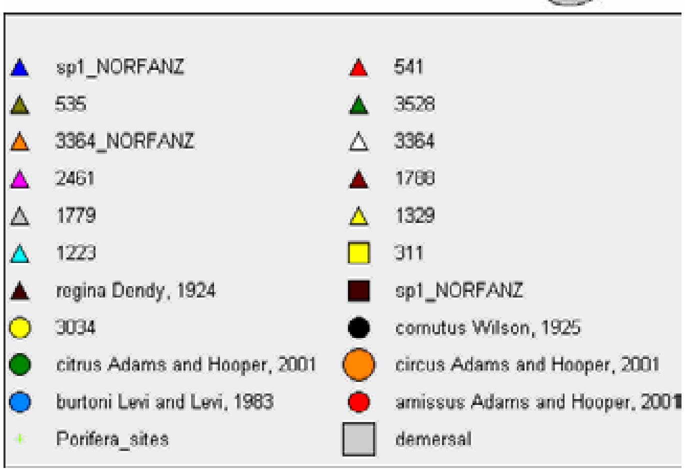


FIG. 44. ***Erylus* (circles), *Geodia* (triangles), *Caminus* and *Pachymatisma* (squares) spp** (QM Biolink database)

Order Hadromerida Topsent, 1894
Family Clionaidae d'Orbigny, 1851

5. *Cliona* spp (Demospongiae: Hadromerida: Clionaidae) (Fig. 45)

Bioregional trends: Widespread, highly speciose; three trends apparent: (1) northern and western deeper water muddy bottom substrates (NP to NWP); (2) shallow water coralline substrata in the southern and central GBR (CEB to NEP); and (3) shallow water rocky substrata in southern waters (BassP, TasP); clear differentiation of northern and southern GBR bioregions, south GBR having highest diversity, northern GBR fauna extending into the eastern part of NP (unlike most other sponge groups).

Summary details: *Cliona* is highly diverse, with 41 (morpho)species recorded, of which only five can be presently assigned reliably to a known taxon. The genus consists of alpha (boring or excavating), beta (thickly encrusting) and gamma (massive, papillose) growth stages that frequently (but not exclusively) invade and bioerode coralline substrata. Species are most diverse on the central and southern GBR (NEP – CEB), and several widespread, biogeographically disjunct species (e.g. *C. margaritifera*, *C. celata*) are records of edible or pearl oyster infections associated with commercial oyster leases, and thus contain no useful bioregionalisation information (i.e. translocation of oyster spat and shell responsible for observed distributions). Other species contain significant data for bioregionalisation, with three species characteristic of particular bioregions: the massive, soft shelly or muddy bottom dwelling *Cliona patera* occurs in the NP – NWP regions, offshore in shallow to deeper waters (15-60m depth). It was at one time thought to have been fished out by trawler activity but has been rediscovered and now known to be relatively widely distributed from data collected by the northern prawn fishery surveys during the past decade. It is known only in the massive (gamma) stage. *Cliona orientalis* occurs in the southern and central GBR (CEB-NEP) in predominantly shallow waters (<40m depth) and is a known 'parasite' of scleractinian corals. It is known from alpha, beta and gamma growth stages. *Cliona* sp. #3297 is a cool temperate shallow water species (<20m depth) occurring in the BassP/ TasP region, found on rock substrate. It is known so far only from beta and gamma growth stages.

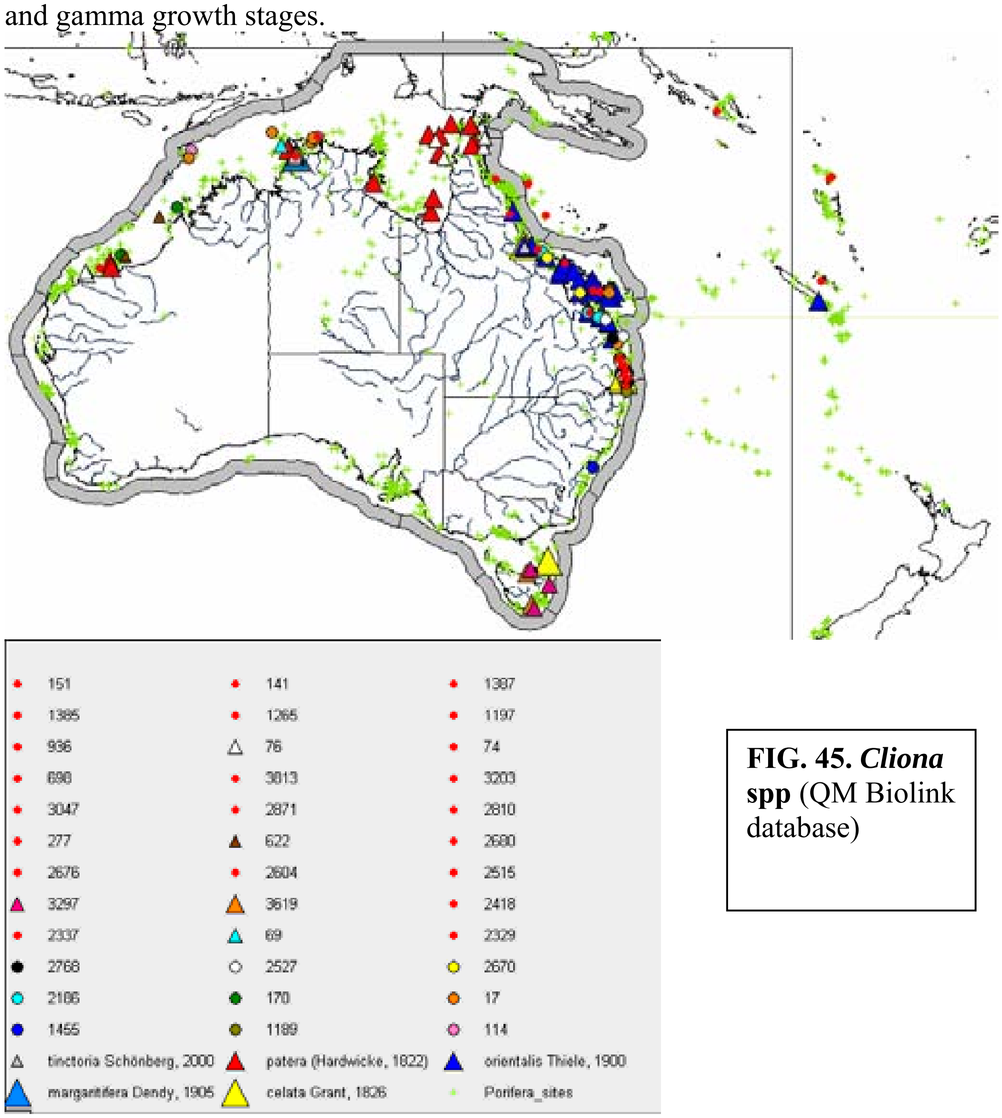


FIG. 45. *Cliona* spp (QM Biolink database)

Family Alectonidae Rosell, 1996 &
Family Hemiasterellidae Lendenfeld, 1889

6. *Neamphius* (Demospongiae: Hadromerida: Alectonidae), *Axos* and *Hemiasterella* spp (Hadromerida: Hemiasterellidae) (Fig. 46)

Bioregional trends: Distinctive east and west coast faunas, with species turnaround at the Wessel Islands (central NP); *Neamphius* characteristic of northern GBR (NEB), *Axos* of north western regions (NP to NWP) and *Hemiasterella* has highest diversity in central western coast (SWB to NWP), with one species characteristic of the southern GBR (NEP-CEB).

Summary details: *Neamphius* is represented by a single described species found in the northern sector of the GBR (NEB), the Coral Sea and elsewhere in the tropical western Pacific. *Axos* consists of two described, geographically sympatric sibling species extending along the tropical north western coasts, from NP to NWP. The genus is possibly endemic to these provinces. *Hemiasterella* is represented by eight so-far unnamed species with the highest diversity on the central western coast, from SWB to NWP, and one species (*Hemiasterella* sp. #2839) characteristic of the central and southern GBR sector (NEP to CEB).

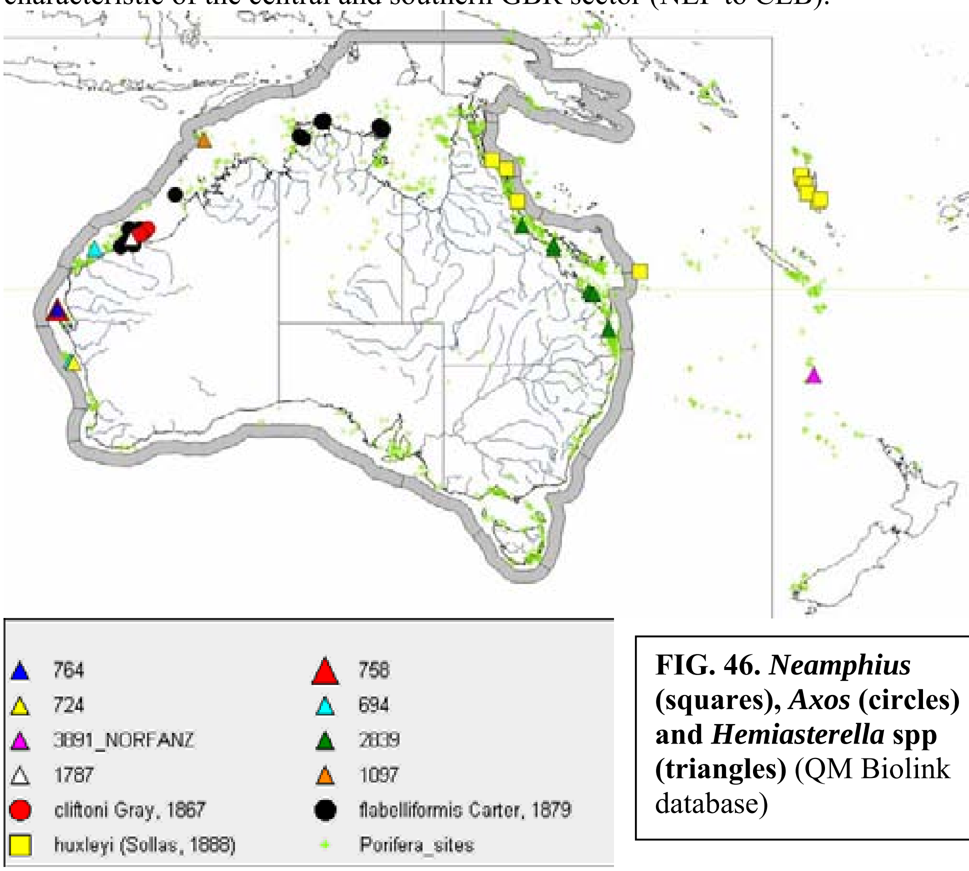


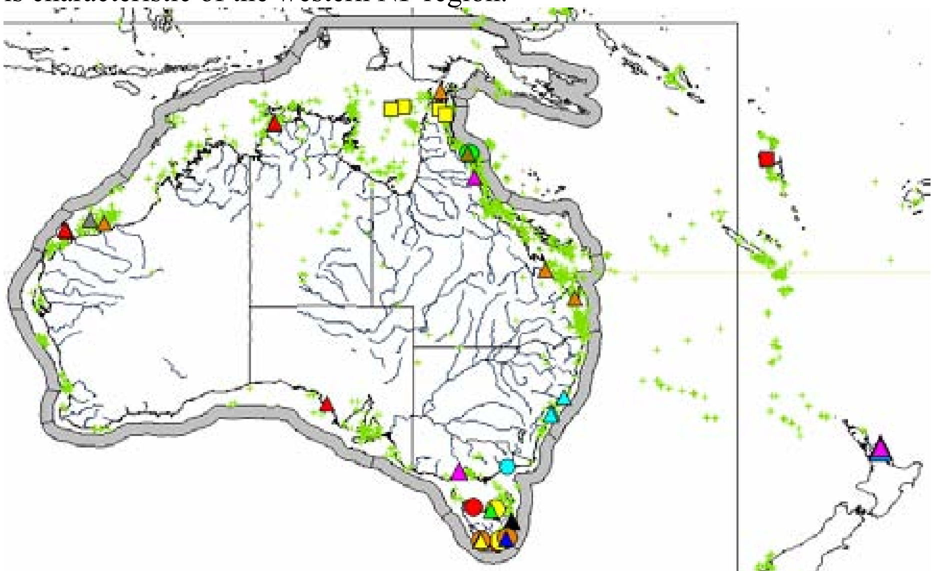
FIG. 46. *Neamphius* (squares), *Axos* (circles) and *Hemiasterella* spp (triangles) (QM Biolink database)

Family Polymastiidae Gray, 1867

7. *Polymastia*, *Atergia* and *Pseudotrachya* spp (Demospongiae: Hadromerida: Polymastiidae) (Fig. 47)

Bioregional trends: Species more abundant, higher diversity and with higher levels of apparent endemism in temperate waters (TasP, BassP), with fewer tropical species which have wider distributions (CEB to NWP).

Summary details: Seventeen species of *Polymastia*, one species of *Atergia* and one of *Pseudotrachya* are reported, of which only four can be presently assigned to a known taxon. Highest diversity occurs in the TasP and BassP regions (9 species), which are reportedly abundant there, none of which have been recorded to date outside these regions. Two species are more widely distributed in the tropics (*Polymastia* spp #483 and #1277) but neither is sufficiently abundant to deduce any bioregional distributional patterns. *Pseudotrachya* sp. #1306 is characteristic of the western NP region.



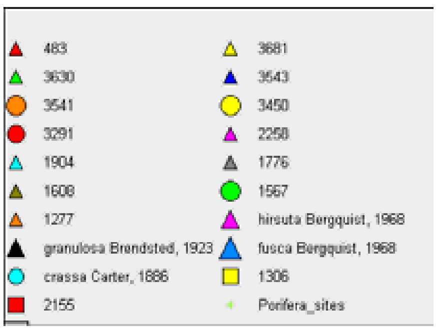


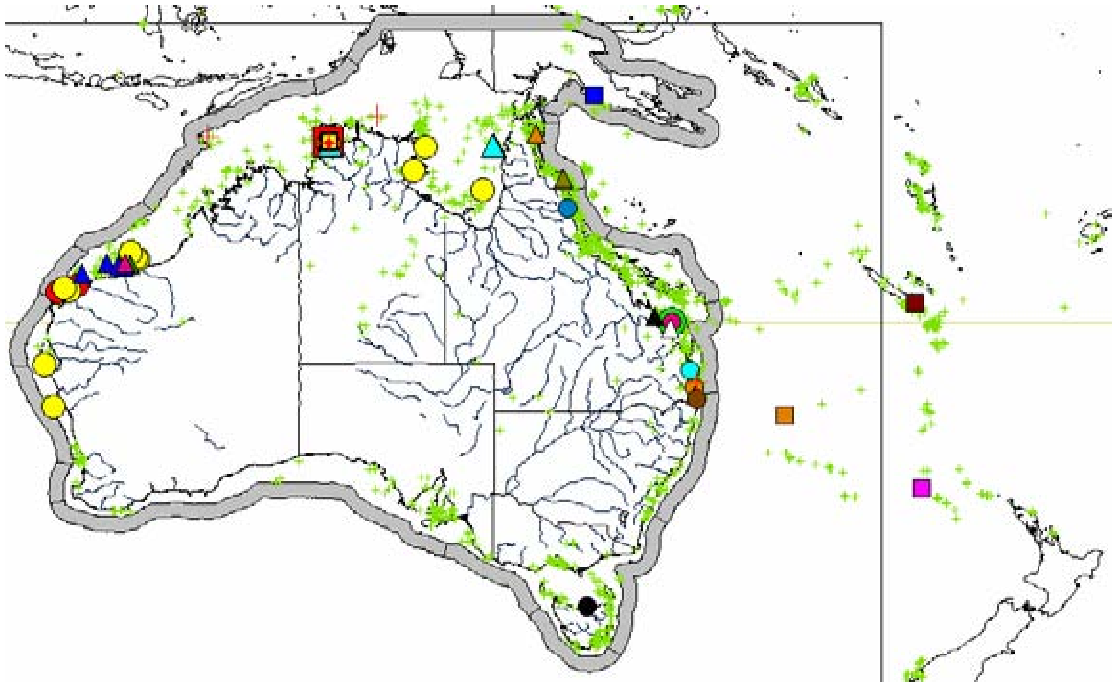
FIG. 47. *Polymastia* (circles and triangles), *Atergia* and *Pseudotrachya* spp (squares) (QM Biolink database)

Family Spirastrellidae Ridley & Dendy, 1886

8. *Spirastrella* spp (Demospongiae: Hadromerida: Spirastrellidae) (Fig. 48)

Bioregional trends: Peaks in diversity correspond to general bioregional sponge 'hotspots' models, occurring at the southern end of the NEP-CEB, western end of the NP and southern end of NWP; species composition differentiates northern and southern sectors of GBR.

Summary details: Twenty six species of *Spirastrella* are recorded, of which only two can be currently assigned to a named taxon. Species records are predominantly tropical, with peaks of diversity in the southern GBR (CEB – 7 species), Darwin region (eastern NP – 7 species) and Port Hedland region (mostly offshore, southern NWP – 5 species), with no or few species common between regions. Only one species (*Spirastrella* sp. #150) is widely distributed across northern to central western coasts (NP to SWB). No overlap in species composition between southern (CEB) and northern GBR (NEB), with 3 species recorded for the latter.



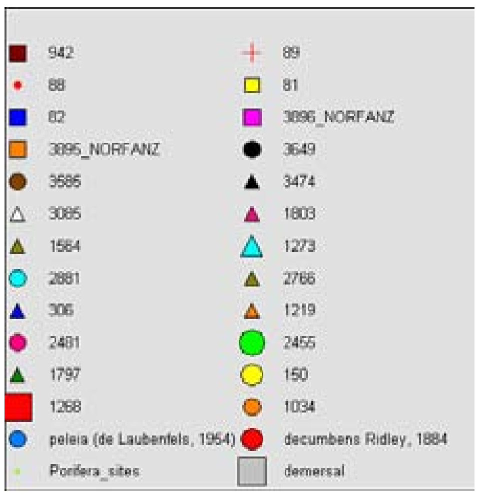


FIG. 48. *Spirastrella* spp (QM Biolink database)

Family Trachycladidae Hallmann, 1917 &
Family Timeidae Topsent, 1928

9. *Trachycladus* (Demospongiae: Hadromerida: Trachycladidae) and *Timea* spp (Hadromerida: Timeidae) (Fig. 49)

Bioregional trends: *Trachycladus* is temperate and indicative of tropical-temperate boundary. *Timea* is tropical, associated with coralline substratum.

Summary details: Two named species of *Trachycladus* and two unnamed species (possibly variations in morphotypes), and three species of *Timea* are recorded, showing markedly different distributions. *Trachycladus laevispirulifer* is widely distributed, both geographically and bathymetrically, throughout temperate Australia (CWP, CEP), extending slightly into the subtropical overlap (CWB, CEB). It is found from moderately deeper coastal waters (~20m depth) to much deeper waters (~400m depth), including from the Norfolk Rise off New Caledonia. It is a reasonable indicator species for the tropical – temperate overlap zones. By contrast, *Timea* spp have only been recorded so far from the tropical eastern and northern coasts, with one species (*Timea* sp. #1389) occurring along the length of the GBR (CEB to NEB), and two other species restricted to the southern GBR (CEB) and Darwin region (eastern NP). The three *Timea* species collected here are associated with dead coral (bioeroding species).

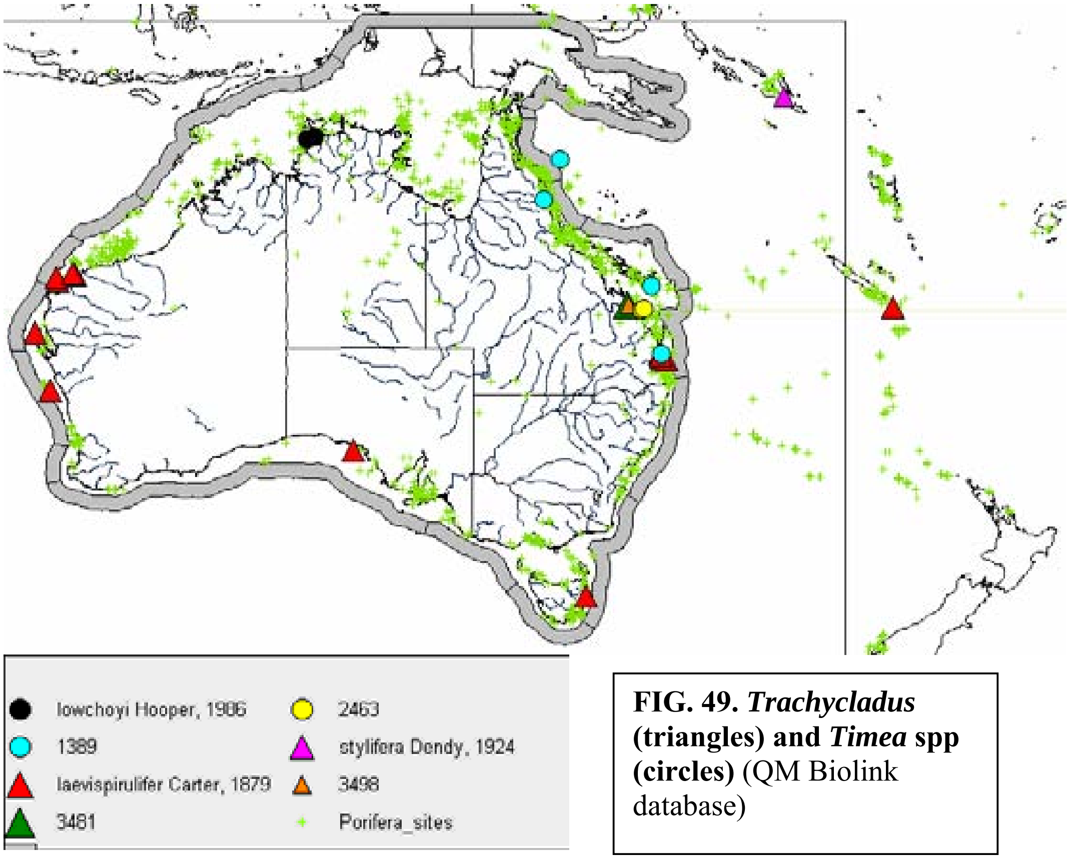


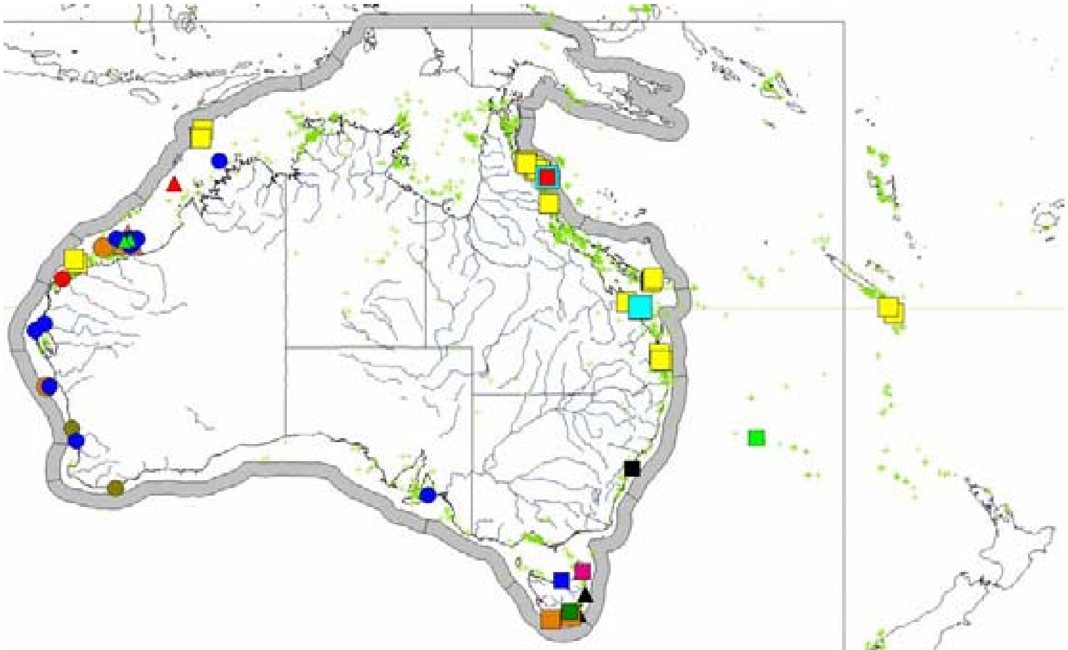
FIG. 49. *Trachycladus* (triangles) and *Timea* spp (circles) (QM Biolink database)

Family Suberitidae Schmidt, 1870

10. *Aaptos*, *Caulospongia*, *Homaxinella* and *Pseudospongosorites* spp (Demospongiae: Hadromerida: Suberitidae) (Fig. 50)

Bioregional trends: *Aaptos* demonstrates a wide tropical distribution (one species), and two peaks of biodiversity on the GBR and Bass Strait regions, each with different (non overlapping) species compositions. *Caulospongia* is endemic to west and southwest coasts.

Summary details: Nine species of *Aaptos* (only one currently assigned to a named taxon) shows a predominantly eastern and north coast distribution, with highest diversity in temperate (TasP & BassP – four species) and tropical GBR regions (CEB, NEP, NEB – four species), with one species (*A. aaptos*) widely distributed from NWP on the west coast to CEB on the east coast and elsewhere in the western Pacific. Temperate species have much more restricted distributions. Four species of *Homaxinella* (two named) were recorded from only TasP (one species) and NWP (three species), with no species in common between regions. Four species of *Caulospongia* (all named) are thought to be endemic to the western and southwestern coasts, with one (*C. perfoliata*) widely distributed from the northwest (NWP) to the southern coast (GulfP), and others found only in the southwest (*C. biflabellata*) or central west coast (two species). Only one species of *Pseudospongosorites* (not yet assigned to a named taxon) was recorded in TasP.



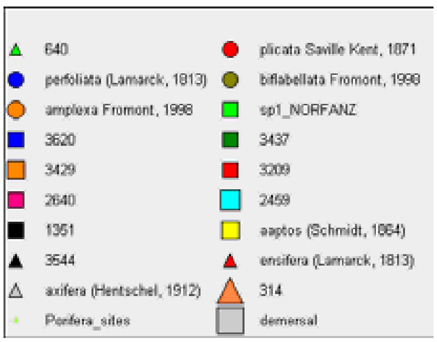


FIG. 50. ***Aaptos*** **(squares),** ***Caulospongia*** **(circles),** ***Homaxinella*** **(triangles) and** ***Pseudospongosorites*** **spp (triangles)** (QM Biolink database)

***Rhizaxinella*, *Terpios* and *Suberites* spp (Demospongiae: Hadromerida: Suberitidae) (Fig. 51)**

Bioregional trends: No broad (gamma) scale regional trends, but several species groups characterize particular meso-scale bioregions, with little or no overlap in species composition between regions. Two regions, one tropical (NP) and one temperate (BassP-TasP) have highest species diversity.

Summary details: Twenty nine species of *Suberites* (only four currently assigned to a named taxon), two species of *Rhizaxinella* (both unnamed), and eight species of *Terpios* (all unnamed) were recorded, none of which are widely distributed in any Australian coastal waters and very few span more than one bioregion. Consequently, several species can characterize particular bioregions. Meso-scale regional species diversity is highest in two regions, TasP-BassP regions (7 species) and NP (7 species), with other faunas having fewer species: CEP (4 species), NEP (5 species), NEB (4 species) and GulfP (3 species).
-CWP-CWB (*Suberites* sp. #704)
-NWP (*Suberites ramulosus cylindrifera* and sp. #327)
-NP (*Suberites* spp #983 and #231, *Terpios* sp. #1297)
-NEB (Suberites spp #3806, #998, #1615)
-NEP (*Terpios* spp #2184 and #2597, *Suberites* sp. #2854)
-CEB (*Suberites* sp. #2909, *Terpios* sp. 439)
-CEP (*Suberites* spp #3570 and #3571, *Terpios* spp #2619 and #2862)
-GulfP (*Suberites* spp #870, #873 and #876)
-BassP-SEB (*Suberites perfectus*)
-TasP (*Rhizaxinella* sp. #3289, *Suberites* spp #450, #3290, #3542, #3601 and *S. cupuloides*).

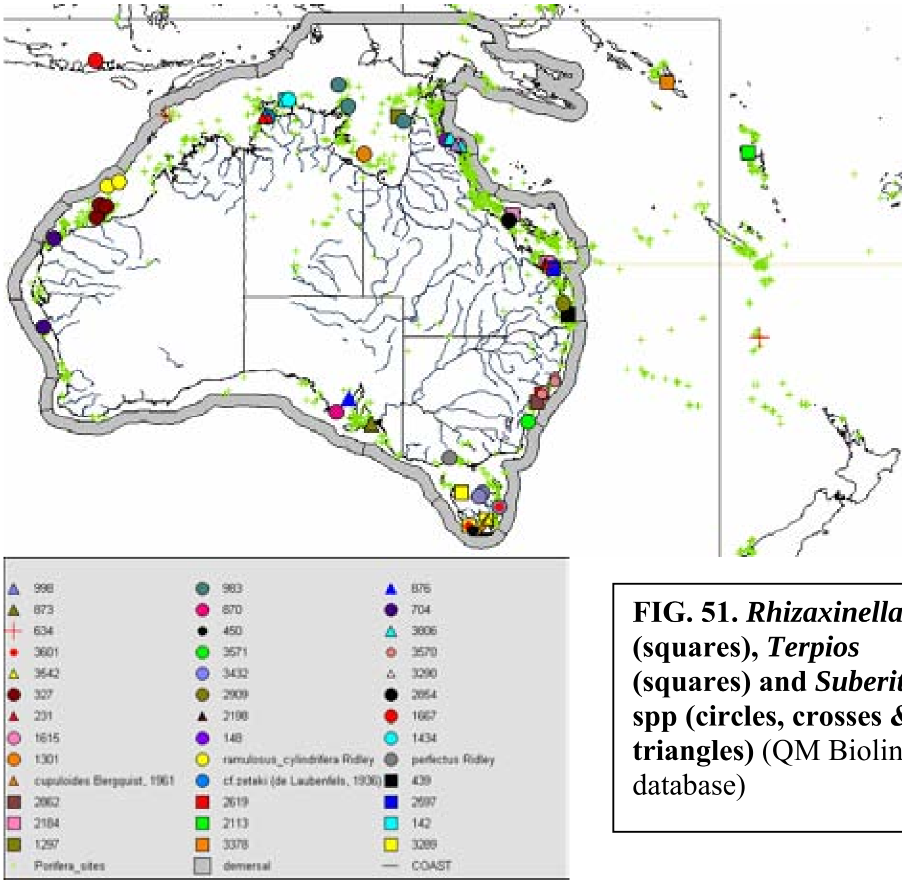


FIG. 51. ***Rhizaxinella*** **(squares),** ***Terpios*** **(squares) and** ***Suberites*** **spp (circles, crosses & triangles)** (QM Biolink database)

Family Tethyidae Gray, 1848

11. ***Tethya*** **and** ***Xenospongia*** **spp (Demospongiae: Hadromerida: Tethyidae) (Fig. 52)**

Bioregional trends: No broad (gamma) scale regional trends, but several species groups characterize particular meso-scale bioregions, with little or no overlap in species composition between regions. Three tropical regions (CEB-NEP, NP and NWB-NWP) have highest species diversity.

Summary details: Twenty eight species of *Tethya* (only eight currently assigned to a known taxon), and one species of *Xenospongia* are recorded, with some species showing distinct bioregionalisation. Species diversity and species composition varies between regions, but most species are restricted to one (or two adjacent) bioregions, and some species present may characterize these regions. *Xenospongia patelliformis* is more widely distributed, found on soft bottoms (muddy, soft shelly subtrata) in relatively deeper (>20-50m), inter-reef, tropical waters from north eastern (NEP) to north western coasts (NWP).
-TasP (4 spp – *Tethya* spp #2276, #3600, #3366, and *T.* cf. *aurantium*)
-CEB-NEP (6 spp – *T. bergquistae*, *T. hooperi*, *T. pulitzeri*, *Tethya* spp #2594, #2993)
-NEB (3 spp – *Tethya* spp #3415, #2249)
-NP (7 spp – *T. coccinea*, *Tethya* spp #148, #200, #219, #862)
-NWB-NWP (8 spp – *Tethya* spp #310, #939)
-SWB (2 spp – *T. robusta*)
-GulfP (1 sp. – *Tethya* sp. #544).

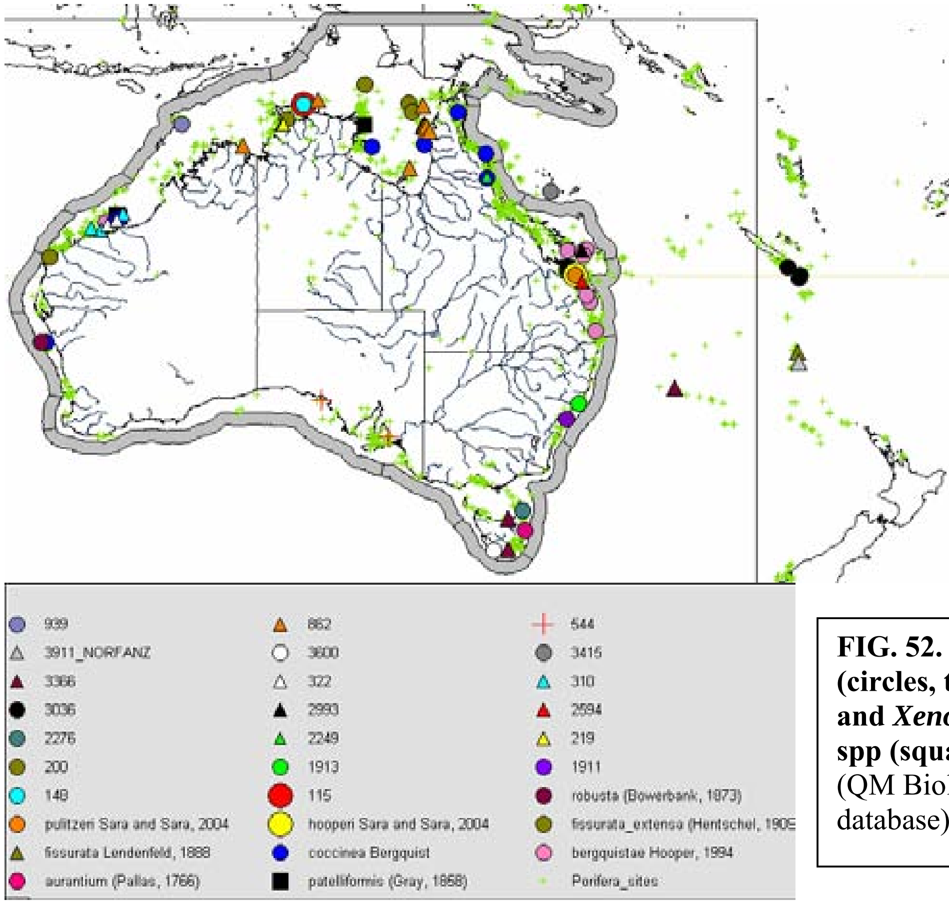


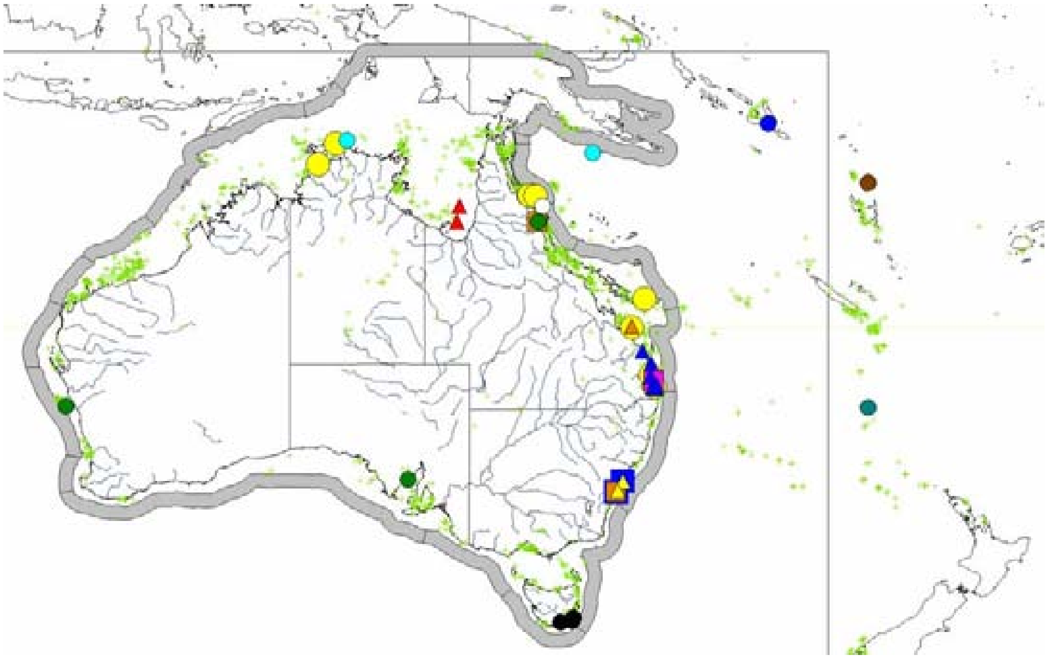
FIG. 52. *Tethya* (circles, triangles) and *Xenospongia* spp (squares) (QM Biolink database)

Order Chondrosida Boury-Esnault & Lopès, 1985
Family Chondrillidae Gray, 1872

12. *Chondrilla* spp (Demospongiae: Chondrosida: Chondrillidae) (Fig. 53)

Bioregional trends: Species composition delineates distinct tropical northern – north eastern (CEB – NP) and temperate bioregions, with northern and southern GBR regions having different species composition.

Summary details: Seventeen species of *Chondrilla* are recorded from this region of which only two can be presently assigned to a named taxon with any reliability. One species (*Chondrilla* sp. #14) has a relatively wide north eastern – northern distribution, from CEB to NP, whereas all others appear to be relatively restricted in their ranges, with several species indicative of particular bioregions: *C. australiensis* from southwestern Australia, SWP to GulfP; *Chondrilla* sp. #2523 in the southern part of CEB; *Chondrilla* sp. #3599 from TasP; *Chondrilla* sp. #2398 from the Gulf of Carpentaria (NP). The highest species diversity (seven species) is recorded from the GBR, with four species occurring in northern (NEB) and southern regions (NEP & CEB), of which only one (*Chondrilla* sp. #14) is common to both.



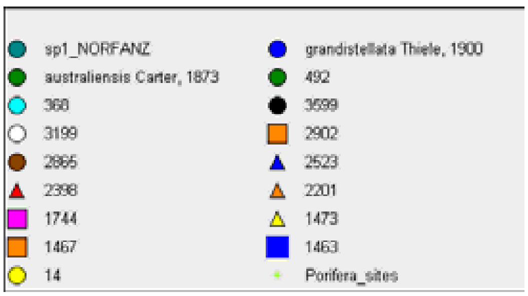


FIG. 53. *Chondrilla* spp (QM Biolink database)

***Chondrosia* spp (Demospongiae: Chondrosida: Chondrillidae) (Fig. 54)**

Bioregional trends: No useful bioregionalisation data from this genus.

Summary details: Ten species of *Chondrosia* have been collected for the region, only one of which can be currently assigned to a known taxon. One morphospecies (*C. corticata*) appears to be widespread, occurring in BassP, NP and also in New Caledonia, whereas others are restricted to particular bioregions.

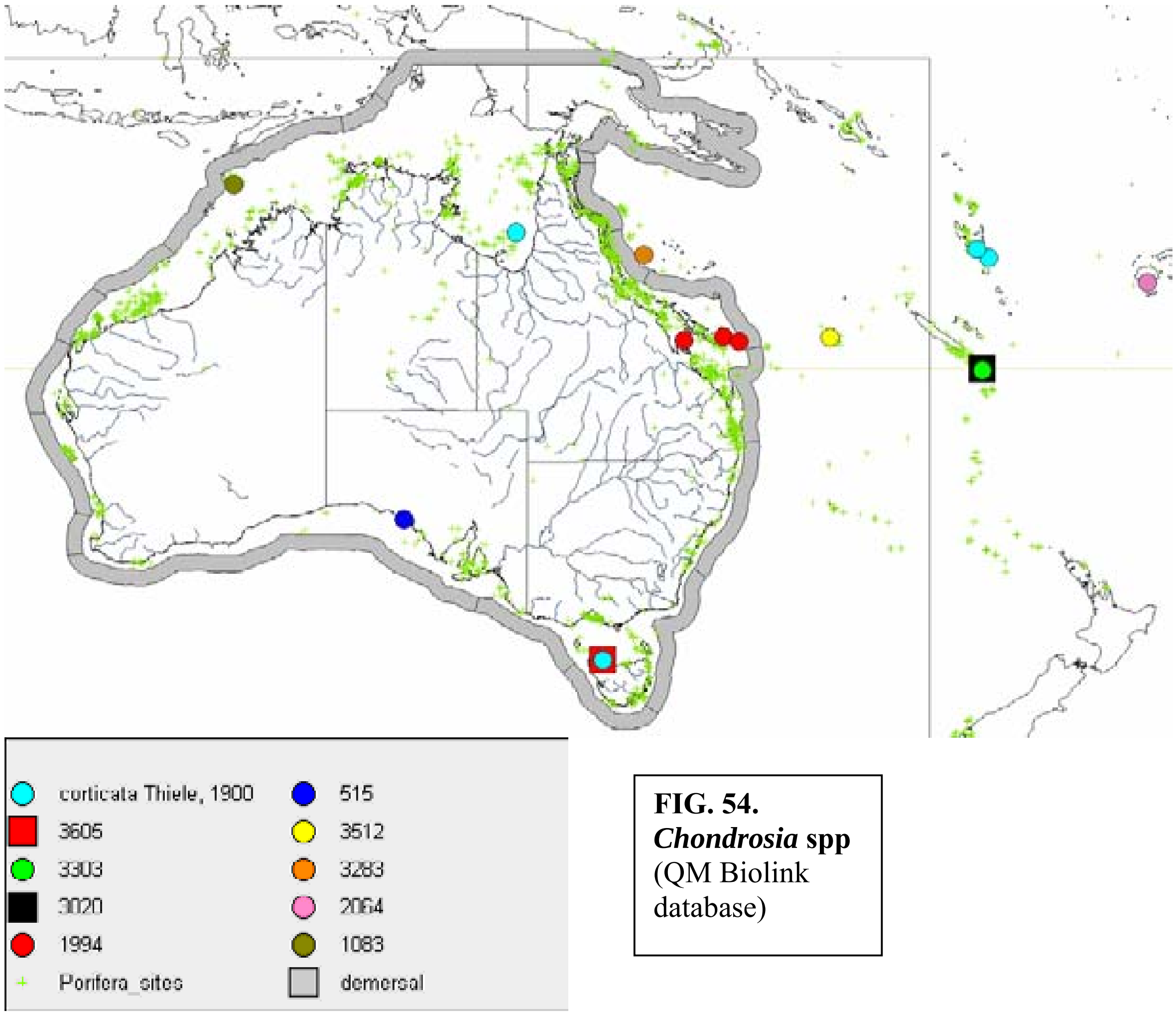


FIG. 54. *Chondrosia* spp (QM Biolink database)

'Coralline sponges'
Subclass Tetractinomorpha
Order Hadromerida Topsent, 1894
Family Acanthochaetetidae Fischer, 1970
Subclass Ceractinomorpha
Order Verticillitida Termier & Termier, 1977
Family Verticillitidae Steinmann, 1882
Order Agelasida Verrill, 1907
Family Astroscleridae Lister, 1900

13. 'Coralline sponges': *Acanthochaetetes* (Hadromerida: Acanthochaetetidae), *Vaceletia* (Verticillida: Verticillidae), and *Astrosclera* spp (Demospongiae: Agelasida: Astroscleridae) (Fig. 55)

Bioregional trends: Exclusively coral reef species living in cryptic habitats. All species show similar patterns of bioregionalisation, based on distribution of coral reef habitats in which they are found, except for the deeper water (>600m) of *Vaceletia* spp.

Summary details: These sponges are often referred to as coralline or hypercalcified sponges, but are phylogenetically not closely related. They are found exclusively in shaded coralline overhangs and caves, throughout the GBR and Coral Sea, with records also known for northwestern Australian coral reefs.

A single morphospecies of *Astrosclera* is known throughout the Indo-west Pacific, although preliminary genetic evidence and subtle morphometric differences have been indicated for widely disjunct regional populations, from the Red Sea to Tahiti (Wörheide et al. 2002). *Acanthochaetetes wellsi* has a similar macrohabitat distribution, although it requires greater shade than *A. willeyana* and is not as prevalent. *Vaceletia* consists of a single described species and several new species, with even more restricted geographic and microhabitat distributions, occurring mainly in deep caves on reefs of the Coral Sea and less frequently on the GBR itself.

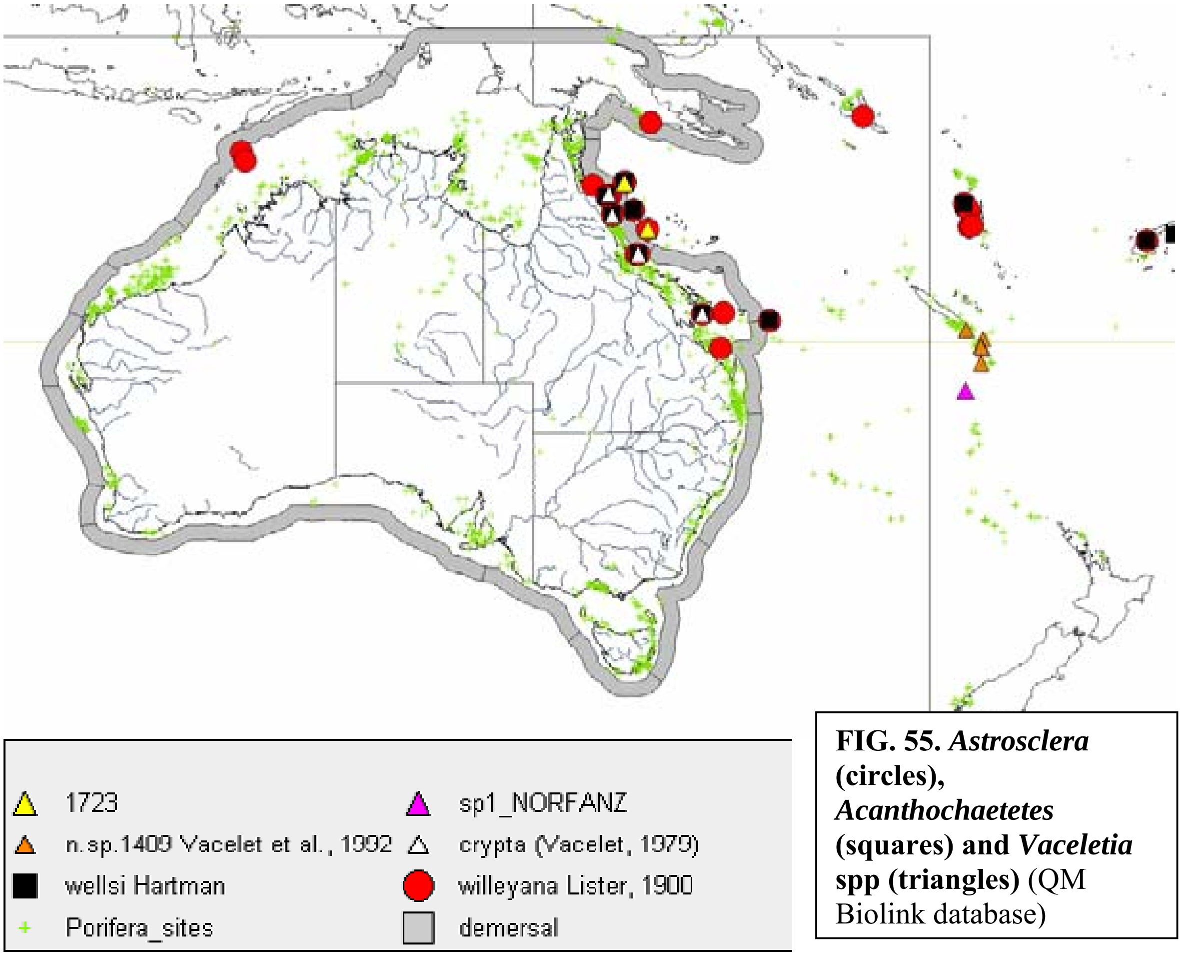


FIG. 55. *Astrosclera* (circles), *Acanthochaetetes* (squares) and *Vaceletia* spp (triangles) (QM Biolink database)

Family Agelasidae Verrill, 1907

14. *Agelas* spp (Demospongiae: Agelasida: Agelasidae) (Fig. 56)

Bioregional trends: Marked east-west species turnover boundary at Torres Straits (NP), with diversity highest in the southern GBR and south east Queensland bioregions (NEP, CEB)

Summary details: Nineteen species of *Agelas* occur within tropical Australasia, of which seven are currently assigned to a name species with any confidence (the remainder possibly new or variable morphotypes of other species). The genus is often a dominant member of the coral reef associated sponge fauna, particularly on the deeper reef slopes. Three of these species (*Agelas mauritiana*, *A. axifera* and *A. gracilis*) have more-or-less widespread tropical distributions, with the former predominately in eastern Australia, and with the Torres Straits being a marked transition zone between eastern and western faunas. The GBR has the highest diversity of species (12 species), with six in the far north (NEB) and nine in the southern portion of the region (NEP, CEB). None have been so far recorded south of the Tweed River, although two species are known in the literature to occur in the CEP region. Four species are recorded for the northern and western tropical faunas, one unique to the region (*Agelas* sp. 3398).

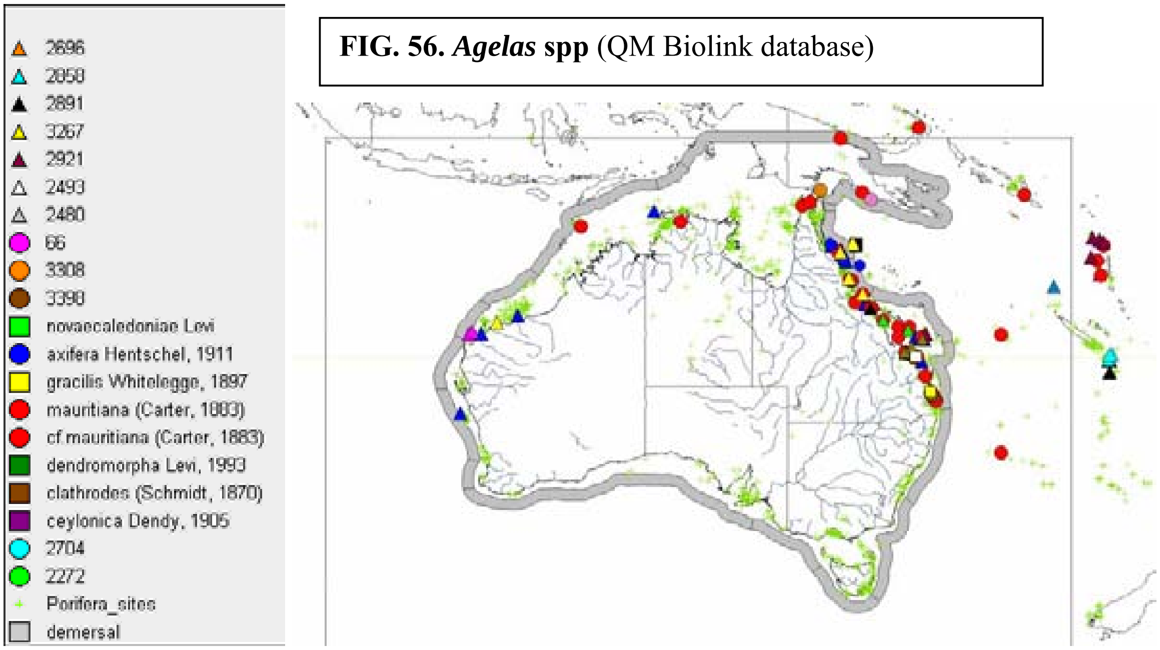


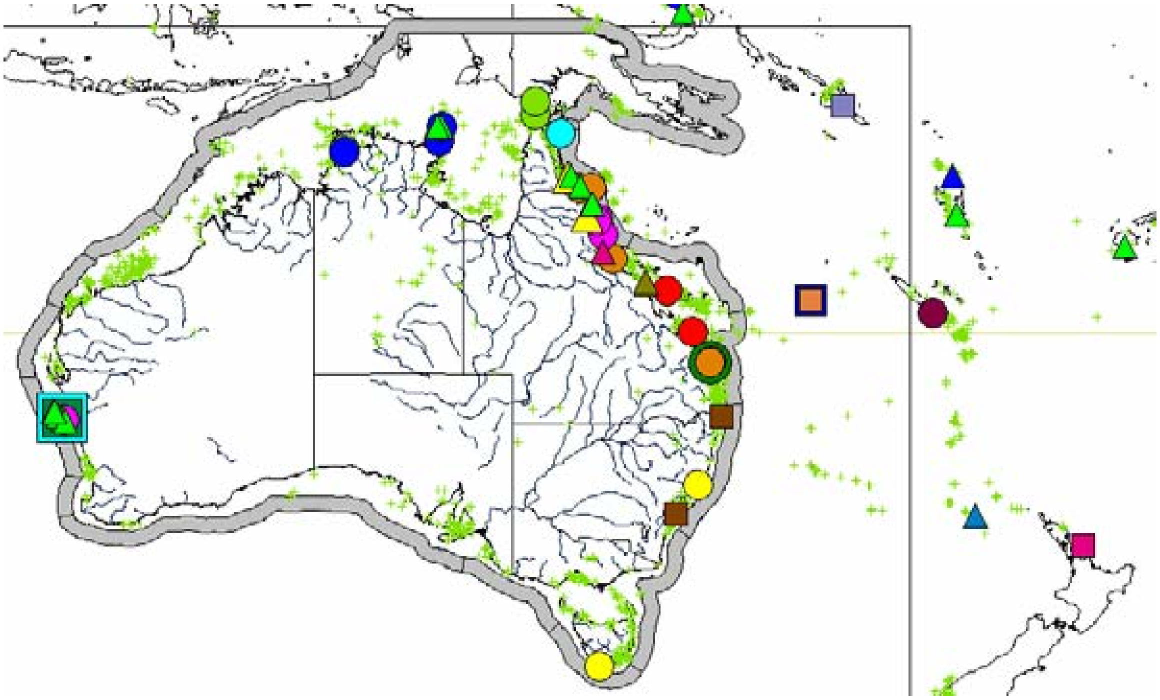
FIG. 56. *Agelas* spp (QM Biolink database)

Subclass Ceractinomorpha
Order Poecilosclerida Topsent, 1928
Suborder Microcionina Hajdu, Van Soest & Hooper, 1994
Family Acarnidae Dendy, 1922

15. Acarnidae (*Acarnus, Cornulum, Damiria, Iophon, Megaciella, Zyzzya* spp (Demospongiae: Poecilosclerida: Microcionina: Acarnidae) (Fig. 57)

Bioregional trends: Distinct regionalization of *Acarnus* spp, including north-south differentiation of GBR, with other genera markers for a few temperate bioregions.

Summary details: *Acarnus* (9 spp, 5 named), *Cornulum* (1 unnamed sp.), Damiria (3 unnamed spp), *Iophon* (1 named sp.), *Megaciella* (2 unnamed spp), *Zyzzya* (6 spp, 2 named) with both tropical and temperate (*Acarnus*) or predominantly temperate distributions (other genera). One widespread species (*Zyzzya fuliginosa*) excavating/ burrowing limestone substrates. Distinct regionalization of *Acarnus* species, with differentiated north-south GBR faunas. Other genera characteristic of a few temperate bioregions:
-north GBR (NEB): *Acarnus hoshinoi*, *A. ternatus*, *Acarnus* sp. #1226, *Zyzzya* sp. #1653.
-south GBR (CEB-NEP): *Acarnus* sp. #1887, 2158, *Zyzzya criceta*, *Zyzzya* sp. #819
-north coast (NP): *Acarnus wolffgangi*
-south east coast (CEP-TasP): *Acarnus* sp. #1927
-central south east coast (CEP-SEB): *Damiria* sp. #1179
-south west coast (SWB): *Damiria* sp. #1679, *Cornulum* sp. #1678



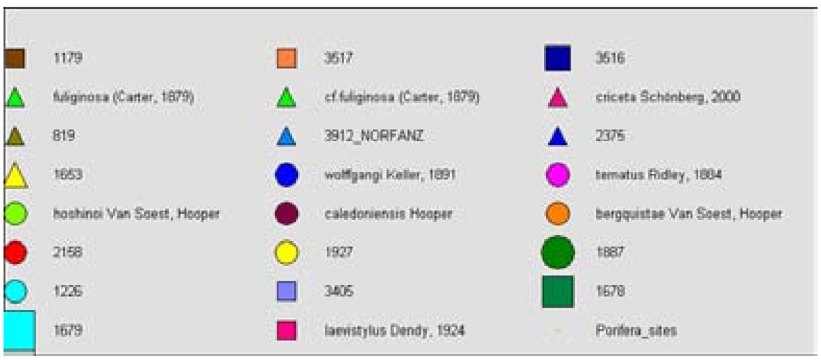


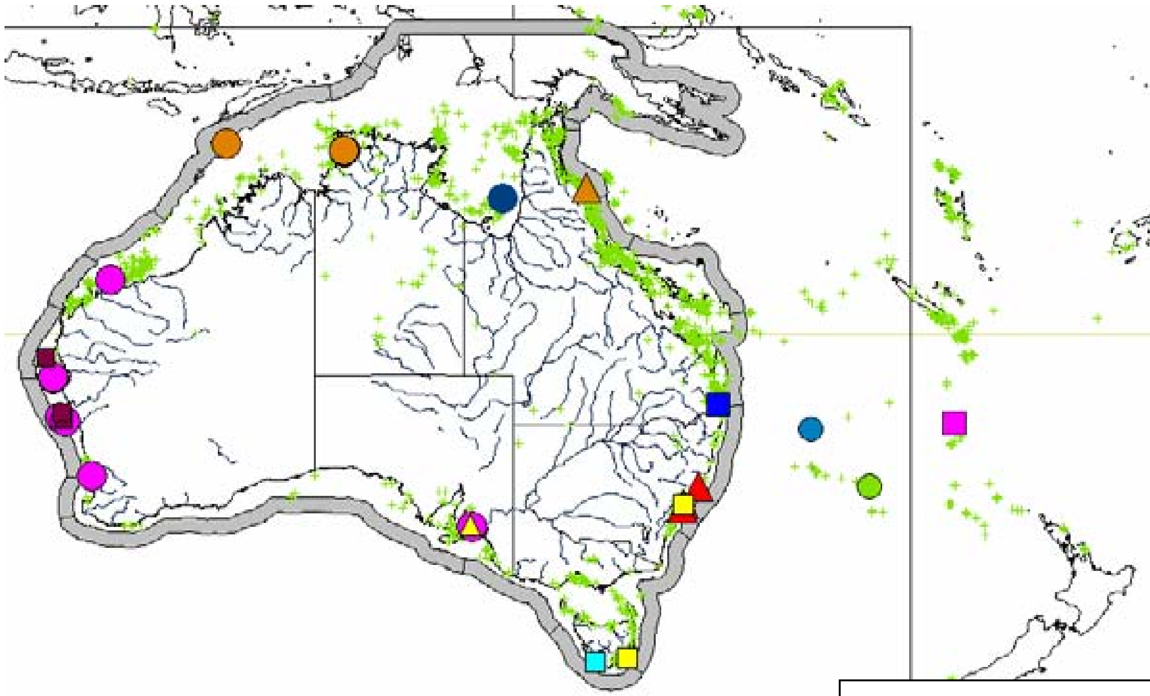
FIG. 57. *Acarnus* (circles), *Cornulum, Damiria, Iophon, Megaciella* (squares) and *Zyzzya* spp (triangles) (QM Biolink database)

Family Microcionidae Carter, 1875

16. *Antho (Antho), A. (Isopenectya), A. (Acarnia), Clathria (Axosuberites)* spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Fig. 58)

Bioregional trends: No peaks in diversity, predominantly temperate, markers for some southern bioregions.

Summary details: *Antho* (8 spp, 5 named) and *Clathria (Axosuberites*) (5 spp, 3 named) have the highest diversity in any world faunas (Hooper, 1994) but are neither diverse nor abundant, but some species are markers for particular bioregions, predominantly temperate:
-north GBR (NEB): *A. punicea*
-north coast (NP): *A. ridleyi*, *Antho* sp. #3796
-south east coast (CEP-TasP): *C. (Axosuberites) thetidis*
-Tasmania (TasP): *C. (Axosuberites)* sp. #3678
-central south east coast (CEP): *A. chartacea*, *C. (Axosuberites) canaliculata*
-south west coast (CWP-SWB-GABB): *A. tuberosa*, *C. (Axosuberites) patula*
-GulfP: *A. saintvincenti*



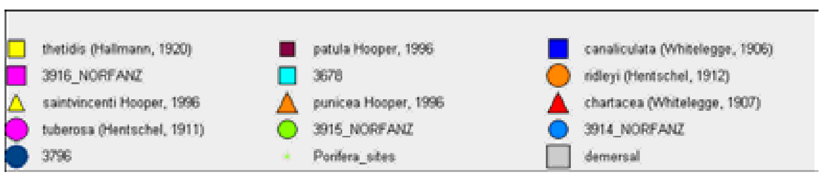
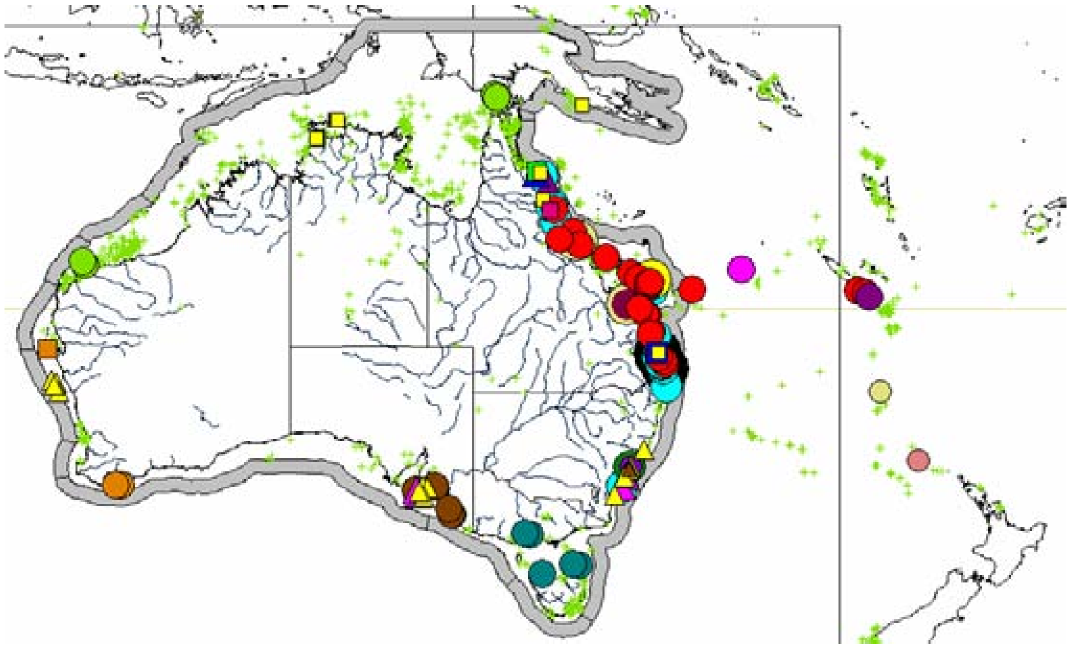


FIG. 58. *Antho (Antho)* (circles), *A. (Isopenectya)* (triangles), *A. (Acarnia)* (circles), *Clathria (Axosuberites)* spp (squares) (QM Biolink database)

***Clathria (Clathria)*, *Clathria (Dendrocia)* and *Clathria (Isociella)* spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Fig. 59)**

Bioregional trends: Peaks in diversity on southern GBR, central south east coast and southern Gulf, with a widely distributed temperate species and two widely distributed GBR species. Species markers for several temperate bioregions.

Summary details: *Clathria (Clathria)* (16 spp, 12 named), *Clathria (Dendrocia)* (5 spp, 3 named) and *Clathria (Isociella)* (5 spp, 3 named) are among the better known sponge groups in Australia, showing peaks in diversity in the GBR (mainly southern and central region: CEB, NEP – 12 spp), central south east coast (CEP – 6 spp) and southern Gulf (GulfP – 3 spp), with no overlap in species composition between each bioregion. Two species are widespread and abundant on the GBR: *C. (C.) kylista* and *C. (C.) conectens*, and one species is widespread across southern Australia: *C. (D.) pyramida*. Other species are clear markers for particular bioregions, mainly in temperate Australia. Only a single species present in the north coast (NP) region (*Clathria (Isociella) eccentrica*) also found on the GBR.
-north GBR (NEB): *C. (C.) basilana*, *C. (Dendrocia)* spp #3197, #3837, *C. (Isociella) skia, C. (Isociella)* sp. #3640
-south and central GBR (CEB-NEP): *C. (C.) kylista*, *C. (C.) conectens*, *C. (C.) angulifera*, *C. (C.) hispidula*, *C. (Clathria)* spp #2711, #3488, *C. (Isociella)* sp. #2897
-central south east coast (CEP): *C. (Dendrocia) dura*, *C. (Clathria) rubens*, *C. (C.) striata*
-Bass Strait and Tasmania (BassP-TasP): *C. (Clathria) transiens*
-southern Gulf (GulfP): *C. (C.) noarlungae*
-south west cape (SWP): *C. (C.) murphyi*
-central west coast (CWP): *C. (Isociella) selachia*



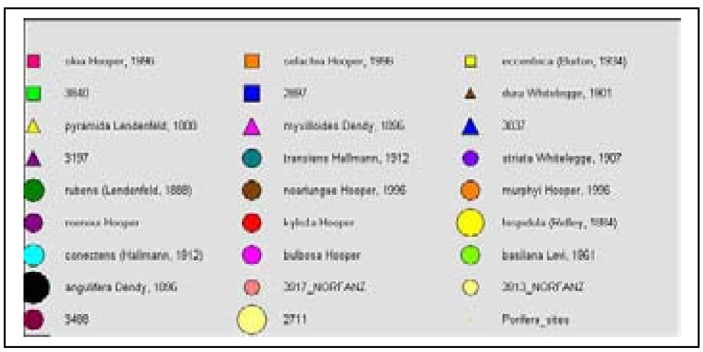


FIG. 59. ***Clathria (Clathria)*** **(circles),** ***Clathria (Dendrocia)*** **(triangles) and** ***Clathria (Isociella)*** **spp (squares)** (QM Biolink database)

Clathria (Microciona) **spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Fig. 60)**

Bioregional trends: Predominantly tropical, highly diverse in and indicative for the GBR faunas, with differentiation between north and south GBR bioregions.

Summary details: Records of this subgenus are predominantly tropical, with only one widely distributed species (*C. (M.) aceratoobtusa*) from central south east coast (CEP) to tropical north coast (NWB), thinly encrusting on a variety of substrates but particularly coral reefs, hence highest diversity is in the GBR (16 spp), with differences in species composition between north and south GBR faunas.
-entire GBR (CEB-NEB): *C. (M.) aceratoobtusa*, *C. (Microciona)* spp #1182, #2114
-north GBR (NEB): *C. (M.) lizardensis*, *C. (Microciona)* sp. #2265
-south GBR (CEB-NEP): *C. (M.) mima, C. (Microciona)* sp. #1839, #1890, #1957, #2177, #2844

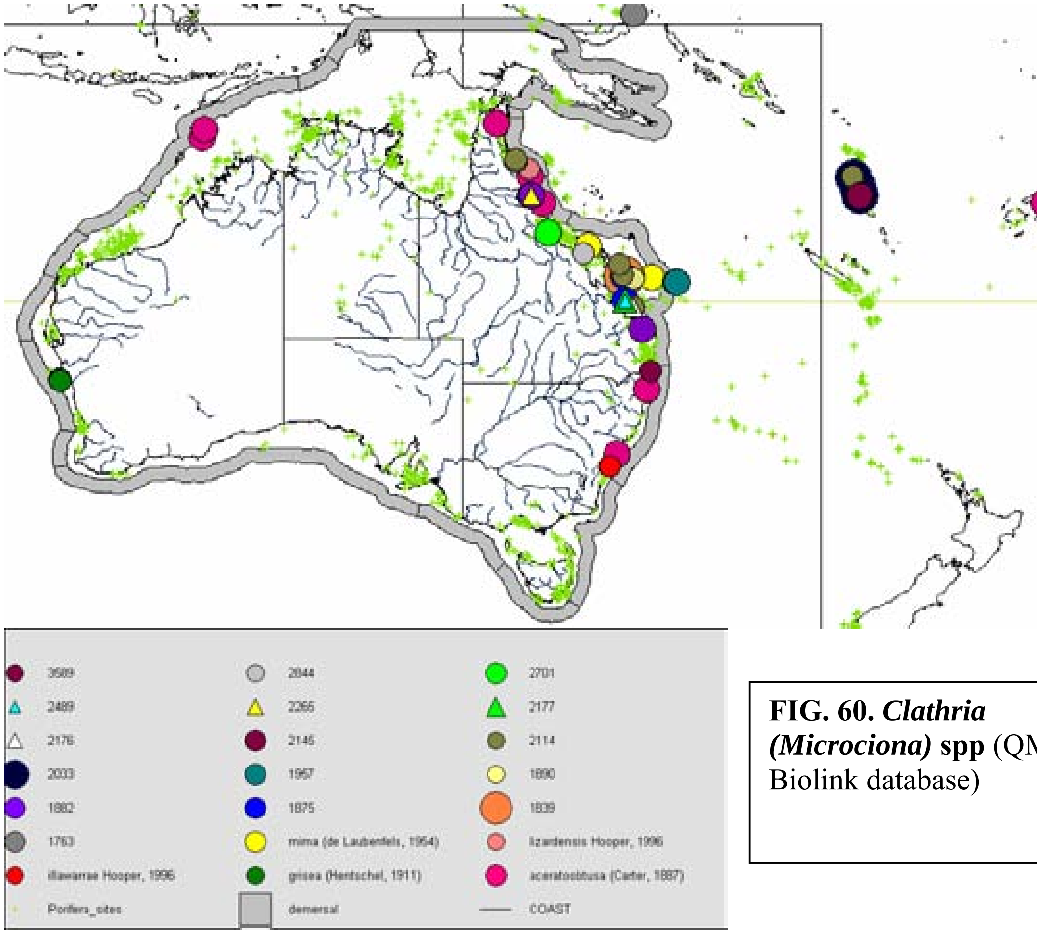


FIG. 60. *Clathria (Microciona)* spp (QM Biolink database)

***Clathria (Thalysias)* spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Figs 61-73)**

Bioregional trends: Highest diversity on the GBR, north coast and north west coast regions, with major species turnover at the eastern NP boundary and the Gulf of Carpentaria with distinctively different suite of species separating east and west coast faunas; no clear differentiation of north and south GBR bioregions.

Summary details: *Clathria (Thalysias)* contains 31 described species in Australian waters (and 12 additonal unnamed species, not shown on these maps), with peaks in diversity on the GBR region (NEB-CEB: 14 spp), the Darwin-Cobourg Peninsula region (west NP: 9 spp), the Gove Peninsula region (central NP: 7 spp), and the Northwest Shelf region (NWP: 11 spp). *Clathria (Thalysias) vulpina* also occurs in all tropical bioregions.

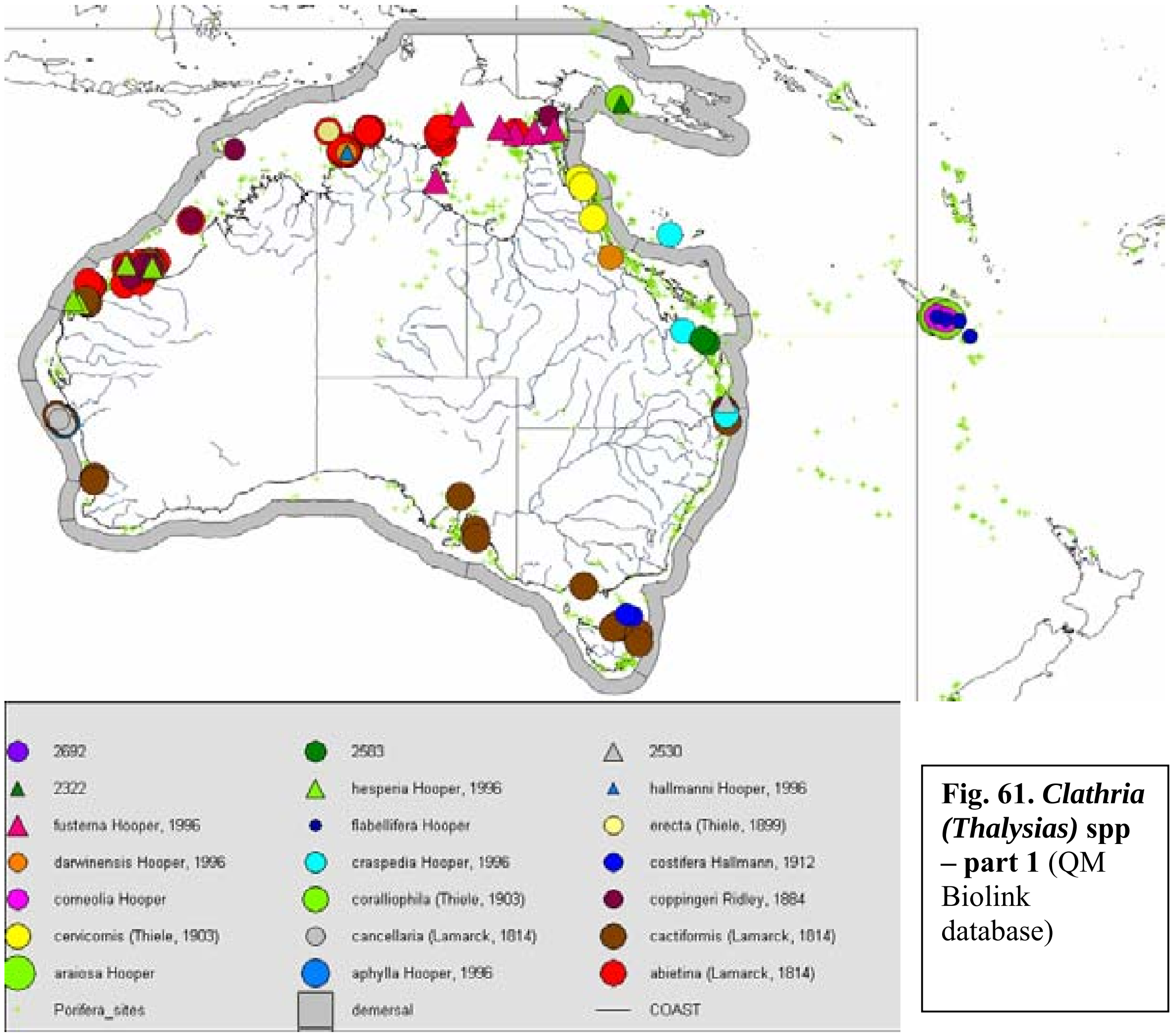


Fig. 61. *Clathria (Thalysias)* spp – part 1 (QM Biolink database)

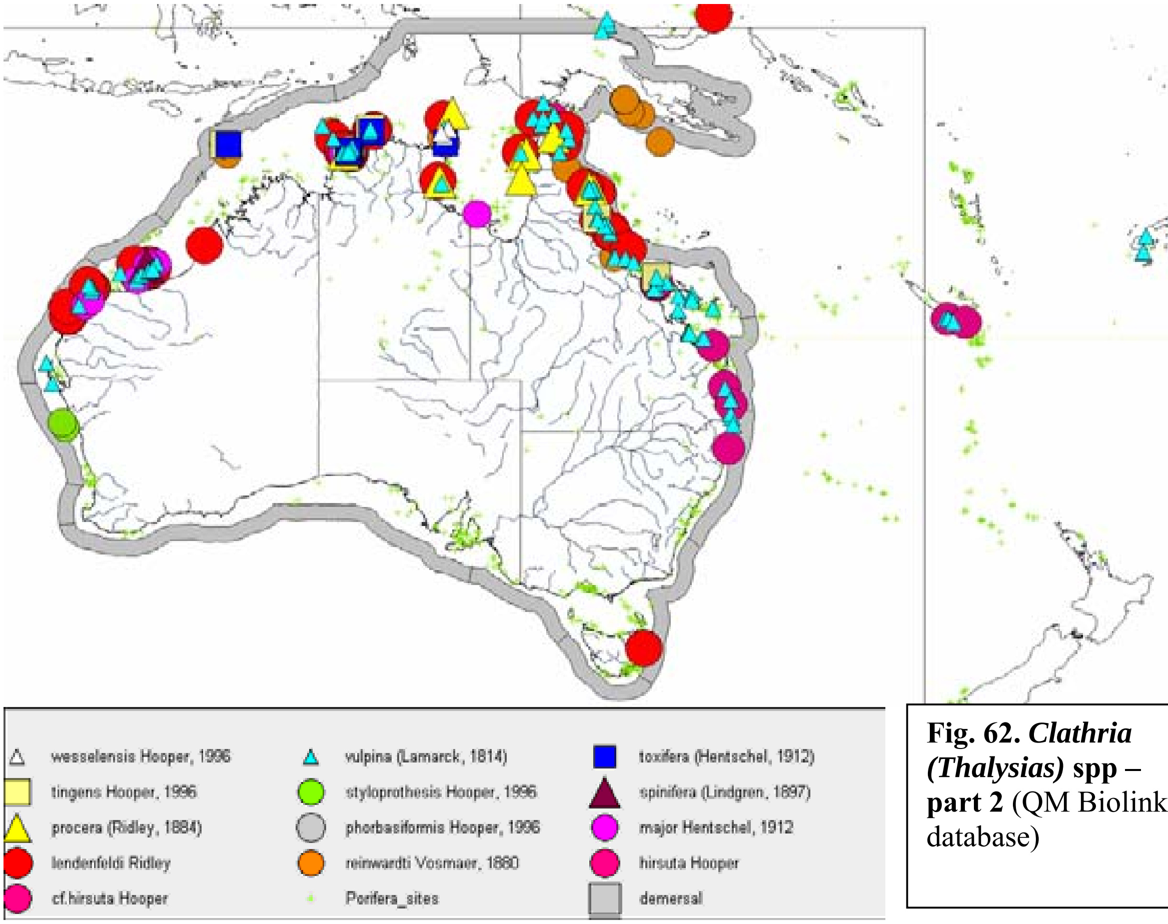


Fig. 62. ***Clathria (Thalysias)* spp – part 2** (QM Biolink database)

Several species support established bioregional patterns:
-tropical Australia: *C. (Thalysias) lendenfeldi, C. (Thalysias) major, C. (Thalysias) reinwardti, C. (Thalysias) tingens, C. (Thalysias) vulpina*
-entire GBR (CEB-NEB): *C. (Thalysias) hirsuta, C. (Thalysias) vulpina*
-north GBR (NEB): *C. (Thalysias) cervicornis, C. (Thalysias)* sp. #2692
-central and south GBR (NEP-CEB): *C. (Thalysias) craspedia, C. (Thalysias)* sp. #2583
-Cape York - Gulf of Carpentaria (east NP): *C. (Thalysias) fusterna, C. (Thalysias) procera*
-Darwin and Gove Peninsulas (west NP): *C. (Thalysias) darwinensis, C. (Thalysias) erecta, C. (Thalysias) hallmanni, C. (Thalysias) wesselensis*
-north and northwest coasts (NP-NWP): *C. (Thalysias) abietina, C. (Thalysias) toxifera*
-northwest shelf (NWP): *C. (Thalysias) hesperia, C. (Thalysias) coppingeri, C. (Thalysias) spinifera*
-south west coast (SWB): *C. (Thalysias) cancellaria, C. (Thalysias) styloprothesis*
-south east coast (CEP-TasP): *C. (Thalysias) costifera*
-temperate Australia (TasP – SWP): *C. (Thalysias) cactiformis*

Special analysis of Northern Planning Area. Ten species occur in the NPA, of which seven are found in the Groote Eylandt, Gove and Wessel Island regions **(Fig. 63)** (*C. (T.) abietina, C. (T.) fusterna, C. (T.) lendenfeldi, C. (T.) procera, C. (T.) toxifera, C. (T.) wesselensis, C. (T.) vulpina*) [*C. (T.) coppingeri, C. (T.) major, C. (T.) reinwardti* not occurring in this zone]. These data corroborate this region as a ‘biodiversity hotspot’ within the NPA. Of these species two are unique to the NPA (*C. (T.) fusterna and C. (T.) wesselensis*).

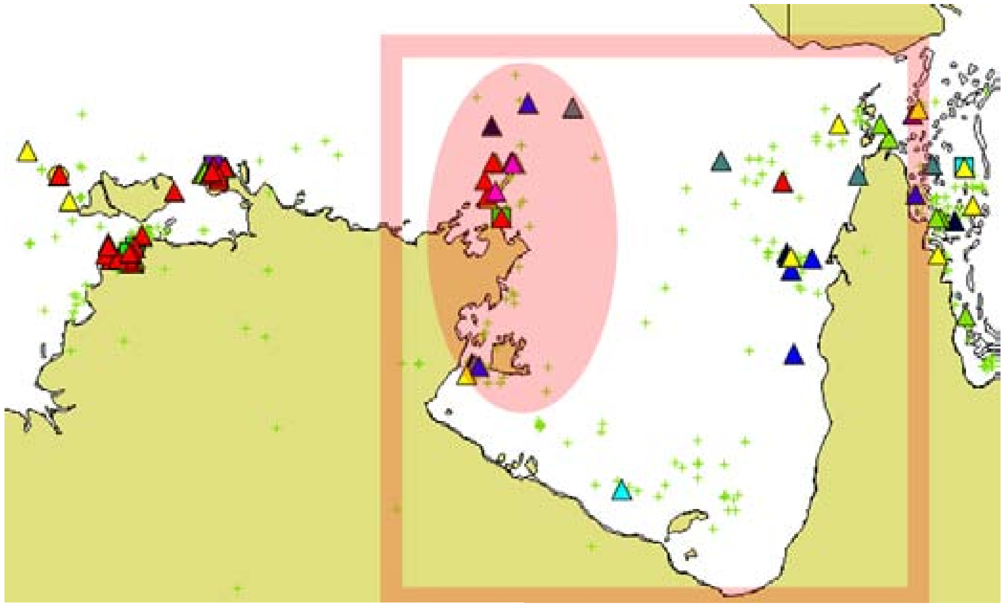


Fig. 63. Highest species richness (red ellipse) of *Clathria (Thalysias)* within the Northern Planning Area (red square) (QM Biolink database).

Actual datapoints and CAAB modelled distributions for these ten key *Clathria (Thalysias)* species found in the NPA are presented in the following figures:

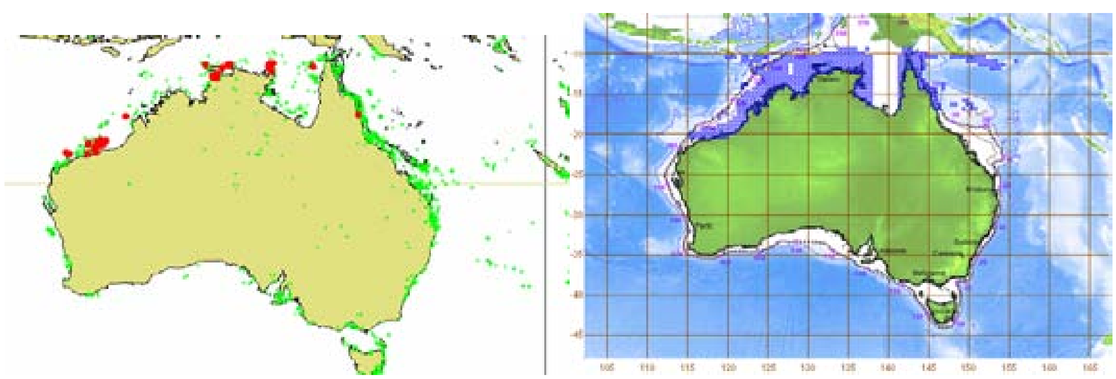


Fig. 64. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) abietina* (Lamarck).

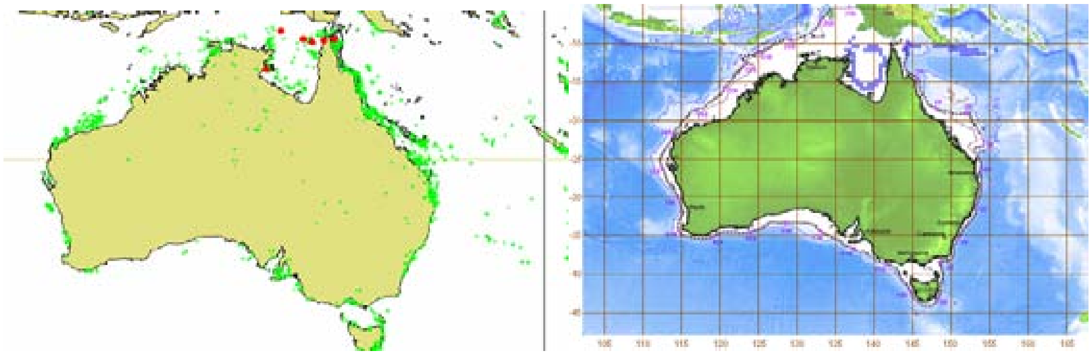


Fig. 65. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) fusterna* Hooper [this species is unique to the NPA]

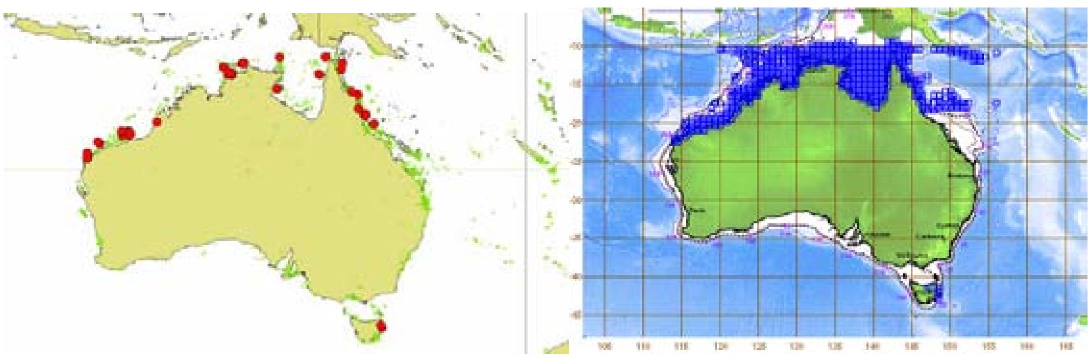


Fig. 66. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) lendenfeldi* (Ridley)

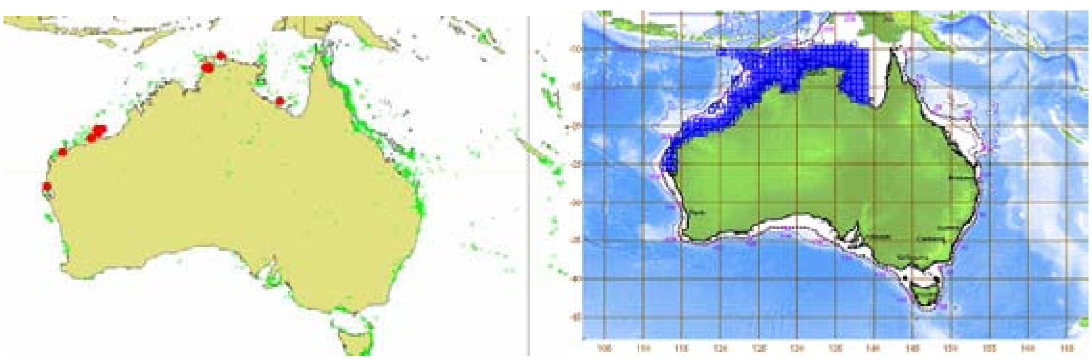


Fig. 67. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) major* Hentschel

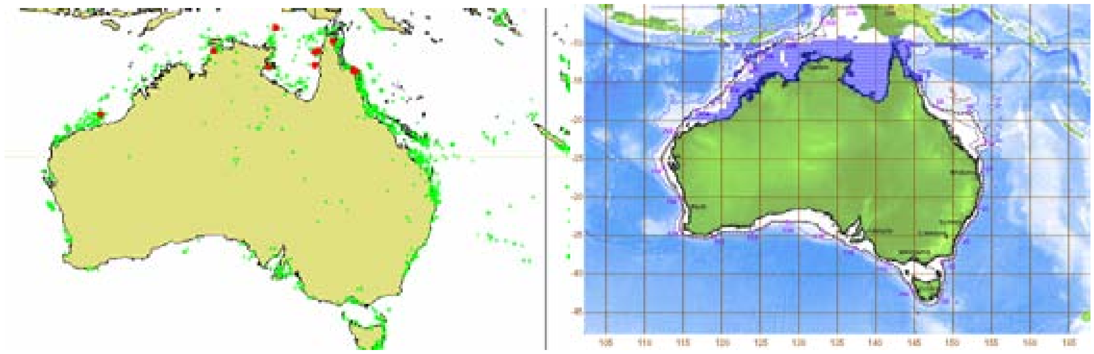


Fig. 68. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) procera* (Ridley)

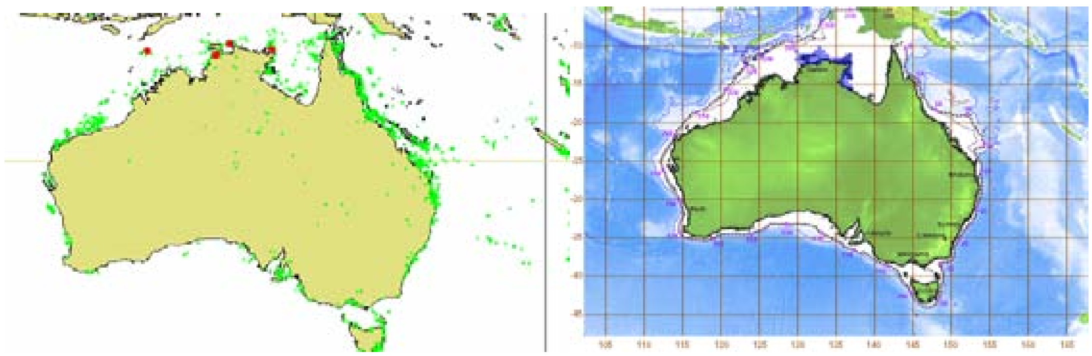


Fig. 69. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) toxifera* (Hentschel)

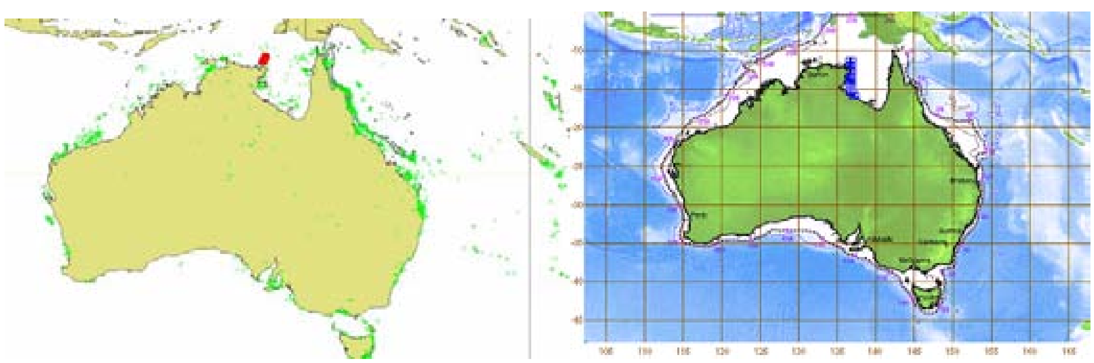


Fig. 70. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) wesselensis* Hooper [this species is unique to the NPA]

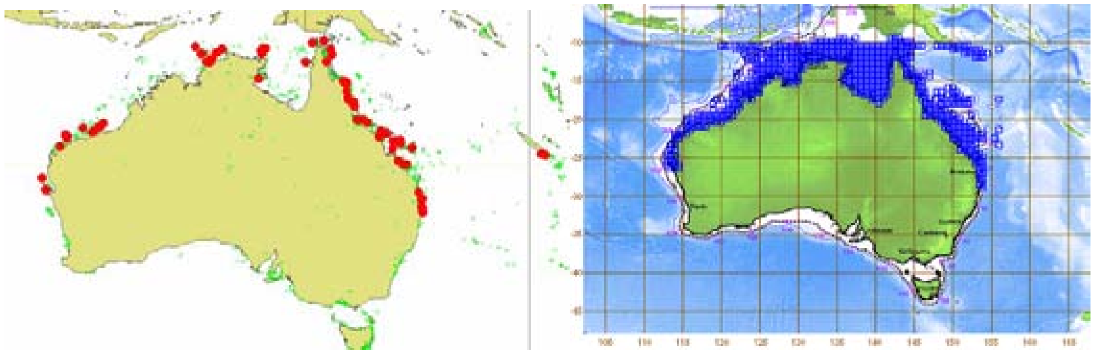


Fig. 71. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) vulpina* (Lamarck)

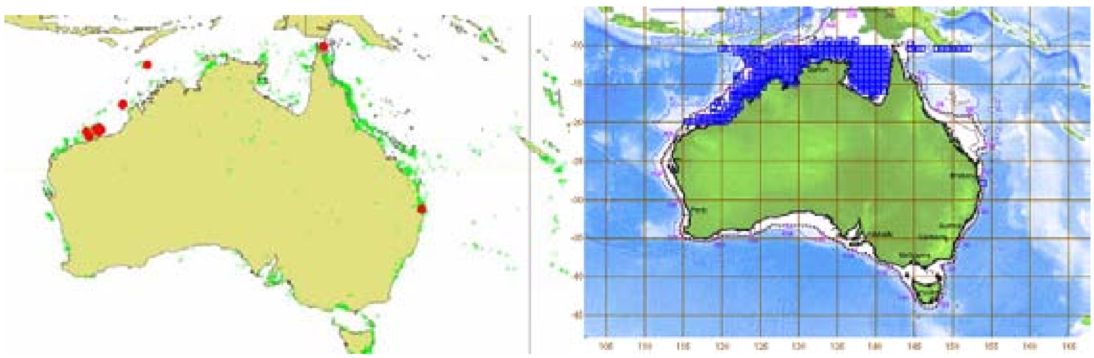


Fig. 72. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) coppingeri* (Ridley)

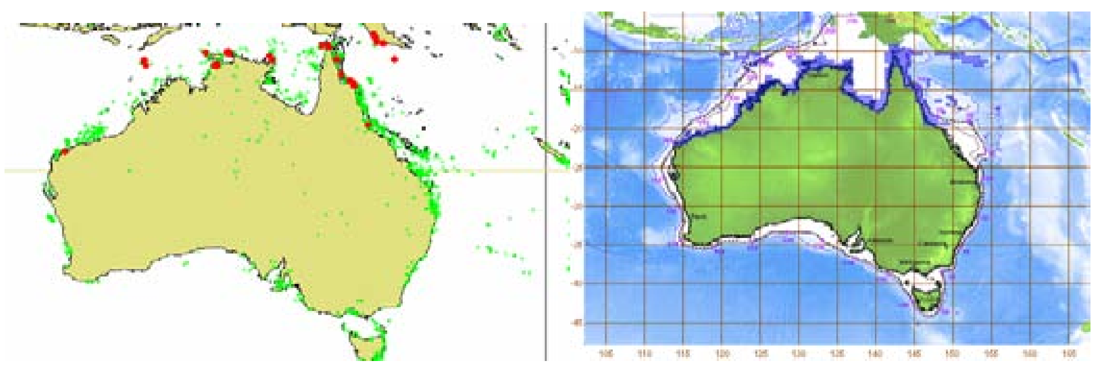


Fig. 73. Specimen records and CAAB modelled distributions for *Clathria (Thalysias) reinwardti* Vosmaer

Clathria (Wilsonella) and _Echinoclathria_ spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Fig. 74)

Bioregional trends: Distinct tropical and temperate species, with highest diversity in temperate bioregions, and several species clear markers for particular bioregions (GulfP, TasP, NEB).

Summary details: *Clathria (Wilsonella)* (10 spp, 8 named) and *Echinoclathria* (15 spp, 12 named) are predominantly temperate species, although several are exclusively tropical, with peaks of diversity in the southern Gulf (GulfP: 7 spp), Tasmania (TasP: 8 spp), and far north GBR (NEB: 4 spp). Only one species (*C. (Wilsonella) australiensis*) is widely distributed throughout temperate coastal Australia (CEB – SWB). Several species are markers for particular bioregions:
-entire GBR (NEP-NEB): *Echinoclathria bergquistae*
-north GBR (NEB): *E. levii*, *E. digitata*
-south GBR (NEP-CEB): *Echinoclathria* sp. #1855, 3587
-north coast (NP): *C. (Wilsonella) tuberosa*, *C. (W.) claviformis*
-south west coast (SWB): *C. (Wilsonella) abrolhosensis*
-southern Gulf (GulfP): *E. parkeri, E. notialis, E. nodosa*
-Tasmania (TasP): *E. riddlei, E. levii, E. egena, E. axinellioides*
-south east coast (TasP-CEP): *E. leporina*
-south coast (TasP-GulfP): *C. (Wilsonella) ensiae*, *E. subhispida*

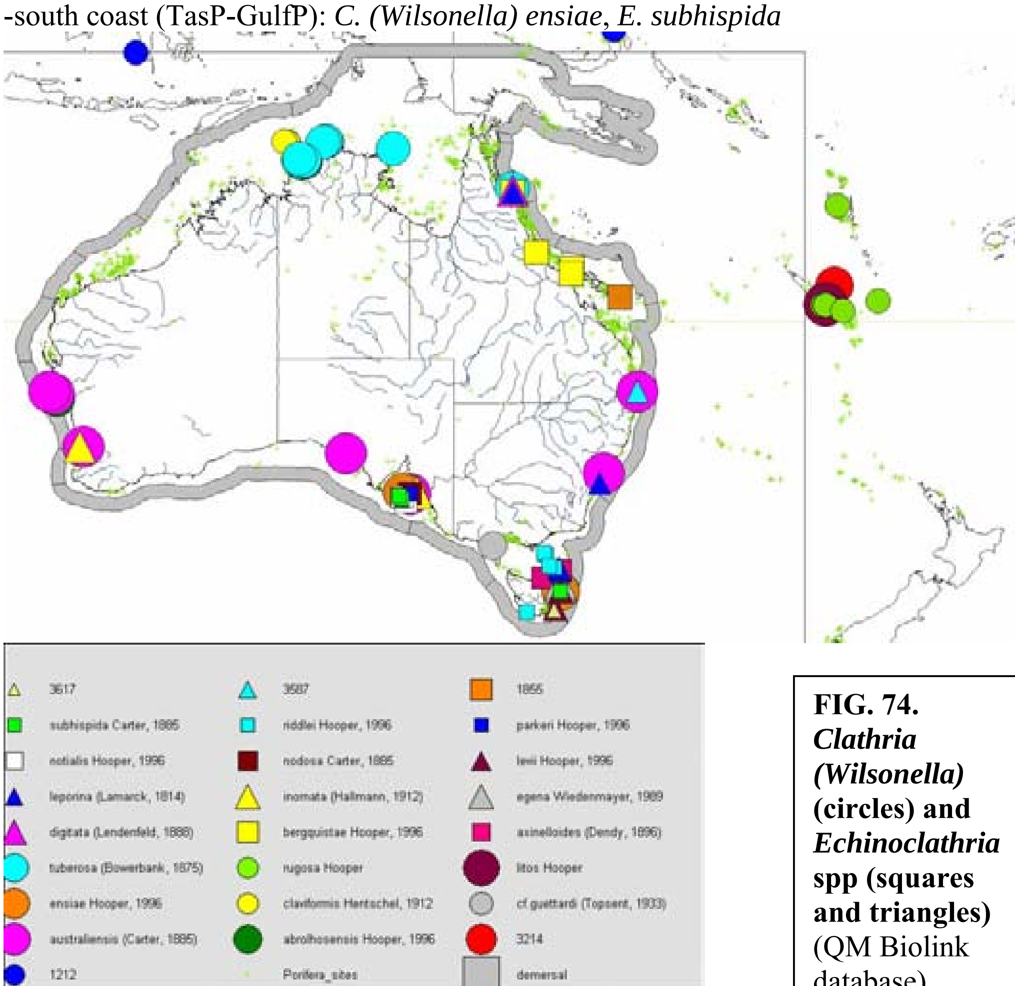


FIG. 74. _Clathria (Wilsonella)_ (circles) and _Echinoclathria_ spp (squares and triangles) (QM Biolink database)

Echinochalina (Echinochalina) and _Echinochalina (Protophlitaspongia)_ spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Fig. 75)

Bioregional trends: Predominantly tropical east coast, with distinct tropical and temperate faunas, with highest diversity on southern GBR – southeast Qld coast, and clearly differentiated northern and southern GBR faunas with only two species common to all the GBR.

Summary details: *Echinochalina* is a highly diverse, predominantly tropical east coast Australian genus with incursions into the southwestern and northwestern Pacific, and highest diversity on the GBR (20 spp). Two subgenera are recognized with *E. (Echinochalina)* having 15 spp (5 named), and *E. (Protophlitaspongia)* having 14 spp (8 named) in the database (several additional species are recorded around the Pacific rim. One species (*E. (E.) tubulosa*) is recorded from both temperate and tropical faunas (GulfP – NEB), whereas all others are restricted to either fauna. Northern and southern GBR faunas are clearly differentiated by their species composition, although several species extend into both bioregions, and the central GBR to southeast Queensland coast (Tweed River) has highest diversity of *Echinochalina* species (13 spp).

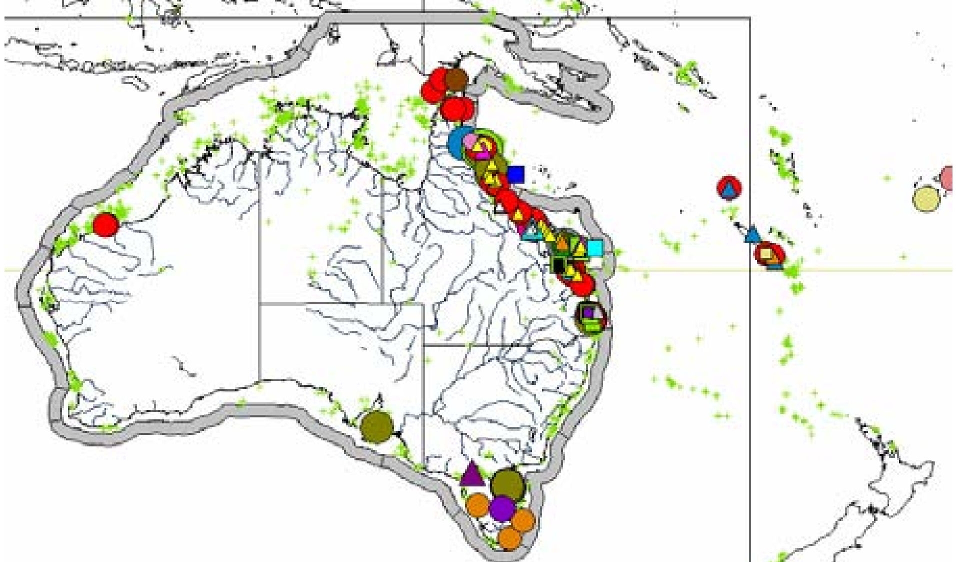
-entire GBR (NEB-CEB): *E. (E.) intermedia*, *E. (P.) isaaci*,

-north GBR (NEB): *E. (E.) barba*, *E. (E.) felixi*, *E. (Echinochalina)* sp. #2099, #2959, #3844, *E. (P.) collata*, *E. (Protophlitaspongia)* sp. #3333

-central-south GBR (NEP): *E. (Echinochalina)* sp. #2819, #2822, *E. (P.) oxeata, E. (P.) laboutei, E. (Protophlitaspongia)* sp. #1991, #2688, #3482

-southeast Qld (CEB): *E. (P.) favulosa, E. (Protophlitaspongia)* sp. #3763

-far south east coastal (BassP-TasP): *E. (Echinochalina)* sp. #3466, #3643, *E. (P.) bispiculata*



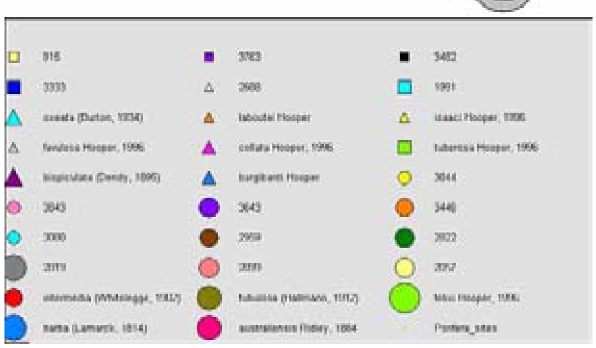


FIG. 75. *Echinochalina (Echinochalina)* (circles) and *Echinochalina (Protophlitaspongia)* spp (squares and triangles) (QM Biolink database)

***Holopsamma* spp (Demospongiae: Poecilosclerida: Microcionina: Microcionidae) (Fig. 76)**

Bioregional trends: Endemic Australian genus predominant in temperate waters, with highest diversity in the south east coast (GulfP to CEP) and a few species unique to particular bioregions.

Summary details: *Holopsamma* (10 spp, 8 named, 2 unnamed) is a peculiar 'honeycombed reticulate' sponges that incorporates copious amounts of detritus into its fibre skeleton in addition to its normal mineral skeleton components. The genus is endemic to the Australian fauna with few incursions into the tropics (including one dubious record of *H. macropora* from Cape York which is probably a cryptic sibling species of the southern Gulf species). Peaks of diversity occur in the southern Gulf (GulfP: 4 spp), Bass Strait and Tasmania (BassP, TasP: 4 spp), south east coast – central east temperate coast (SEB-CEB: 6 spp). Two species are widely distributed and geographically sympatric throughout temperate waters (*H. arborea*, *H. favus*) from CEP to CWB, two are common in south east coastal waters (*H. laminaefavosa*, *H. rotunda*) from Bass Strait to Fraser Island (BassP – CEB), and one from the southern Gulf (GulfP) to the Tweed River (*H. crassa*). Other species appear to be unique to particular bioregions:

-south GBR (NEP-CEB boundary): *Holopsamma* sp. #1830

-south east Qld (CEB): *H. pluritoxa*

-southern Gulf (GulfP): *H. macropora*, *Holopsamma* sp. indeterminate #816 [missing all native spicules]

-Great Australian Bight (GABB): *H. ramosa*

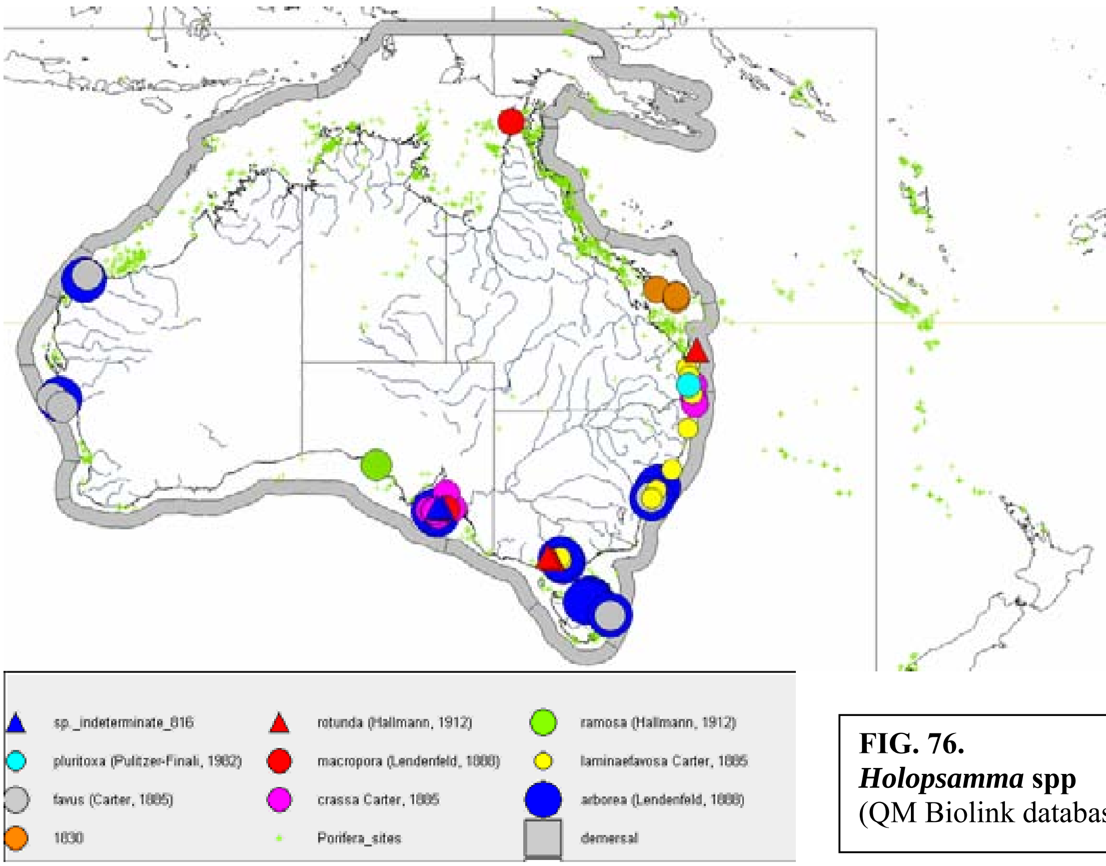


FIG. 76.
***Holopsamma* spp**
(QM Biolink database)

Family Raspailiidae Hentschel, 1923

17. *Axechina, Amphinomia, Ceratopsion, Trikentrion* spp (Demospongiae: Poecilosclerida: Microcionina: Raspailiidae) (Fig. 77)

Bioregional trends: Distinctive east and west coast faunas with species turnover at eastern part of NP; southern GBR with higher diversity and different species composition than northern GBR.

Summary details: *Axechina* (1 named sp.), *Amphinomia* (1 named sp.), *Ceratopsion* (10 spp, 5 unnamed) and *Trikentrion* (1 named sp.) are a predominantly tropical group of sponges with one genus and species (*Amphinomia sulphurea*) apparently endemic to northwest Australia (NWP-NP). The three genera with only single species in Australian waters are all restricted to north west and north Australia, with *Axechina raspailioides* and *Trikentrion flabelliforme* also relatively abundant at collection sites. By comparison, *Ceratopsion* is most diverse in the southern GBR (6 spp), with two species showing relatively wide distributions: *C. palmata* across the north west and north (NWP-NP), and *C. clavata* along the length of the GBR and into the western Pacific. *Ceratopsion aurantiaca* extends into temperate waters off the Sydney coast, where it was originally described, but has been recently found in the southern GBR and Solomon Islands. Apart from the southern GBR few species are unique to any bioregion:
-south GBR (NEP): *Ceratopsion* spp #3496, #2806, #2825, #2846
-north west coast (NWP): *C. montebelloensis*

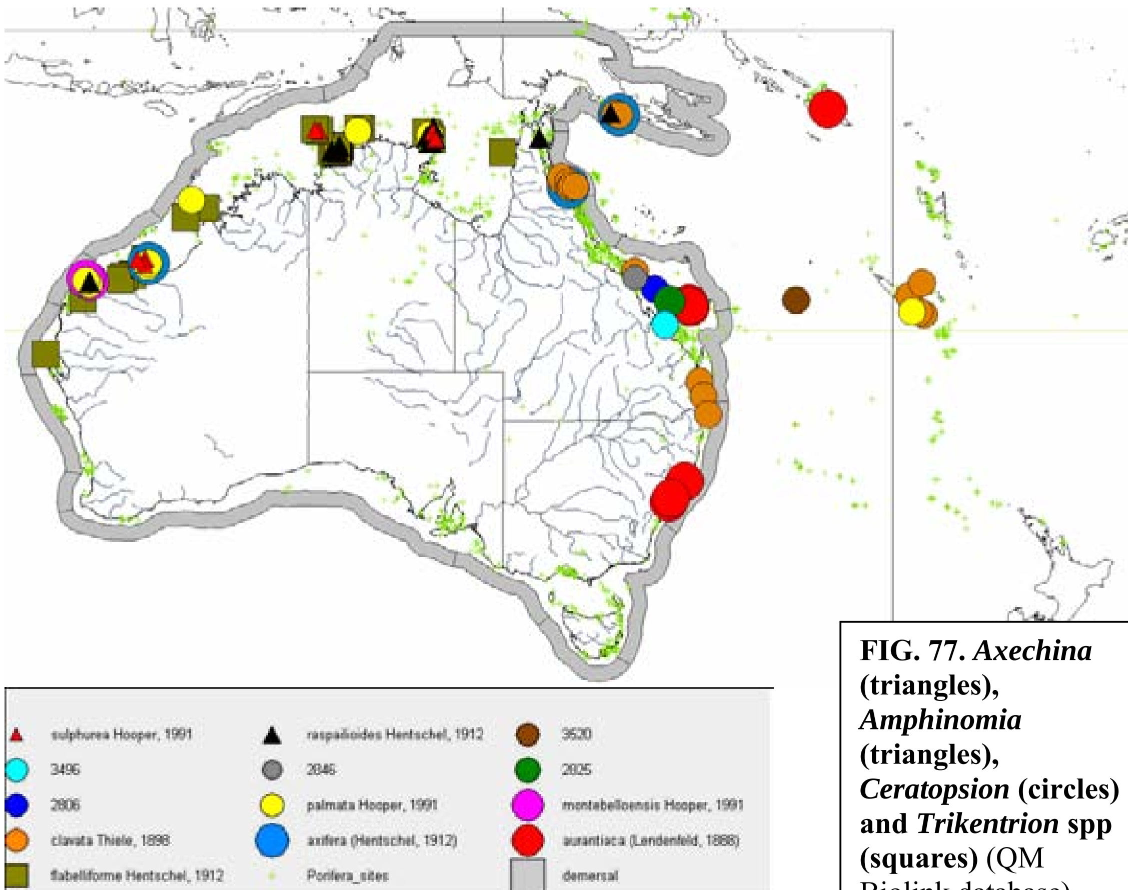


FIG. 77. *Axechina* (triangles), *Amphinomia* (triangles), *Ceratopsion* (circles) and *Trikentrion* spp (squares) (QM Biolink database)

***Echinodictyum* spp (Demospongiae: Poecilosclerida: Microcionina: Raspailiidae) (Figs 78-84)**

Bioregional trends: Predominantly tropical but extending along entire extent of west coast, with highest diversity on the tropic on both sides of the coast. Several species widely distributed in tropics but several others are indicators of southern GBR (NEP-CEB), northern Gulf (NP), north west coast and south west coast bioregions.

Summary details: *Echinodictyum* (Demospongiae, Poecilosclerida, Microcionida, Raspailiidae) is only moderately diverse in Australian waters (17 spp, 9 named), but sometimes highly abundant at particular collection sites, especially on the north and northwest coasts. Database records indicate peaks of diversity on the tropic of the northwest coast (NWP: 6 spp), and the tropic of the southern GBR (8 spp), with three species common to both diversity 'hotspots'. The genus is predominantly tropical with incursions deep into the south west coast (although there are undoubtedly collections in southern Australian museums which contain species of *Echinodictyum* but which have not yet been identified as such). Three species are widely distributed throughout tropical Australia: *E. mesenterinum* (SWB – CEB), *E. conulosum* (NWP – CEB), *E. asperum* (NWP – CEB); one species is widely distributed on the north and north west coasts: *E. cancellatum* (NWP – NP, with incursion into the top of NEB); and one species is disjunct in distribution, occurring on both central west and east coasts: *E. nidulus* (SWB-CWB & NEP). Several species are markers for particular bioregions:

-south GBR to south east Qld (NEP – CEB): *Echinodictyum* spp #1178, #1620, #2001, #2088, #2789, #3089

-Gulf of Carpentaria (NP): *E. carlinoides*

-north west coastal (NWP): *E. rugosum*

-mid to south west coastal (southern part of NWP - SWP): *E. clathrioides*

-south west coast (SWB): *E. austrinum*

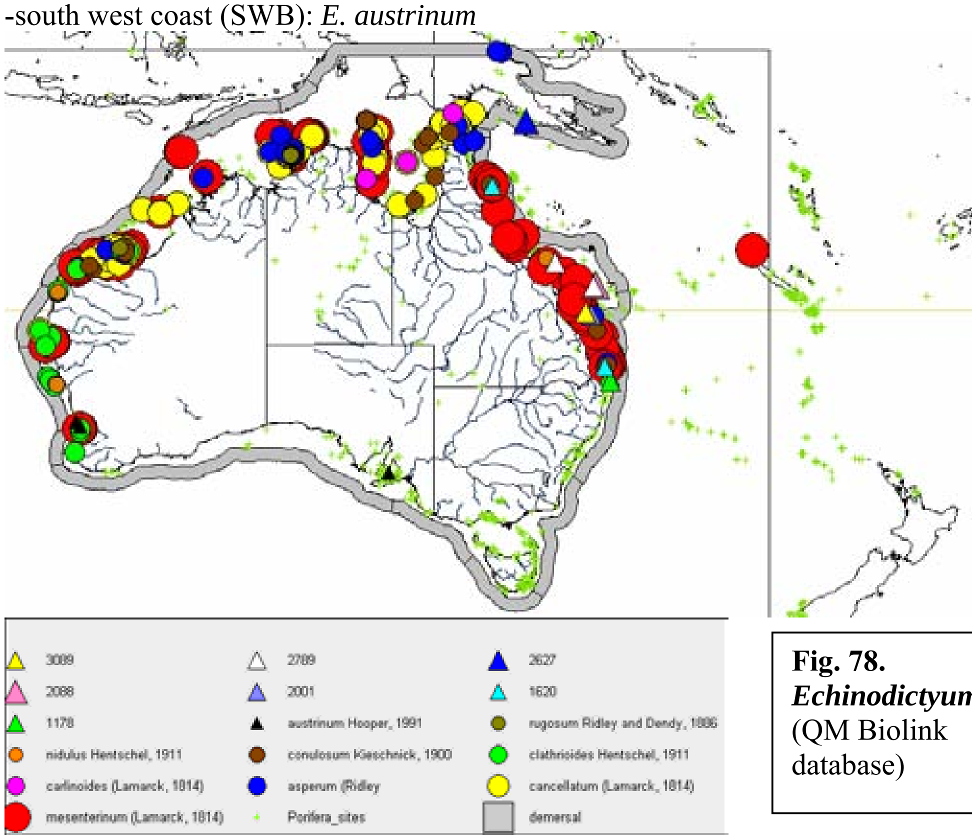
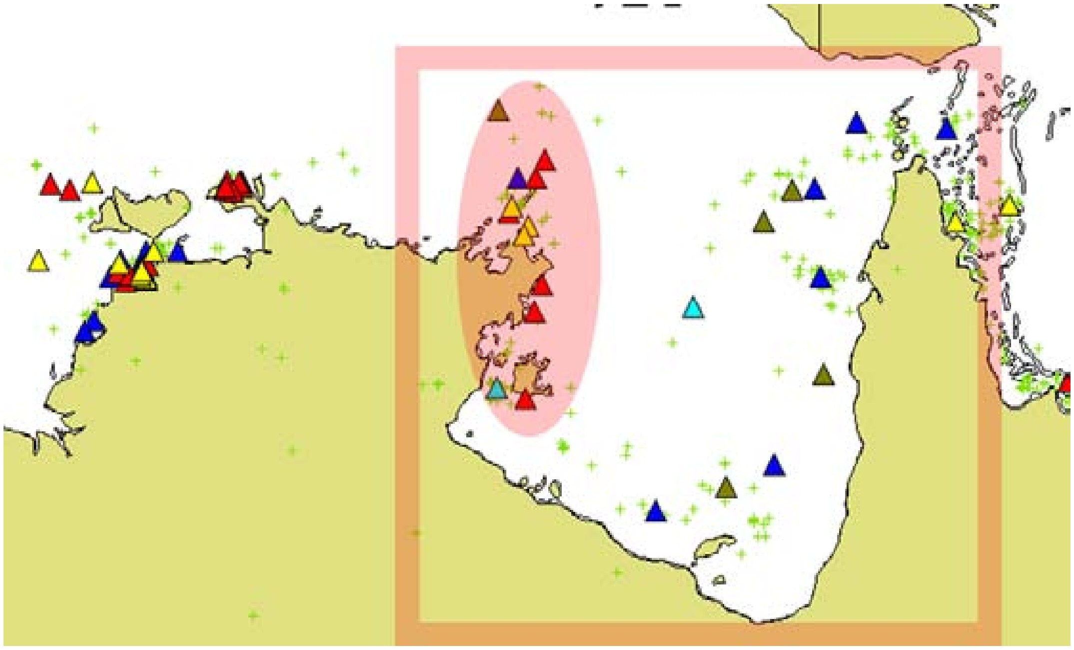


Fig. 78. ***Echinodictyum* spp** (QM Biolink database)

Special analysis of Northern Planning Area. Of the 17 Echinodictyum species five occur in the NPA, all of which are found only in the Groote Eylandt, Gove and Wessel Island regions (red elliptical in **Fig. 79**) (*E. asperum, E. cancellatum, E. carlinoides, E. conulosum, E. mesenterinum*), representing a putative 'biodiversity hotspot' in the NPA. By comparison the Gulf of Carpentaria, Torres Strait and areas west of the Wessel Islands have fewer species of *Echinodictyum*. There are no unique *Echinodictyum* species in the NPA.



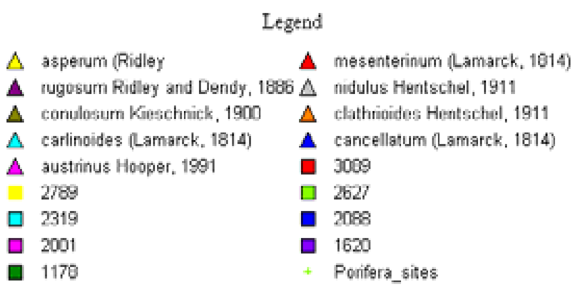


Fig. 79. Highest species richness (red ellipse) of *Echinodictyum* within the Northern Planning Area (red square) (QM Biolink database)

Actual datapoints and CAAB modelled distributions for these five key *Echinodictyum* species found in the NPA are presented in the following figures.

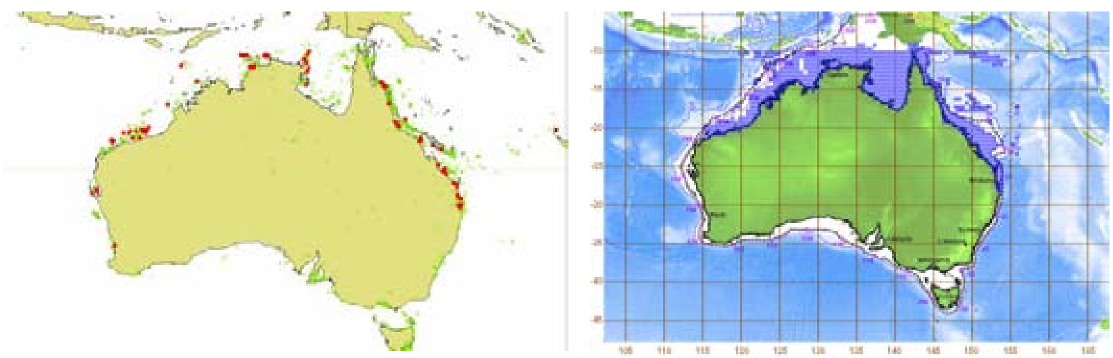


Fig. 80. Specimen records and CAAB modelled distributions for *Echinodictyum mesenterinum* (Lamarck). Small green crosses represent collecting sites.

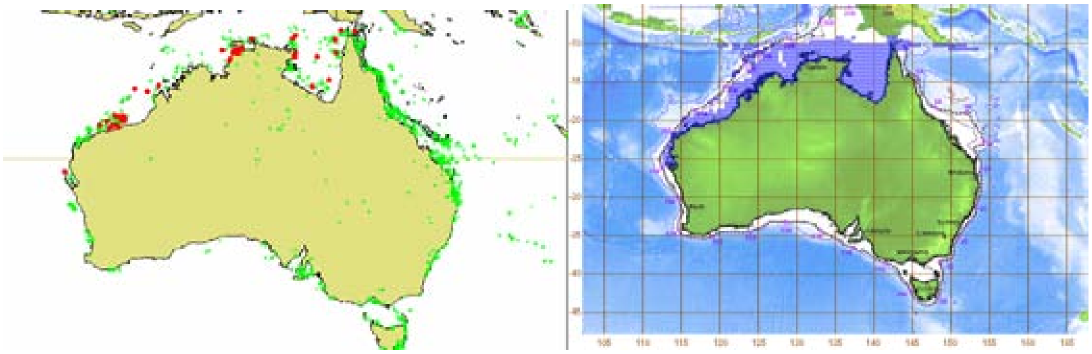


Fig. 81. Specimen records and CAAB modelled distributions for *Echinodictyum cancellatum* (Lamarck).

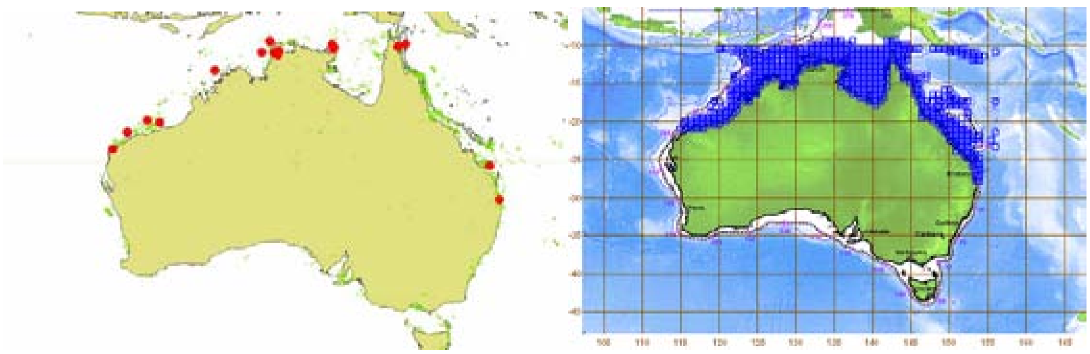


Fig. 82. Specimen records and CAAB modelled distributions for *Echinodictyum asperum* (Lamarck).

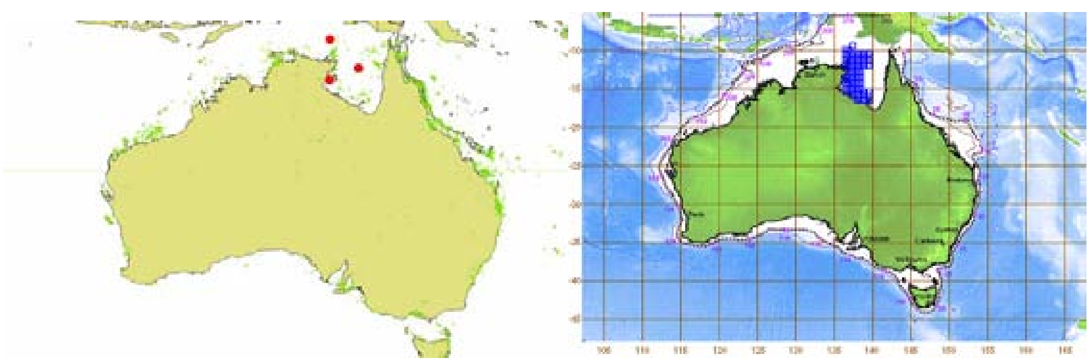


Fig. 83. Specimen records and CAAB modelled distributions for *Echinodictyum carlinoides* (Lamarck).

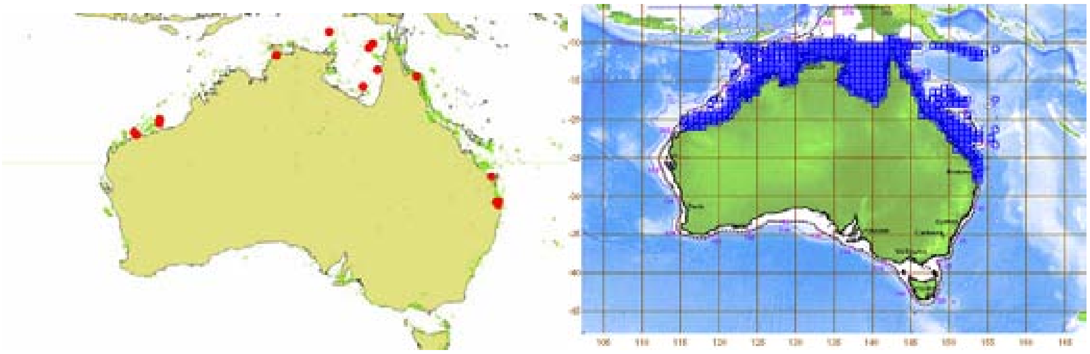


Fig. 84. Specimen records and CAAB modelled distributions for *Echinodictyum conulosum* (Kieschnick).

***Ectyoplasia*, *Eurypon, Lithoplocamia, Plocamione* and *Thrinacophora* spp (Demospongiae: Poecilosclerida: Microcionina: Raspailiidae) (Fig. 85)**

Bioregional trends: Exclusively tropical records, one genus abundant and restricted to north and west coasts and another with east-west species pair bounded by Cape York (NP).

Summary details: *Ectyoplasia* (2 named spp), *Eurypon* (2 unnamed spp), *Lithoplocamia* (1 named sp.), *Plocamione* (1 unnamed sp.) and *Thrinacophora* (2 spp, 1 named), are exclusively tropical but not diverse. *Ectyoplasia* is restricted to the north and northwest coasts, with both species geographically sympatric in their distributions (NWP to NP, with small incursions into CWP in the south west). *Thrinacophora* is represented by an east-west species pair, with the boundary at Cape York (NP), although *T. cervicornis* was also recently recorded from the southern Papuan Barrier Reef (NWP-NP), and *Thrinacophora* sp. #1993 found only on the GBR (NEP, NEB).

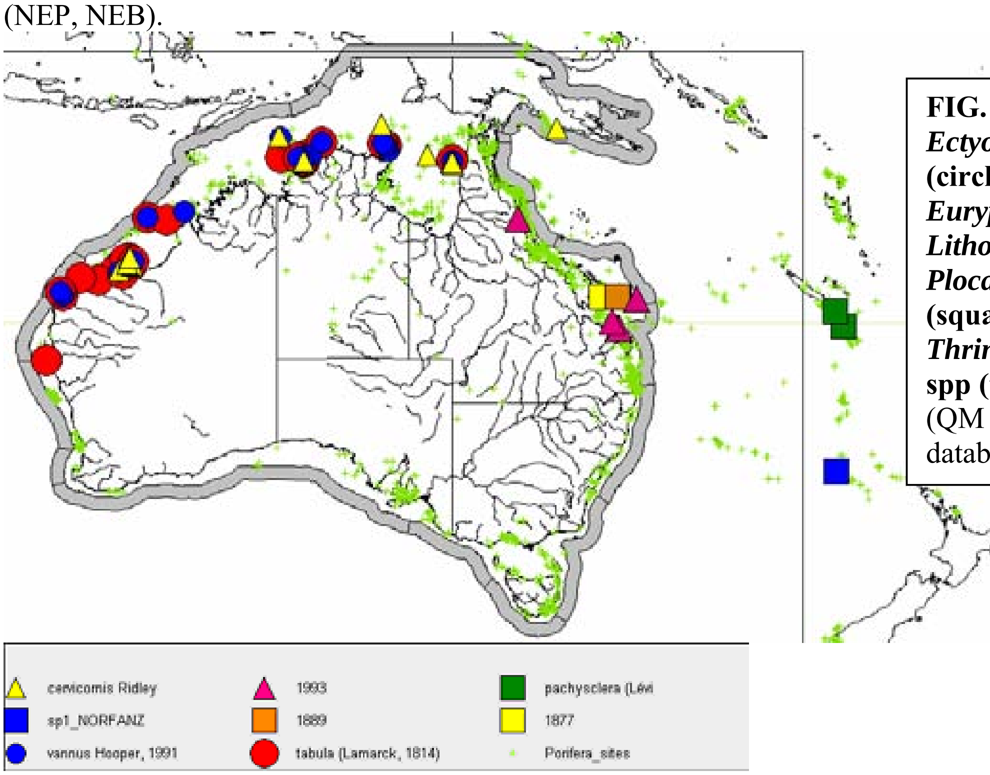


FIG. 85. *Ectyoplasia* (circles), *Eurypon, Lithoplocamia, Plocamione* (squares) and *Thrinacophora* spp (triangles) (QM Biolink database)

Raspailiids with rhabdostyles (*Aulospongus, Endectyon, Raspailia (Raspaxilla)* spp) (Demospongiae: Poecilosclerida: Microcionina: Raspailiidae) (Fig. 86)

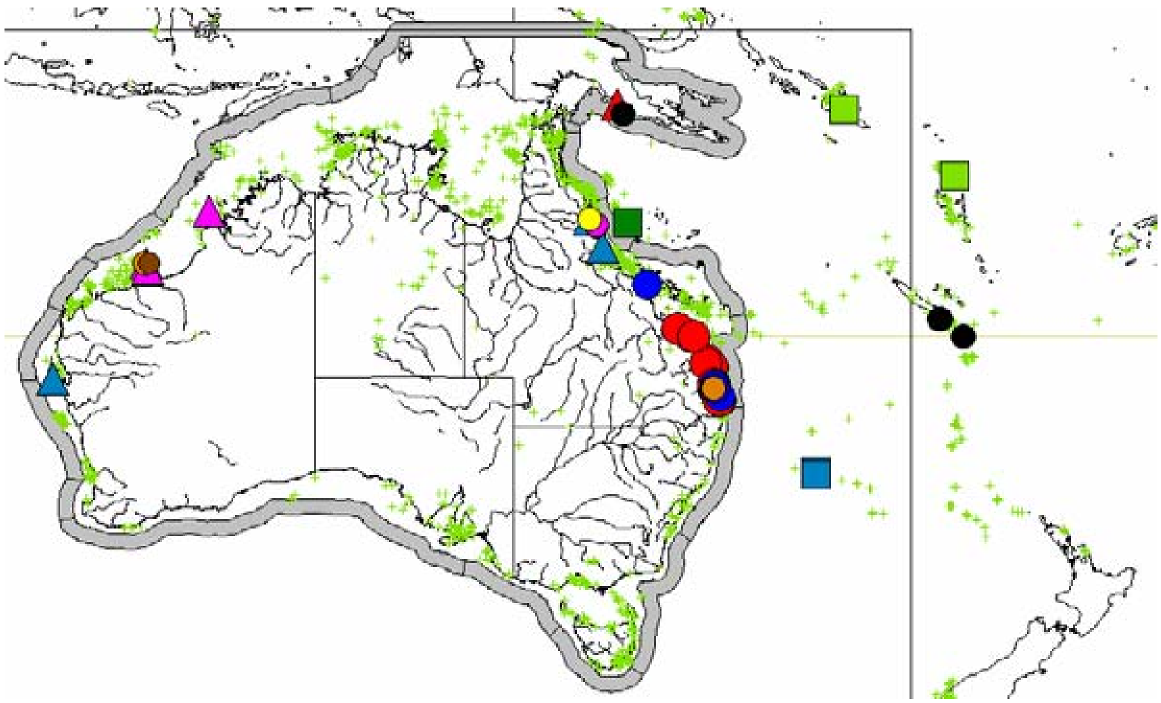
Bioregional trends: Predominantly tropical distributions, two species with widely disjunct mid-east and mid-west distributions; north-south differentiation of the GBR indicated.

Summary details: *Aulospongus* (3 spp, 1 named), *Endectyon* (3 spp, 2 named) and *Raspailia (Raspaxilla)* (7 spp, 4 named) have a common character in the form of rhabdostyles echinating their skeletons, but are otherwise not closely related. None are diverse or abundant at any site, and are restricted mainly to the tropics. Several species distributions support bioregional boundaries, including north-south differentiation of the GBR. Two species (*R. (Raspaxilla) compressa, Endectyon elyakovi*) have widely disjunct distributions on west (NWP-CWP) and east (CEB) coasts.

-north GBR (NEB): *R. (Raspaxilla) reticulata*, *R. (Raspaxilla)* sp. #2264, *Aulospongus* sp. #2349

-south GBR (NEP, CEB): *R. (Raspaxilla)* sp. #1081, #1696

-north west coast (NWP): *R. (Raspaxilla) wardi*, *Endectyon thurstoni*



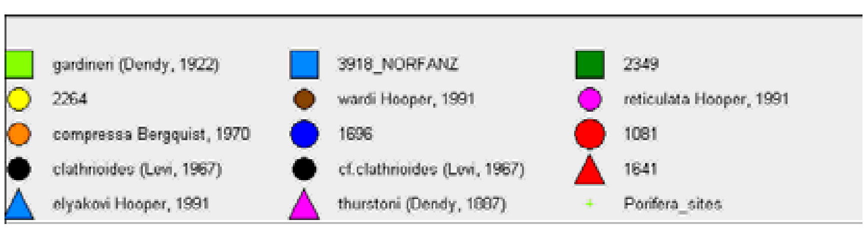


FIG. 86. *Aulospongus* (squares), *Endectyon* (triangles), *Raspailia (Raspaxilla)* spp (circles) (QM Biolink database)

***Raspailia (Clathriodendron, Hymeraphiopsis, Parasyringella, Raspailia)* spp (Demospongiae: Poecilosclerida: Microcionina: Raspailiidae) (Fig. 87)**

Bioregional trends: Equally diverse in tropics and temperate waters, although records are depauperate for south west and southern Australian coasts. Several species indicative of bioregional distributions, and species composition supports differentiation of north and south bioregions on GBR.

Summary details: *Raspailia* is a moderately highly diverse group of species divided into subgenera (see also *R. (Raspaxilla)* included in analysis above): *Clathriodendron* (11 spp, 6 named), *Hymeraphiopsis* (1 unnamed sp.), *Parasyringella* (3 named spp) and *Raspailia* (16 spp, 5 named). Species are equally diverse in tropical and temperate bioregions, although so far there are no database records yet from the south west and south coasts (SWB to WBassB). One species (*R. (Raspailia) vestigifera*) is widely distributed in the tropics, from central west coast (CWP) to the Wessel Islands (NP), and two others (*R. (Parasyringella) australiensis*, *R. (Clathriodendron) arbuscula*) from the southern GBR (NEP) and south east Queensland (CEB) extending into the Gulf of Carpentaria (NP). Several groups of species are markers for particular bioregions:

-north GBR (NEB: 6 spp): with bioregional markers *R. (R.) wilkinsoni, R. (Raspailia)* spp #3189, #1695

-south GBR (NEP: 4 spp): *R. (Raspailia)* spp #3003, #3054, #3463

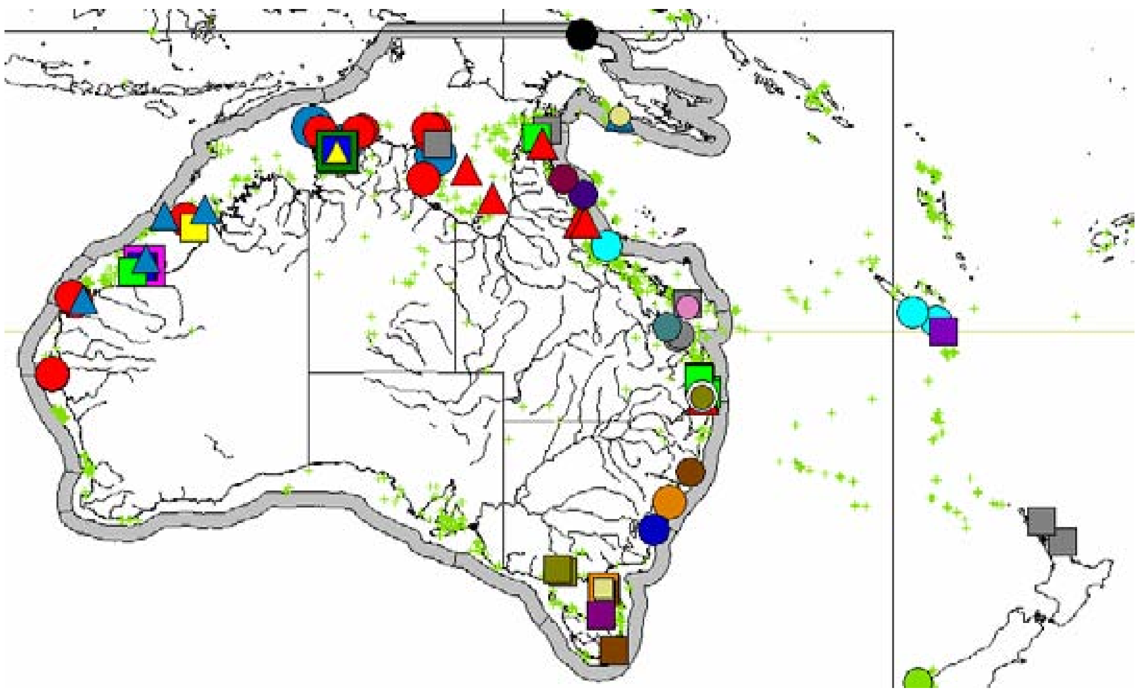
-south east Queensland (CEB: 4 spp): *R. (Raspailia)* spp #2714, #2953

-north coast (NP: 7 spp): *R. (Parasyringella) nuda, R. (Clathriodendron) keriontria, R. (Clathriodendron) darwinensis*

-north west coast (NWP: 6 spp): *R. (Parasyringella) elegans, R. (Clathriodendron) melanorhops, R. (Clathriodendron) desmoxyiformis*

-central south east coast (CEP: 3 spp): *R. (R.) gracilis, R. (Raspailia)* spp # 1695, #3578

-Bass Strait and Tasmania (BassP, TasP: 5 spp): *R. (C.) cacticutis, R. (Clathriodendron)* spp #850, #910, #3554, #3644



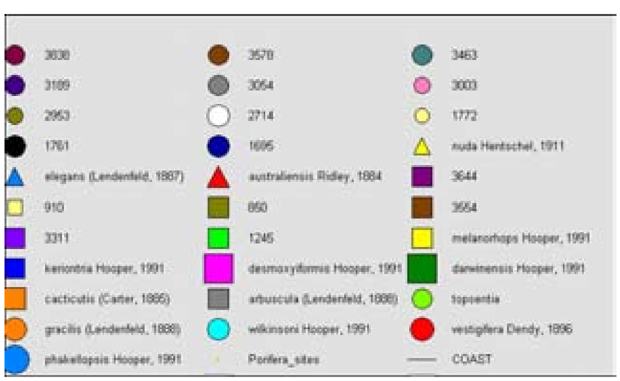


FIG. 87. *Raspailia (Clathriodendron* (squares), *Hymeraphiopsis* (squares), *Parasyringella* (triangles) and *Raspailia* spp (circles)) (QM Biolink database)

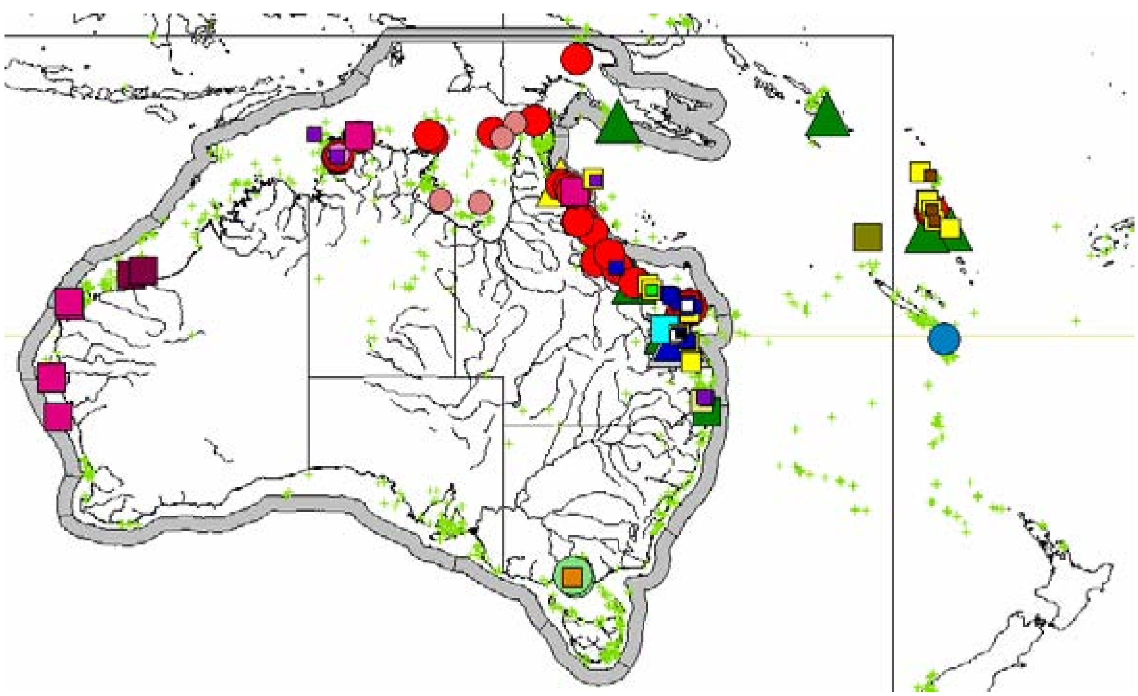
Family Rhabderemiidae Topsent, 1928 &
Suborder Mycalina Hajdu, Van Soest & Hooper, 1994

Family Esperiopsidae Hentschel, 1923 &
Family Isodictyidae Dendy, 1924

18. Rhabderemiidae (Demospongiae: Poecilosclerida: Microcionina), Esperiopsidae and Isodictyidae spp (Demospongiae: Poecilosclerida: Mycalina) (Fig. 88)

Bioregional trends: Heterogeneous group showing differing distributions, ranging from north east coast (from GBR and western Pacific island rim (*Rhabdermia*, *Ulosa*)), north east and north coast (from GBR to Darwin (*Coelocarteria*)), and north west and north coast (from central west to northern GBR (*Esperiopsis*). North-south GBR bioregional split not well supported.

Summary details: Database records of Rhabderemiidae (*Rhabderemia* (4 spp, 1 named)), Esperiopsidae (*Amphilectus* (1 unnamed spp), *Esperiopsis* (5 spp unnamed), *Ulosa* (10 spp, 1 named), and Isodictyidae (*Coelocarteria* (5 spp, 1 named)) are predominantly tropical, with differing patterns of distribution. *Rhabderemia* is restricted to the GBR and western Pacific island arc with 3 spp in the southern GBR. *Coelocarteria* has one widely distributed tropical species (*C. singaporensis*) from the southern GBR (CEB) to the Darwin region (west NP), with another sibling species (*Coelocarteria* sp. #1445) restricted to soft sediments in the Gulf of Carpentaria (east NP). *Esperiopsis* has one species (*E.* sp. #48) extending from the central west coast (CWP) to the northern GBR (NEB). *Ulosa spongia* has a similar distribution to *Rhabderemia* spp, extending along the GBR into the Pacific rim. Species diversity of all taxa is highest in the southern GBR (NEP: 9 spp), but species composition only weakly supports north-south split in GBR bioregions.
-north GBR (NEB): *Rhabderemia* sp. #3834
-south GBR (NEP, CEB): *Rhabderemia* spp #2195, #2196, *Amphilectus* sp. #3487, *Ulosa* spp #2472, #1851, #1856, #2804
-Gulf of Carpentaria (NP): *Coelocarteria* sp. #1445
-Darwin region (NP): *Ulosa* sp. # 41
-north west coastal (NWP): *Esperiopsis* sp. #334
-Bass Strait (BassP): *Coelocarteria* sp. #892, *Esperiopsis* sp. #888



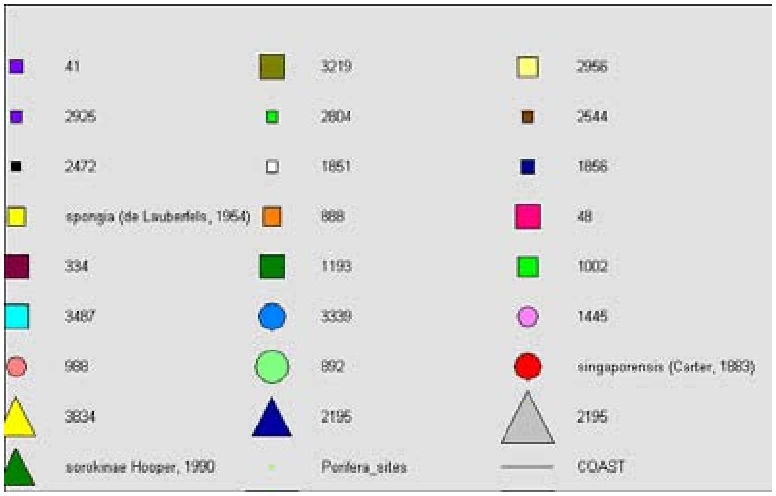


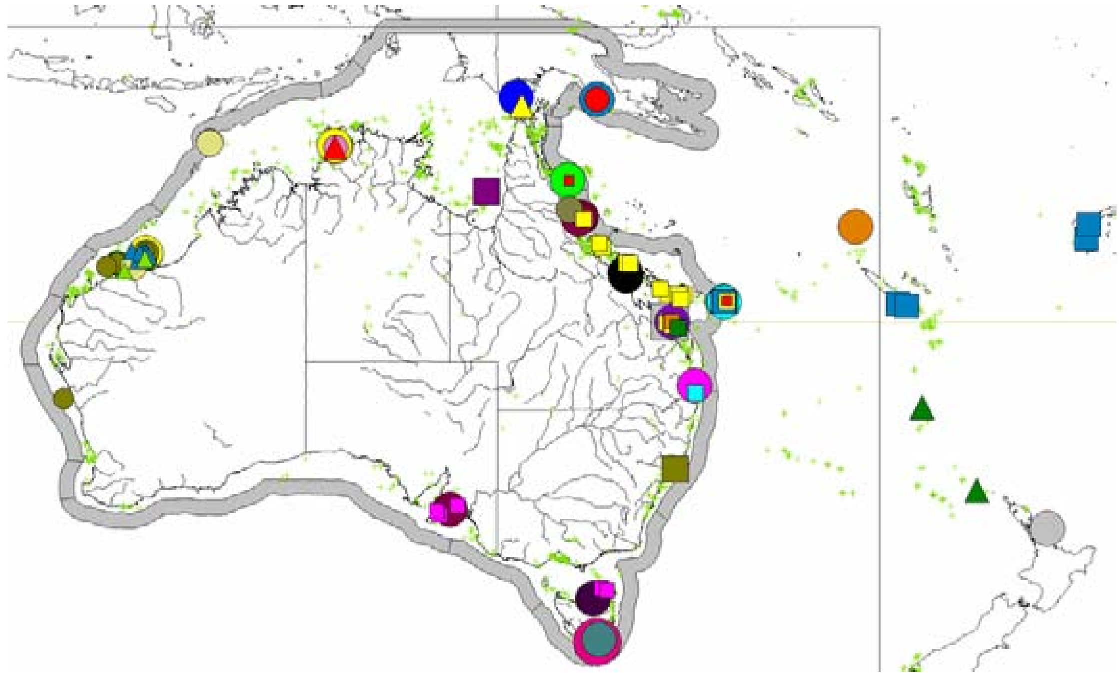
FIG. 88. Rhabderemiidae (triangles), Esperiopsidae (squares), Isodictyidae spp (circles) (QM Biolink database)

Family Desmacellidae Ridley & Dendy, 1886

19. *Biemna*, *Sigmaxinella*, *Desmacella* and *Neofibularia* spp (Demospongiae: Poecilosclerida: Mycalina: Desmacellidae) (Fig. 89)

Bioregional trends: Higher diversity on east than west coasts, and in tropics than temperate regions; differentiation between north and south GBR; few species shared between bioregions.

Summary details: Species of Desmacellidae are frequently toxic, and often associated with coral substrate. Records contain four genera, *Biemna* (21 spp, 4 named), *Sigmaxinella* (2 named spp), *Desmacella* (3 spp, 1 named) and *Neofibularia* (9 spp, 3 named), which are diverse and abundant in several localities. Peaks in diversity increase around the coast from west to east: north west coast (NWP: 5 spp), Darwin region (NP: 3 spp), north GBR (NEB: 7 spp) and south GBR (NEP: 9 spp). Tropical and temperate faunas are clearly differentiated by their species composition, including separation of northern and southern GBR faunas, and few species occur in more than one bioregion.
-north GBR (NEB): *Biemna* spp #2260, #1662, #1611, #3451, *Desmacella* sp. #808
-south GBR (NEP): *Biemna* spp #817, #2467, #1977, *Neofibularia irata, N. hartmani, Neofibularia* spp #2589, #2206
-south east Queensland (CEB): *Biemna microstrongyla*, *Neofibularia* sp. #2765
-central south east coast (CEP): *Desmacella* sp. #1915
-Tasmania (TasP): *Biemna rufescens*, *Biemna* sp. #3451, #3288
-southern Gulf (GulfP): *Biemna tubulata*
-north and north west coasts (NP-NWP): *Biemna saucia*
-north coast (NP): *Biemna* sp. #188, *Neofibularia* sp. #3795, *Sigmaxinella flabellata*
-north west coast (NWP): *Biemna* sp. #317, #410, #793, #1977, *Desmacella ithystela, Sigmaxinella soelae*



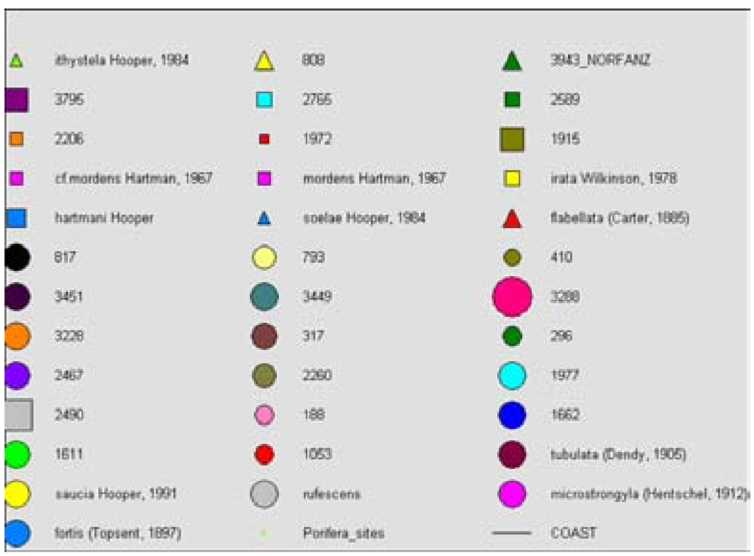


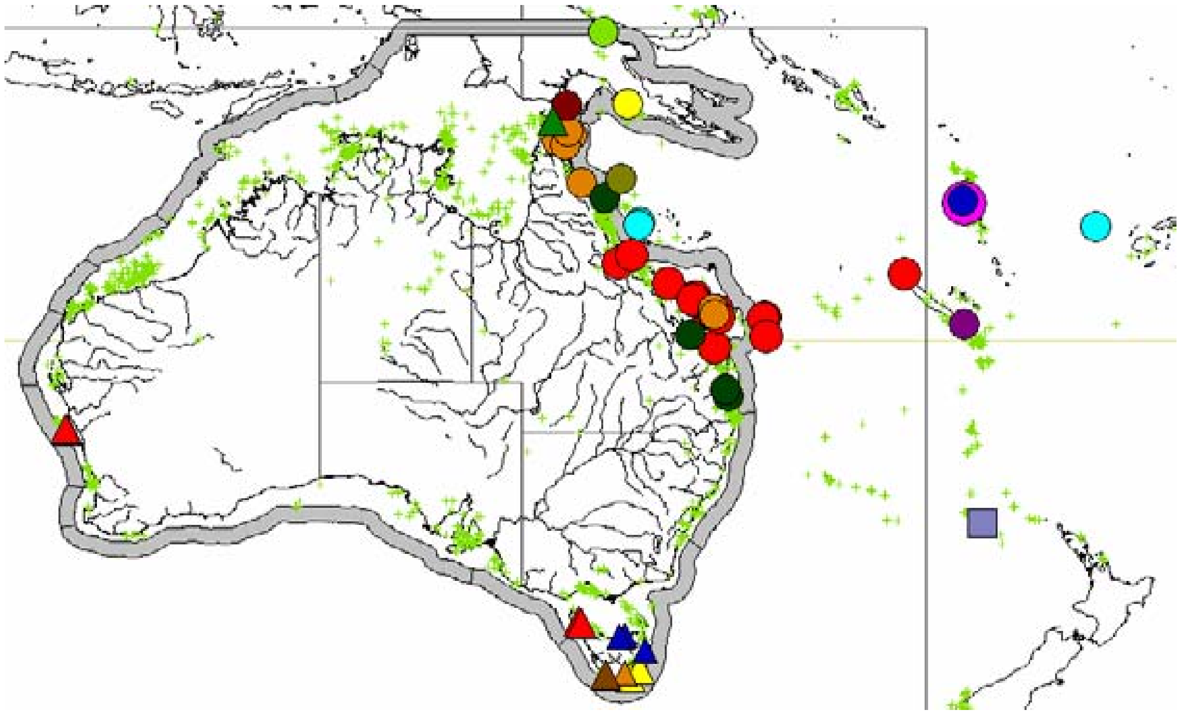
FIG. 89. *Biemna* (circles), *Sigmaxinella* (triangles), *Desmacella* (triangles), *Neofibularia* spp (squares) (QM Biolink database)

Family Podospongiidae de Laubenfels, 1936

20. Podospongiidae spp (Demospongiae: Poecilosclerida: Mycalina) (Fig. 90)

Bioregional trends: Exclusively or predominantly tropical (*Diacarnus*) and temperate sponges (*Sigmosceptrella*) show peaks in diversity at the far north GBR and Tasmania, respectively. Northern and southern GBR bioregions are clearly differentiated.

Summary details: Database records of *Diacarnus* (11 spp, 3 named), *Podospongia* (1 unnamed sp.) and *Sigmosceptrella* (6 spp, 2 named) show markedly different distributions. *Diacarnus* is exclusively tropical, distributed throughout the GBR and the Pacific island rim, with highest diversity in the far north GBR (6 spp). There is clear differentiation of the northern and southern GBR bioregions. *Podospongia* is exclusively deep water, and *Sigmosceptrella* is temperate, with the exception of a single record of an undescribed species from Cape York, and has a peak in diversity in Tasmania (TasP: 5 spp).



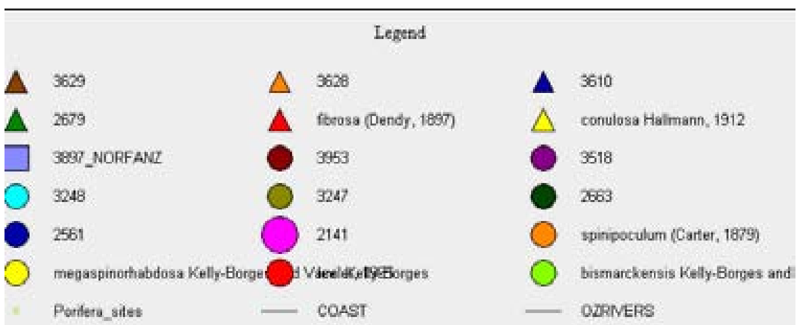


FIG. 90. *Diacarnus* (circles), *Podospongia* (squares) and *Sigmosceptrella* spp (triangles) (QM Biolink database)

Family Mycalidae Lundbeck, 1905

21. *Mycale (Arenochalina)*, *Mycale (Carmia)* and *Phlyctaenophora* spp (Demospongiae: Poecilosclerida: Mycalina: Mycalidae) (Fig. 91)

Bioregional trends: Equal diversity in temperate as in tropical bioregions; no clear delineation between north-south GBR bioregions in terms of species composition; several species characterise particular bioregions.

Summary details: *Mycale (Arenochalina)* (13 spp, 2 named), *M. (Carmia)* (15 spp, 4 named) and *Phlyctaenophora (Barbozia)* (2 spp, 1 named) are distributed equally in tropical and temperate Australia, although database records are presently depauperate for the south west coast. Species with only single records are not differentiated on maps presented here. Only one species (*M. (Arenochalina) mirabilis*) has a widespread tropical and temperate distribution, from the southern Gulf (GulfP) throughout eastern Australia to Cape York (NEB), with a single record from the north west coast (NWP). No clear differentiation between north and south GBR bioregions is indicated, although GBR bioregions have marginally higher diversity. Other species appear to be more restricted to one or few bioregions:

-GBR (NEB-CEB: 10 spp): *M. (C.) tylostrongyla*, *M. (Carmia)* sp. #1822

-central south east coast (CEP: 6 spp): *M. (C.) spongiosa*

-south east and south coasts (CEP-GulfP): *M. (A.) flammula*, *M. (Carmia)* sp. #842
-Bass Strait and Tasmania (BassP-TasP: 5 spp): M. (Carmia) sp. #3651
-southern Gulf and western Bass Strait (GulfP-WBassB: 4 spp): *M. (A.)* sp. #829
-north coast (NP-NWB: 3 spp): *M. (C.)* sp. #239
-north west coast (NWP: 2 spp)
-south west coast (SWB: 3 spp): *M. (C.) fistulata, M. (C.) sulcata*

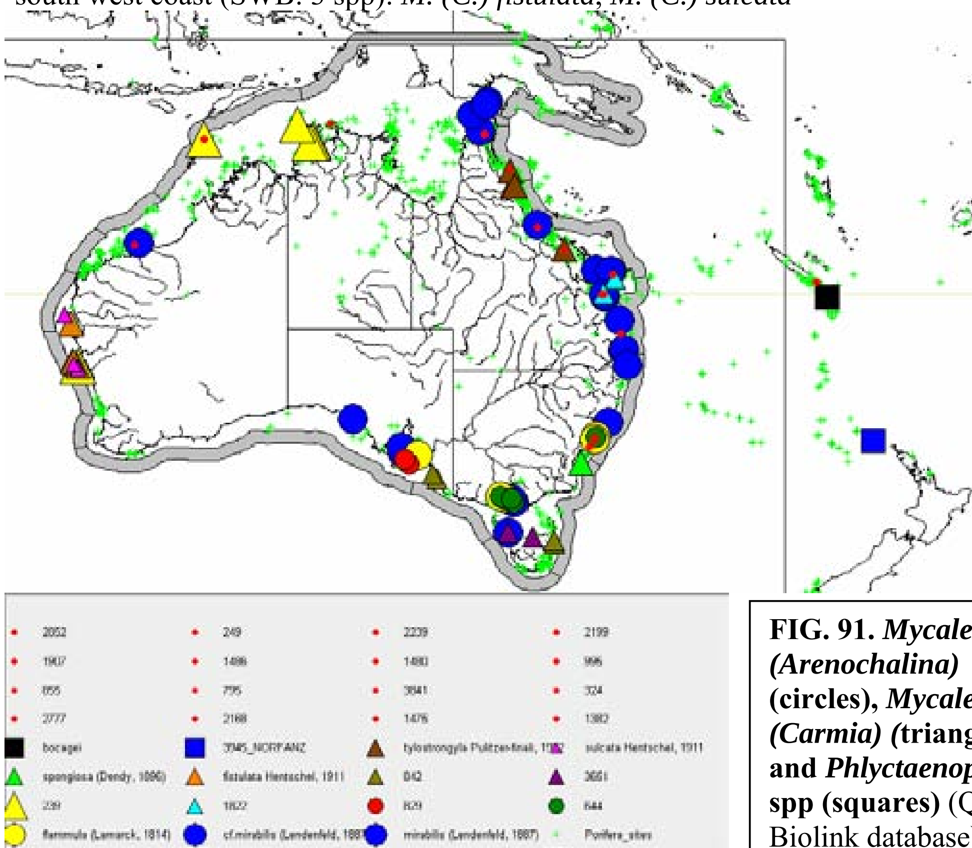


FIG. 91. ***Mycale (Arenochalina)*** **(circles),** ***Mycale (Carmia) (*****triangles) and** ***Phlyctaenophora*** **spp (squares)** (QM Biolink database)

***Mycale (Acamasina)*, *Mycale (Aegogropila), Mycale (Mycale)* and *Mycale (Oxymycale)* spp (Demospongiae: Poecilosclerida: Mycalina: Mycalidae) (Fig. 92)**

Bioregional trends: Highest diversity in tropics; substantially different species compositions differentiate south and north GBR bioregions, east and west coast faunas, and tropical and temperate bioregions.

Summary details: Together these subgenera contain a highly diverse assemblage of species, some of which are also abundant at some site (e.g. Northwest Cape to the Port Hedland region on the mid north west coast, NWP, has exceptionally high biomass of *Mycale* spp; CSIRO Marine Research survey data). Database records of *M. (Acamasina)* contains 1 unnamed sp.; *M. (Aegogropila)* with 18 spp, 2 named; *M. (Mycale)* with 19 spp, 4 named; and *M. (Oxymycale)* with 5 unnamed spp. Species with only single records are not differentiated on maps presented here. Records contain predominantly tropical species, with peaks of diversity occurring in the southern portion of the north west coast (CWB, NWP: 10 spp), Darwin region (western part of NP: 9 spp), far northern GBR (NEB: 9 spp), central and southern GBR (NEP, CEB: 9 spp), and fewer species in the central south east coast (CEP: 6 spp), and Bass Straight and Tasmanian bioregions (BassP, TasP: 6 spp). Northern and southern bioregions of the GBR are clearly differentiated based on species composition. One species (*M. (M.)* spp #80) is widely distributed across tropical Australia, from the southern GBR (CEB) to north west coastal (NWP); one spans the west and north coasts, from the south west coast to Cape York (SWB – NP: *M. (M.) pectinicola*); and two span the north west coast to the Gulf of Carpentaria (NWP-NP: *M. (M.) ridleyi, M. (Aegogropila)* sp. #358). Other species are more restricted to one or few bioregions:

-north GBR (NEB): *M. (Aegogropila)* spp #1217, #251, *M. (M.) horrida*
-south GBR (NEP, CEB): *M. (M.)* spp #1117, *M. (Aegogropila) parishii*
-north coast (NP): *M. (M.)* spp #250, #251
-north west coast (CWB, NWP): *M. (Aegogropila)* spp #396, #763, *M. (Acamasina)* sp. #710
-central south east coast (CEP): *M. (Aegogropila) ancorina, M. (A.)* spp #1482, #3572, *M. (M.) cylindrica*
-Bass Straight and Tasmanian bioregions (BassP, TasP): *M. (Aegogropila)* sp. # 3299, *M. (M.)* spp #889, #909
-southern Gulf (GulfP): M. (M.) sp. #822

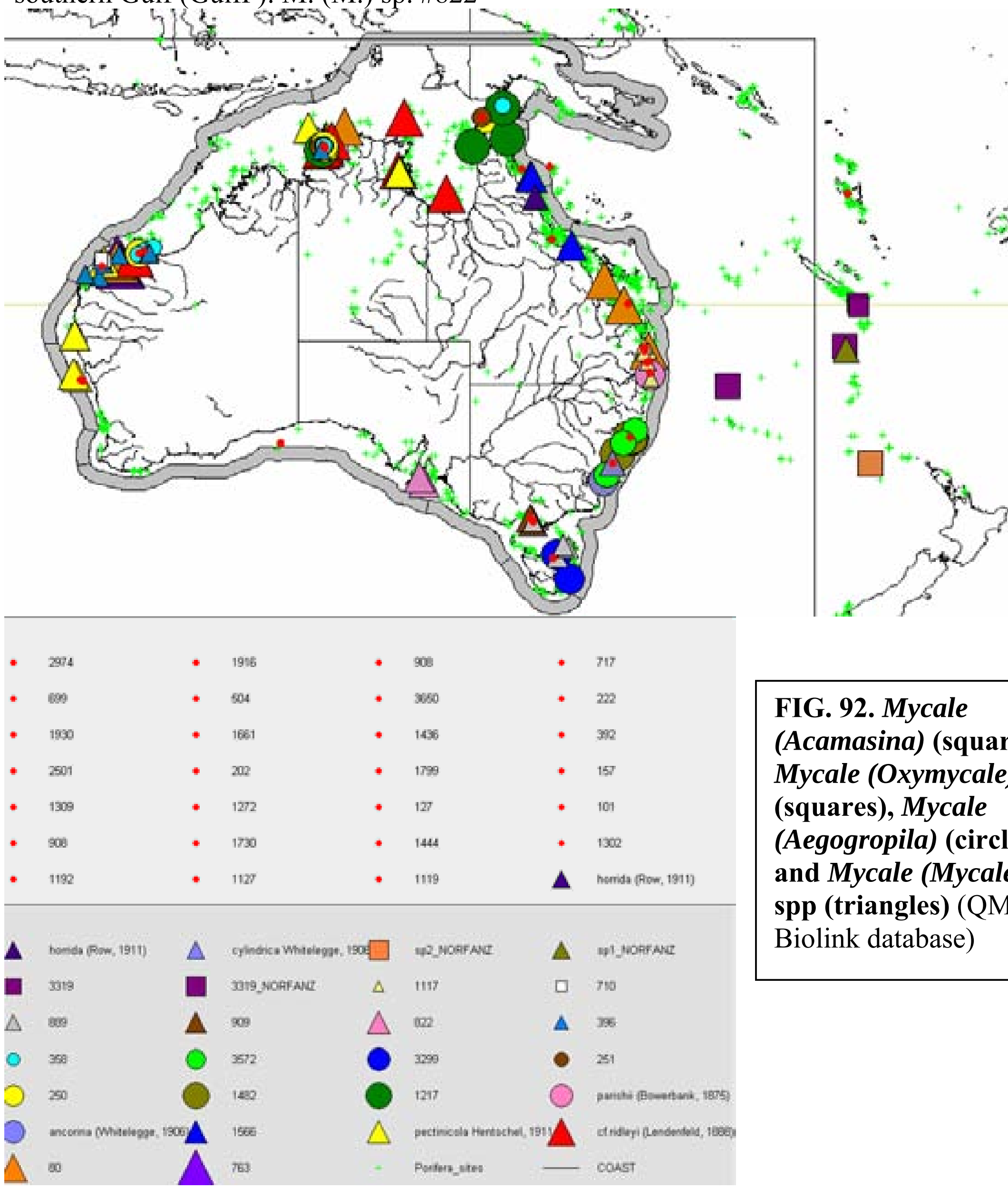


FIG. 92. *Mycale (Acamasina)* (squares), *Mycale (Oxymycale)* (squares), *Mycale (Aegogropila)* (circles) and *Mycale (Mycale)* spp (triangles) (QM Biolink database)

Suborder Myxillina Hajdu, Van Soest & Hooper, 1994
Family Chondropsidae Carter, 1886

22. *Psammoclemma* spp (Demospongiae: Poecilosclerida: Myxillina: Chondropsiidae) (Fig. 93)

Bioregional trends: The genus provides good corroboration of north east, south east and southern bioregions; genus predominantly eastern Australian in distribution; north and south

GBR bioregions differentiated; peaks of diversity in one tropical bioregion (southern GBR) and one temperate fauna (Tasmania – Bass Strait).

Summary details: Records of *Psammoclemma* are highly diverse, consisting of 59 spp (only 2 so far named), with two peaks in diversity: one tropical (southern GBR (NEP), with 20 spp), and one temperate (Tasmania-Bass Strait (BassP, TasP), with 19 spp). Species with only single records are not differentiated on maps presented here.

East and south east coastal faunas are far more diverse than northern and western coastal faunas. There is a distinct boundary between GBR and southern faunas, with an overlap zone in south east Queensland, and only a few species overlap in their distributions between tropical and temperate faunas. North and south GBR bioregions are clearly differentiated in terms of species diversity and species composition, but mainly of rare species. One species (*Psammoclemma* sp. #271) occurs throughout the tropical east and temperate southeast coasts, from the southern Gulf (GulfP) to far north Queensland (NEB); one (*Psammoclemma densum*) occurs extensively throughout temperate and subtropical waters (southern NWP – southern NEP); one (*Psammoclemma* sp. #59) highly disjunct tropical – warm temperate from SWB, NP to Norfolk Ridge; five (*Psammoclemma* spp #391, #2980, #1372, #1375, #2910) are widely distributed along the length of the GBR (NEB-CEB); and three (*Psammoclemma* spp #481, #827, #839) are widely distributed throughout the south east coast, from the Great Australian Bight (GABB) to central south east coast (CEB).

Several species exhibit distinct bioregional distributions:

-north GBR (NEB: 10 spp): *Psammoclemma chaliniformis*

-central and south GBR (NEP: 20 spp): *Psammoclemma* sp. #2978, #2979

-south east Queensland (CEB: 9 spp): *Psammoclemma* sp. #1801

-wider south east coast (CEP-SEB): *Psammoclemma* sp. #1240

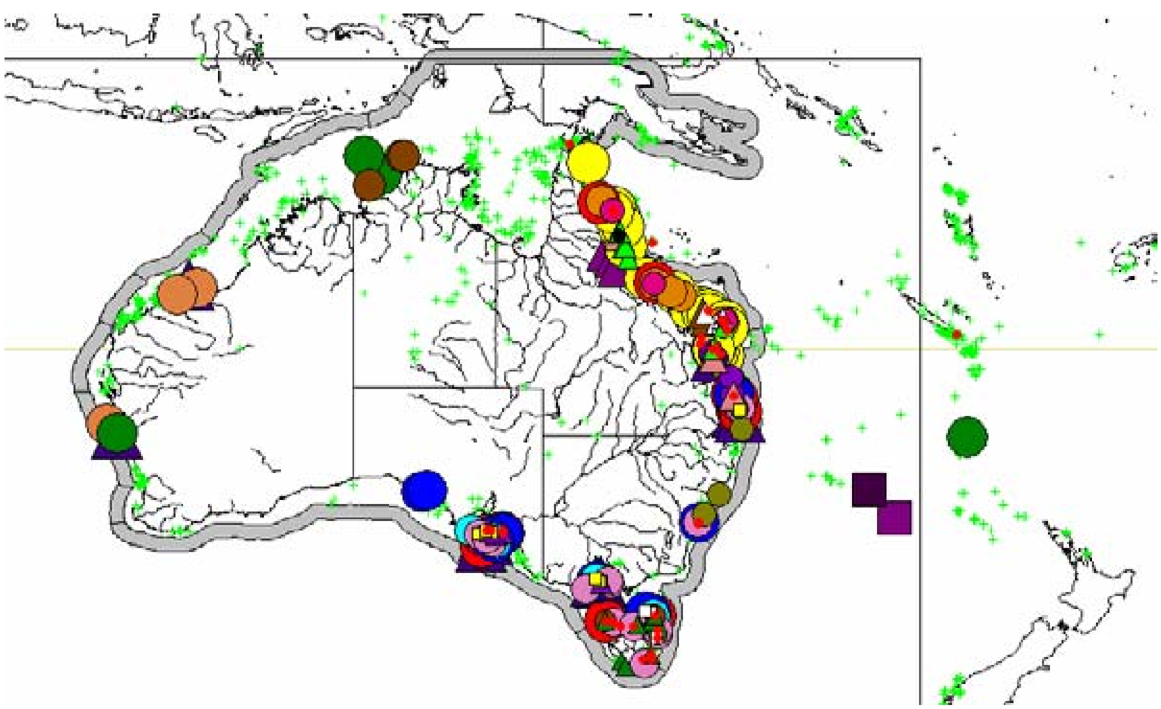
-central south east coast (CEP: 5 spp): *Psammoclemma* sp. #1183

-Bass Strait and Tasmania (BassP-TasP: 19 spp): *Psammoclemma* spp #900, #1304, #3427

-southern Gulf (GulfP: 11 spp): *Psammoclemma* sp. #485

-central south west coast (NWP-SWB): *Psammoclemma* sp. #248

-north coast (NP): *Psammoclemma* sp. #84



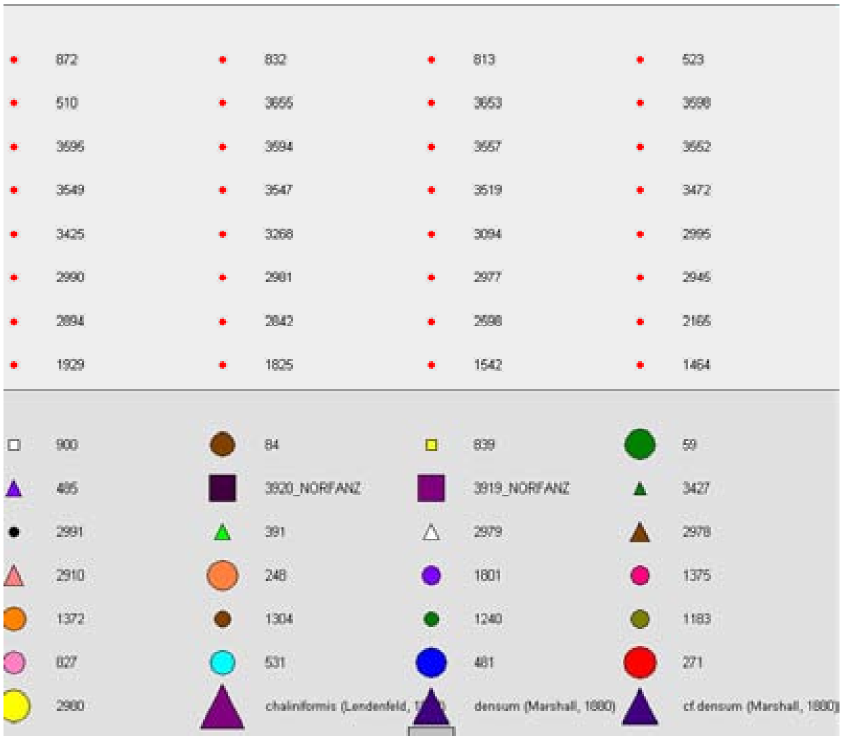


FIG. 93. *Psammoclemma* spp (QM Biolink database)

Phoriospongia, _Chondropsis_ and _Batzella_ spp (Demospongiae: Poecilosclerida: Myxillina: Chondropsiidae) (Fig. 94)

Bioregional trends: Predominantly eastern Australian, *Phoriospongia* and *Batzella* tropical and temperate, *Chondropsis* with exclusively temperate distributions; peaks in diversity on the southern GBR, central south east coast and Tasmania-Bass Strait; north and south GBR bioregions clearly differentiated.

Summary details: *Phoriospongia* (29 spp, only 1 named so far), *Chondropsis* (12 unnamed spp) and *Batzella* spp (9 unnamed spp). Species with only single records are not differentiated on maps presented here. Predominantly eastern Australian distribution, in tropical and temperate waters. *Phoriospongia* and *Batzella*, and *Chondropsis* with markedly different distributions, with the latter confined to Bass Strait – Tasmanian region. Peaks in diversity on the southern GBR (NEP: 12 spp), central south east coast (CEP: 9 spp), and Tasmania – Bass Strait (TasP, BassP: 12 spp) with little overlap in species composition. North and south GBR bioregions clearly differentiated in species diversity and species composition. One widely distributed species (*Phoriospongia* sp. #293) in tropical waters, extending into the central south east coast.
-north GBR (NEB): *Phoriospongia* spp #1298, #3093
-south GBR (NEP): *Phoriospongia* spp #1827, #1831, #1838, #2160,
-south east Queensland (CEB): *Phoriospongia* sp. #1080
-central south east coast (CEP): *Phoriospongia* spp #1456, #1462, #1483
-Tasmania and Bass Strait (BassP, TasP): *Chondropsis* spp #3447, #3553

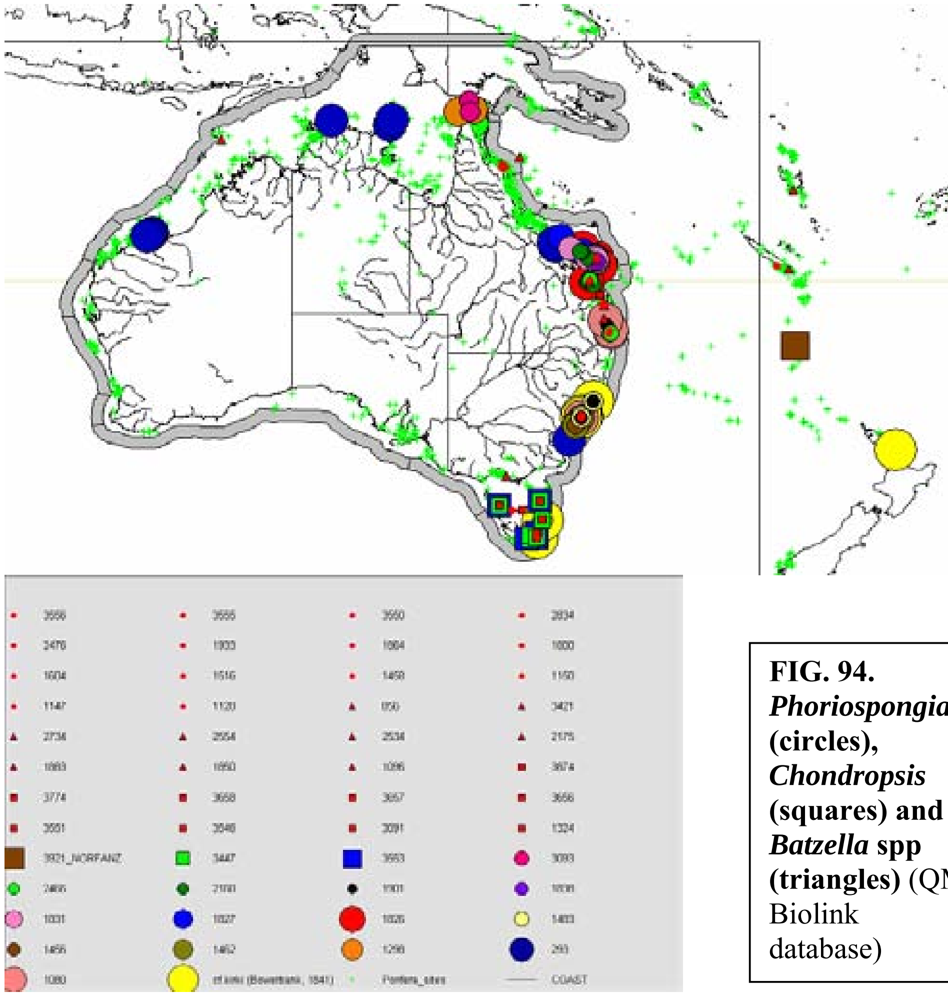


FIG. 94. *Phoriospongia* (circles), *Chondropsis* (squares) and *Batzella* spp (triangles) (QM Biolink database)

***Strongylacidon* and *Psammoclemma* + algal complex spp (Demospongiae: Poecilosclerida: Myxillina: Chondropsiidae) (Fig. 95)**

Bioregional trends: Confined to eastern Australian region; north and south GBR differentiated in terms of species diversity; highest diversity in southern GBR; little overlap in species between bioregions.

Summary details: *Strongylacidon* (16 spp, 3 named) and a peculiar *Psammoclemma* + macroalgal complex (with a single unnamed sp.) neither diverse nor abundant, confined to the eastern Australian fauna, but with temperate and tropical distributions. Peak in diversity in the southern GBR (NEP: 6 app). Only one species (*S. stelliderma*) distributed across more than one bioregion, but confined to southern waters (GulfP – TasP). Several species characteristic of particular bioregions:

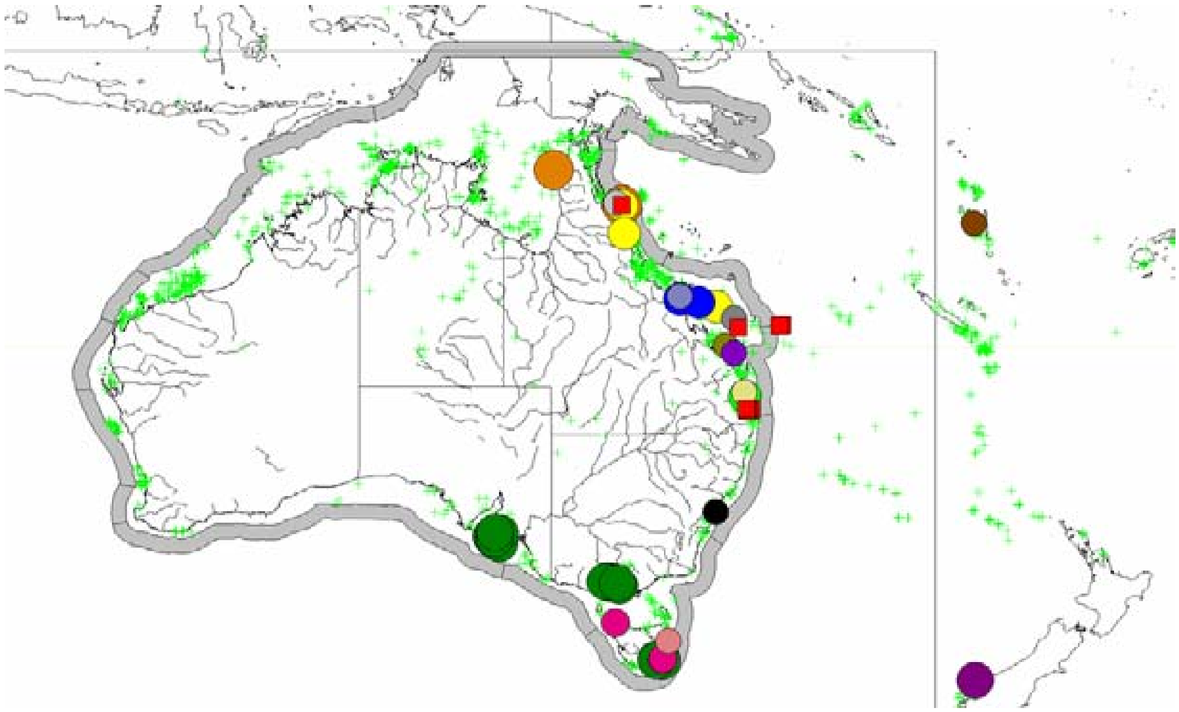
-north GBR (NEB): *S. inaequalis*, *Strongylacidon* sp. #1619

-south GBR (NEP): *Strongylacidon* spp #2181, #2588, #2796, #2840

-south east Queensland (CEB): *Strongylacidon* sp. #1398, #2900

-central south east coast (CEP): *Strongylacidon* sp. #1484

-Tasmania (TasP): *Strongylacidon* sp. #904, #3443



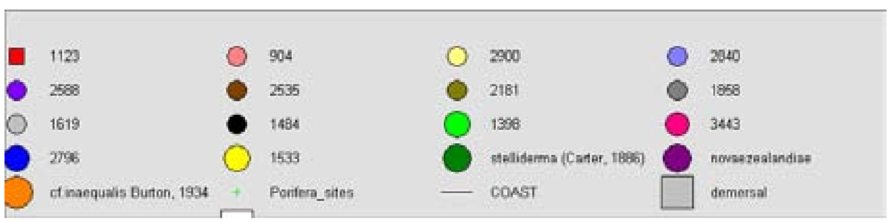


FIG. 95. *Strongylacidon* (circles), and *Psammoclemma* + algal complex spp (squares) (QM Biolink database)

Family Coelosphaeridae Dendy, 1922

23. *Coelosphaera, Histodermella* and *Inflatella* spp (Demospongiae: Poecilosclerida: Myxillina: Coelosphaeridae) (Fig. 96)

Bioregional trends: Highest diversity in the Gulf of Carpentaria (NP); north and south GBR bioregions differentiated.

Summary details: *Coelosphaera* (9 unnamed spp), *Histodermella* (2 unnamed spp) and *Inflatella* (3 unnamed spp) have only a single widely distributed species (*Coelosphaera* #1299) across the north coast (NWP – NP), and one species (*Coelosphaera* sp. #469) with disjunct tropical distribution on west and east coasts (NWP, NEP). Highest diversity is in the Gulf of Carpentaria (NP: 4 spp), reflecting the habitat preferences of *Coelosphaera* for soft substrates. North and south GBR bioregions differentiated. Few other patterns are evident, but several species are restricted to particular bioregions.

-north GBR (NEB): *Histodermella* sp. #3642

-south GBR (NEB): *Coelosphaera* sp. #1979

-Gulf of Carpentaria (NP): *Coelosphaera* spp #987, #1310, #1316

-Tasmania (TasP): *Coelosphaera* sp. #3677, Inflatella sp #879

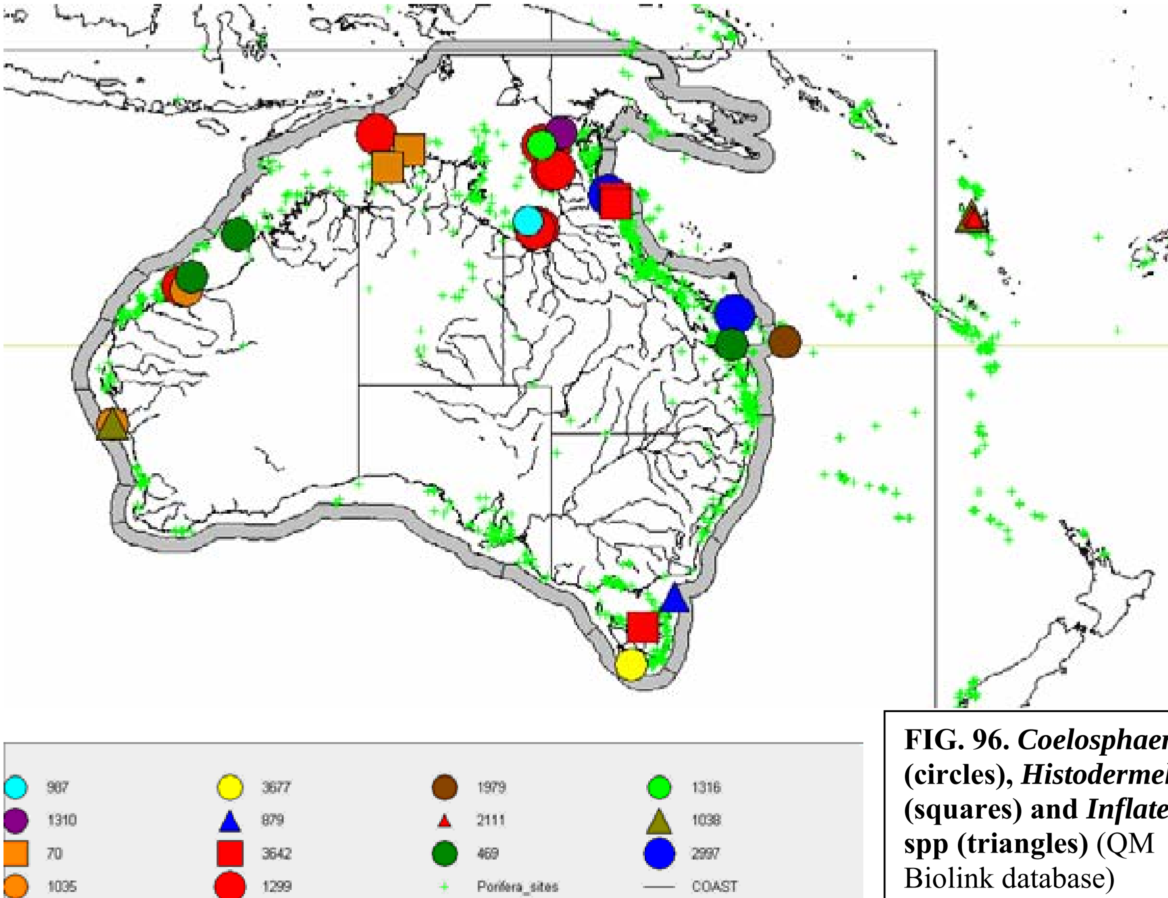


FIG. 96. *Coelosphaera* (circles), *Histodermella* (squares) and *Inflatella* spp (triangles) (QM Biolink database)

***Lissodendoryx* (*Acanthodoryx, Anomodoryx, Ectyodoryx, Lissodendoryx* and *Waldoschmidtia*) spp (Demospongiae: Poecilosclerida: Myxillina: Coelosphaeridae) (Fig. 97)**

Bioregional trends: Temperate and tropical peaks in diversity, but only one species considered significant component of the benthos on GBR, and two for southern temperate waters of south and south west coasts; poor differentiation of GBR bioregions.

Summary details: *Lissodendoryx* has five subgenera, with database records consisting of *Acanthodoryx* (3 spp, 1 named), *Anomodoryx* (2 spp, 1 named), *Ectyodoryx* (10 spp, 1 named), *Lissodendoryx* (15 spp, 4 named) and *Waldoschmidtia* (2 spp, 1 named). Species with only single records are not differentiated on maps presented here. Peaks in diversity occur at the far north GBR (NEB: 5 spp) and Tasmania-Bass Strait (5 spp), with no species overlapping into adjacent bioregions, but species diversity is relatively low for the genus and only one species (*L. (Ectyodoryx)* sp. #1001) could be considered a significant component of the benthos on coral reefs of the GBR. Two other species (*L. (Ectyodoryx) maculatus, L. (Lissodendoryx)* sp. #489) extend across temperate and subtropical waters from the south to mid west coasts (GulfP – CWB). Northern and southern bioregions of the GBR are poorly differentiated. Few species characterise particular bioregions:
-entire GBR (NEB-CEB): *L. (Ectyodoryx)* sp. #1001
-north GBR (NEB): *L. (Ectyodoryx) aspera, L. (Acanthodoryx) fibrosa*
-central south east coast (CEP): *L. (Waldoschmidtia)* sp. #1926
-Bass Strait-Tasmania (TasP, BassP, WBassB): *L. (Anomodoryx) dendyi, L. (Lissodendoryx) isodictyalis, L. (L.)* sp. #841, #849
-south west coast (SWB): *L. (Anomodoryx)* sp. #1039
-north coast (western NP): *L. (Lissodendoryx) timorensis*, *L. (L.)* sp. #50

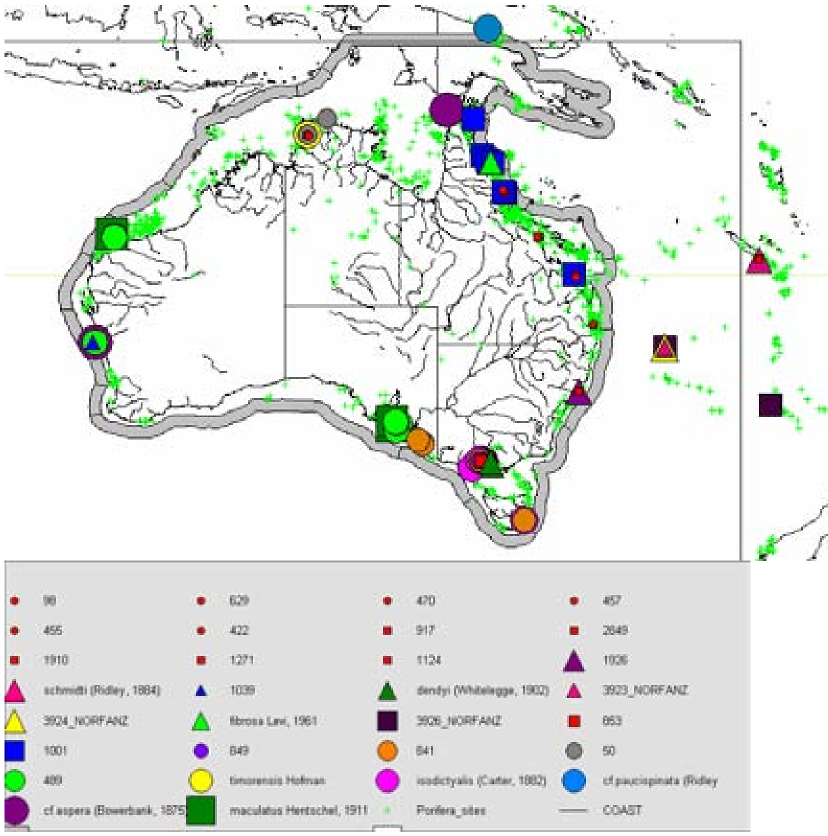


FIG. 97. ***Lissodendoryx*** **(*Acanthodoryx*** **(triangles),** ***Anomodoryx*** **(triangles),** ***Ectyodoryx*** **(squares),** ***Lissodendoryx*** **(circles) and** ***Waldoschmidtia*** **spp (triangles)** (QM Biolink database)

Family Tedaniidae Ridley & Dendy, 1886

24. Tedaniidae (*Tedania, Hemitedania*), Crambeidae (*Monanchora*) and Dendoricellidae (*Dendoricella, Fibulia, Pyloderma*) spp (Demospongiae: Poecilosclerida: Myxillina) (Fig. 98)

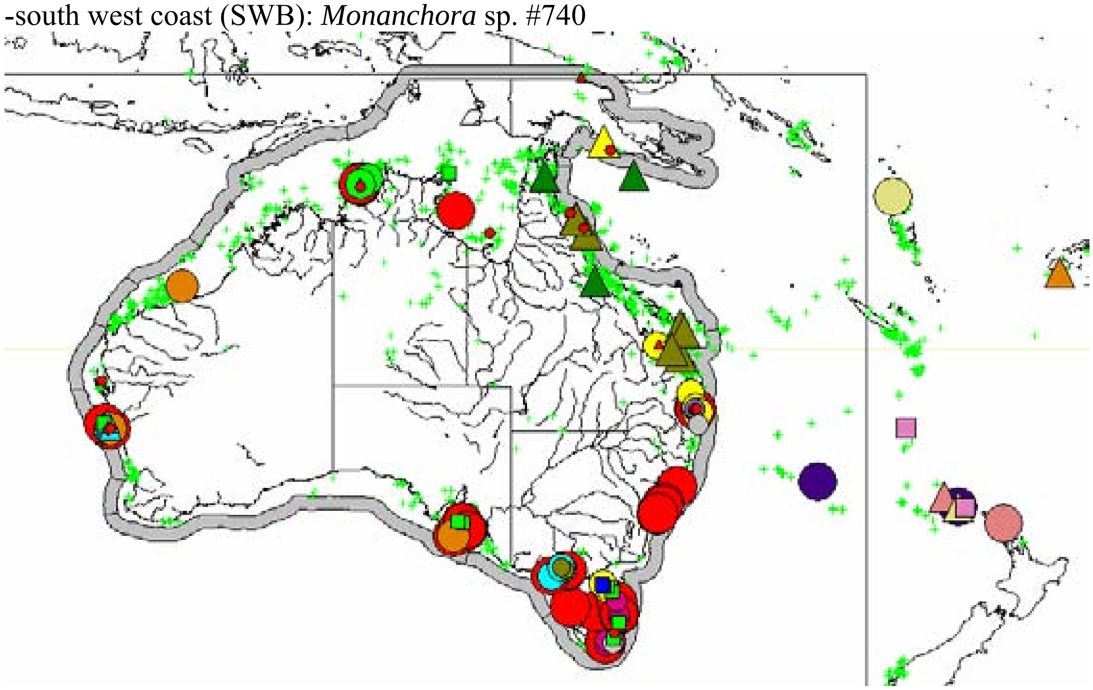
Bioregional trends: Predominantly temperate (*Tedaniai Fibulia*) or tropical (*Monanchora*) spp showing markedly different distributions; only few species abundant; peaks in diversity in southern (Bass Strait, Tasmania, south west coast) and central east coast bioregions; northern and southern bioregions of GBR undifferentiated.

Summary details: Tedaniidae (*Tedania (Tedania)* (21 spp, 3 named), *Tedania (Tedaniopsis)* (1 unnamed sp.), *Hemitedania* (1 named sp.)), Crambeidae (*Monanchora* (12 spp, 2 named) and Dendoricellidae (*Dendoricella* (1 unnamed sp.), *Fibulia* (2 unnamed spp), *Pyloderma* (1 unnamed sp.)) are diverse but only few species are ever abundant in any particular locality. Species with only single records are not differentiated on maps presented here. *Tedania* and *Fibulia* spp are predominantly temperate, where they can be significant components of the benthos. One species (*T. anhelans*, formerly known as *T. digitata*) is distributed throughout the south east and south coasts, extending from GulfP to CEB, with isolated records from SWB and NP. It is a highly toxic species (referred to as the 'fire sponge') and suspected to be transported by human activities (bilge water, ship fouling etc.) (CSIRO CRIMP database). By comparison, *Monanchora* is predominantly tropical, with three species occurring along the GBR into southern PNG (CEB-NEB), and one unique to the south west coast (SWB). Peaks in diversity occur in the Tasmania – Bass Strait (7 spp), GBR (7 spp), south east Queensland (7 spp), and south west coast bioregions (6 spp). Several species are distributed across adjacent bioregions (e.g. *T. (Tedania)* sp. #246 and *Fibulia* sp. #837 across the south and mid west coasts: from TasP-NWP; *T. (Tedania)* sp. #462 across the south and mid east coasts: SEB-NEP), whereas most species appear to be restricted to particular bioregions:

-entire GBR (CEB-NEB): *T. (Tedania)* sp. #433, *Monanchora* spp #994, #1541

-north coast (NP): *T. (Tedania)* sp. #27

-Tasmania and Bass Strait (BassP, TasP): *T. (Tedania)* sp. #848, #899, *Fibulia* sp. #893
-south west coast (SWB): *Monanchora* sp. #740



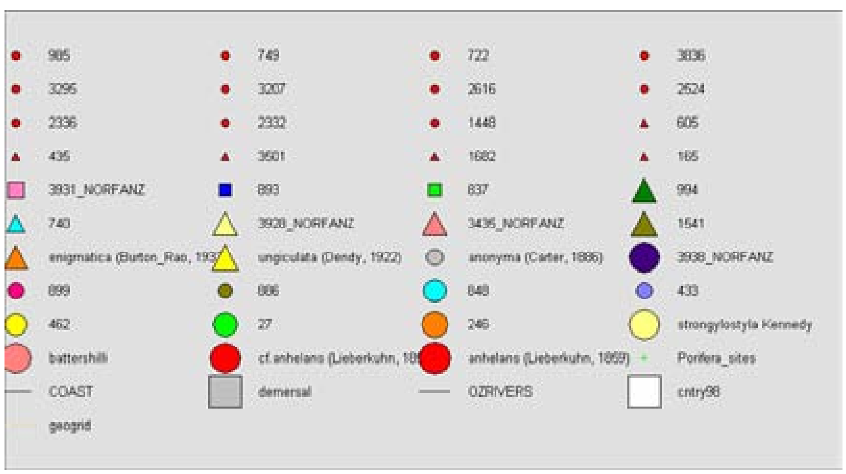


FIG. 98. *Tedania, Tedaniopsis, Hemitedania* (circles), *Monanchora* (triangles), *Dendoricella*, *Fibulia* and *Pyloderma* spp (squares) (QM Biolink database)

Family Crellidae Dendy, 1922
Family Phellodermidae Van Soest & Hajdu, 2002

25. Crellidae (*Crella*) and Phellodermiidae (*Echinostylinos*) spp (Demospongiae: Poecilosclerida: Myxillina) (Fig. 99)

Bioregional trends: One widespread species in temperate and tropical waters, and one common in temperate south east waters; highest diversity in northern GBR and differentiated from southern GBR; diversity higher on east than west coast.

Summary details: *Crella* (with subgenera *Crella, Grayella, Yvesia*) has database records for 18 spp (4 named), and *Echinostylinos* with 5 unnamed spp for the Australian fauna. Species with only single records are not differentiated on maps presented here. Two species (*C. incrustans*, *C. spinulata*) are common components of the temperate and tropical faunas, respectively, comprising significant components of the benthos in some localities (e.g. Darwin region, NP). The former species is restricted to the south east Australian coast (GulfP-CEB) whereas the latter has a nearly circum-continental distribution. The highest diversity occurs in the northern GBR (8 spp), with one widespread GBR species (*C. (Crella)* sp. #1525), and diversity is higher on the east than west coasts. *Echinostylinos*, by comparison, is relatively rare and confined mainly to deeper waters apart from a tropical shallow water species in NP. A few species are restricted to particular bioregions:

-north GBR (NEB): *C. (Crella) cyathophora*

-Darwin region (western NP): *Echinostylinos* sp. #1275

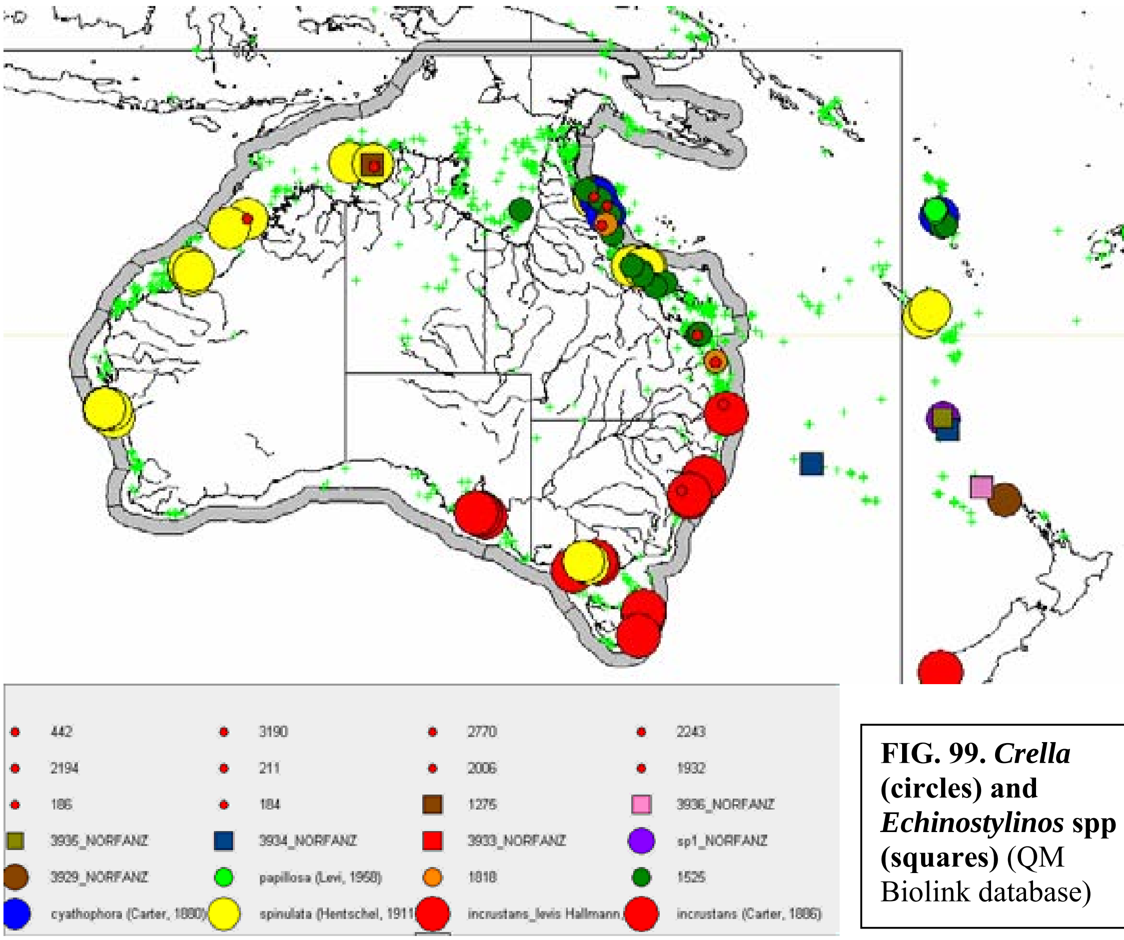


FIG. 99. *Crella* (circles) and *Echinostylinos* spp (squares) (QM Biolink database)

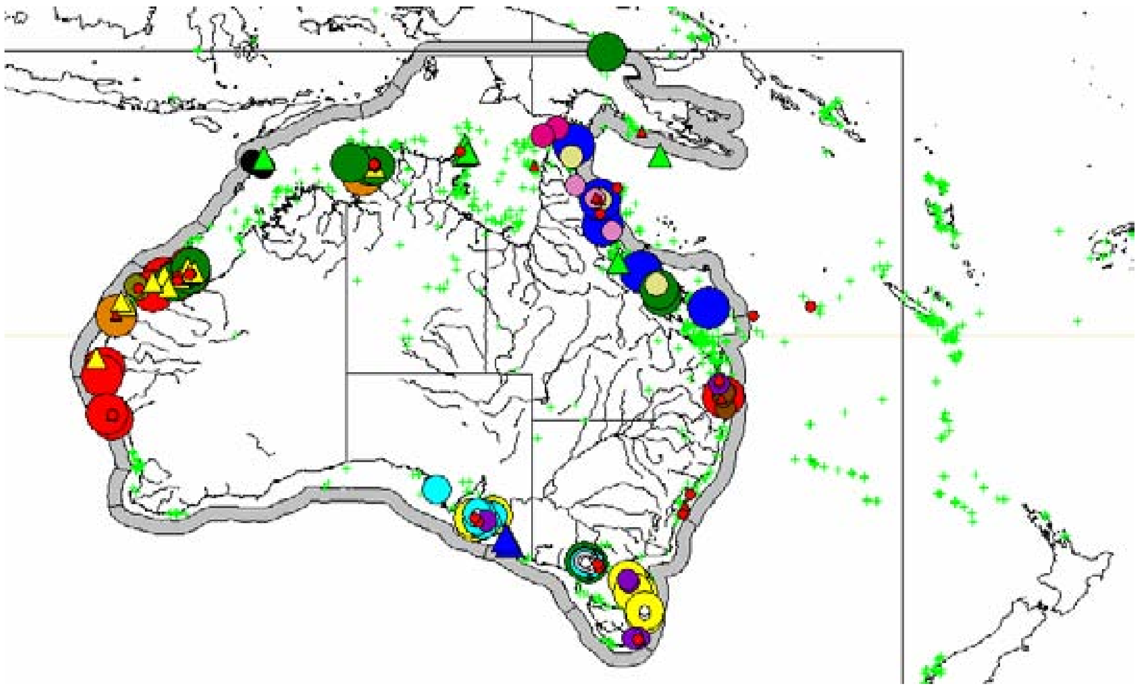
Family Desmacididae Schmidt, 1870

26. *Desmapsamma* and *Desmacidon* spp (Demospongiae: Poecilosclerida: Myxillina: Desmacididae) (Fig. 100)

Bioregional trends: Temperate and tropical species distributions both with peaks of high diversity; north and south GBR regions differentiated; north east, south east and central west coasts clearly differentiated by their species composition.

Summary details: *Desmapsamma* (34 spp, only 2 named) and *Desmacidon* (12 unnamed spp) contain a diverse assemblage of species with some species also abundant in particular localities (e.g. North West Shelf, NWP). Species with only single records are not differentiated on maps presented here. Both genera have tropical and temperate species. Peaks of diversity occur in the northern GBR (NEB: 10 spp), north coast (NP: 7 spp), Bass Strait – Tasmania (BassP-TasP: 10 spp), southern Gulf (GulfP: 7 spp), and north west coast (11 spp). Northern and southern bioregions of the GBR are moderately well differentiated by their species composition. Several species have wider distributions across several bioregions: *Desmapsamma* sp. #241 and Desmacidon sp. #980 throughout tropical Australia (NWP-NEP); *D. psammodes* with a disjunct distribution on the tropic either side of the continent (SWB-NWP, and CEB); *Desmapsamma* sp. #1528 throughout the GBR (NEP-NEB); *Desmapsamma* sp. #502 in south east Australian region (GulfP-TasP); *Desmacidon* sp. #255 throughout the north west coast (NWP-western NP). Other species are restricted to one or few bioregions:

-north GBR (NEB): *Desmapsamma* spp #423, #3048
-south east Queensland (CEB): *Desmapsamma* sp. #1125
-Bass Strait and Tasmania (BassP, TasP, SEB): *Desmapsamma* sp. #617, #831
-southern Gulf (GulfP): *Desmacidon* sp. #840
-north west coast (southern part of NWP): *Desmapsamma* sp. #1746



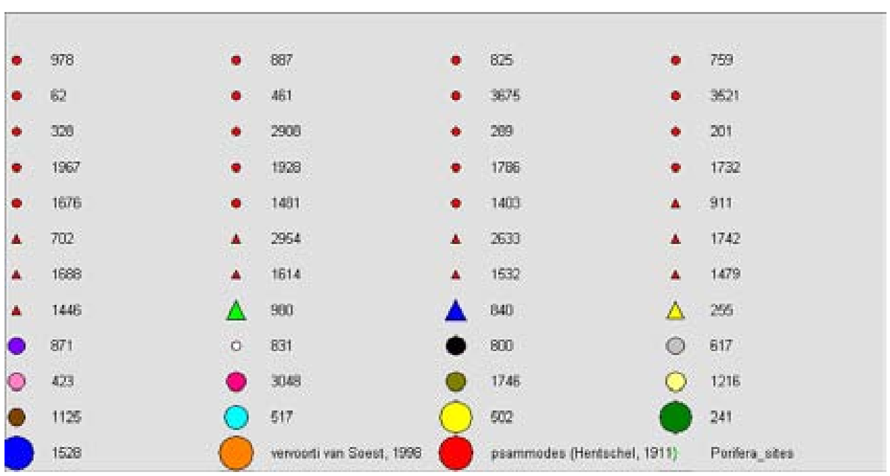


FIG. 100. *Desmapsamma* (circles) and *Desmacidon* spp (triangles) (QM Biolink database)

Family Hymedesmiidae Topsent, 1928

27. Hymedesmiidae spp (*Acanthancora, Hamigera, Hemimycale, Hymedesmia, Phorbas, Spanioplon*) (Demospongiae: Poecilosclerida: Myxillina) (Fig. 101)

Bioregional trends: Higher diversity in tropical east coast than other bioregions, with north and south GBR bioregions differentiated by their species composition.

Summary details: Hymedesmiidae is represented in database records by the following genera: *Acanthancora* (2 spp, 1 named), *Hamigera* (2 named spp), *Hemimycale* (4 unnamed spp), *Hymedesmia* (9 spp, 3 named), *Phorbas* (14 spp, 1 named) and *Spanioplon* (1 unnamed sp.). No species are exceptionally abundant or diverse, but peaks in diversity occur in the north GBR (NEB: 5 spp) and south GBR-south east Queensland (NEP-CEB: 6 spp), with both GBR bioregions differentiated by their species compositions. Diversity higher in tropics and on east coast than in temperate and west coast faunas. Two species show widespread tropical distributions: *Phorbas* sp. #1259 throughout tropical Australia (NWP-CEB); *Phorbas* sp. #1134 throughout the GBR (NEP-NEB). Other species were recorded from single bioregions:
-north GBR (NEB): *Phorbas* sp. #1539, *Hamigera strongylata*, *Spanioplon* sp. #2518
-south GBR (NEP-CEB): *Hymedesmia mertoni, H. grisea*
-central south east coast (CEP): *Hamigera dendyi*
-Bass Strait and Tasmania (BassP, TasP): *Acanthancora clavilobata, Acanthancora* sp. #3652
-north west coast (southern part of NWP): *Phorbas* sp. #713
-south west coast (SWB): *P. fictitioides*

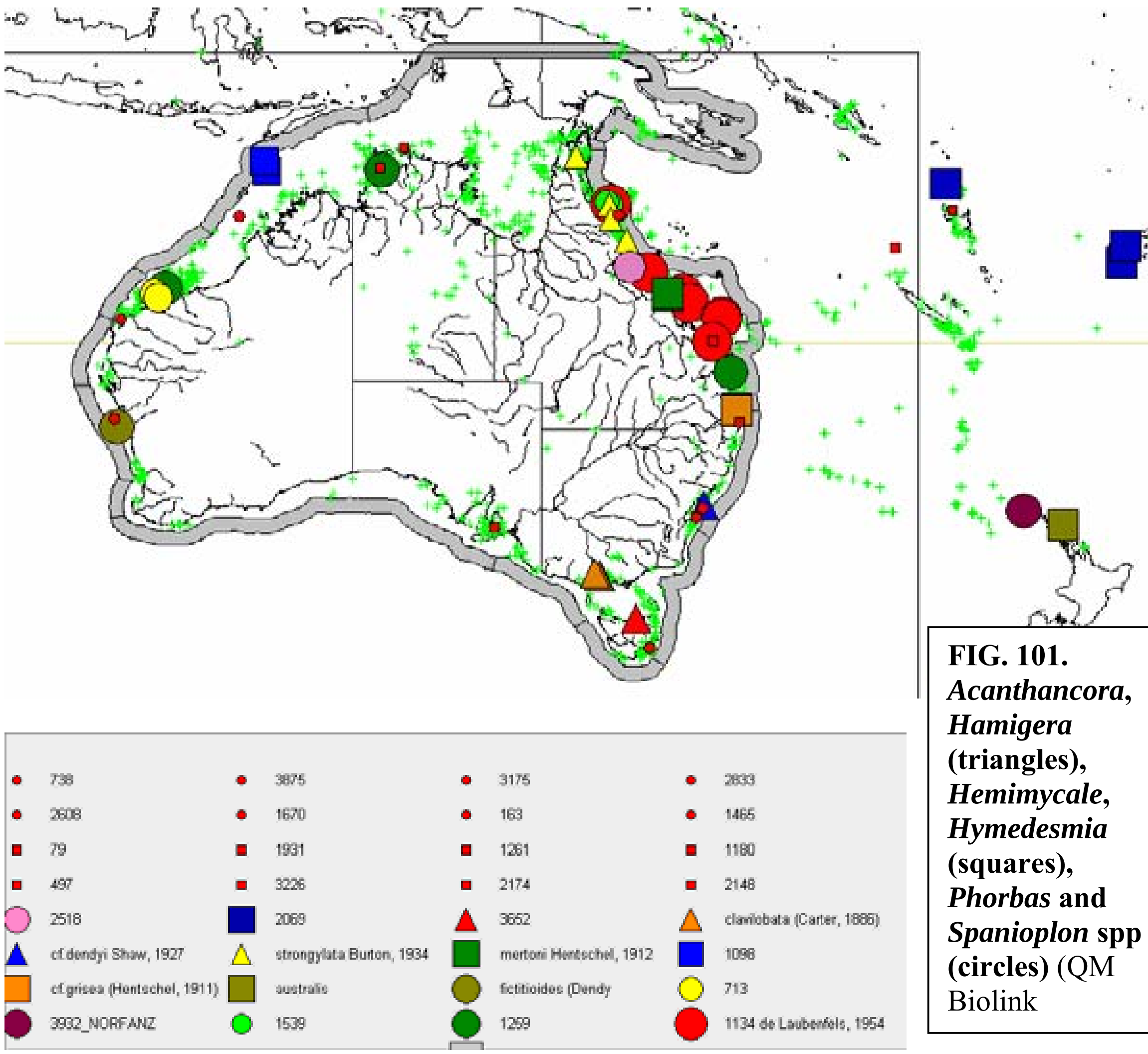


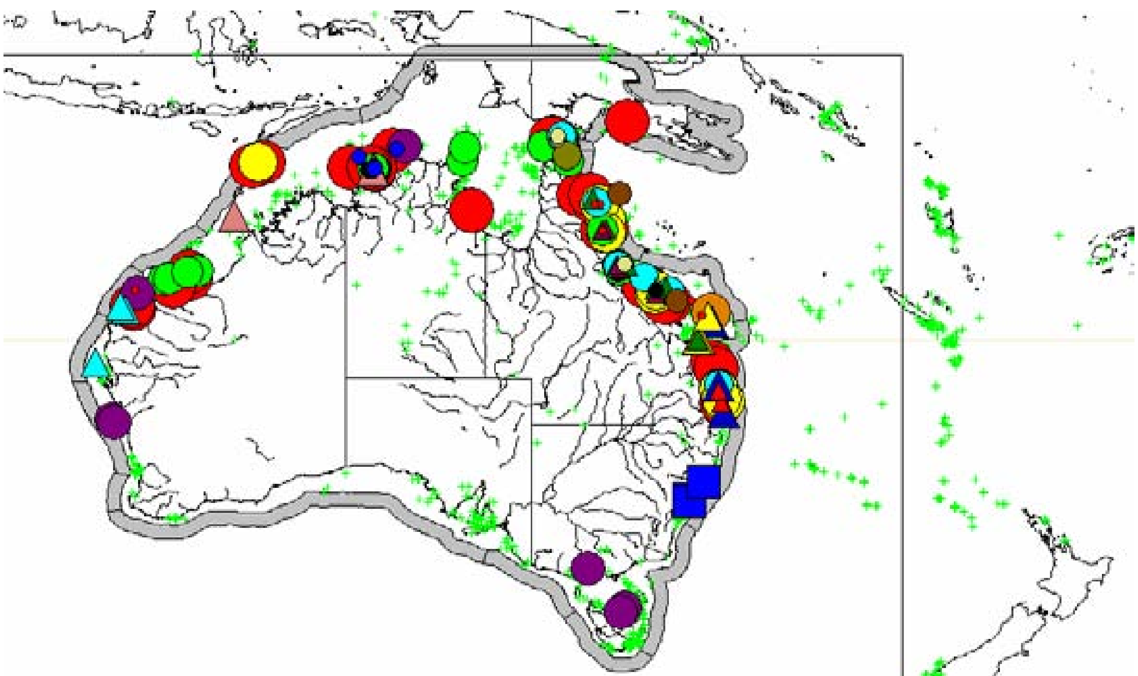
FIG. 101. *Acanthancora*, *Hamigera* (triangles), *Hemimycale*, *Hymedesmia* (squares), *Phorbas* and *Spanioplon* spp (circles) (QM Biolink

Family Iotrochotidae Dendy, 1922

28. Iotrochotidae *(Iotrochota, Iotrochotopsamma*) spp (Demospongiae: Poecilosclerida: Myxillina) (Fig. 102)

Bioregional trends: Predominantly tropical; several spp with wide tropical distributions, but GBR with higher diversity and different species composition than west and north coasts, and north and south GBR bioregions differentiated.

Summary details: *Iotrochota* (26 spp, 6 named) and *Iotrochotopsamma* (1 named sp.) are diverse, contain some abundant species in local populations, and predominantly tropical. Species are frequently epiphytic, bioeroding, chemically toxic, boring into or smothering coralline substrates. Peaks of diversity occur in the northern GBR (NEB: 12 spp), southern GBR (NEP: 15 spp), south east Queensland (CEB: 7 spp), Darwin region (western part of NP: 6 spp) and north west coast (NWP: 6 spp). There is one widely distributed species (*I. acerata*) occurring in both tropical and temperate bioregions (TasP, SWB, NWP, NP) that is possibly translocated by human activities (bilge water, ship hull fouling); two widely distributed, geographically sympatric, tropical species (*I. baculifera, I. coccinea*) extending from the north west coast (NWP) to south east Queensland (CEB); and one (*Iotrochota* sp. #377) occurring on soft substrates from the north west coast (NWP) to the northern GBR (NEB). Northern and southern GBR-south east Queensland bioregions are clearly differentiated on the basis of species diversity and species composition. Several species are markers for particular bioregions:
-entire GBR (NEB-CEB): *Iotrochota* spp #2193, #2386, #2818
-north GBR (NEB): *I. purpurea*, *Iotrochota* spp #2682, #2256
-south GBR (NEP): *I. foveolaria, Iotrochota* sp. #1844
-south east Queensland (CEB): *Iotrochota* spp #1828, #2330
-central south east coast (CEP): *Iotrochotopsamma arbuscula*
-Darwin region (western part of NP): *Iotrochota* spp #61, #161
-mid west coast (CWP): *Iotrochota* sp. #701



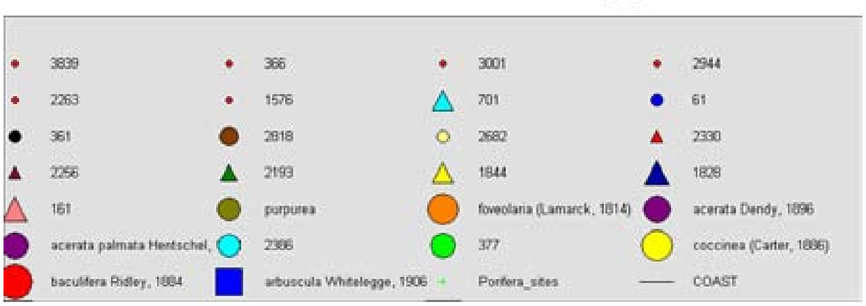


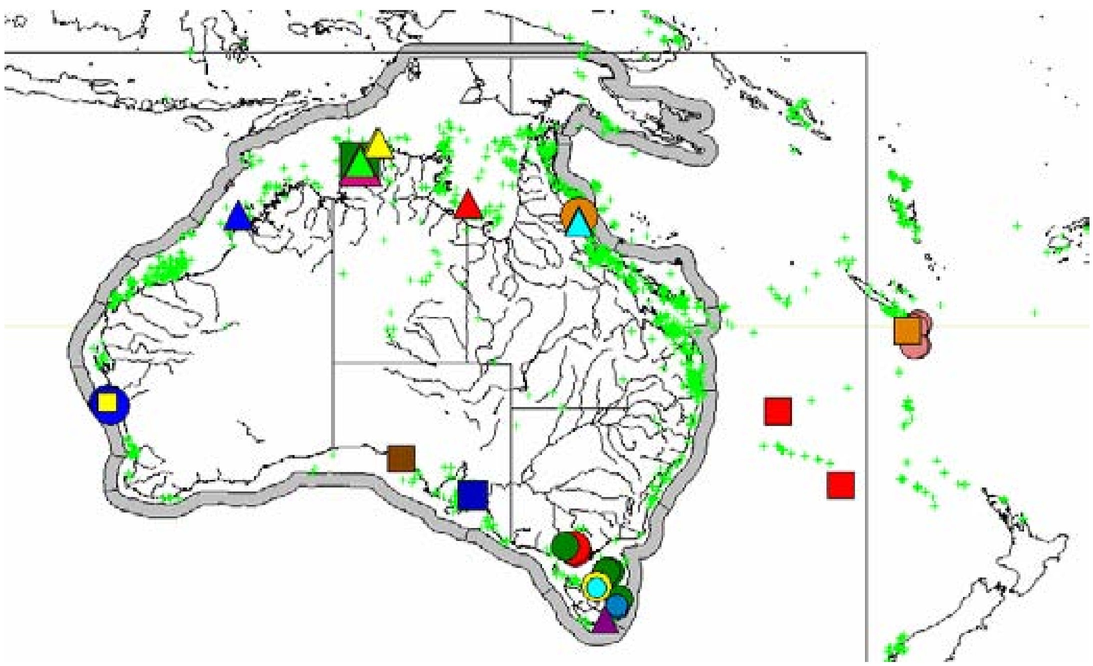
FIG. 102. *Iotrochota* (circles) and *Iotrochotopsamma* spp (squares) (QM Biolink database)

Family Myxillidae Dendy, 1922

29. Myxillidae (*Ectyonops, Forcepia, Myxilla, Psammochela, Stelodoryx*) spp (Demospongiae: Poecilosclerida: Myxillina) (Fig. 103)

Bioregional trends: Tropical and temperate genera, with temperate and tropical peaks in diversity (*Myxilla* predominantly tropical); species in GBR region poorly represented.

Summary details: Myxillidae is represented in collections by: *Ectyonops* (1 unnamed sp.), *Forcepia* (7 spp, 1 named), *Myxilla* (7 unnamed spp), *Psammochela* (4 unnamed spp) and *Stelodoryx* (2 spp, 1 named), which are neither diverse nor abundant in localities sampled to date, and genera show markedly different patterns in their distributions (*Myxilla* predominantly tropical, *Forcepia* and *Psammochela* predominantly temperate). Highest diversity occurs in the Bass Strait – Tasmania (BassP, TasP: 6 spp) and Darwin regions (western part of NP: 4 spp), with only two species recorded so far for the entire GBR. Only one species (*Forcepia (Forcepia)* sp. #851) spans more than a single bioregion (BassP-TasP), which also has a remarkable diversity (5 spp) of *Forcepia* spp. Several species are markers for some bioregions:
-north GBR (NEB): *F. (Forcepia)* sp. #424, *Myxilla (Ectyodoryx)* sp. #420
-Tasmania-Bass Strait (TasP-BassP): *F. (Forcepia) biceps*, *F. (Forcepia)* spp #851, #906, #3637, #3638, Myxilla (Burtonancora) sp. #3452



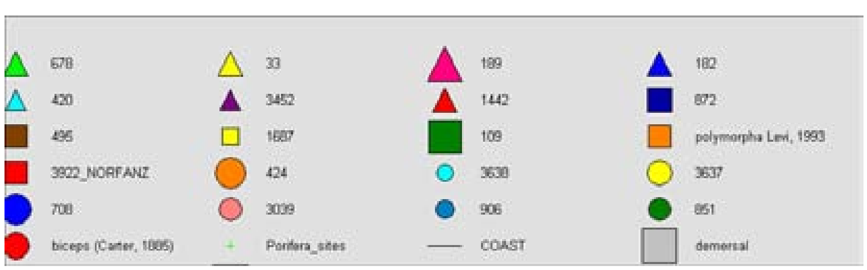


FIG. 103. *Ectyonops*, *Forcepia* (circles), *Myxilla* (triangles), *Psammochela* and *Stelodoryx* spp (squares) (QM

Suborder Latrunculina Kelly & Samaai, 2002
Family Latrunculiidae Topsent, 1922

30. *Latrunculia* spp (Demospongiae: Poecilosclerida: Latrunculina: Latrunculidae) (Fig. 104)

Bioregional trends: Low diversity, low abundance, but species show distinct bioregionalisation with no overlap in distributions.

Summary details: Six species, two named, showing distinct regional distributions:
-north GBR (NEB): *Latrunculia* spp #2390, #2691
-southeast coast (CEB-SEB): *Latrunculia brevis*
-Bass Strait: *Latrunculia conulosa*
-south west coast (SWB): *Latrunculia* sp. #1686
-north west shelf (NWP): *Latrunculia* spp #1048

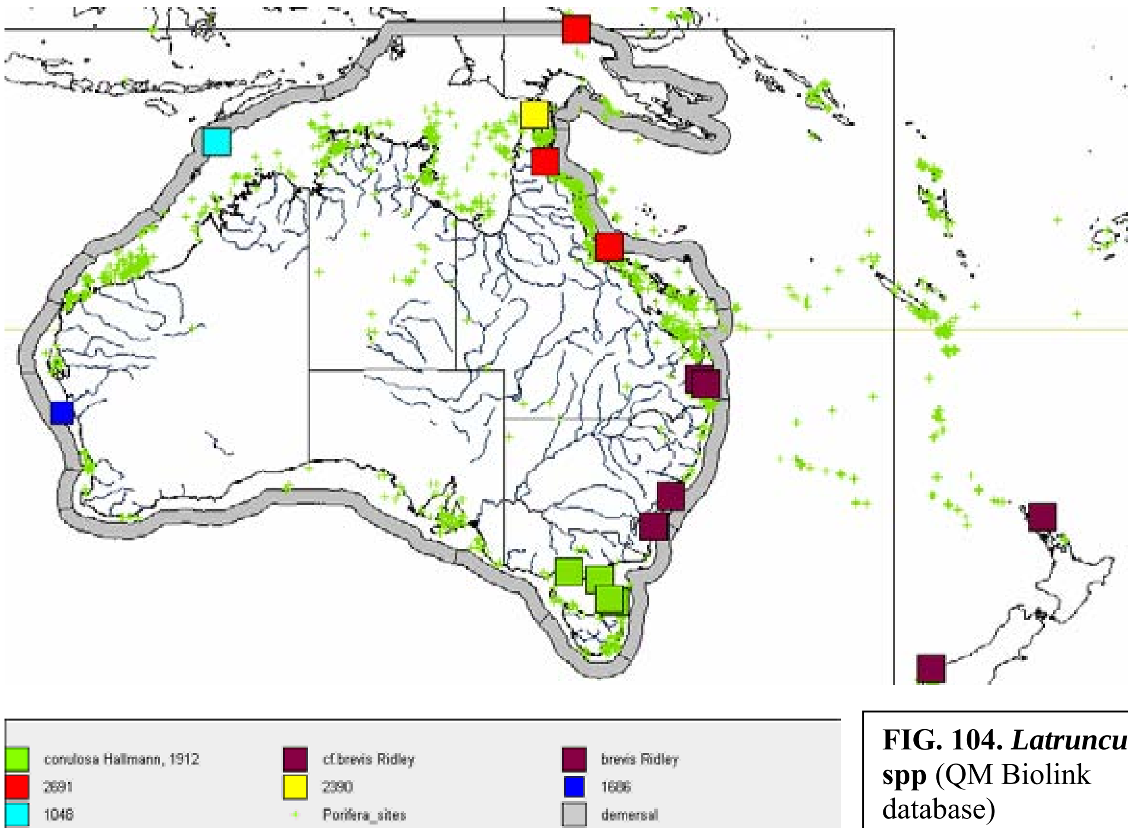


FIG. 104. ***Latrunculia* spp** (QM Biolink database)

Order Halichondrida Gray, 1867
Family Axinellidae Carter, 1875

31. *Auletta*, *Dragmacidon* and *Ptilocaulis* spp (Demospongiae: Halichondrida, Axinellidae) (Fig. 105)

Bioregional trends: Exclusively tropical, nearly completely east coast group of species, most coral reef associated, indicator of north-south differentiation of GBR.

Summary details: *Auletta* (6 unnamed spp), *Dragmacidon* (6 spp, 2 named), *Ptilocaulis* (11 spp, 3 named), exclusively tropical distribution, nearly completely east coast group of species, two widespread species *Dragmacidon australis* and *Ptilocaulis fusiformis*, both associated with coral reef distribution, former in both north east (to CEB) and northern bioregions (to NWP), the latter restricted to western Pacific (CEB-NEB and Pacific island arc). Highest diversity on the GBR (NEB-CEP) (9 spp *Ptilocaulis*), with north-south split indicated:
-north GBR (NEB): *Ptilocaulis* spp #454, #3816, *Auletta* sp.#3817

-south GBR (NEP-CEB): *Ptilocaulis* spp #3490, #2791

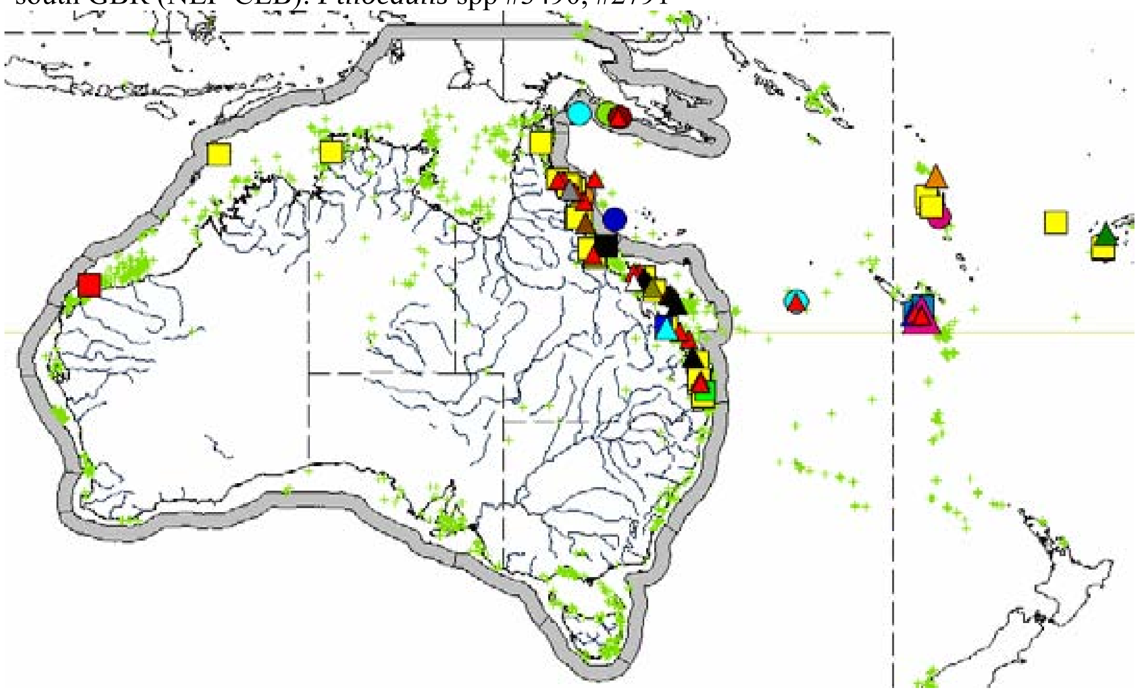


FIG. 105. *Auletta* (circles), *Dragmacidon* (squares) and *Ptilocaulis* spp (triangles) (QM Biolink database)

***Cymbastela* spp (Demospongiae: Halichondrida: Axinellidae) (Fig. 106-111)**

Bioregional trends: Good bioregion markers for GBR (NEP-CEB), NP, SWB and GulfP, and east-west tropical species pairs supporting a major faunal change at Torres Strait.

Summary details: Unique group of cyanobacterial-associated sponge species some occupying distinct coral reef-associated habitats, most diverse and abundant in the tropics but also with temperate species. The genus is endemic to the southern Indo-west Pacific, and with the most species (7 described and 13 undescribed morphospecies) in Australia. Highest diversity in GBR (5 spp), unique bioregional associations for particular species:
-restricted to GBR (NEB-CEB): *C. coralliophila*
-widespread east coast, GBR (NEB) to south east coastal (SEB): *C. concentrica*
-restricted to north coast (NP): *C. stipitata*
-widespread north and north west coasts (NP – NWP): *C. vespertina*
-restricted to south west (SWB): *C. marshae*
-restricted to south (GulfP): *C. notiaina*

Special analysis of Northern Planning Area. Only two species are known so far to occur in the NPA (*C. vespertina, C. coralliophila*) **(Fig. 107)**, but there are two sets of east-west species-pairs occurring either side of this region: *C. vespertina* and *C. stipitata* in the west, and *C. coralliophila* and *C. concentrica* in the east, both strongly associated with coral reef habitats (red ellipses in **Fig. 107**). There appears to be no overlap between these east-west species-pairs, suggesting strongly determinant biogeographic influences in their regional distributions, and species turnover occurring across the NP barrier (Gulf of Carpentaria).

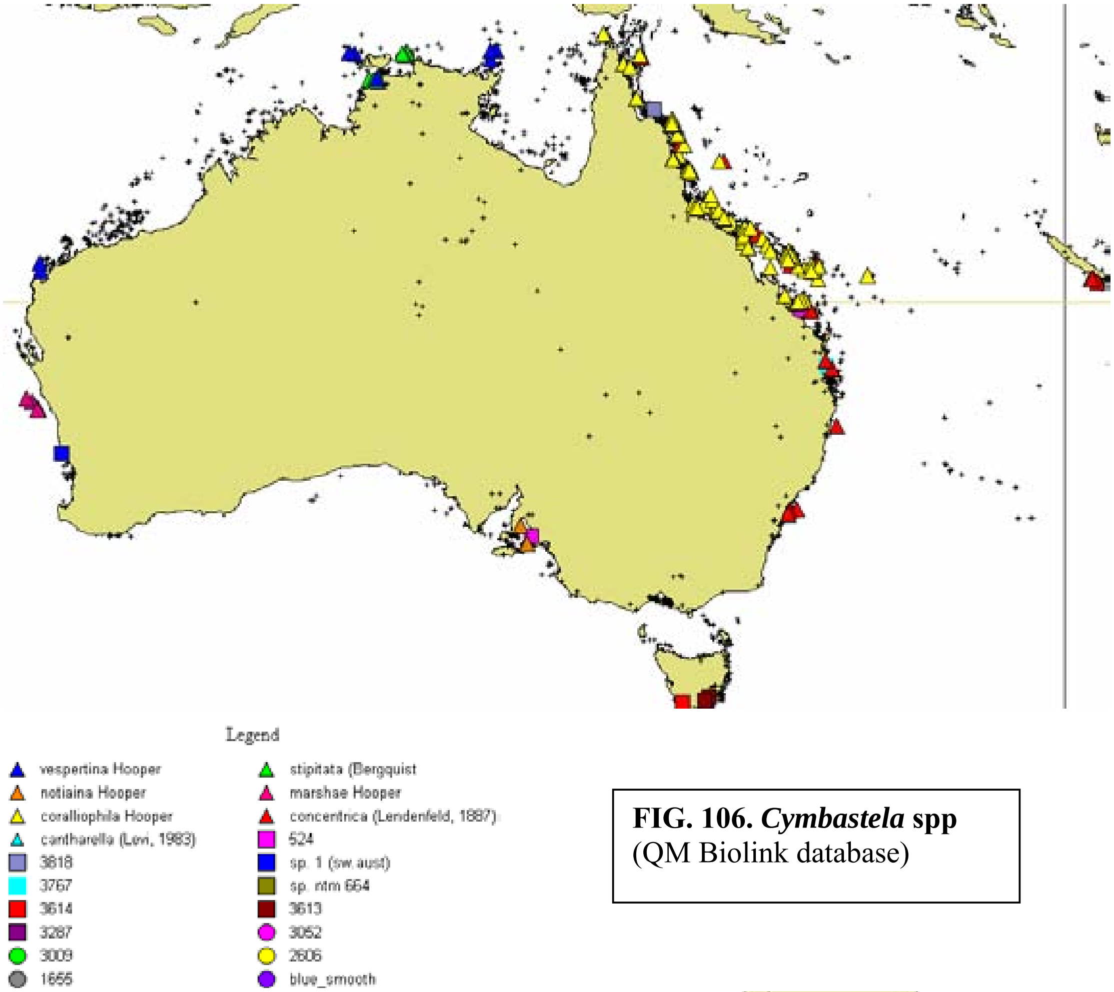


FIG. 106. ***Cymbastela*** **spp** (QM Biolink database)

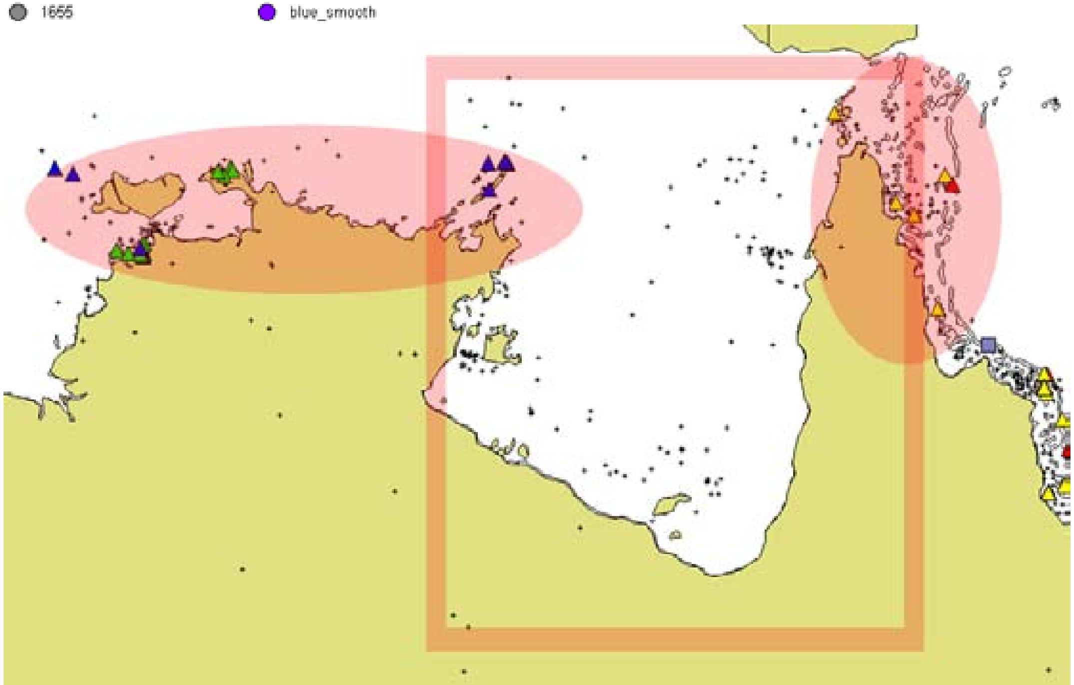


FIG. 107. Distribution of *Cymbastela* species in the NPA (red square). Red ellipses indicate east-west species pairs (QM Biolink database) (black crosses represent sampling sites) (see previous figure for species legend).

Actual datapoints and CAAB modelled distributions for these four key *Cymbastela* species found bounding the NPA are presented in the following figures.

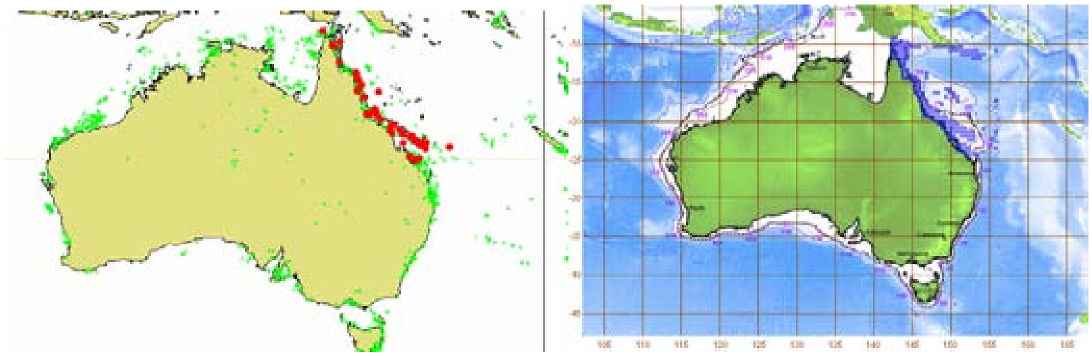


Fig. 108. Specimen records and CAAB modelled distributions for *Cymbastela coralliophila* Hooper & Bergquist (largely geographically sympatric with *C. concentrica*)

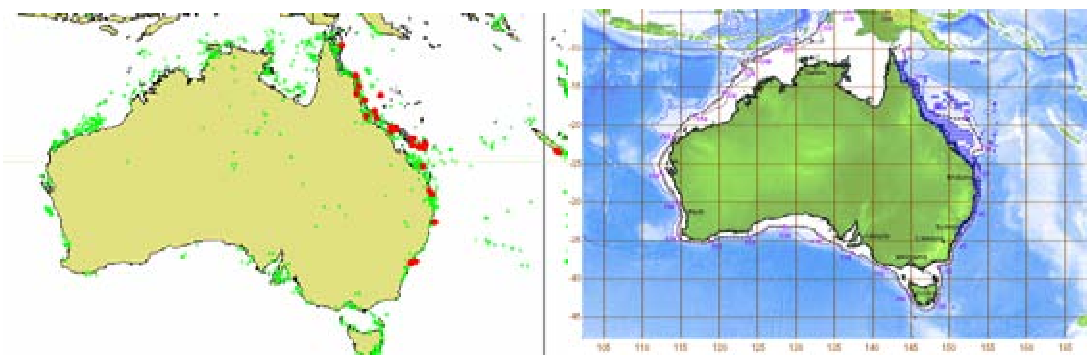


Fig. 109. Specimen records and CAAB modelled distributions for *Cymbastela concentrica* (Lendenfeld) (largely geographically sympatric with *C. coralliophila*)

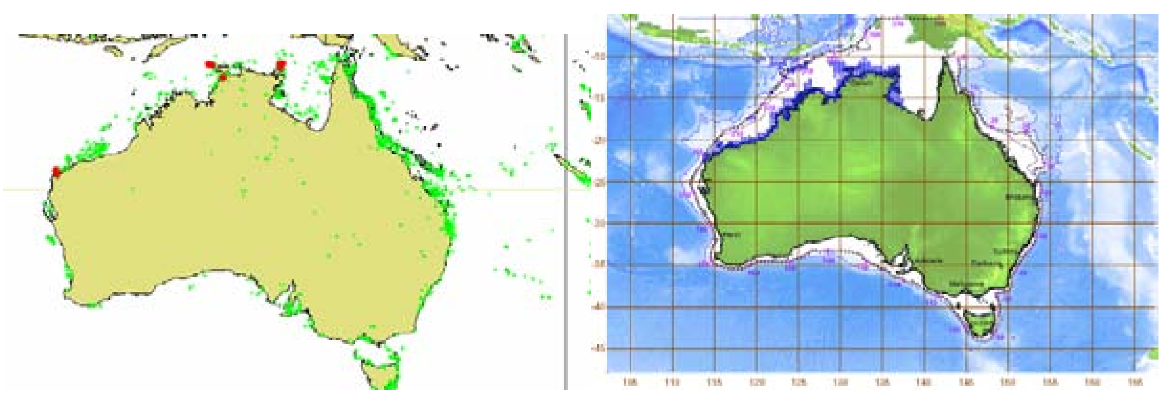


Fig. 110. Specimen records and CAAB modelled distributions for *Cymbastela vespertina* Hooper & Bergquist (occurs within the geographical range of *C. stipitata*)

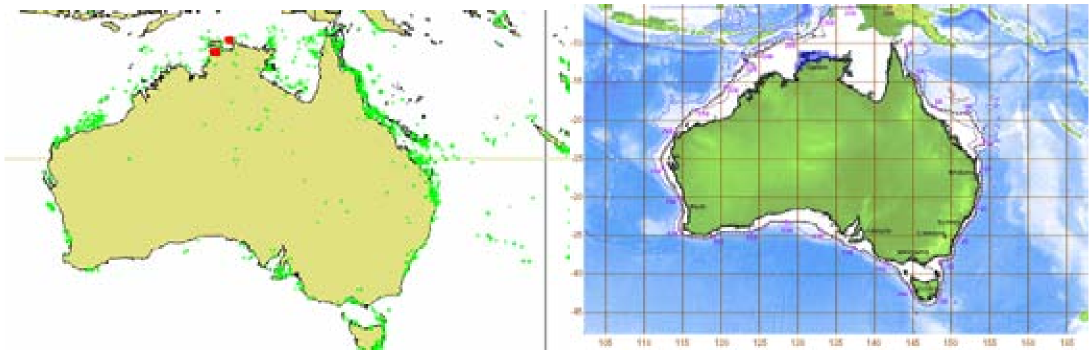
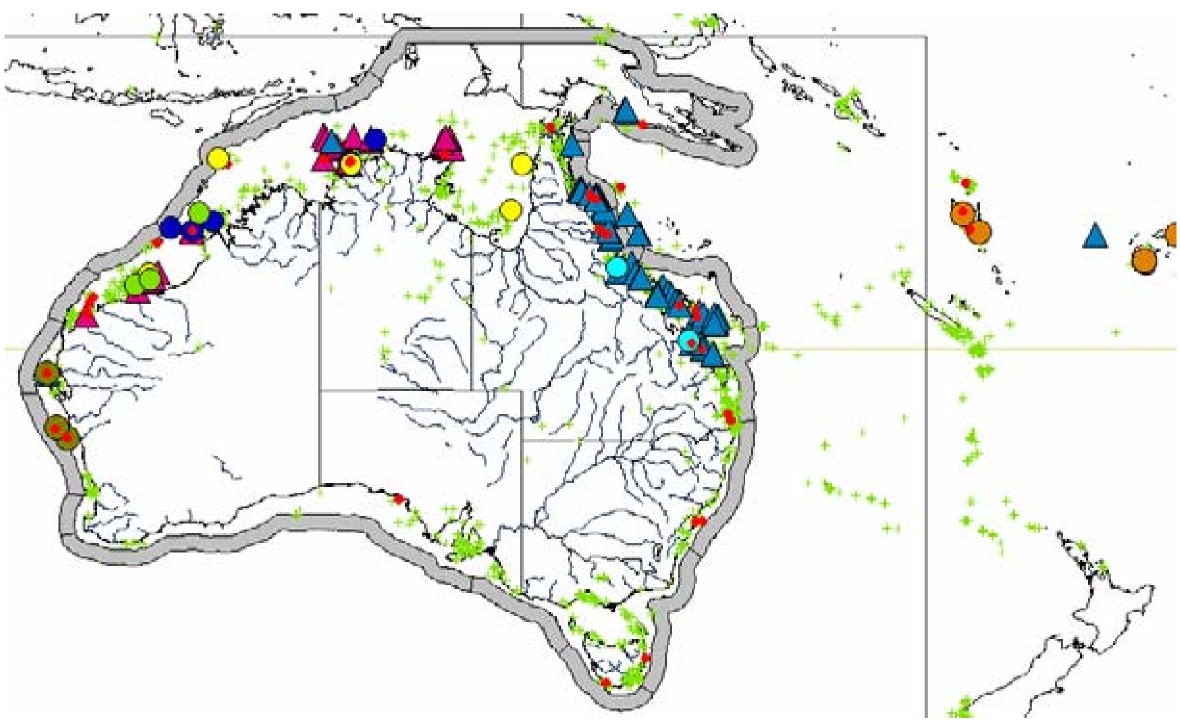


Fig. 111. Specimen records and CAAB modelled distributions for *Cymbastela stipitata* (Bergquist & Tizard) (occurs within the geographic range of *C. vespertina*)

***Axinella* spp (Demospongiae: Halichondrida, Axinellidae) (Fig. 112)**

Bioregional trends: East-west species pair differentiating GBR – north and northwest faunas; species markers for GBR, NWP, NP and CWP.

Summary details: Very high diversity (53 spp, only 2 currently named with confidence), primarily tropical Australian distribution (most unnamed species not differentiated in this analysis). East-west species pair: *Axinella flabellata* widely distributed throughout GBR (from CEB-NEB) on east coast, another *A. aruensis* on north and northwest coast (western side of NP – NWP), and other species confined only to NWP (*Axinella* sp. #559), NP-NWB (*Axinella* sp. #26) and CWP (*Axinella* sp. #728).



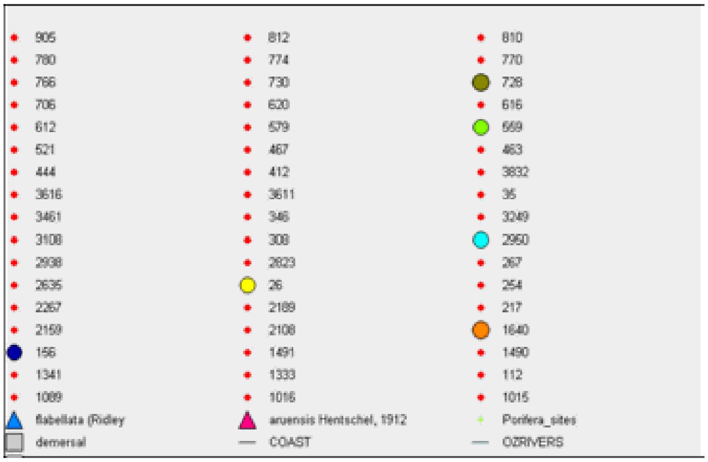
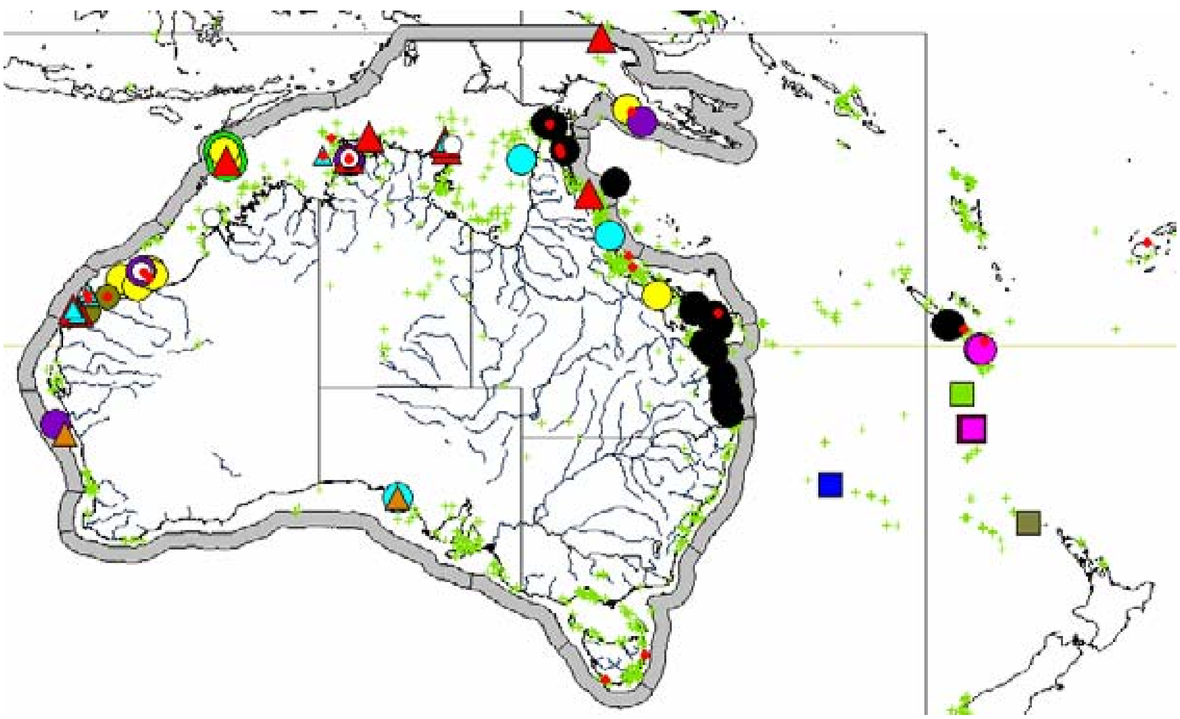


FIG. 112. *Axinella* spp (QM Biolink database)

***Phakellia* spp (Demospongiae: Halichondrida, Axinellidae) (Fig. 113)**

Bioregional trends: Predominantly tropical, highest diversity on north west coast, higher diversity on north GBR than south GBR.

Summary details: Predominantly tropical, with highest diversity in northwestern Australia (NP-NWP: 17 spp). Highly speciose (37 species, only 5 named with confidence) and some regional populations (e.g. *P. stipitata* on GBR) also highly abundant. Several species (*P. dendyi*, *Phakellia* spp #131, #646) with widespread tropical distributions.
-entire GBR (NEB-CEB): *P. stipitata*
-northern GBR (NEB): *P. carduus*
-north and northwest coasts (NP-NWP): *P. conulosa*, *Phakellia* sp. #244
-north west coast (NWP): *Phakellia* spp #508, #705



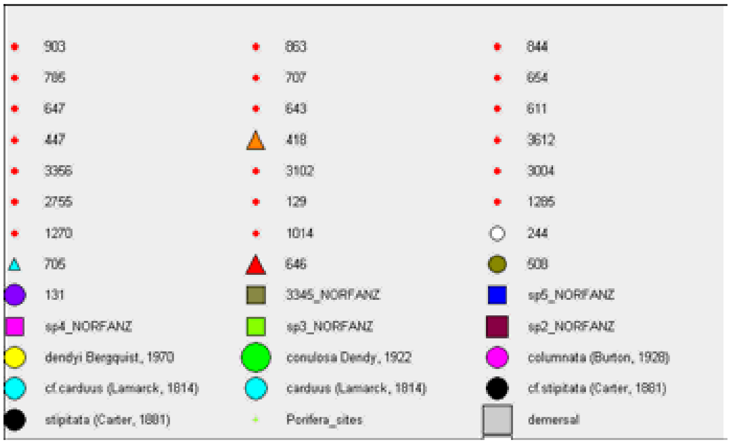


FIG. 113.
***Phakellia* spp**
(QM Biolink database)

***Reniochalina* spp (Demospongiae: Halichondrida, Axinellidae) (Fig. 114)**

Bioregional trends: Strong bioregional marker for tropical fauna, strong differentiation between north east and north west (NWB-NWP) faunas.

Summary details: Nineteen species (only 2 named so far), with extensive tropical distribution from CEB to NWP, and two species (*R. stalagmites*, *Reniochalina* sp. #122) also highly abundant in some regional faunas (e.g. NP). Highest diversity (8 spp) on northwest coastal (NP to NWP).

-north west coastal (NWP-NWB): *Reniochalina* spp #172, #285, #287, #798

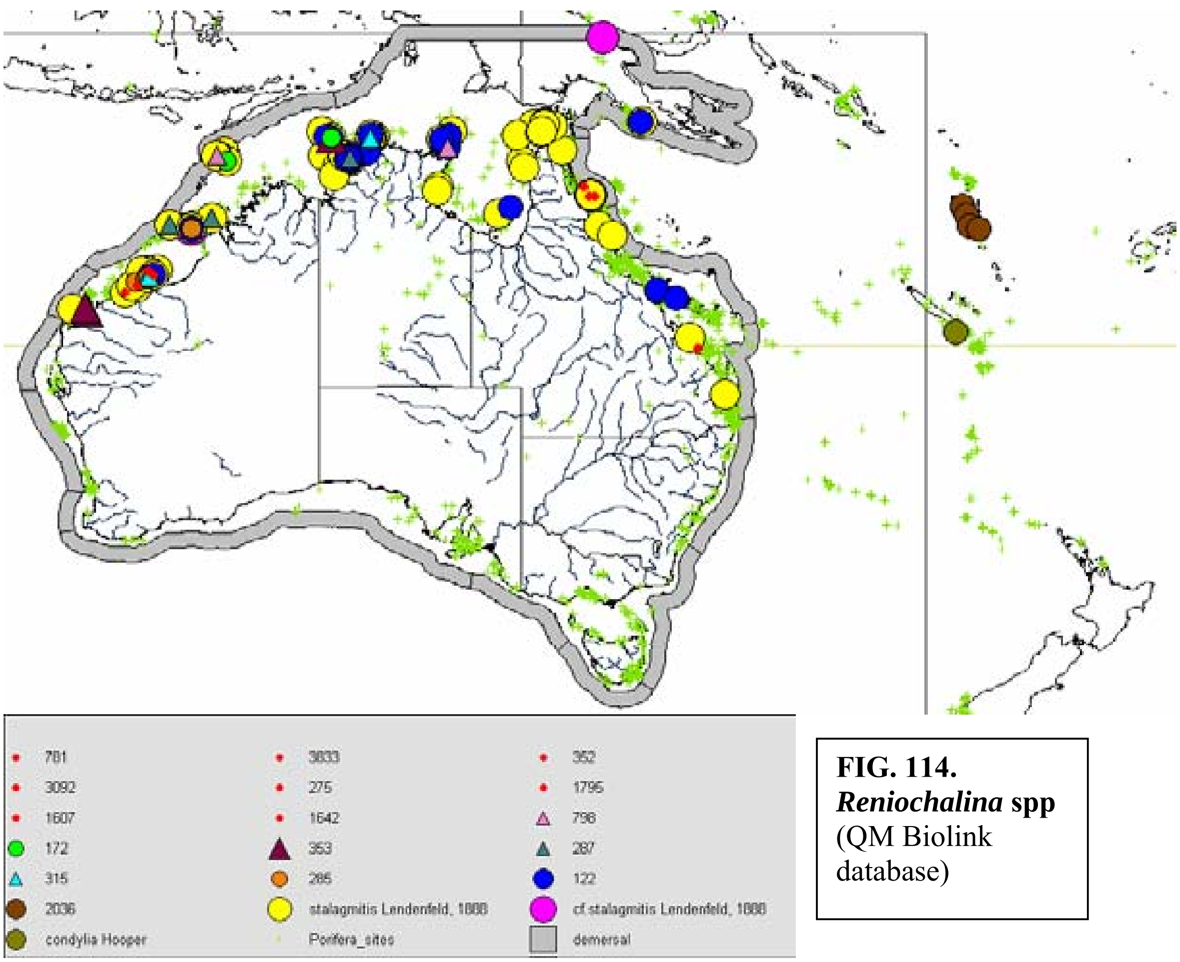


FIG. 114.
***Reniochalina* spp**
(QM Biolink database)

Family Desmoxyidae Hallmann, 1917

32. *Desmoxya*, *Didiscus*, *Higginsia*, *Myrmekioderma*, *Parahigginsia* spp (Demospongiae: Halichondrida: Desmoxyidae) (Fig. 115)

Bioregional trends: Strong bioregional marker for tropical fauna, with peaks of diversity on north east (NEB) and north west (NWP) coasts, but most common to both bioregions, and NP fauna less diverse.

Summary details: Records of family Desmoxyidae consist of *Desmoxya* (3 spp, 2 named), *Didiscus* (1 sp unnamed), *Higginisia* (8 spp, 5 named), *Myrmekioderma* (5 spp, 3 named) and *Parahigginsia* (2 spp, 1 named) have nearly exclusively tropical distributions, with highest diversity in GBR (7 spp) and north west coast (7 spp), with most species extending into both regions, but a species poor region in NP (3 spp). The family contains three very common and often abundant spp: *H. scabra, H. mixta* and *M. granulosa* (southern GBR (CEB) to north west coastal (NWP)).

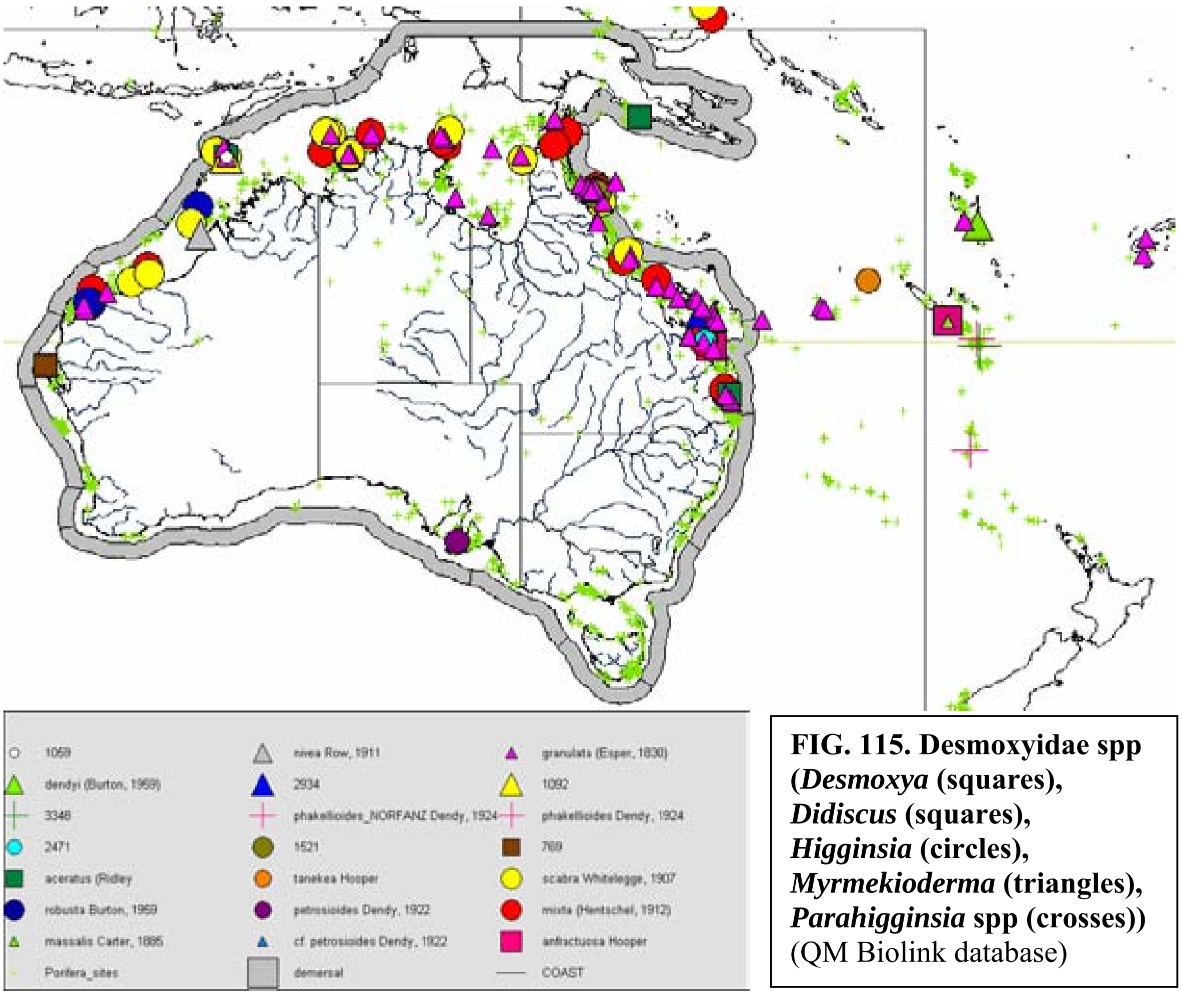


FIG. 115. Desmoxyidae spp (*Desmoxya* (squares), *Didiscus* (squares), *Higginsia* (circles), *Myrmekioderma* (triangles), *Parahigginsia* spp (crosses)) (QM Biolink database)

Family Dictyonellidae Van Soest, Diaz & Pomponi, 1990

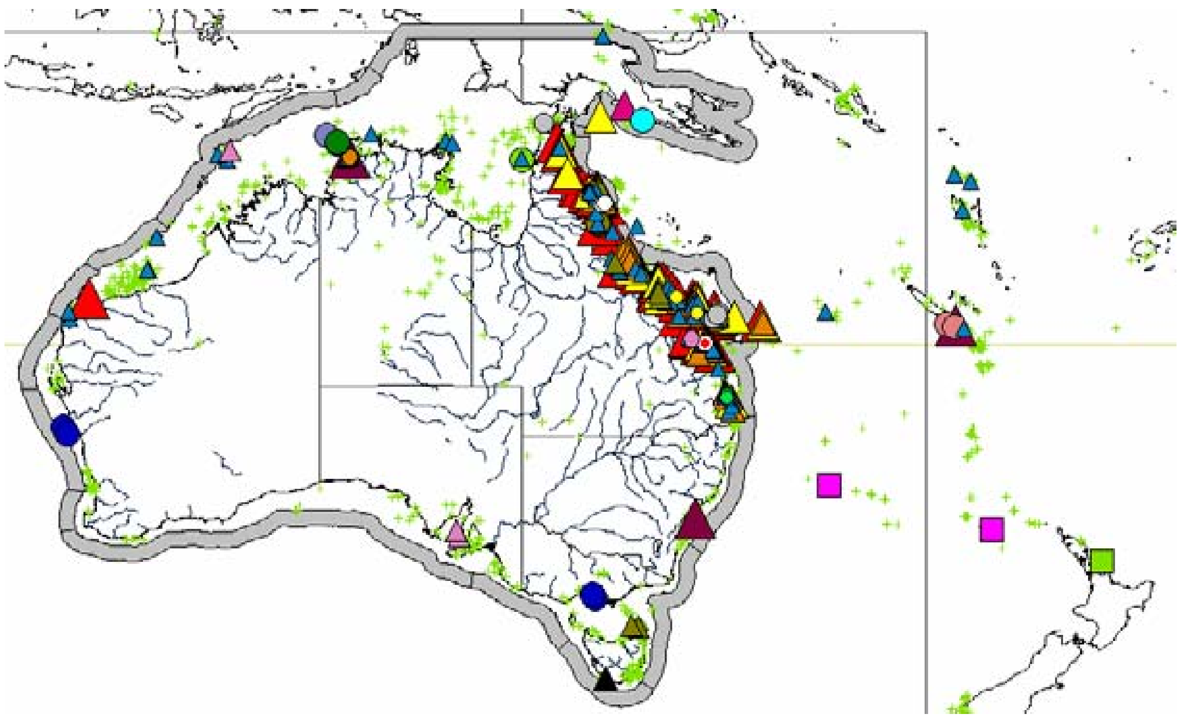
33. *Acanthella* spp (Demospongiae: Halichondrida: Dictyonellidae) (Fig. 116)

Bioregional trends: Predominantly tropical, highly indicative surrogate of GBR bioregion but without strong support for any north-south GBR differentiation.

Summary details: Highly diverse predominantly tropical genus (26 species recorded, 7 named), some species very abundant in coral reef habitats, with several characteristic of GBR fauna. Highest diversity in the GBR (10 spp) but species poor indicators of any northern – southern differentiation of GBR bioregions. One species (*A. cavernosa*) with widespread tropical distribution from CEB-NWP.

-entire GBR (NEB-CEB): *A. costata, A. constricta, A. klethra*, *Acanthella* spp #1562, #2161, #2802

-southern GBR (NEP-CEB): *Acanthella* spp #583, #3002, #3462



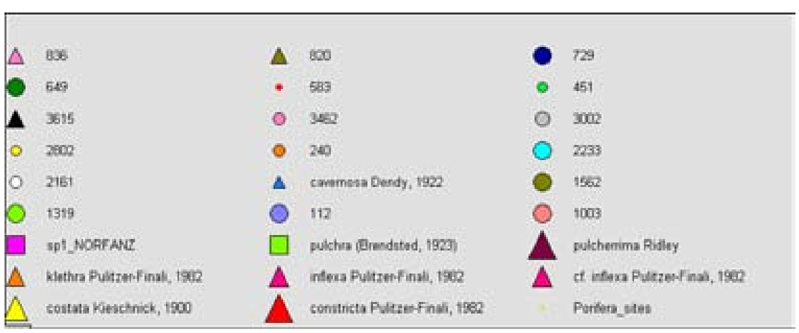


FIG. 116. ***Acanthella* spp** (QM Biolink database)

***Liosina* and *Rhaphoxya* spp (Demospongiae: Halichondrida: Dictyonellidae) (Fig. 117)**

Bioregional trends: Predominantly tropical, highest diversity on GBR, some support for north-south differentiation of GBR, a few species also markers for south eastern bioregions.

Summary details: *Liosina* (6 spp, 2 named) and *Rhaphoxya* (11 spp, 4 named) have mainly tropical records with highest diversity in the GBR (8 species). Two (*L. paradoxa* and *R. pallida*) are widely distributed on the GBR and the former is also frequently abundant. Some support for differentiation of northern and southern GBR bioregions. Also apparent endemic species for south east and south bioregions:

-north GBR (NEB): *Liosina* spp #425, 2129

-south GBR (NEP-CEB): *Rhaphoxya* spp #2586, 2785
-south east coast (CEP): *Rhaphoxya* sp. #2609
-Bass Strait (BassP): *Rhaphoxya felina*
-southern Gulf (GulfP): *Liosina* sp. #834

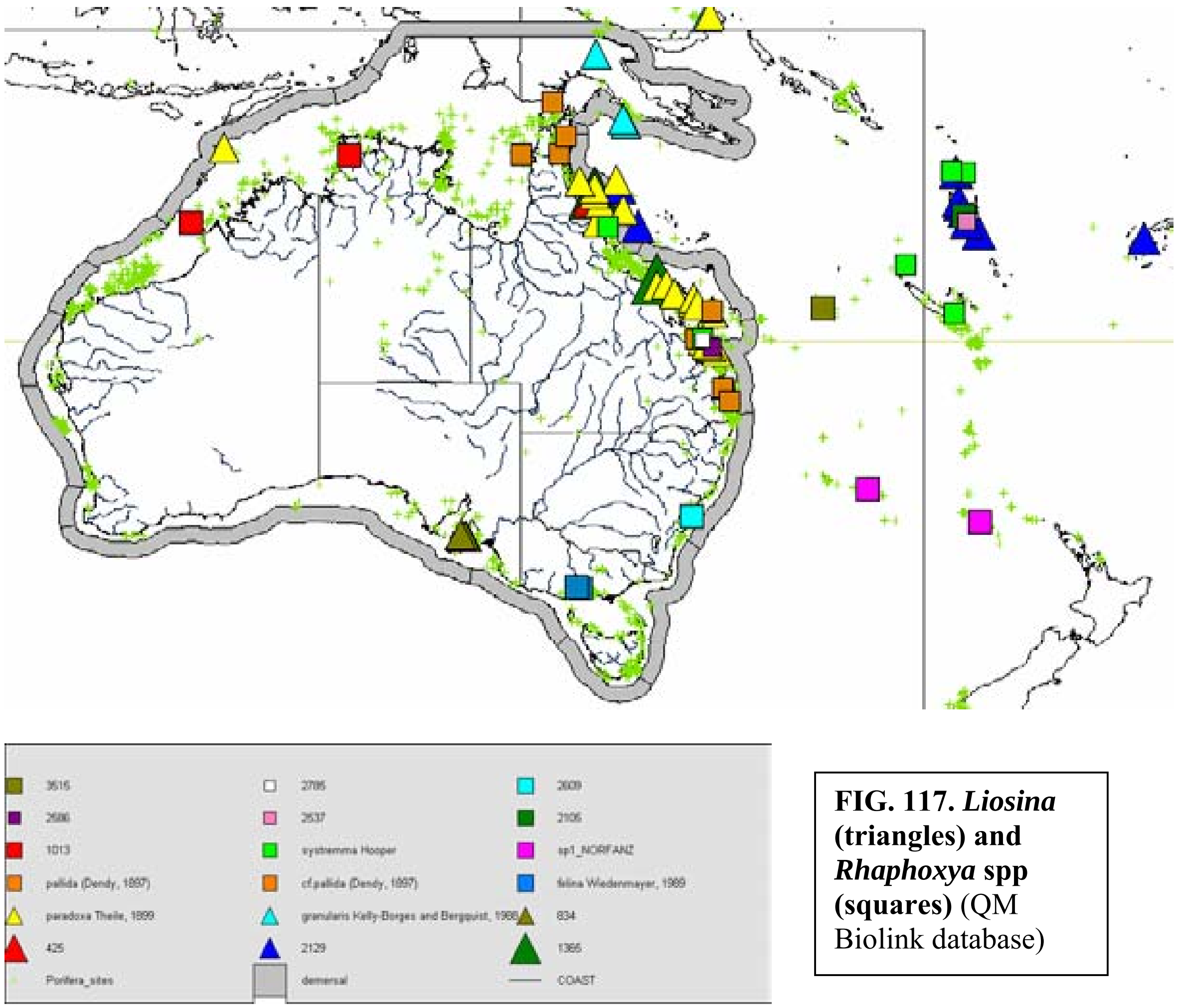
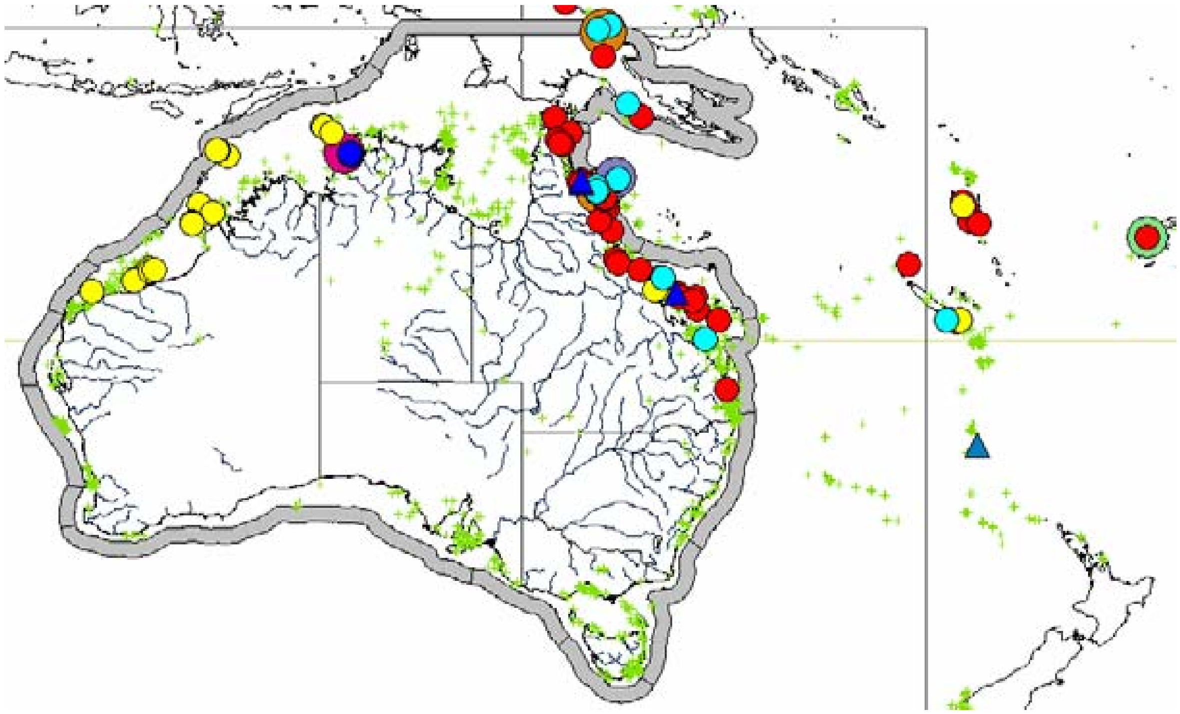


FIG. 117. ***Liosina*** **(triangles) and** ***Rhaphoxya*** **spp (squares)** (QM Biolink database)

Dictyonella **and** ***Stylissa*** **spp (Demospongiae: Halichondrida: Dictyonellidae) (Fig. 118)**

Bioregional trends: Exclusively tropical, highest diversity on GBR, strong species differentiation between east and west coast faunas, no indication of north-south bioregionalisation on GBR.

Summary details: *Dictyonella* (2 unnamed species) and *Stylissa* (8 spp, 4 named) are represented by exclusively tropical collections, with highest diversity (6spp) in the GBR. Strong indication of east-west species differentiation, but not indicative of any north-south regionalization within the GBR.
-north and south GBR (CEB-NEB), and extending into the Pacific islands: *Stylissa carteri*, *S. massa*, *Stylissa* spp #1637, 1741, *Dictyonella* sp. #2801
-north west coast (NWB, NWP): *S. flabelliformis*, *S. hapalia*, *Stylissa* sp. #1251



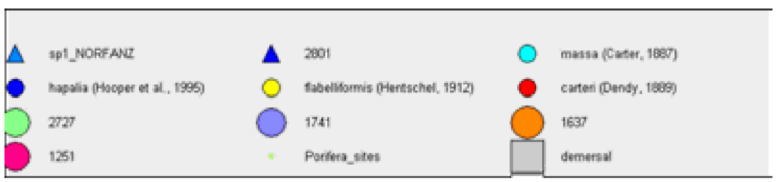


FIG. 118. *Dictyonella* (triangles) and *Stylissa* spp (circles) (QM Biolink database)

Family Halichondriidae Gray, 1867

34. *Axinyssa* spp (Demospongiae: Halichondrida: Halichondriidae) (Fig. 119)

Bioregional trends: Tropical group most diverse on GBR and clearly differentiating north and south GBR bioregions, and species composition different on east vs. north coasts.

Summary details: The genus is diverse in tropical Australasian waters (41 spp, only 3 named so far), but never abundant in any locality sampled to date. Highest diversity is on the GBR (21 spp), with clearly differentiated north and south bioregions (with only two species common to both, *Axinyssa* sp. #1878, #3489). North and northwest coast faunas low diversity (3 spp) but different from east coast species:

-northern GBR (NEB: 12 spp): *Axinyssa* spp #2257, #2929, #3252, #3849

-southern GBR (NEP-CEB: 10 spp): *Axinyssa* spp #1939, #2590, #2824, #3464

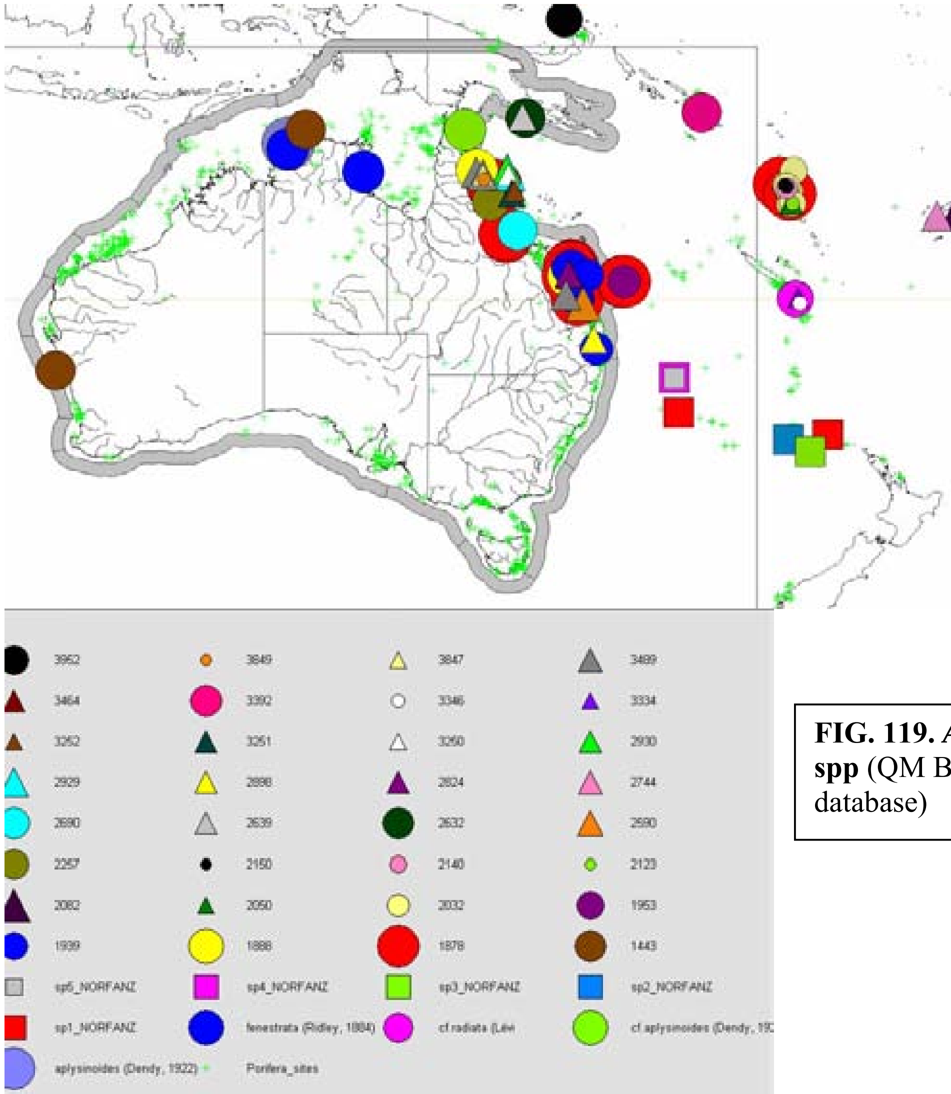
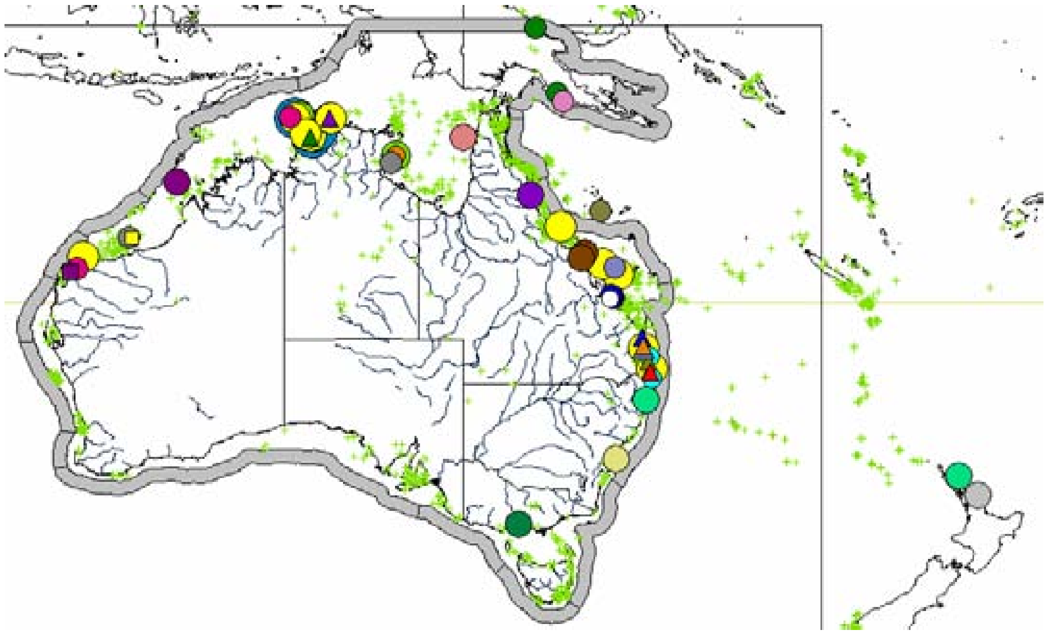


FIG. 119. *Axinyssa* spp (QM Biolink database)

***Ciocalypta, Ciocalapata* and *Collocalypta* spp (Demospongiae: Halichondrida: Halichondriidae) (Fig. 120)**

Bioregional trends: Tropical group with a single widely distributed species and several species markers for eastern and northern bioregions (CEB, NEP, NP)

Summary details: *Ciocalypta* (28 spp, 6 named), *Ciocalapata* (1 unnamed sp) and *Collocalypta* (1 unnamed sp) show moderate diversity but low abundance with the exception of *Ciocalypta tyleri* distributed across the tropics (from CEB-NWP). Peaks of diversity occur in the Northwest Shelf (NWP: 6 spp), Darwin region (NP: 5 spp), central east coast (lower CEB: 8 spp), and central and southern GBR (NEP: 6 spp), with only one species (*C. tyleri*) common to all regions.



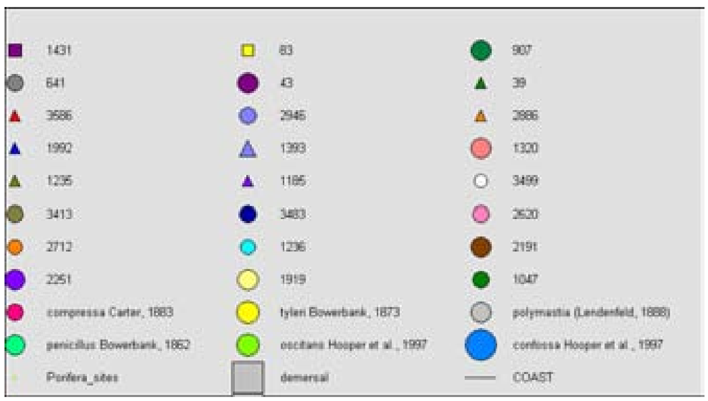
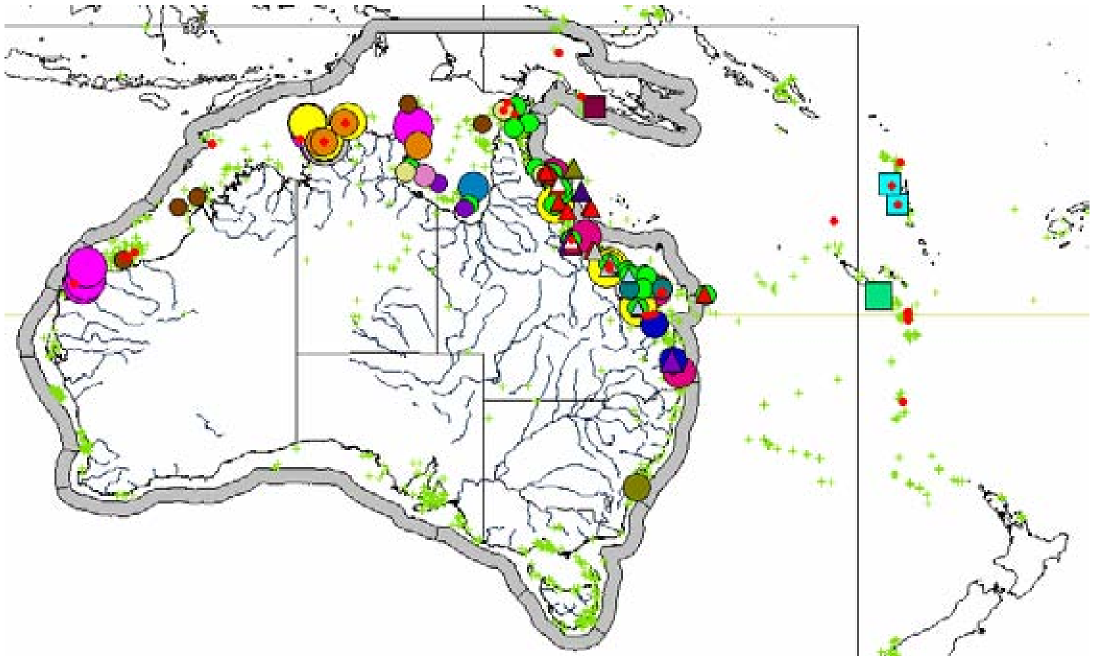


FIG. 120. *Ciocalypta* (circles, triangles), *Ciocalapata* (squares) and *Collocalypta* spp (squares) (QM Biolink database)

***Halichondria* spp (Demospongiae: Halichondrida: Halichondriidae) (Figs 121-122)**

Bioregional trends: Peaks of diversity on GBR, Darwin, Gulf of Carpentaria, Sydney and Tasmanian regions, with little overlap between species. North and south GBR bioregions differentiated.

Summary details: Collections consist of tropical and temperate faunas. Highly speciose (82 spp, only 6 currently named), with highest diversity on the GBR (31 spp), and northern and southern GBR differentiated by species composition with overlap in only a small number of species. Other peaks of diversity in the Darwin region (NP: 10 spp), Gulf of Carpentaria (NP: 8 spp), TasP (5 spp) and Sydney region (6 spp). Differentiation of eastern and western species indicated by turnover of species pair *H. stalagmites* (east, NEP-NP) and *H. phakellioides* (west, NWP-NP) at NP. Also indicated is a distinct Gulf of Carpentaria fauna (NP) associated with soft sediments (6 spp mostly unique to the region). Most species represented by one or few records and therefore not differentiated in maps.
-entire GBR (CEB-NEB): *H. bergquistae*, *Halichondria* spp #1227
-north GBR (NEB): *Halichondria* spp #1984, #2702, #2922
-south GBR (CEB): *Halichondria* spp #1186, #2807, #2658
-central south east coast (CEP): *Halichondria* spp #3581, #3582, #3583, #3584
-north coast (NP): *H. vansoesti*, *H. darwinensis*, *Halichondria* spp #2404, 3582
-Tasmania (TasP): *Halichondria* spp #896, #898, #3448, #3680
-south west coast (SWB): *Halichondria* spp #744, #809, #806



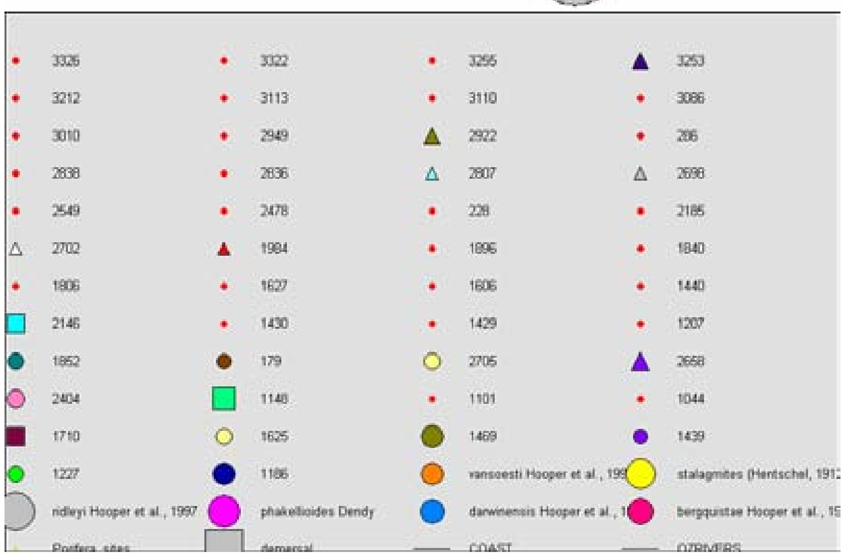


FIG. 121. *Halichondria* spp – part 1 (QM Biolink database)

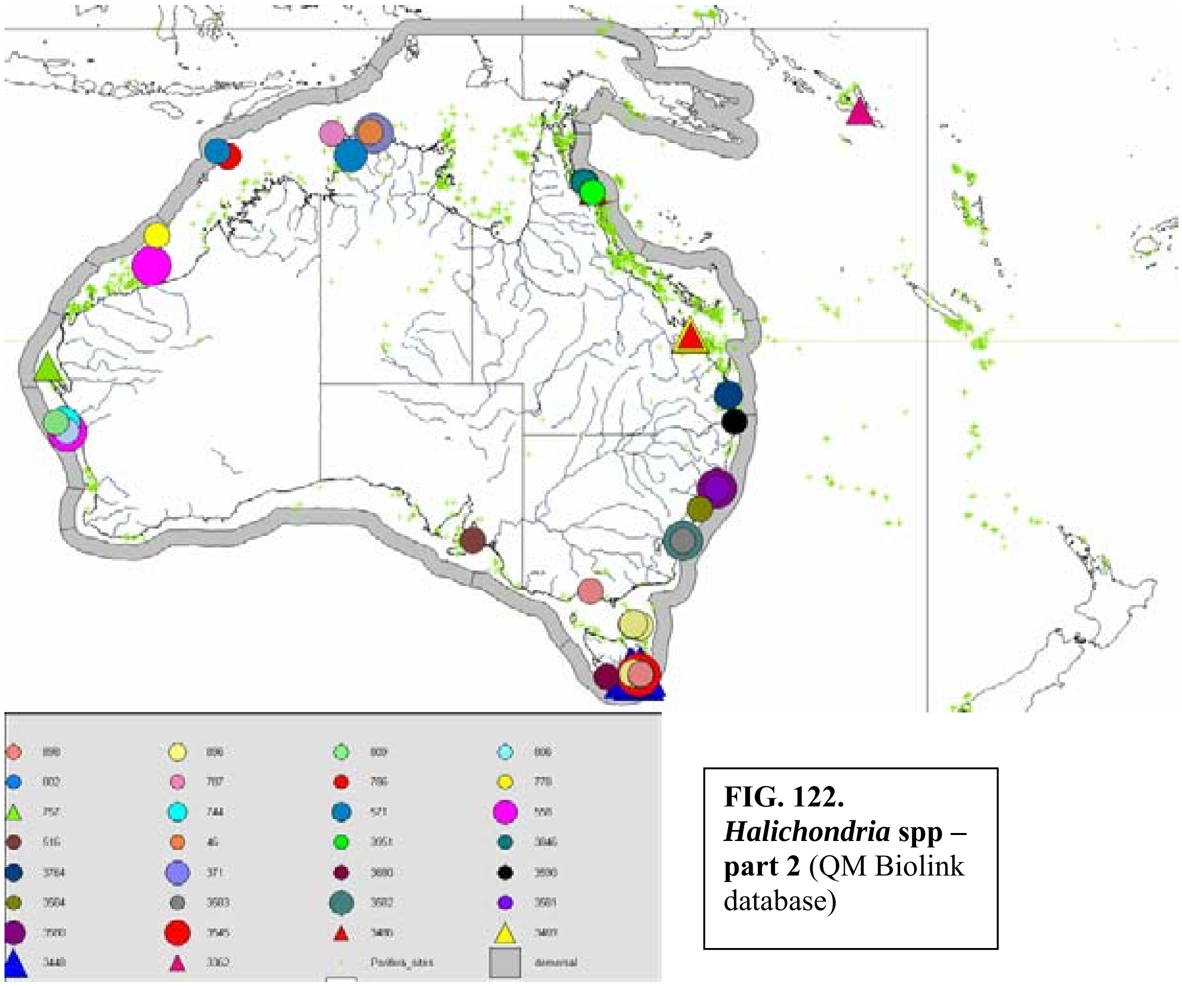


FIG. 122. ***Halichondria* spp – part 2** (QM Biolink database)

***Hymeniacidon, Amorphinopsis* and *Epipolasis* spp (Demospongiae: Halichondrida: Halichondriidae) (Fig. 123)**

Bioregional trends: Relatively low diversity and abundance on GBR but north and south bioregions supported; NP and CEP differentiated from GBR faunas.

Summary details: *Hymeniacidon* (20 spp, 3 named), *Amorphinopsis* (8 spp, 3 named) and *Epipolasis* (4 unnamed spp) have highest diversity in Darwin region (NP: 8 spp) and Sydney region (CEP: 4 spp), with low diversity (and abundance) on the GBR although species groups differentiate northern and southern GBR bioregions. Species groups also characteristic of other bioregions:
-north GBR (NEB): *Amorphinopsis* sp. #3136, *Hymeniacidon* spp #1623, #2261
-south GBR (CEB-NEP): *Amorphinopsis* sp. #2334, *Hymeniacidon* sp. #1862, *Epipolasis* sp. #799
-central south east coast (CEP): *Hymeniacidon* spp #1453, #1487, #2335, #3575
-Darwin region (NP): *Amorphinopsis excavans, A. sacciformis, A. foetida*, *Hymeniacidon vernonensis, H. popeae, H. gracilis*
-northwest coast (NWP): *Amorphinopsis* sp. #1785, *Epipolasis* sp. #452, *Hymeniacidon* spp #395, #557
-southern coast (WBassB-GulfP): *Hymeniacidon* sp. #509

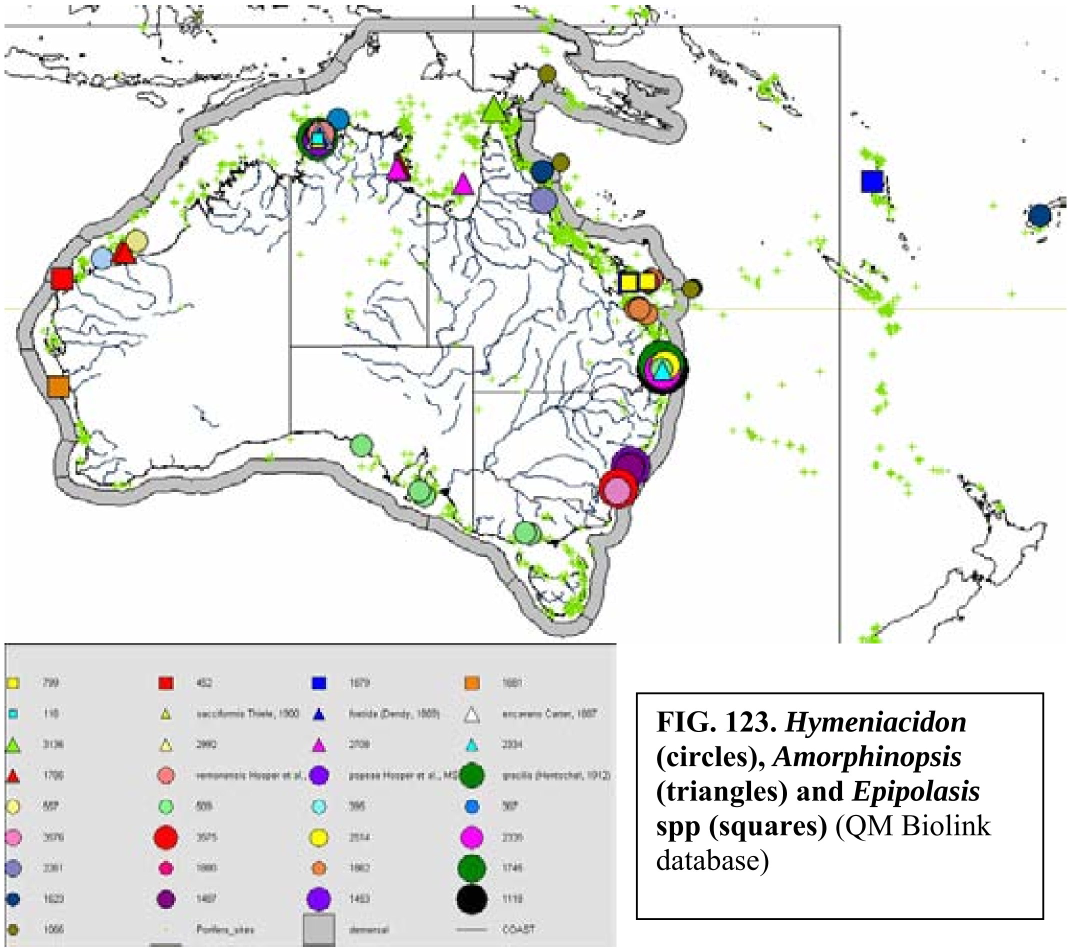
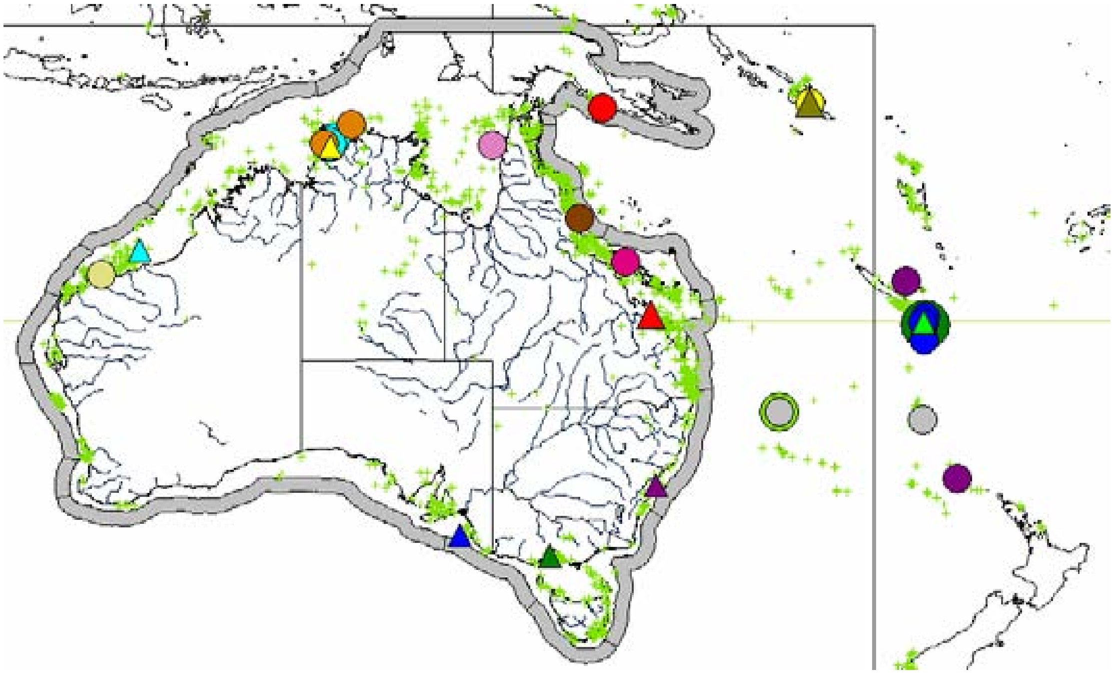


FIG. 123. *Hymeniacidon* (circles), *Amorphinopsis* (triangles) and *Epipolasis* spp (squares) (QM Biolink database)

***Spongorites* and *Topsentia* spp (Demospongiae: Halichondrida: Halichondriidae) (Fig. 124)**

Bioregional trends: No ubiquitous species, low diversity, few or single unique species define particular bioregions.

Summary details: *Spongosorites* (8 unnamed spp), and *Topsentia* (14 spp, 4 named) are neither diverse nor abundant, with no widely distributed species and only one small peak of diversity in the Darwin region (NP). No overlap in species composition between adjacent areas, and single or few species can define particular bioregions:
-central and southern GBR (NEP, CEB: 3 spp): *Spongosorites* sp. #2471, *Topsentia* sp. #1322, #3254
-north coast (NP: 3 spp): *Topsentia halichondrioides*, *T. dura*, *Spongosorites* sp. #57
-northwest coast (NWP: 2 spp): *Topsentia* sp. #1438, *Spongosorites* sp. #349
-GulfP: *Spongosorites* sp. #1131
-BassP: *Spongosorites* sp. #1417
-CEP: *Spongosorites* sp. #1461



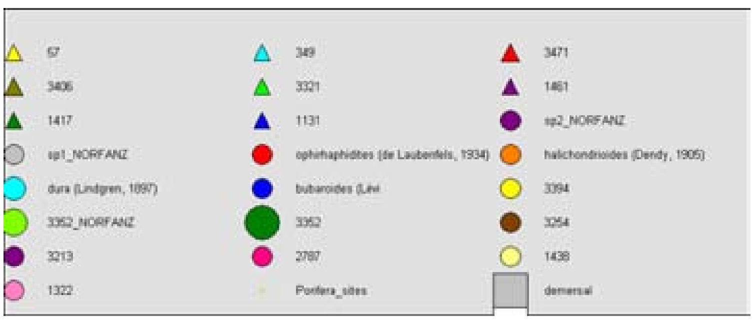


FIG. 124. *Spongosorites* (triangles) and *Topsentia* spp (circles) (QM Biolink database)

Order Haplosclerida Topsent, 1928
Suborder Haplosclerina Topsent, 1928
Family Callyspongiidae de Laubenfels, 1936

35. *Dactylia* spp (Demospongiae: Haplosclerida: Callyspongiidae) (Fig. 125)

Bioregional trends: Predominantly found in the GBR region, with highest diversity in the southern region, diminishing both north and south; one widely distributed south and east coast species, two ‘apparently endemic’ southern species.

Summary details: *Dactylia* (17 spp, 4 named) is predominantly confined to the north and central east Australian coast, especially the GBR region, with some species being highly prevalent and extending throughout the GBR (*D. pseudoreticulata*, *Dactylia* spp #1368, #1376, #1584). One species (*Dactylia* sp. #1846) widespread from the southern Gulf to Cape York (GulfP – NEB). Species with only single records are not differentiated on maps presented here. Peaks in diversity occur in the central and southern GBR (NEP: 15 spp), with species diversity diminishing to the north (NEB: 7 spp) and south (CEB: 4 spp, and CEP: 1 sp.). Few species are markers for particular bioregions, aside from those occurring on the central and southern GBR:
-south GBR (NEP): *Dactylia* spp #1823, #1941, #2581, #2600, #2813, #2943
-central south east coast (CEP-CEB): *D. radix*
-southern Gulf (GulfP): *D. annulata*
-Tasmania (TasP): *Dactylia* spp #

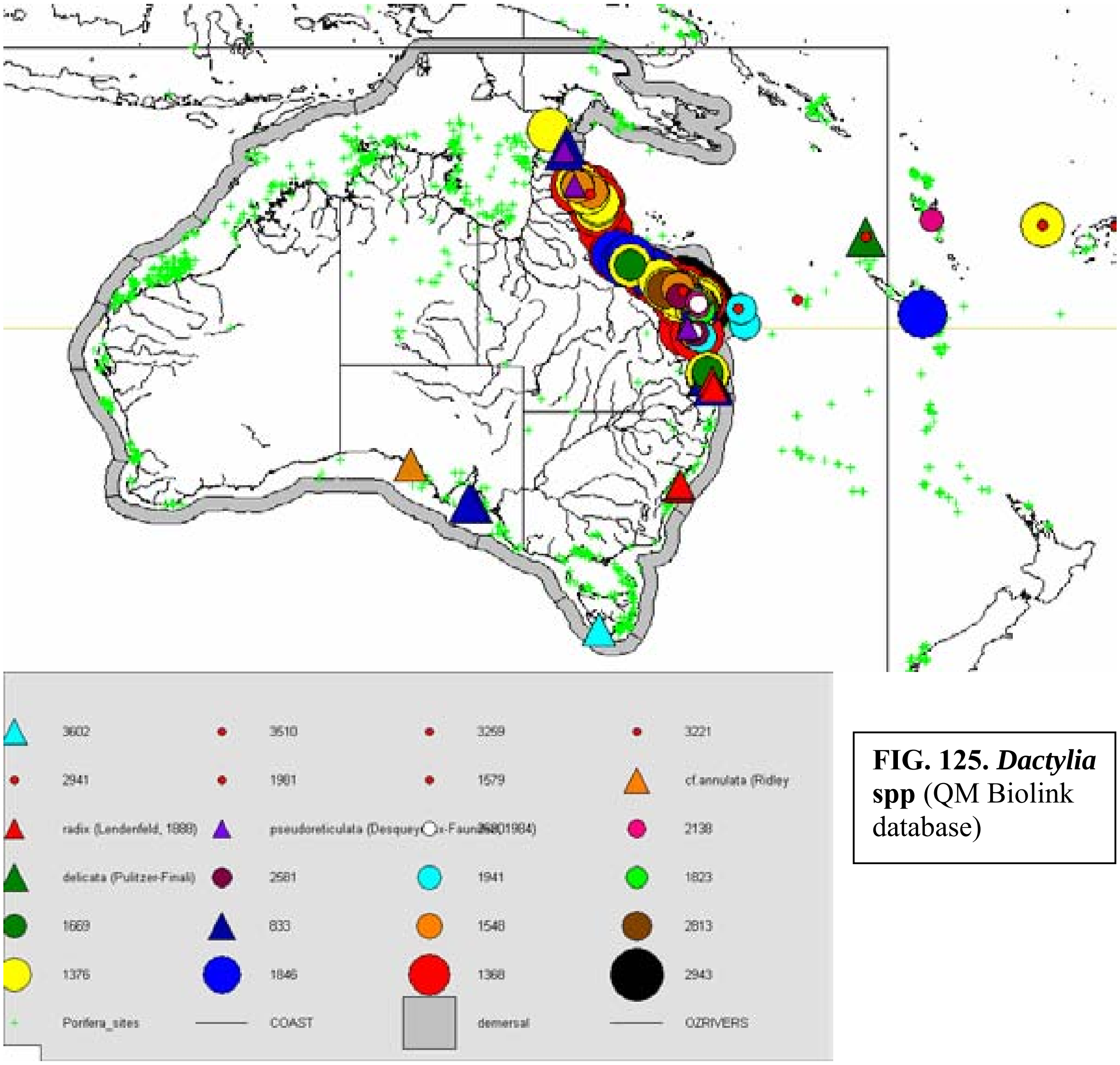
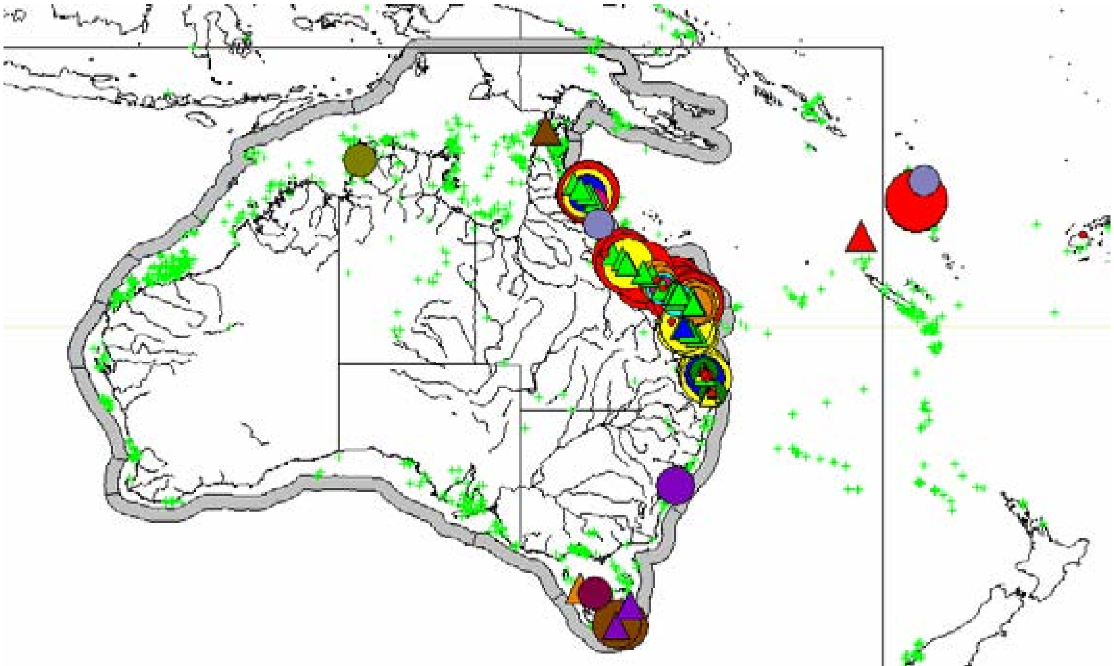


FIG. 125. *Dactylia* spp (QM Biolink database)

Arenosclera and _Siphonochalina_ spp (Demospongiae: Haplosclerida: Callyspongiidae) (Fig. 126)

Bioregional trends: Predominantly east coast, tropical species most diverse on the GBR and in south east Queensland, but with north and south GBR regions not clearly delineated. Both genera are good markers for the GBR.

Summary details: *Arenosclera* (9 spp, 1 named) and *Siphonochalina* (21 spp, 1 named) have predominantly tropical distributions, similar to those seen in *Dactylia* spp, exclusively east coast and with only few species records for temperate waters. Species with only single records are not differentiated on maps presented here. Peaks in diversity occur in the northern GBR (NEB: 7 spp), central and southern GBR (NEP: 10 spp) and south east Queensland (11 spp), although delineation of northern and southern GBR bioregions is not clear, with several widely distributed species along the length of the GBR (*Arenosclera* sp. #1363, *S. deficiens* and *Siphonochalina* spp #1373), and only few unique species. A few species are markers for specific bioregions:
-north GBR (NEB): *Arenosclera* sp. #3114
-south GBR (NEP): *A. arabica, Siphonochalina* sp. #2816
-south east Queensland (CEB): *Arenosclera* spp #2773, #2775, *Siphonochalina* sp. #2778
-Bass Strait and Tasmania (BassP-TasP): *Arenosclera* sp. #193, #3426, *Siphonochalina* sp. #3561, #3562
-Darwin region (western part of NP): *Siphonochalina* sp. #363



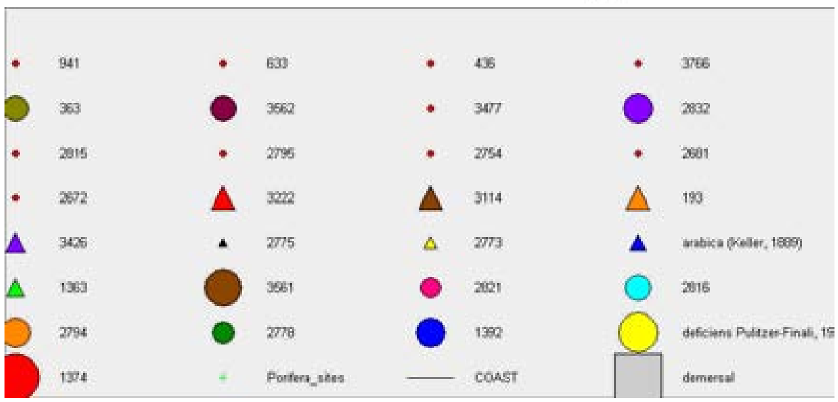


FIG. 126. *Arenosclera* (triangles) and and *Siphonochalina* spp (circles) (QM Biolink database)

***Callyspongia* (*Cladochalina, Toxochalina, Spinosella* and *Euplacella*) spp (Demospongiae: Haplosclerida: Callyspongiidae) (Fig. 127)**

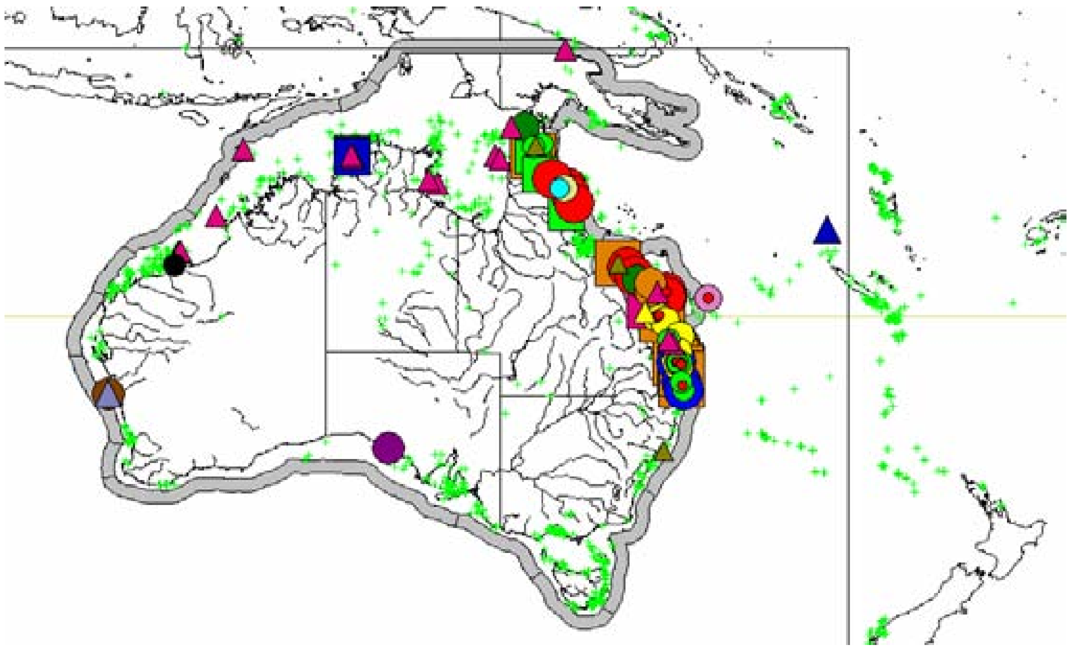
Bioregional trends: Predominantly tropical east coast distribution, particularly associated with the GBR, without clear differentiation of northern and southern GBR bioregions but with marginally higher diversity on the central and southern GBR; one widely distributed tropical species.

Summary details: *Callyspongia* subgenera *Cladochalina* (4 named spp), *Toxochalina* (4 spp, 2 named), *Spinosella* (1 unnamed sp.) and *Euplacella* (19 unnamed spp) are predominantly tropical, especially associated with coral substrates on the GBR, with marginally higher diversity on the central and southern GBR (15 spp), diminishing slightly northwards (northern GBR, NEB: 8 spp) and southwards (south east Queensland, CEB: 9 spp). Species with only single records are not differentiated on maps presented here. Northern and southern GBR bioregions are not well differentiated by their species composition. One species (*C. (Toxochalina) schulzei*) occurs across the tropics, from mid-north west coast to the southern GBR (NWP-NEP), several species occur throughout the GBR (*C. (Euplacella)* spp #387, #2559, #2814, *C. (Toxochalina)* sp. #553), with others restricted to one or two bioregions:

-north GBR (NEB): *C. (Cladochalina) subarmigera*, *C. (Euplacella)* sp. #1527

-south GBR (NEP): *C. (Euplacella)* sp. #1949, #2820, *C. (Cladochalina) vaginalis, C. (Toxochalina)* sp. #3504

-south east Queensland (CEB): *C. (Euplacella)* spp #387, #1176
-north coast (NP): *C. (Cladochalina) diffusa*
-south west coast (SWB): *C. (Euplacella)* sp. #715, *C. (Spinosella)* sp. #734



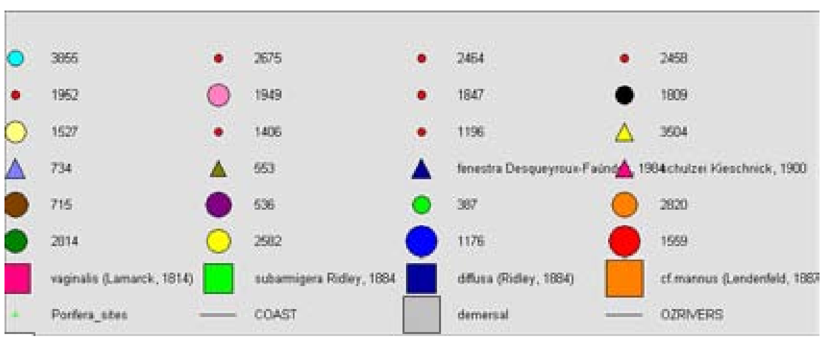


FIG. 127. *Callyspongia* (*Cladochalina* (squares), *Toxochalina*, *Spinosella* (triangles) and *Euplacella* (circles) spp (circles) (QM Biolink database)

***Callyspongia* (*Callyspongia*) spp (Demospongiae: Haplosclerida: Callyspongiidae) (Fig. 128-129)**

Bioregional trends: Highly diverse subgenus, and very abundant in some habitats; predominant in the tropics and especially on the GBR; highest diversity in the central-southern GBR, with northern and southern GBR bioregions differentiated on the basis of species diversity and species composition; poor diversity in temperate waters.

Summary details: *Callyspongia (Callyspongia)* is one of the most diverse of all sponge subgenera, with database records containing 145 spp, only 11 so far named, distributed throughout Australian waters. Species with only single records are not differentiated on maps presented here. The highest diversity is in the tropics, particularly on the north east coast, with differential peaks in diversity occurring in the northern GBR (NEB: 40 spp), central and southern GBR (NEP: 52 spp), south east Queensland (CEB: 19 spp), central south east coast (CEP: 6 spp), north coast (NP: 15 spp) and north west coast (NWP: 13 spp). In some regions populations are highly abundant although not necessarily accompanied by high species diversity (e.g. Darwin and North West Shelf region). A few species have wide distributions throughout tropical Australasia (e.g. *C. (C.) aerizusa*, *C. (C.) carens, C. (Callyspongia)* sp. #108, #138, #3070), or within broad bioregions such as the GBR (NEB-NEP: *C. (Callyspongia)* spp #1369, #1946,

#2022, #2025, #2879, #2998), or the north west and north coasts (NWP-NP: *C. (Callyspongia)* sp. #102, #233), whereas most species are restricted to single bioregions:
-north GBR (NEB): *C. (C.) communis, C. (C.)* spp #1203, #1300, #2392, #2393, #2395, #2673, #3127, #3206, #3266
-central and south GBR (NEP): *C. (C.)* spp #234, #385, #1379, #1837, #2695, #2798, #2935
-south east Queensland (CEB): *C. (C.)* spp #672, #916, #1116, #2498, $2976
-central south east coast (CEP): *C. (C.) trichita, C. (C.)* sp. #1452, #1898
-Tasmania (TasP): *C. (C.)* sp. #3296
-southern Gulf (GulfP): *C. (C.)* sp. #532
-north coast (NP): *C. (C.)* sp. #234, #1314, #2709
-north west coast (NWP): *C. (C.)* sp. #407, #553, #1819
-south west coast (SWB): *C. (C.)* sp. #755

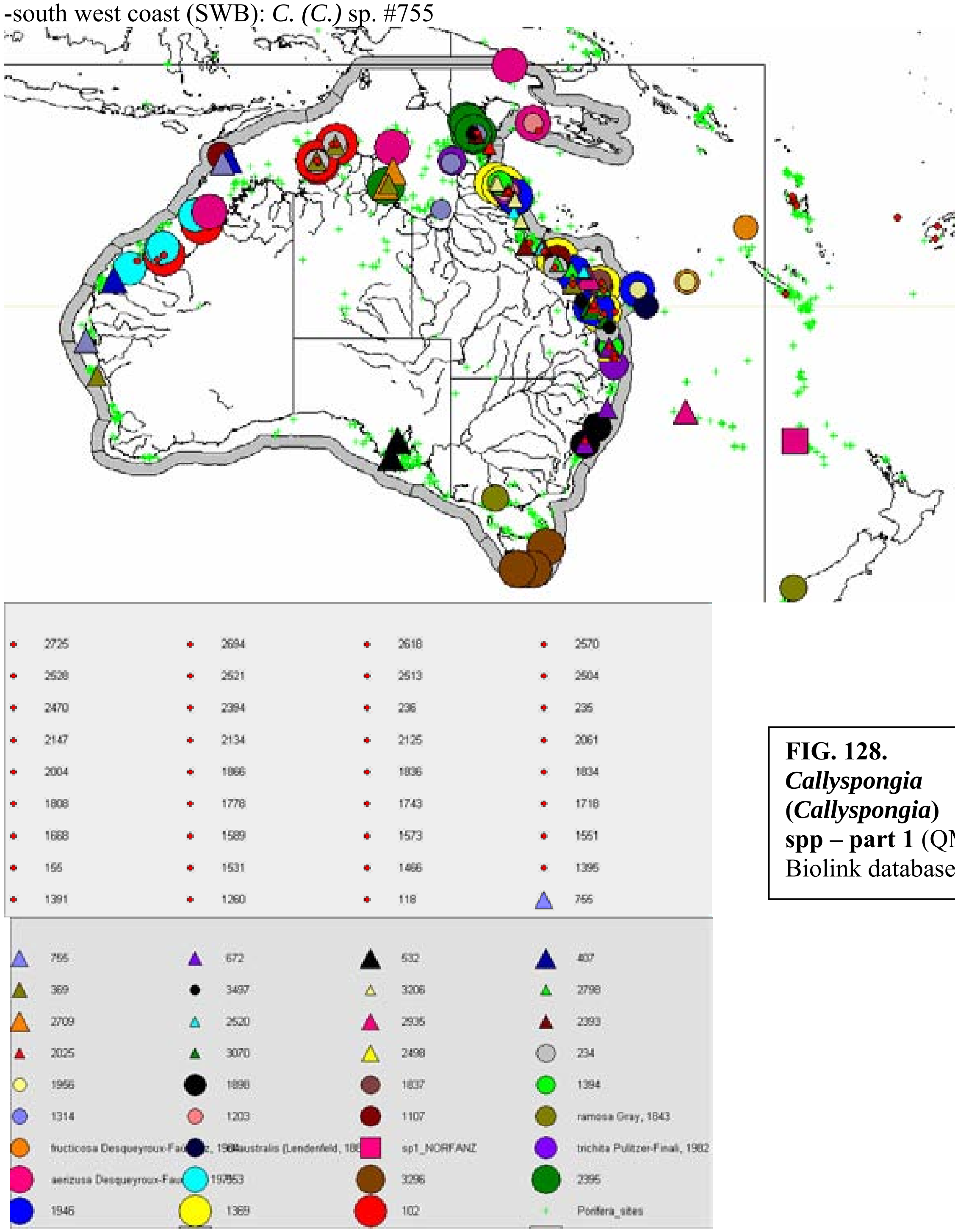


FIG. 128. ***Callyspongia* (*Callyspongia*) spp – part 1** (QM Biolink database)

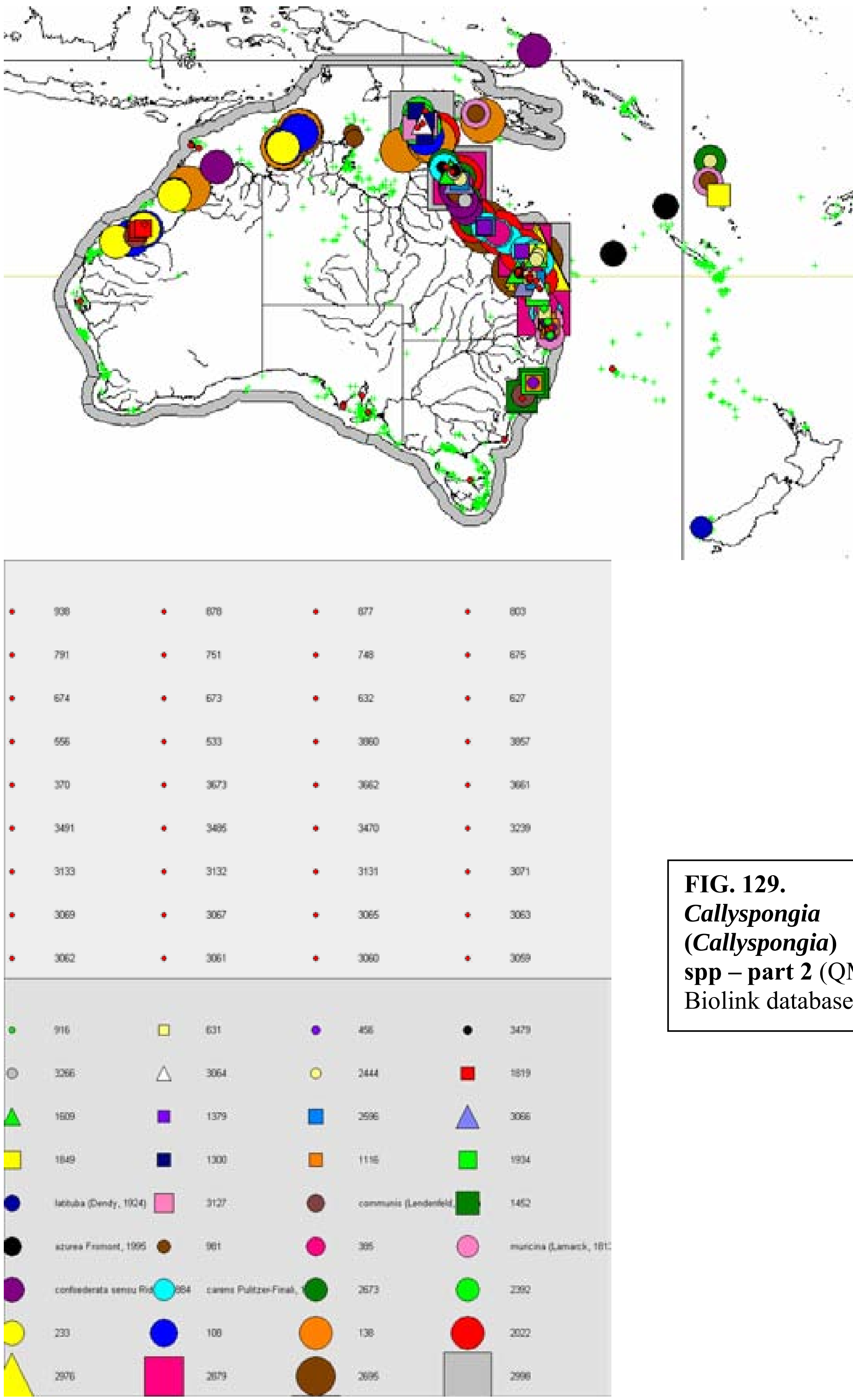


FIG. 129. *Callyspongia* (*Callyspongia*) spp – part 2 (QM Biolink database)

Family Chalinidae Gray, 1867

36. *Haliclona (Gellius, Reniera, Rhizonera), Chalinula* and *Cladocroce* spp (Demospongiae: Haplosclerida: Chalinidae) (Fig. 130)

Bioregional trends: Nearly exclusively tropical distribution, with highest diversity on the GBR and south east Queensland regions; north and south GBR regions not well differentiated, but north eastern and north/ northwestern faunas clearly differentiated in composition.

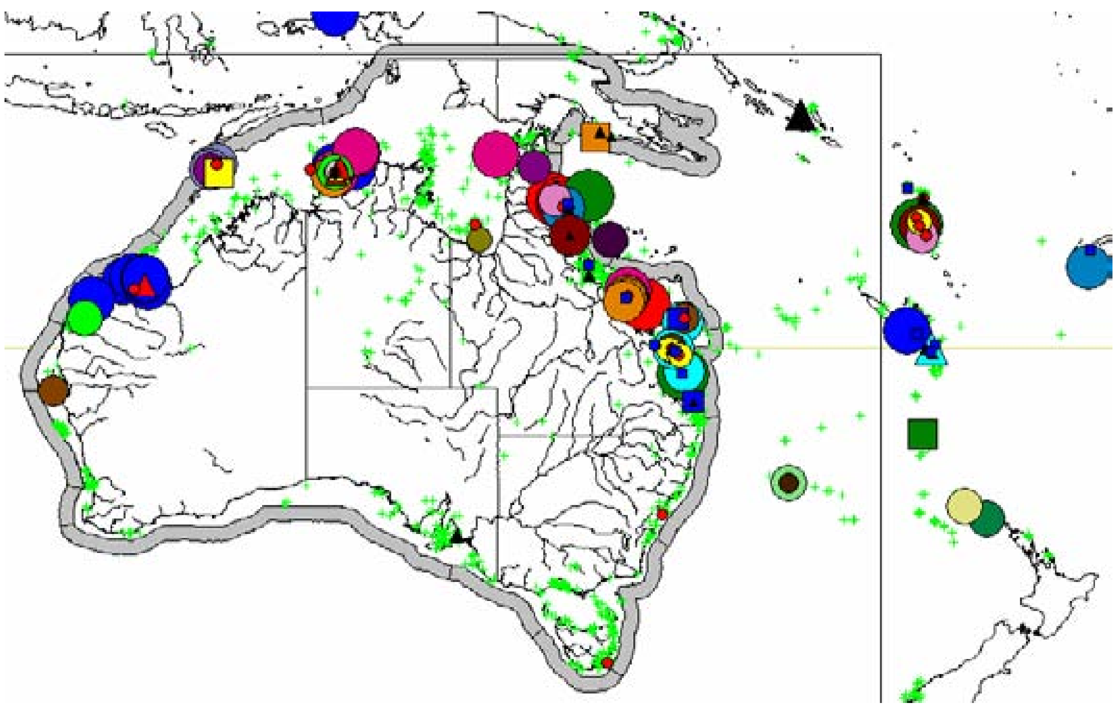
Summary details: *Haliclona (Gellius)* (15 unnamed spp), *H. (Reniera)* (43 spp, 3 named), *H. (Rhizonera)* (1 unnamed sp.), *Chalinula* (10 spp, 1 named) and *Cladocroce* (5 spp, 1 unnamed) are recorded in database records, with nearly exclusively tropical distributions. Species with only single records are not differentiated on maps presented here. Peaks in diversity occur in the northern GBR (NEB: 15 spp), central GBR to south east Queensland (NEP-CEB: 21 spp), Darwin region (western part of NP: 10 spp) and north west coast (NWP: 8 spp). Few species are distributed across more than one bioregion with the exception of *H. (Reniera) rosea* on the north coast to the central GBR region (NP-NEP), *H. (Reniera)* spp #90, #607 on the north west and north coast (NWP-NP), and *H. (Reniera)* spp #1733, #2182 along the GBR. Northern and southern GBR bioregions poorly differentiated but fauna on east and north/ north west coast well differentiated in their species composition and species diversity. Other species are markers for particular bioregions:

-north GBR (NEB): *H. (Reniera)* spp #801, #2067, #2555

-south GBR and south east Queensland (NEP-CEB): *H. (Reniera)* sp. #753, #1292, #2466

-north coast (NP): *H. (Reniera)* sp. #95, *H. (Gellius)* sp. #195

-north west coast (NWP): *H. (Reniera)* sp. #789, *Chalinula confusa*



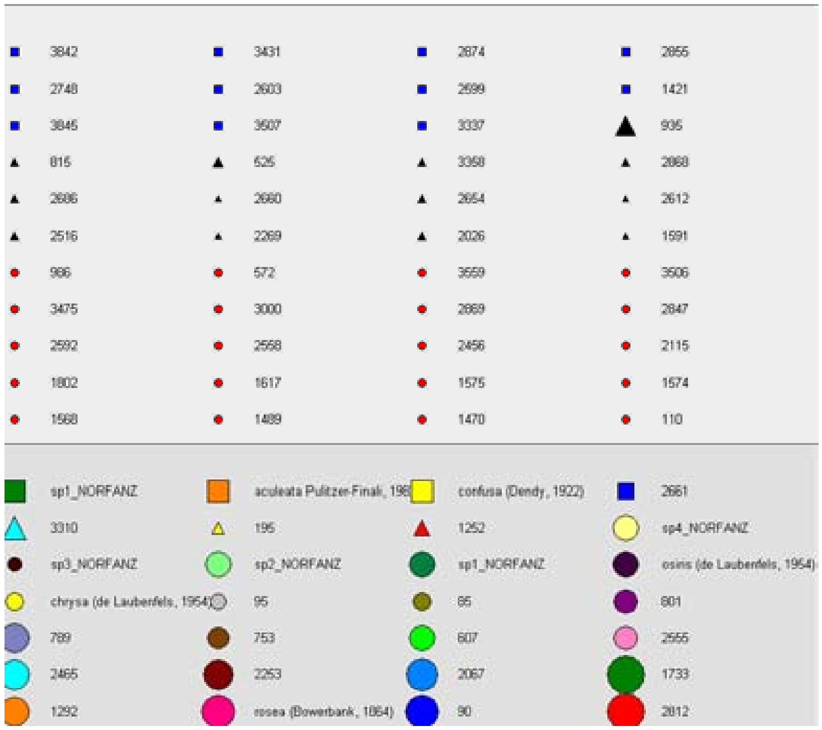


FIG. 130. ***Chalinula, Cladocroce*** **(squares),** ***Haliclona (Gellius, Rhizoniera)*** **(triangles),** ***Haliclona (Reniera)*** **(circles)** (QM Biolink database)

Haliclona (Haliclona) **spp (Demospongiae: Haplosclerida: Chalinidae) (Fig. 131-132)**

Bioregional trends: Predominantly tropical, highly diverse, often highly abundant in coral reef habitats; most diverse on the GBR (but without any significant differentiation of northern and southern GBR bioregions), and in the western part of NP; apart from a few widely distributed species north east and north west faunas are significantly different in terms of species composition and species diversity.

Summary details: *Haliclona (Haliclona)* (105 spp, only 11 named) is highly diverse, widely distributed, predominant in (but not confined to) tropical coral reef habitats where they may be very abundant in local populations. Peaks of diversity are in the northern GBR (NEB: 26 spp), central and southern GBR (NEP: 24 spp), and north coast (primarily the western part of NP: 27 spp), with significantly fewer species in south east Queensland (CEB: 4 spp), central south east coast (CEP: 2 spp), and north west coast (NWP: 15 spp). Species with only single records are not differentiated on maps presented here. Northern and southern GBR bioregions are not significantly differentiated by either species composition or species diversity, with most species spanning the GBR. One species (*H. (H.) cymaeformis*, containing an obligatory algal symbiont) is widely distributed throughout the tropics and subtropics, extending from the southern GBR (NEP) to the south west coast (SWB). Several species (*H. (H.) aculeate, H. (H.)* spp #1205, #1381, #1515, #1954) are distributed throughout the GBR, and two (*H. (H.)* spp #36, #384) are found on the north west and north coasts (NWP-NP). Other species are generally restricted to one or few bioregions:
-north GBR (NEB): *H. (H.) nematifera, H. (H.)* spp #65, #1581, #2685
-south GBR (NEP): *H. (H.)* spp #628, #1031, #1971, #2164, #2843
-south east Queensland (CEB): *H. (H.)* sp. #1892
-central south east coast (CEP): *H. (H.) venustina, H. (H.)* spp #3573, #3574
-Tasmania-Bass Strait (TasP-BassP): *H. (H.)* spp #858, #3286, #3669, #3671
-north coast (NP): *H. (H.) amboinensis, H. (H.) turquoisia, H. (H.) pigmentifera, H. (H.)* spp #47, #64, #144, #147, #238, #1311
-north west coast (NWP): *H. (H.) lamellata, H. (H.)* spp #164, #175, #697, #760
-south west coast (SWB): *H. (H.)* spp #735, #737, #750

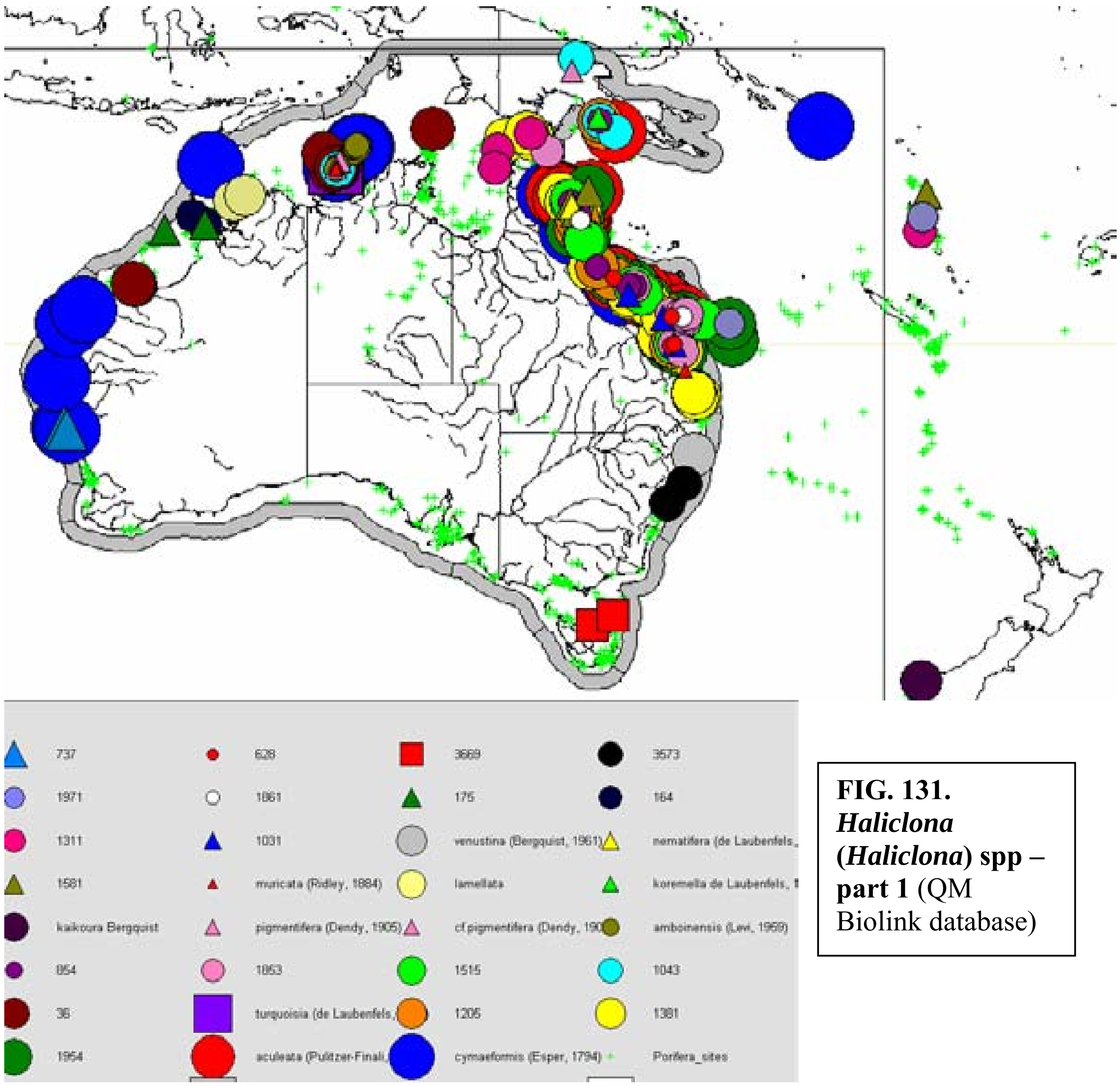


FIG. 131. *Haliclona* (*Haliclona*) spp – part 1 (QM Biolink database)

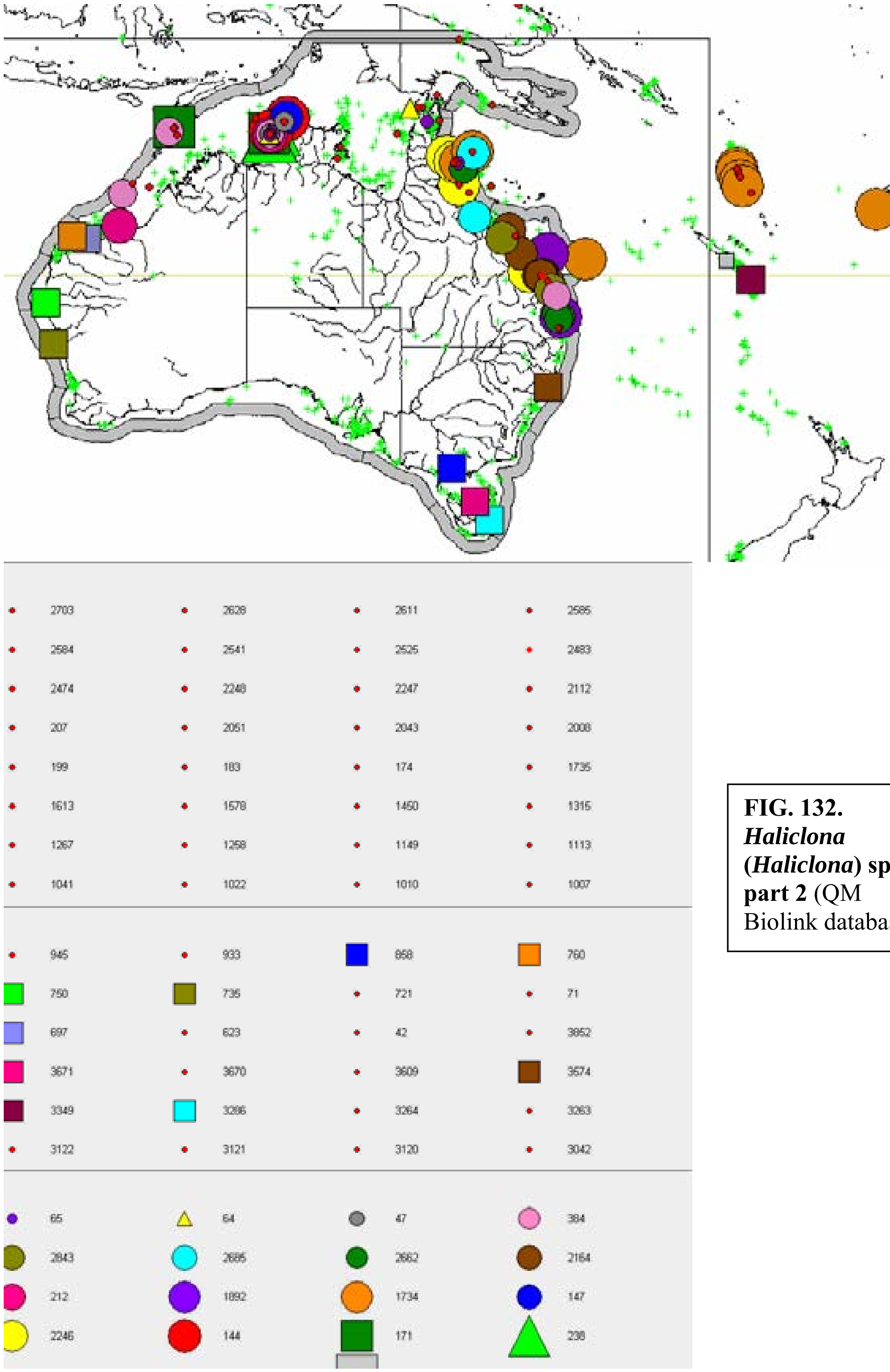


FIG. 132. *Haliclona* (*Haliclona*) spp – part 2 (QM Biolink database)

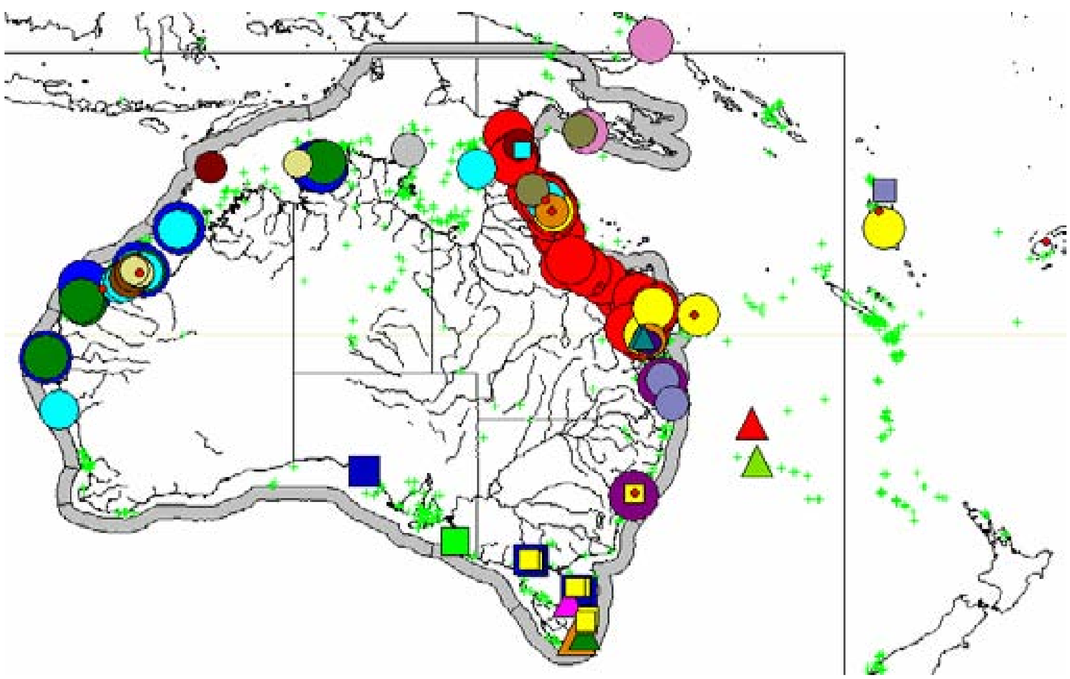
Family Niphatidae Van Soest, 1980

37. *Amphimedon, Hemigellius* and *Microxina* spp (Demospongiae: Haplosclerida: Niphatidae) (Fig. 133)

Bioregional trends: Predominantly tropical, not highly diverse but frequently abundant at some localities; distinctive north eastern, north western and south eastern faunas with little overlap in species composition; species diversity approximately similar on both sides of the continent; northern and southern GBR bioregions not differentiated.

Summary details: *Amphimedon* (32 spp, 3 named), *Hemigellius* (2 unnamed spp) and *Microxina* (3 unnamed spp) are predominantly tropical in distribution, with distinctive east and west coast faunas, with few species spanning both sides of the continent (*Amphimedon* sp. #167 extends from the south west coast to the northern GBR, SWB-NEB). Species with only single records are not differentiated on maps presented here. Peaks in diversity occur on the northern GBR (NEB: 9 spp), southern GBR (NEP: 8 spp), south east Queensland (CEB: 2 spp), north coast (NP: 7 spp), north west coast (NWP: 6 spp). There are several species widely distributed between adjacent bioregions, markers for these larger biomes: *Amphimedon* spp #365, #382 extending from the mid west coast to the north coast and constituting a north western fauna (CWP-NP); *A. terpensis* along the length of the GBR (NEP-NEB) – a north eastern fauna; *Hemigellius* sp. #513 along the south coast (GulfP-BassP), and *Microxina* sp. #884 in the south east corner (BassP-CEP). North and south GBR regions not clearly differentiated. Other species are restricted to one or few bioregions:

-north GBR (NEB): *Amphimedon* sp. #2641, *Microxina* sp. #840
-south GBR (NEP): *A. sulcata*, *Amphimedon* sp. #3049
-south east Queensland (CEB): *Amphimedon* sp. #2776
-central south east coast (CEP): *Amphimedon* sp. #1399
-Tasmania and Bass Strait (TasP-BassP): *Amphimedon* spp #3440, #3558, #3664
-north coast (NP): *A. paraviridis*
-northwest coast (NWP): *Amphimedon* sp. #1789



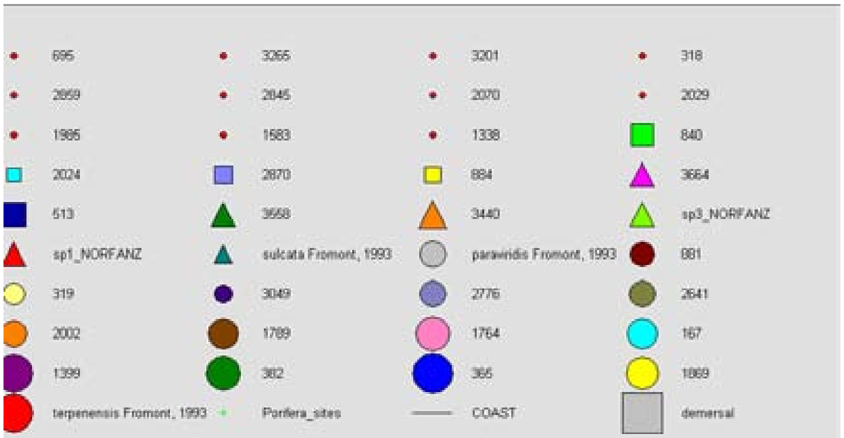


FIG. 133. *Amphimedon* (circles, triangles), *Hemigellius* and *Microxina* spp (squares) (QM Biolink database)

***Cribrochalina* and *Gelliodes* spp (Demospongiae: Haplosclerida: Niphatidae) (Fig. 134)**

Bioregional trends: Predominantly tropical, with highest diversity in the northern GBR and north west coast; on the east coast diversity decreases from north to south; eastern and western coastal faunas marginally differentiated based on species composition.

Summary details: *Cribrochalina* (40 spp, only 3 named) and *Gelliodes* (16 spp, 1 named) are predominantly tropical, with peaks of diversity on the northern GBR (NEB: 21 spp), southern GBR (NEP: 14 spp), south east Queensland (CEB: 4 spp), north coast (NP: 9 spp), north west coast (12 spp). Species with only single records are not differentiated on maps presented here. Several species have broader tropical distributions (*G. fibulatus*), or predominantly north-northwest tropical (NWP-NP: *C. olemda, Cribrochalina* spp #560, #1293, *Gelliodes* sp. #337), south to north west coast (SWB-NWP: *Gelliodes* sp. #555), or along the entire GBR (CEB-NEB: *Cribrochalina* sp. #2178, *Gelliodes* spp #1215, #1383, #1621), whereas others are more useful markers for particular bioregions:

-north GBR (NEB): *Cribrochalina* spp #1303, #2563, *Gelliodes* spp #1618, #2244
-south BR (NEP): *Cribrochalina* spp #1367, #2163
-south east Queensland (CEB): *Cribrochalina* sp. #2666, *Gelliodes* sp. #1177
-central south east coast (CEP): *Cribrochalina* sp. #1359
-Tasmania and Bass Strait (TasP-BassP): *Cribrochalina* spp #1412, #3560, #3663, #3679, *Gelliodes* sp. #3441
-north coast (NP): *Gelliodes* sp. #777
-north west coast (NWP): *Cribrochalina* sp. #318, *Gelliodes* sp. #619
-south west coast (SWB): *Cribrochalina* sp. #742

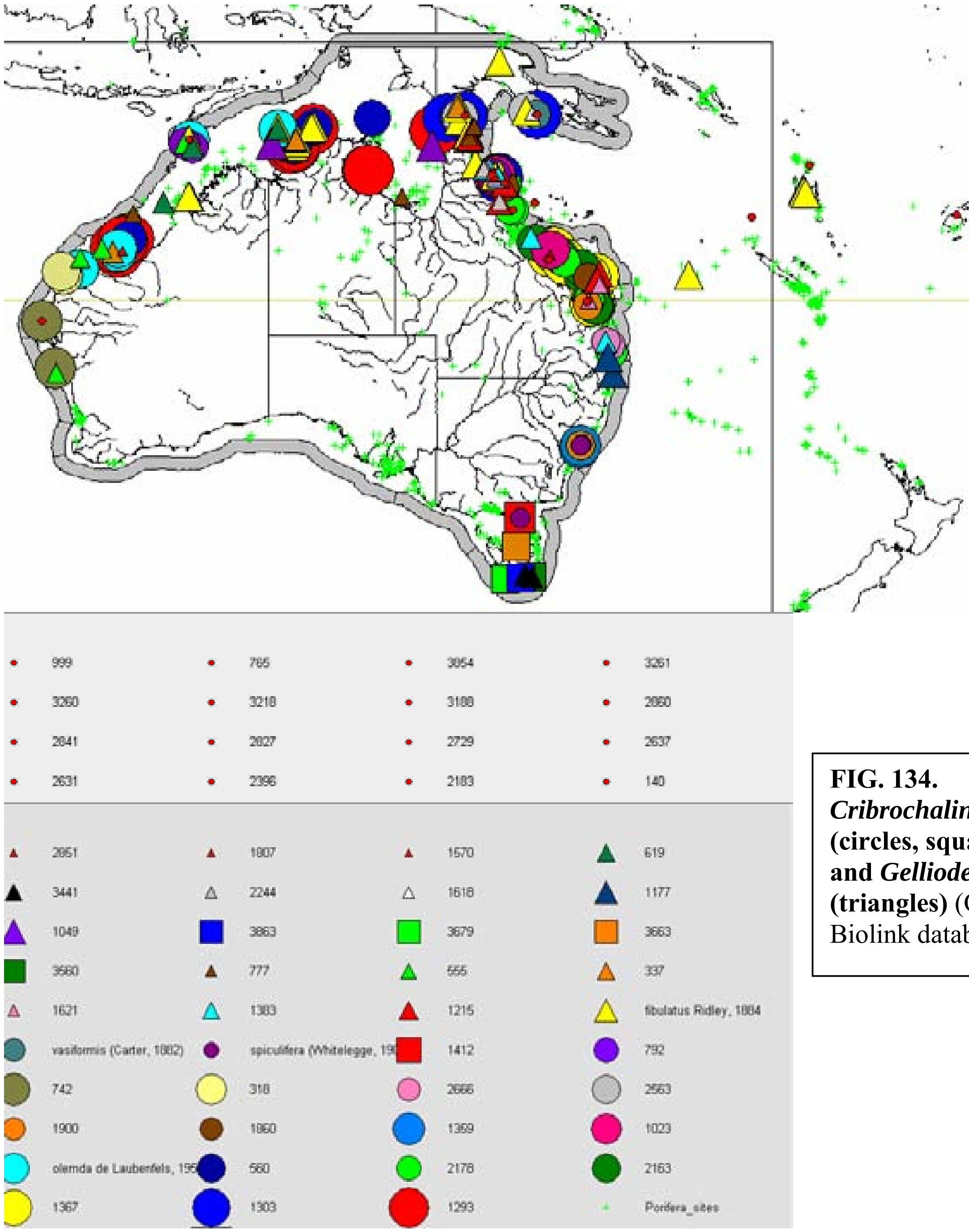


FIG. 134. *Cribrochalina* (circles, squares), and *Gelliodes* spp (triangles) (QM Biolink database)

***Niphates* spp (Demospongiae: Haplosclerida: Niphatidae) (Figs 135-136)**

Bioregional trends: Predominantly tropical, with west and east coast faunas distinctively different; GBR with overwhelmingly highest diversity, but no clear differentiation of northern and southern GBR bioregions; only one widely distributed tropical species spanning both east and west coast faunas, but several species within each of these faunas defining broader continental bioregions.

Summary details: *Niphates* (95 spp, only 1 named so far), is highly diverse, with database records mainly from tropical bioregions, and peaks of diversity occurring on the GBR (northern GBR (NEB: 29 spp), southern GBR (NEP: 33 spp)), diminishing southwards (south east Queensland (CEB: 13 spp)) and westwards (NP: 6spp). Species with only single records are not differentiated on maps presented here. West and east coast faunas are substantially differentiated

by their respective species compositions and levels of species diversity, with only one species (*Niphates* sp. #321) found on both sides of the continent. Within each of these continental faunas, however, several species are markers for the broad adjacent bioregions, spanning the length of either the west (SWB-NP: *Niphates* spp #307, #320) or east coasts (CEB-NEB: *Niphates* spp #1122, #1943, #586, 1980). North and south GBR bioregions are not clearly differentiated by either their species diversity or species composition.
-north GBR (NEB): *Niphates* spp #1821, #1569, #2023, #2391
-south GBR (NEP): *Niphates* spp #1234, #2857, #2678, #2687, #2697
-south east Queensland (CEB): *Niphates* sp. #2331, #2665, #3081
-central south east coast (CEP): *Niphates* sp. #3579
-Tasmania-Bass Strait (TasP, BassP): *Niphates* sp. #3665
-north west coast (NWP): *Niphates* sp. #321
-south west coast (SWB): *Niphates* sp. #723, #1689

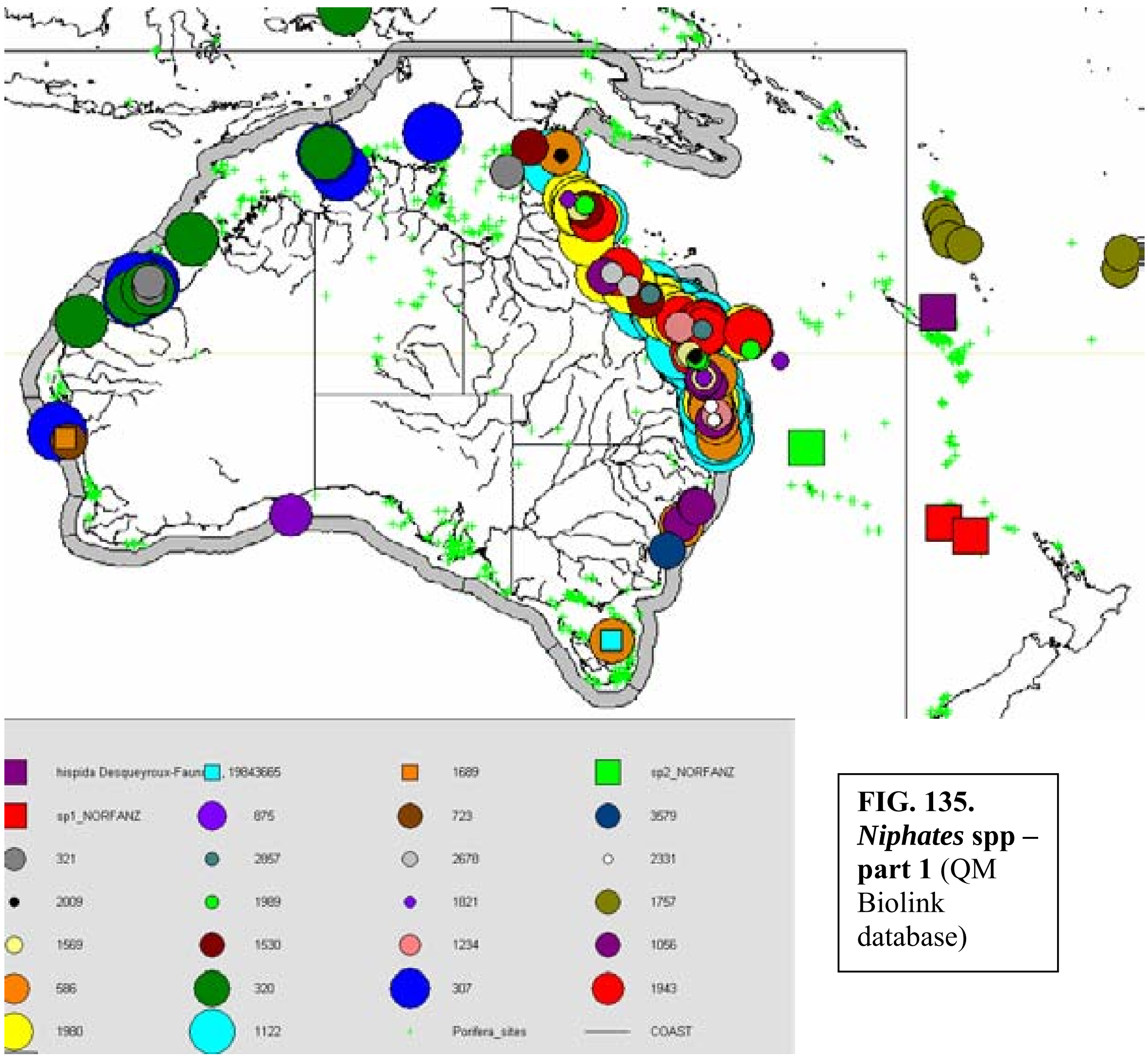


FIG. 135. *Niphates* spp – part 1 (QM Biolink database)

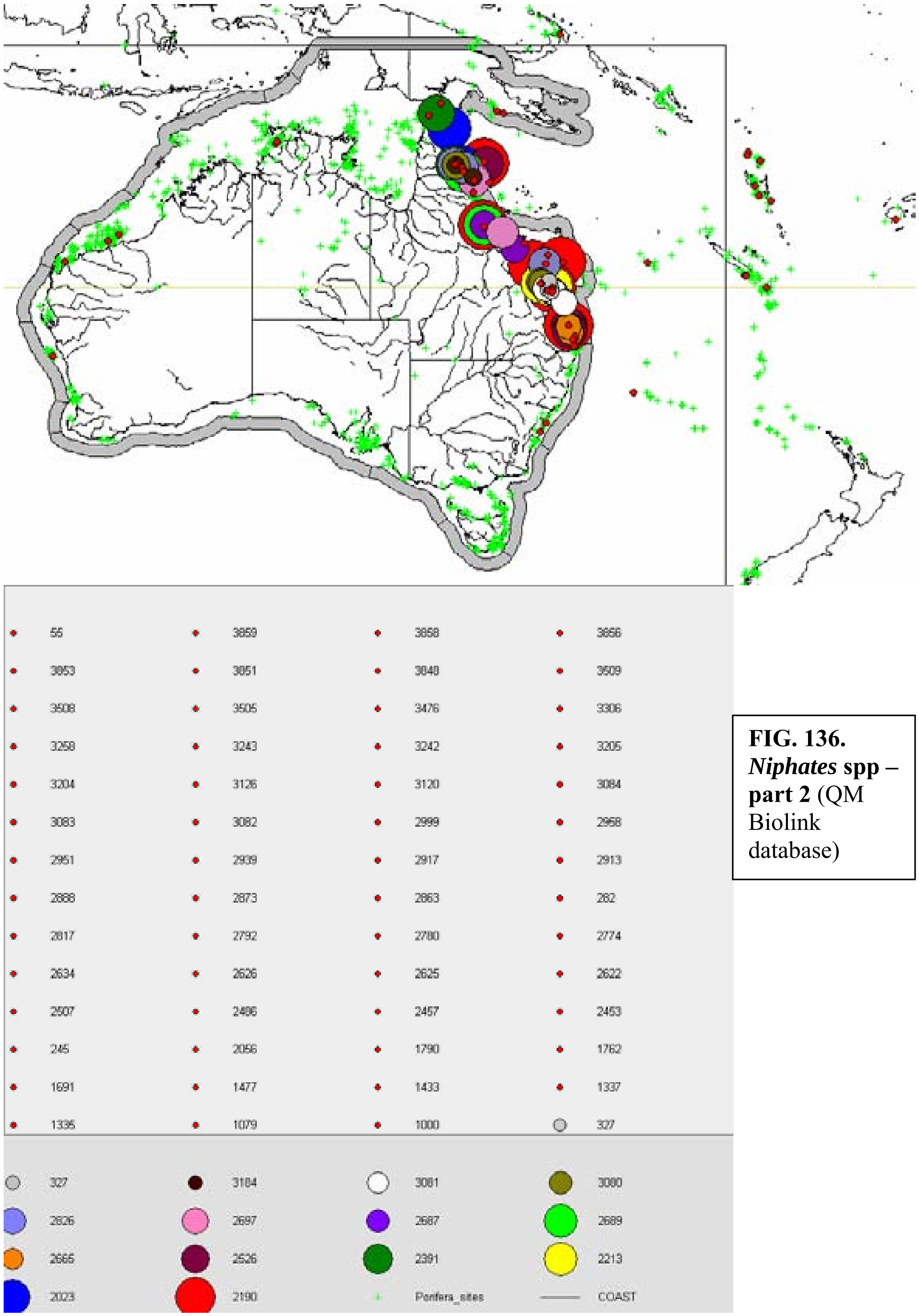


FIG. 136. *Niphates* spp – part 2 (QM Biolink database)

Suborder Petrosina Boury-Esnault & Van Beveren, 1982
Family Petrosiidae Van Soest, 1980

38. *Xestospongia* spp (Demospongiae: Haplosclerida: Petrosiidae) (Fig. 137)

Bioregional trends: Nearly exclusively tropical distribution with peak in diversity on the northern GBR, diminishing southwards and westwards.

Summary details: *Xestospongia* (30 spp, only 2 named), is represented in collections by mainly widely distributed tropical species, with peaks on diversity seen in the northern GBR (NEB: 11 spp), diminishing southwards (southern GBR (NEP: 7 spp), south east Queensland (CEB: 4 spp)) and westwards (north coast (NP: 5 spp), and north west coast (NWP: 3 spp)). Species are predominant in the inter-reef region and at the base of coral reefs, including the GBR. One species (*X. testudinaria*) occurs throughout the tropical Indo-west Pacific, sometimes with high population abundance at the small (local site) scale, and three other species (*X. bergquistia* (east coast), *Xestospongia* spp #158, #565 (north and north west coasts)) occur widely and sometimes in geographical sympatry with *X. testudinaria*. A few rare species can define particular bioregions:

-north GBR (NEB): *Xestospongia* spp #1726, #2387, #3179, #3198, #3257, #3808

-south GBR (NEP): *Xestospongia* spp #2133, #2853, #2937

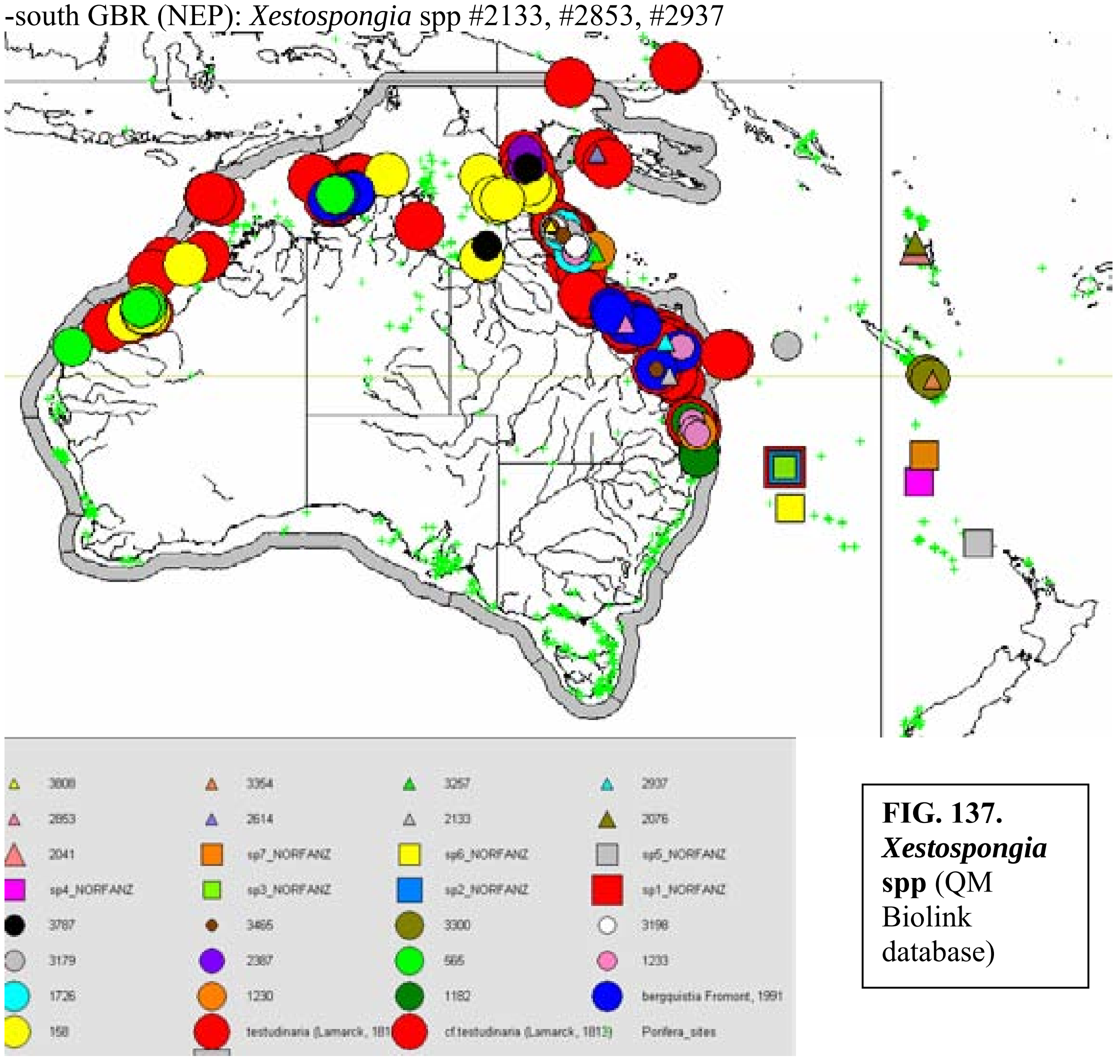


FIG. 137. *Xestospongia* spp (QM Biolink database)

***Acanthostrongylophora*, *Neopetrosia* and *Petrosia (Strongylophora)* spp (Demospongiae: Haplosclerida: Petrosiidae) (Fig. 138)**

Bioregional trends: Exclusively tropical; most common on GBR but without differentiation of northern and southern GBR bioregions; poor bioregional markers.

Summary details: *Acanthostrongylophora* (2 spp, 1 named), *Neopetrosia* (3 named spp) and *Petrosia (Strongylophora)* (9 spp, 2 named) are exclusively tropical, not diverse, and only two (cryptic) sibling species (*N. exigua*, *N. pacifica* – considered by some to be synonymous) common in tropical Australasia (from NWP-NEP). The GBR has six species, without any substantial differentiation between northern and southern bioregions. Neopetrosia is found exclusively associated with coral reefs, whereas *Acanthostrongylophora* and *Petrosia (Strongylophora)* are found in other habitats as well (e.g. soft benthos). No species appear to be useful markers for any bioregion.

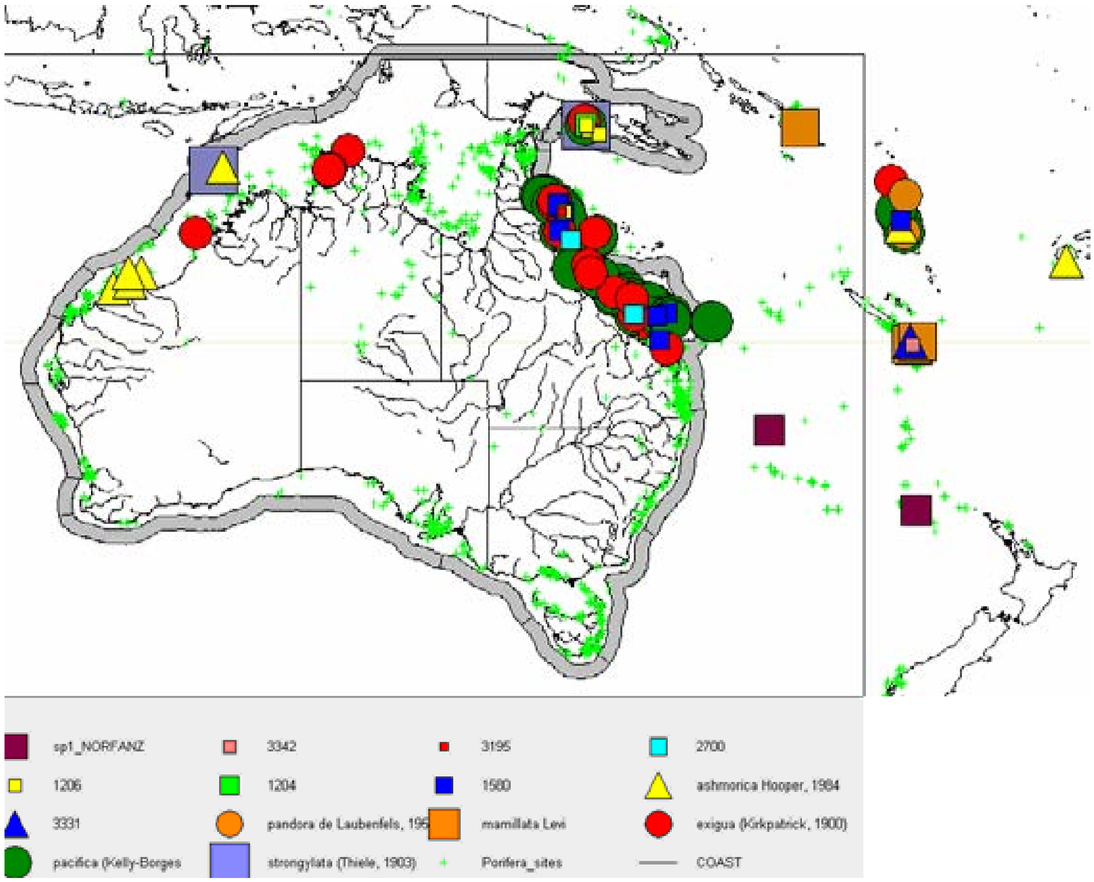


FIG. 138. *Acanthostrongylophora* (triangles), *Neopetrosia* (circles) and *Petrosia (Strongylophora)* spp (squares) (QM Biolink database)

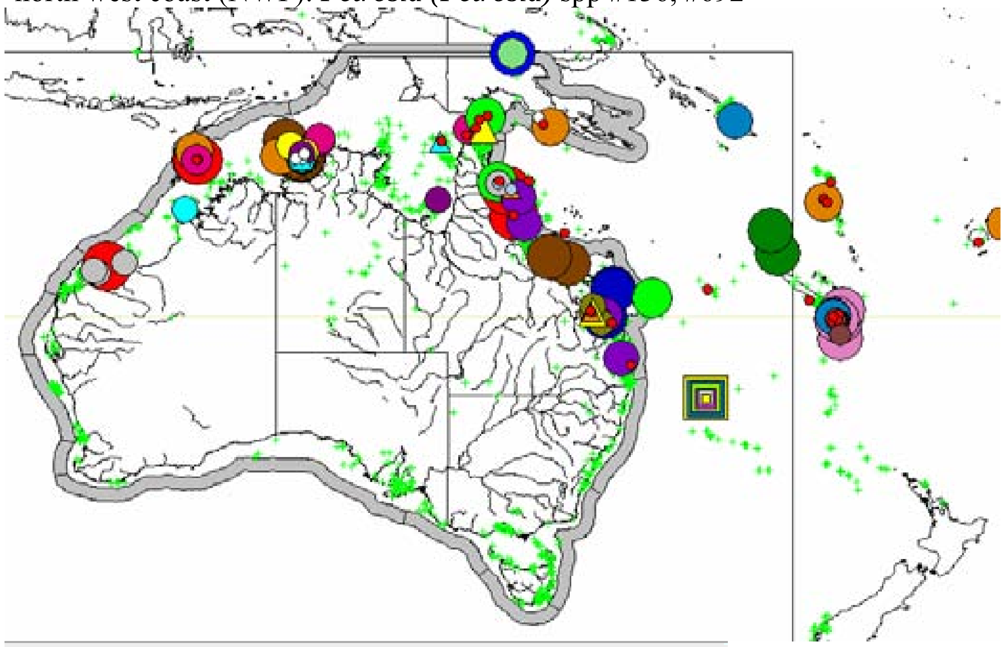
***Petrosia (Petrosia)* spp (Demospongiae: Haplosclerida: Petrosiidae) (Fig. 139)**

Bioregional trends: Predominantly tropical, coral reef species; peaks in the GBR and NP but little overlap between north GBR, south GBR and NP species composition.

Summary details: *Petrosia (Petrosia)* (56 spp, 7 named) are highly diverse but rarely abundant in any of the surveyed localities, predominantly tropical in distribution, and predominantly associated with coral reef habits. Species with only single records are not differentiated on maps presented here. Peaks in diversity occur in the Darwin region (NP: 8 spp), northern GBR (NEB: 15 spp) and southern GBR (NEP: 10 spp), with little overlap in species distribution between these three localities. A few species occur in both western and eastern continental faunas (*P. (P.) nigricans, P. crassa*) and two (*Petrosia (Petrosia)* sp. #113, #1021) occur across the tropical belt (NWP-NEB). Several species also occur in northern and southern bioregions of the GBR (CEB-NEB: *Petrosia (Petrosia)* spp #1976, #2197), with species composition differentiating both regions, but by-and-large most species are restricted to one or few adjacent bioregions:

-north GBR (NEB): *Petrosia (Petrosia)* sp. #3804

-south GBR (NEP): *Petrosia (Petrosia)* spp #1601, #3073, #3468
-north coast (NP): *Petrosia (Petrosia)* spp #134, #312, #357
-north west coast (NWP): *Petrosia (Petrosia)* spp #136, #692



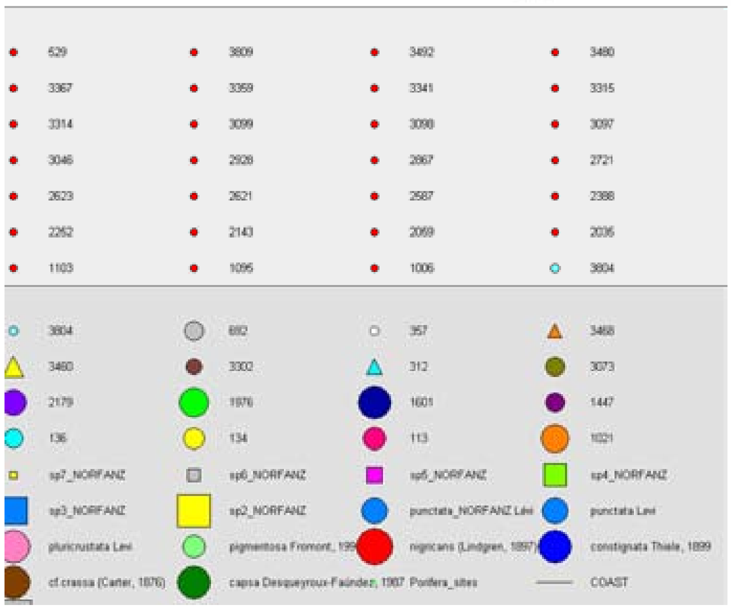


FIG. 139. *Petrosia (Petrosia)* spp (QM Biolink database)

Family Phloeodictyidae Carter, 1882

39. *Aka, Calyx* and *Pachypellina* spp (Demospongiae: Haplosclerida: Phloeodictyidae) (Fig. 140)

Bioregional trends: Nearly exclusively tropical distributions; equal diversity on eastern and western coasts; north and south GBR differentiated.

Summary details: *Aka* (26 spp, 2 named), *Calyx* (1 unnamed sp.) and *Pachypellina* (14 unnamed spp) are represented in collections by predominantly tropical species with diversity approximately similar on both sides of the continent: northern GBR (NEB: 7 spp), southern GBR (NEP: 6 spp), Darwin region (western part of NP: 8 spp) and north west coast (NWP: 10 spp). Species with only single records are not differentiated on maps presented here. Many species are bioeroding, boring into coralline substrates or embedded in soft sediments. Several species are distributed on both east and west coasts (NWP-NEP: *Aka mucosa*, *Aka* spp #331, #332), and one throughout the GBR (NEB-NEP: *Aka* sp. #1373), with several other species restricted to single bioregions. Northern and southern bioregions on the GBR are differentiated in terms of species composition.

-north GBR (NEB): *Aka* spp #1636,1736, 1738
-south GBR (NEP): *Aka* sp. #2169
-north west coast (NWP): *Pachypellina* sp. #566

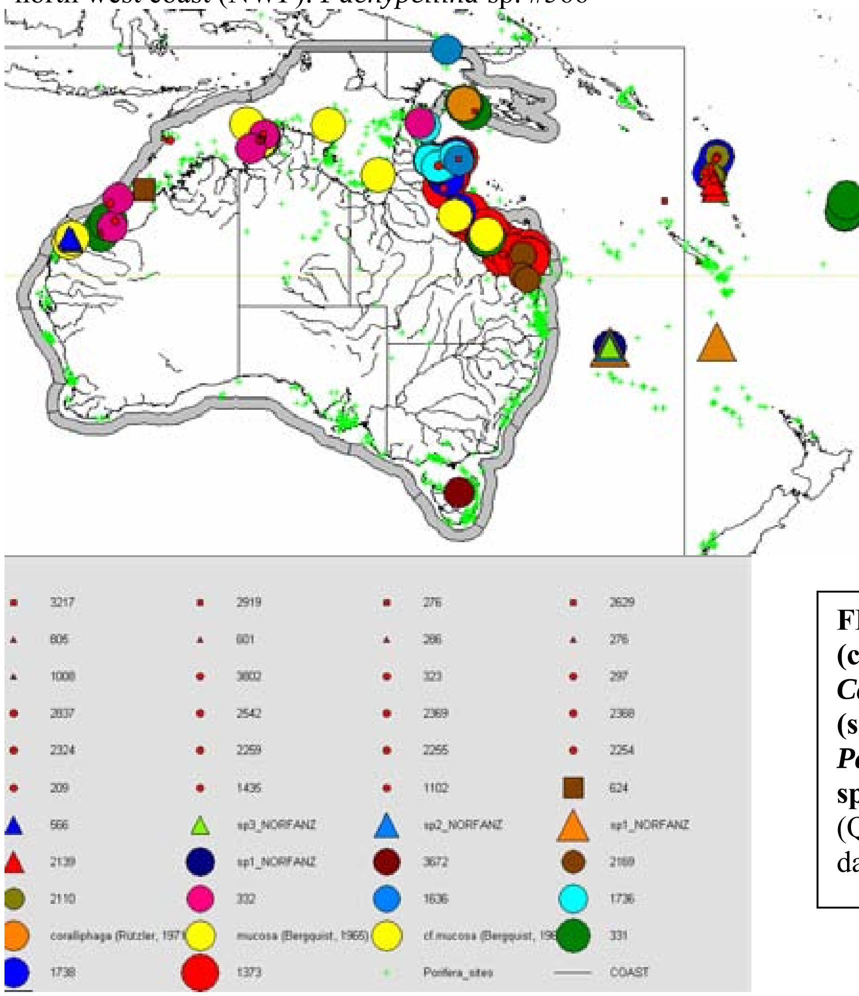


FIG. 140. *Aka* (circles), *Calyx* (squares) and *Pachypellina* spp (triangles) (QM Biolink database)

***Oceanapia* spp (Demospongiae: Haplosclerida: Phloeodictyidae) (Fig. 141)**

Bioregional trends: Ubiquitous in many marine habitats, highly diverse and frequently abundant in some; highest diversity in the soft sediments of NP and NWP, with lower diversity in the GBR; species composition clearly differentiates eastern and western NP faunas, and those in the GBR and NWP bioregions; north and south GBR bioregions not clearly delineated; east and west coast faunas clearly differentiated with only a few widely distributed species spanning both coasts.

Summary details: *Oceanapia* (73 spp, 9 named) are ubiquitous in nearly all habitats, ranging from bioeroding and burrowing into soft sediments to free-living on hard and soft substrata. Species database records are predominantly tropical although it is likely that further sampling of temperate habitats will uncover a similar high diversity. Species with only single records are not differentiated on maps presented here. Several species are widely distributed across east and west coasts (SWB-CEP: *O. ramsayi, Oceanapia* sp. #135), several are restricted to either western and north coasts (SWB-NP: *O. toxophila*, *Oceanapia* spp #94, #96; NWP-NP: *O. macrotoxa, Oceanapia* sp. #303) or to north east coasts (NEP-NEB: *O. renieroides, Oceanapia* sp. #1220).

Species are particularly diverse and frequently also abundant in the soft benthos of the Gulf of Carpentaria (eastern part of NP), the North West Shelf (NWP) and the inter-reef region of the GBR (NEB-NEP). The highest diversity occurs in the Darwin region (western NP: 18 spp) and Gulf of Carpentaria (eastern NP: 18 spp), with about half the species different between each of these zones, and with other peaks in diversity on the north west coast (NWP: 16 spp), northern GBR (8 spp), southern GBR (13 spp), south east Queensland (CEB: 6 spp) and south west coast (SWB: 8 spp). The northern and southern bioregions of the GBR are not well differentiated in terms of species diversity or species composition, but they differ significantly from more southern (CEB) and western (NP) faunas.

-north GBR (NEB): *O. sagittaria, Oceanapia* sp. #3100
-south GBR (NEP): *Oceanapia* spp #1384, #1868, #2835, #2940
-central south east coast (CEP): *Oceanapia* sp. #1353
-Gulf of Carpentaria (eastern NP): *Oceanapia* spp #669, #1312, #1313, #1321, #2401
-Darwin region (western NP): *O. amboinensis, Oceanapia* spp #192, #1291
-north west coast (NWP): *Oceanapia* sp. #563
-south west coast (SWB): *O. abrolhensis, Oceanapia* sp. #1692

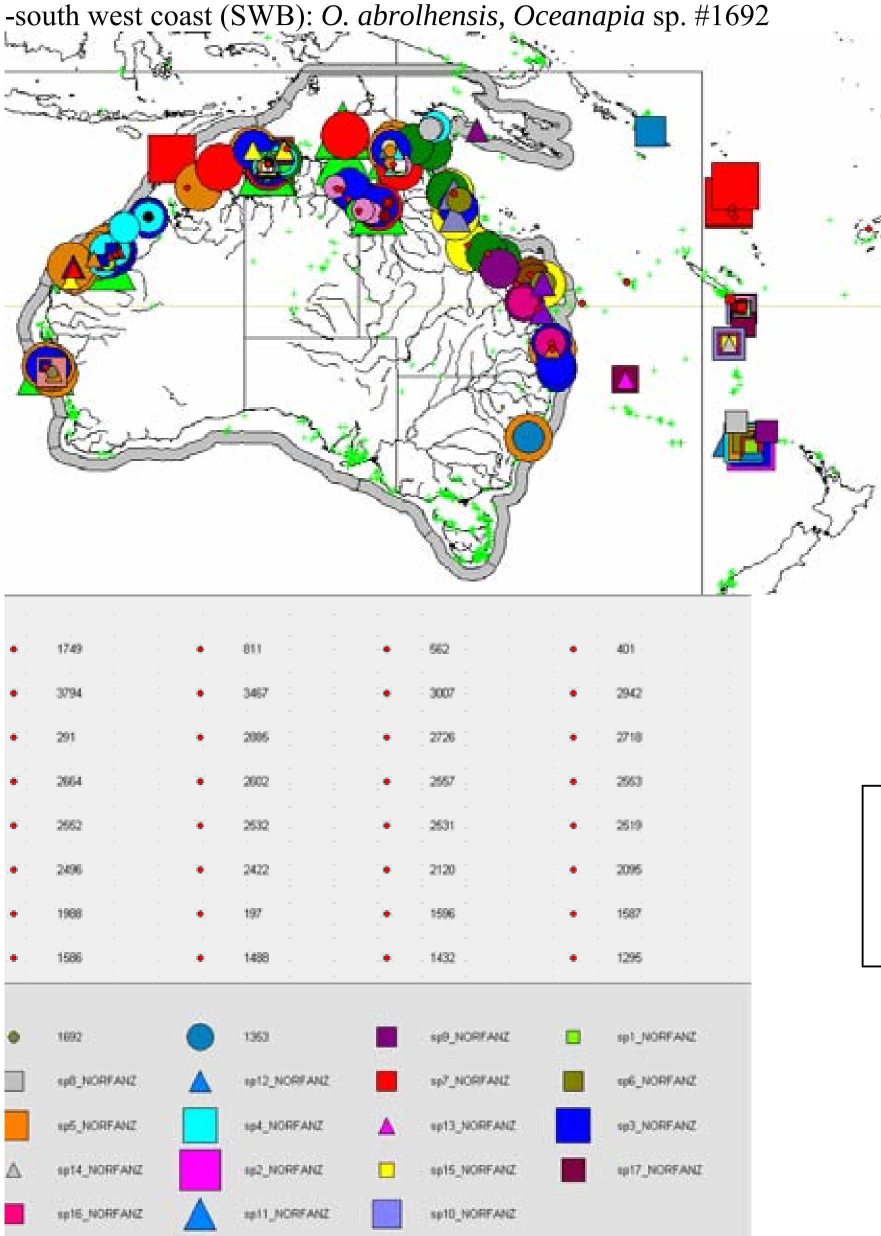
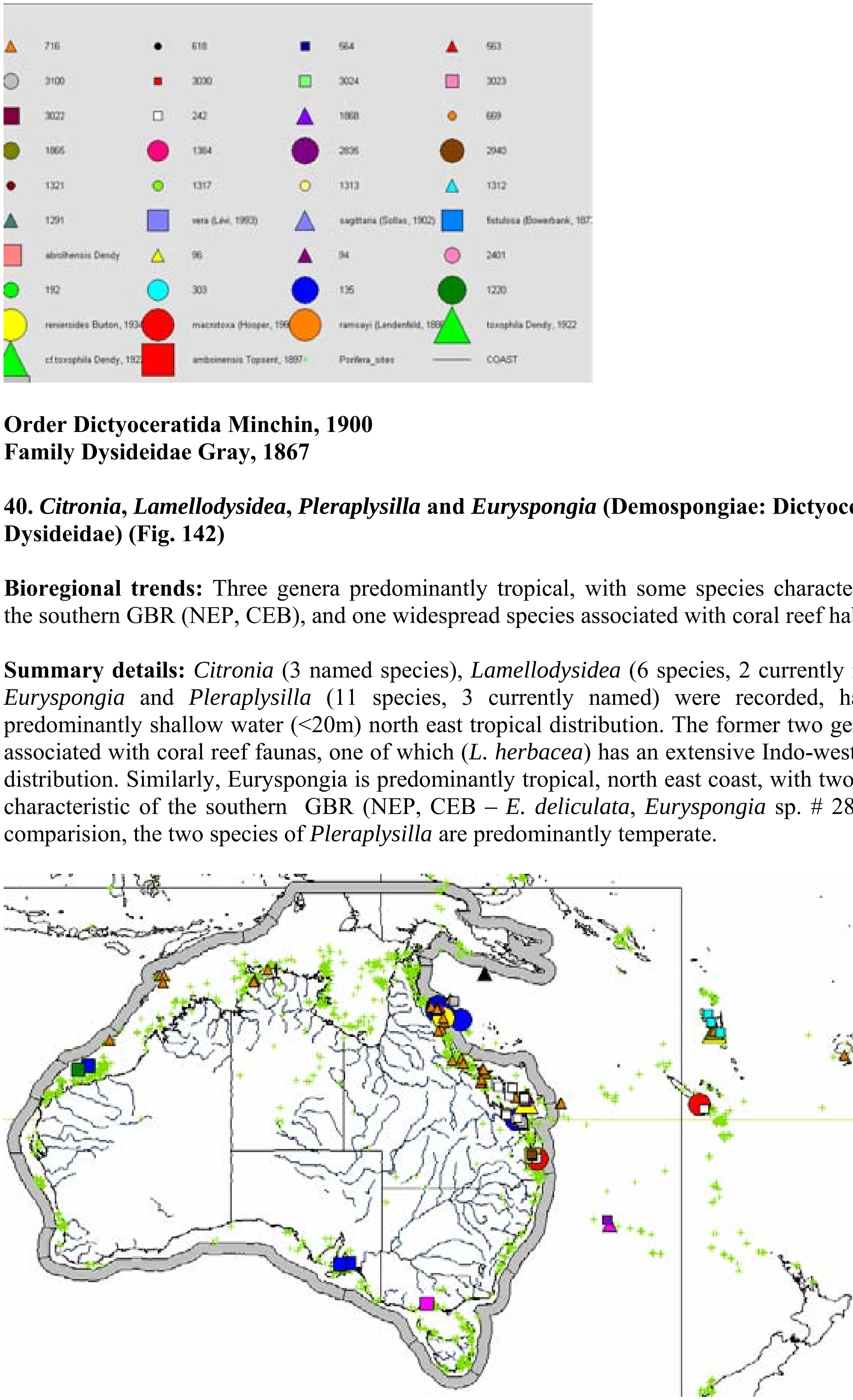


FIG. 141.
***Oceanapia* spp**
(QM Biolink database)



Order Dictyoceratida Minchin, 1900
Family Dysideidae Gray, 1867

40. *Citronia*, *Lamellodysidea*, *Pleraplysilla* and *Euryspongia* (Demospongiae: Dictyoceratida: Dysideidae) (Fig. 142)

Bioregional trends: Three genera predominantly tropical, with some species characteristic of the southern GBR (NEP, CEB), and one widespread species associated with coral reef habitats.

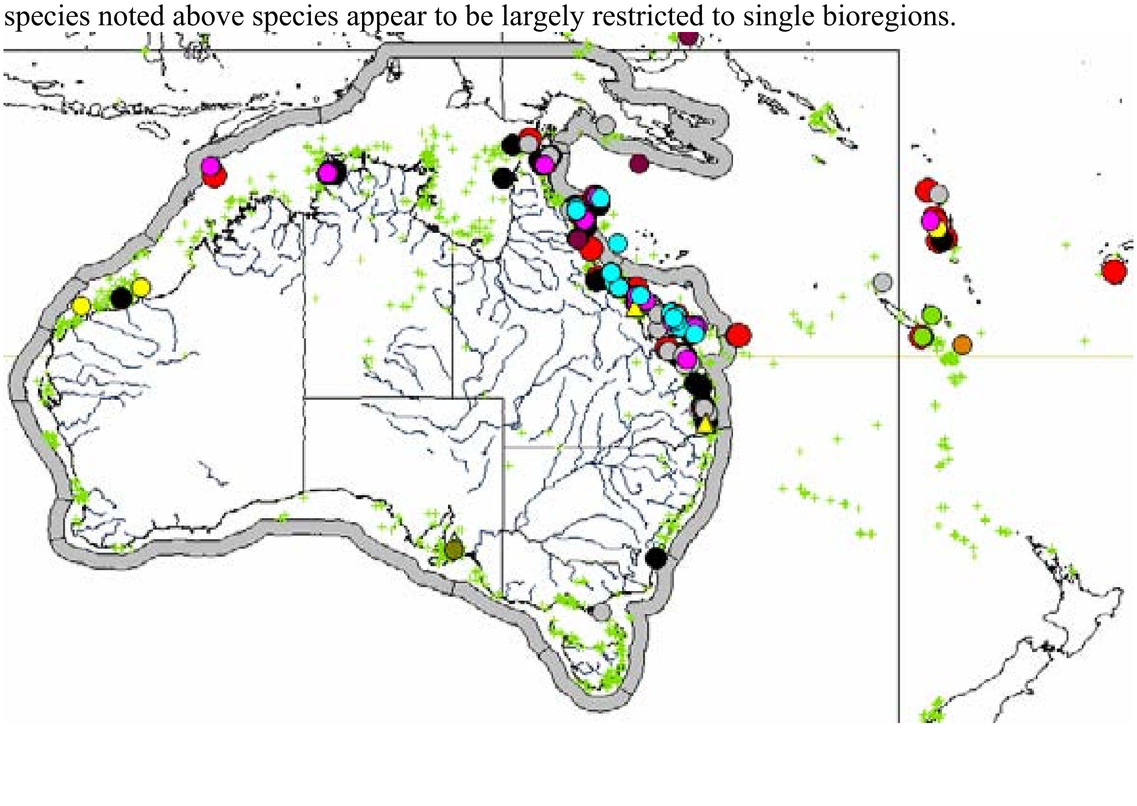
Summary details: *Citronia* (3 named species), *Lamellodysidea* (6 species, 2 currently named), *Euryspongia* and *Pleraplysilla* (11 species, 3 currently named) were recorded, having a predominantly shallow water (<20m) north east tropical distribution. The former two genera are associated with coral reef faunas, one of which (*L. herbacea*) has an extensive Indo-west Pacific distribution. Similarly, Euryspongia is predominantly tropical, north east coast, with two species characteristic of the southern GBR (NEP, CEB – *E. deliculata*, *Euryspongia* sp. # 2896). By comparision, the two species of *Pleraplysilla* are predominantly temperate.

FIG. 142. ***Citronia*** **(circles),** ***Lamellodysidea*** **(triangles),** ***Pleraplysilla*** **and** ***Euryspongia*** **spp (squares)** (QM Biolink database)

Dysidea **spp (Demospongiae: Dictyoceratida: Dysideidae) (Fig. 143-144)**

Bioregional trends: Probably a high proportion of species phototrophic. Few species with wide geographical distributions largely correspond to coral reef localities. Highest diversity in the southern and central GBR. Several species restricted to and indicative of particular tropical and temperate bioregions, and *Dysidea* species composition corroborates north – south split in GBR faunas.

Summary details: *Dysidea* is a highly diverse genus distributed predominantly (but not exclusively) in tropical shallow waters (<30m depth), and often also highly prevalent in population size, especially in coral reef habitats. Many species are host to a diversity of cyanobacterial symbionts and consequently many species may be at least partially phototrophic (hence their predominance in shallow, clear waters). Of 67 species recorded here only 12 can be presently assigned to a known taxon. Several species are widely distributed throughout tropical Australia, associated with the distribution of coral reefs themselves (*D. cf. avara*, *D. cf. pallescens*, *D. arenaria*, *Dysidea* sp. #16). Highest diversity (27 species) occurs in the southern and central GBR (CEB, NEP) – only species with more than one record are differentiated on maps. Other species appear to be more useful markers for particular bioregions: northern and central GBR (NEB, NEP) - *D. lizardensis* [a species name currently in manuscript], *Dysidea* spp #1214, #1547; far northern GBR (NEB) – *D. fragilis*, *Dysidea* spp #2266, #2920; central GBR (NEP) – *Dysidea* sp. #1848; southern GBR (CEB) – *Dysidea* spp #2389, #2905; eastern Gulf of Carpentaria (NP) – *Dysidea* sp. # 2389; central west coast (CWP, NWP) - *D. dakini*; south eastern coast (GulfP-WBassB) – Dysidea sp. #507. Aside from the four widely distributed species noted above species appear to be largely restricted to single bioregions.



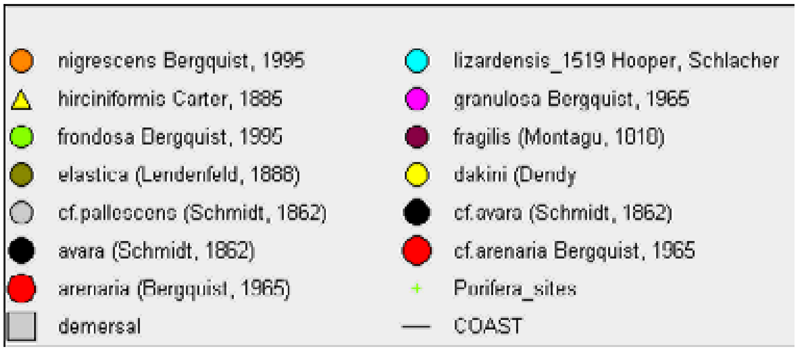


FIG. 143. ***Dysidea* spp – part 1** (QM Biolink database)

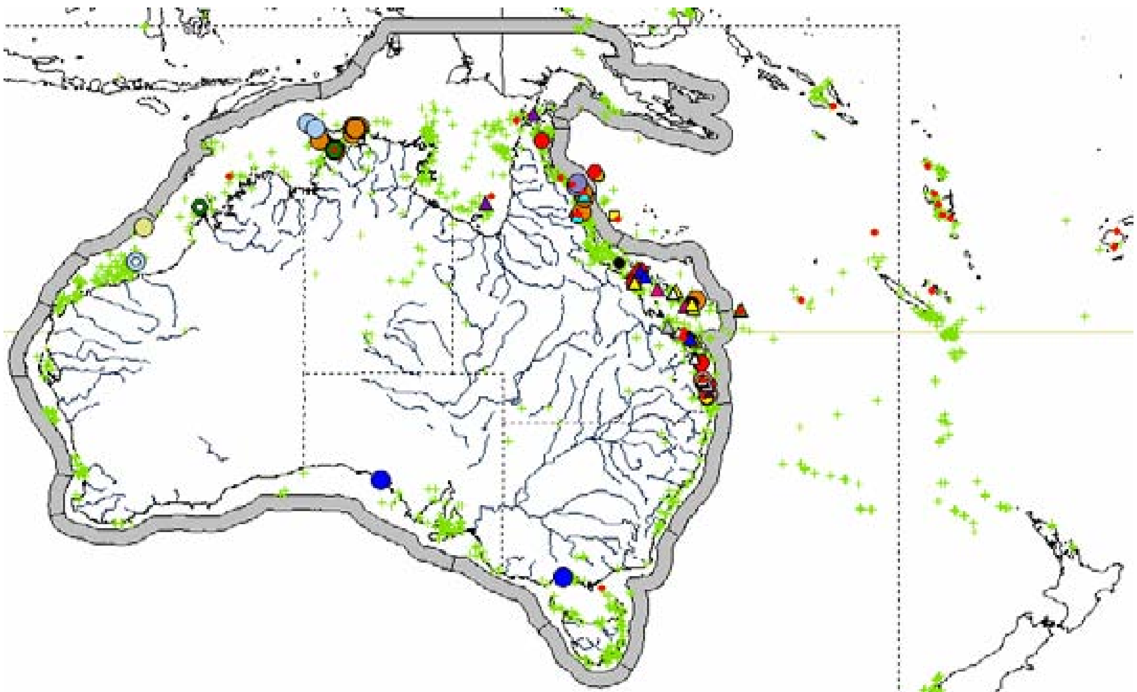


FIG. 144. ***Dysidea* spp – part 2** (QM Biolink database)

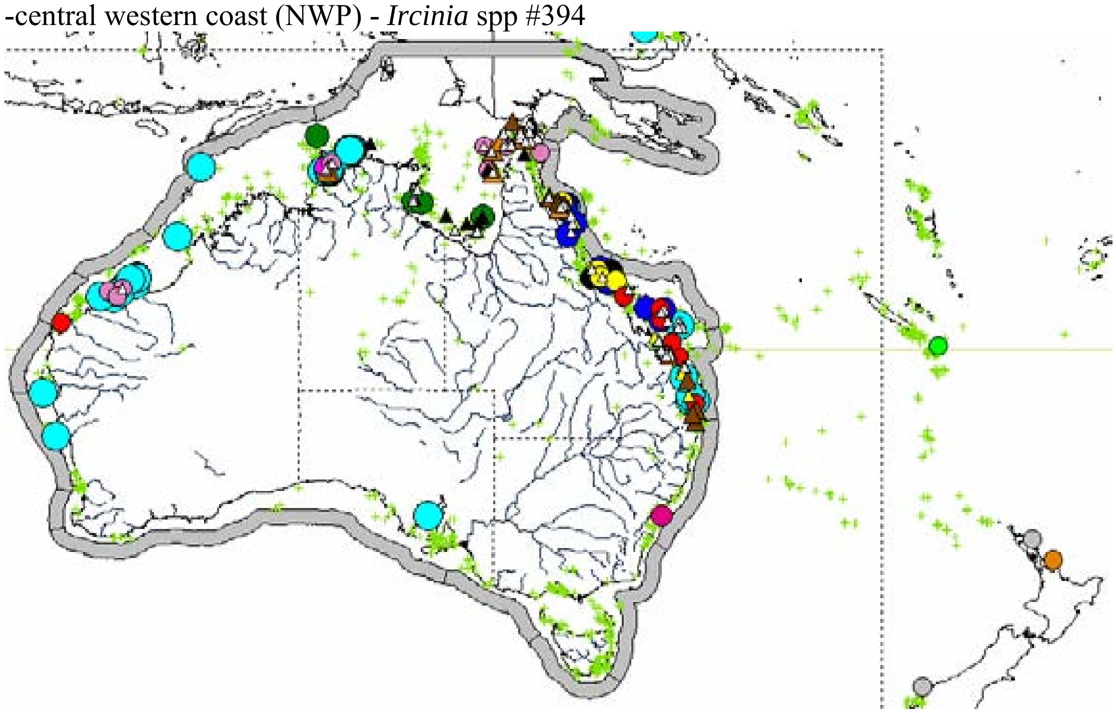
Family Irciniidae Gray, 1867

41. *Ircinia* spp (Demospongiae: Dictyoceratida: Irciniidae) (Figs 145-147)

Bioregional trends: Collections contain predominantly tropical *Ircinia* species records, but this undoubtedly represents a bias of the 'active' sponge collection agencies. Few widely distributed species, but many species corroborate particular bioregions, with relatively few species shared between major bioregions. Data corroborate splits between: north and south GBR; GBR and NP faunas (although occasional incursions of GBR fauna into the eastern Gulf of Carpentaria); NP and western coastal provinces; poorly resolved corroboration between NWP and south western provinces.

Summary details: *Ircinia* is highly diverse and often also numerically prevalent throughout regional Australian sponge faunas, with species living in clear (coral reef) to very muddy and turbid waters. 76 morphospecies are recorded here, although species determination is very difficult for some taxa and some of these may be morphological variants of other taxa. Of these only eight species can be presently assigned to a known taxon. Few species appear to have widespread Australian distributions (e.g. *Ircinia* sp. #1), or throughout tropical Australia (CEB to NWP - *Ircinia* spp #1255), although it is likely that these consist of several cryptic sibling species hiding amongst a morphospecies. More frequently, however, there are many groups of species characteristic of particular bioregions, with some bioregions repeatedly corroborated by many taxa:

-entire GBR (NEB to CEB) - *Ircinia* spp #1244, #1944
-far north GBR (NEB) – *Ircinia* spp #1550, #2710, #3173, #3810
-central and southern GBR (CEB, NEP)– *Ircinia wistarii*, *Ircinia cf. ramosa*, *Ircinia* spp #1242, #1380, #1876, #1523, #1534, #2683, #3077, #3079
-central south east coast (CEP) - *Ircinia* spp #1909, #2769
-entire north coast (NP to NWP) - *Ircinia* spp #1228, #2716, #1254
-Gulf of Carpentaria to Darwin (NP) - *Ircinia* spp #1294, #1256, #2707, #2400, #3790
-Bass Strait (BassP) - *Ircinia* spp #3434
-central southern coast (GulfP) - *Ircinia* spp #527
-central western coast (NWP) - *Ircinia* spp #394



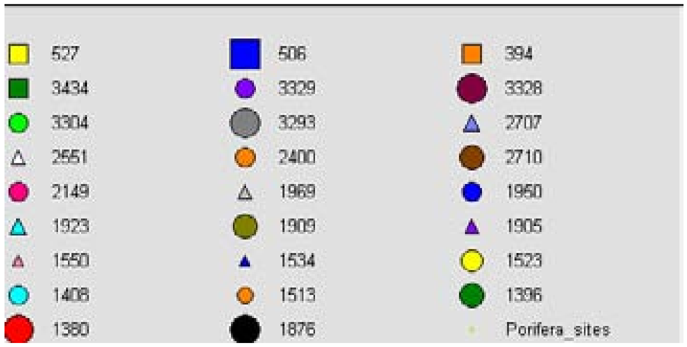
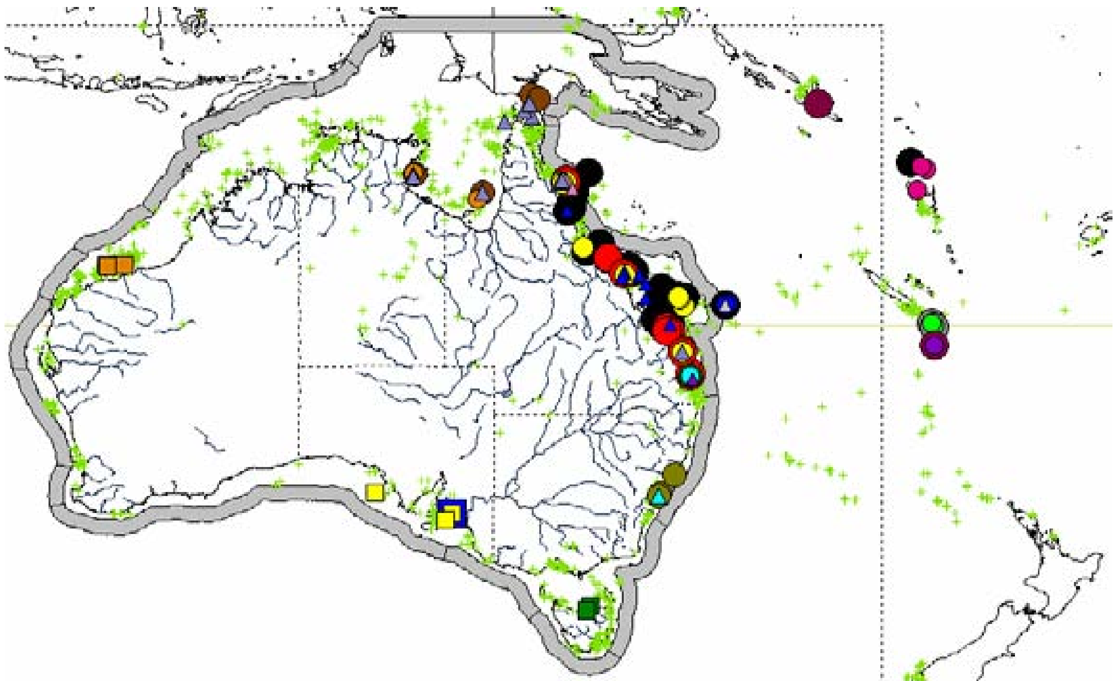


FIG. 145. *Ircinia* spp – part 1 (QM Biolink database)



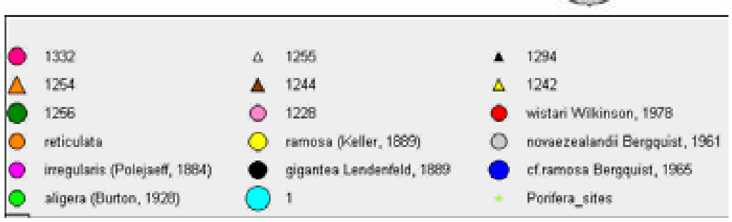
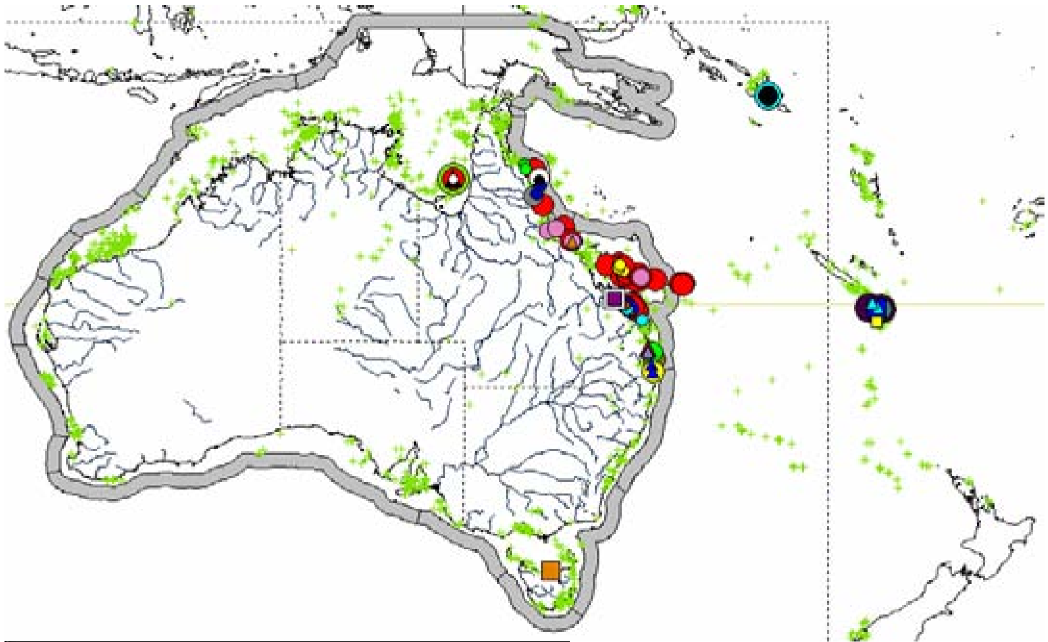


FIG. 146. *Ircinia* spp – part 2 (QM Biolink database)



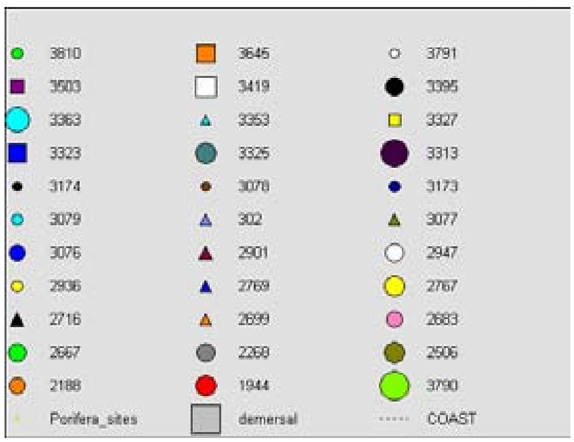


FIG. 147. *Ircinia* spp – part 3 (QM Biolink database)

***Psammocinia*, *Collospongia* and *Sarcotragus* spp (Demospongiae: Dictyoceratida: Irciniidae) (Figs 148-149)**

Bioregional trends: Greater number of temperate species, but trends similar to Ircinia, with species distributions corroborating particular bioregions: split between northern and southern GBR; GBR and NP; GBR and CEP; distinct BassP and TasP faunas.

Summary details: Fourty two species of *Psammocinia* and five species of *Collospongia* and *Sarcotragus* are recorded, with only five species currently named. Only one species (*Psammocinia* sp. #487) with a wide temperate and tropical distribution, although this might concern more than one cryptic sibling species hiding within a morphotype. Several species indicative of major bioregional distributions, nearly mirroring the closely related genus *Ircinia*. Taxa differentiate:
-entire GBR (NEB to CEB) – *Psammocinia* spp #1191, #1867
-far north GBR (NEB) – *Psammocinia auris*, *Psammocinia* spp #1727, #2385, #3103
-central and southern GBR (CEB, NEP) – *Psammocinia* spp #1181, #1191, #1407, #3422, #2772
-central south east coast (CEP) – *Psammocinia* spp #1339, #1459, #1472, #1874, #1912
-Gulf of Carpentaria to Darwin (NP) – *Psammocinia* spp #3788, #3789
-Bass Strait (BassP-TasP) – *Psammocinia* spp #3603, #3646, #3430, #3648, #3537
-central southern coast (GulfP) – *Psammocinia rugosa*
-central western coast (NWP) – *Psammocinia* spp #305, #1791

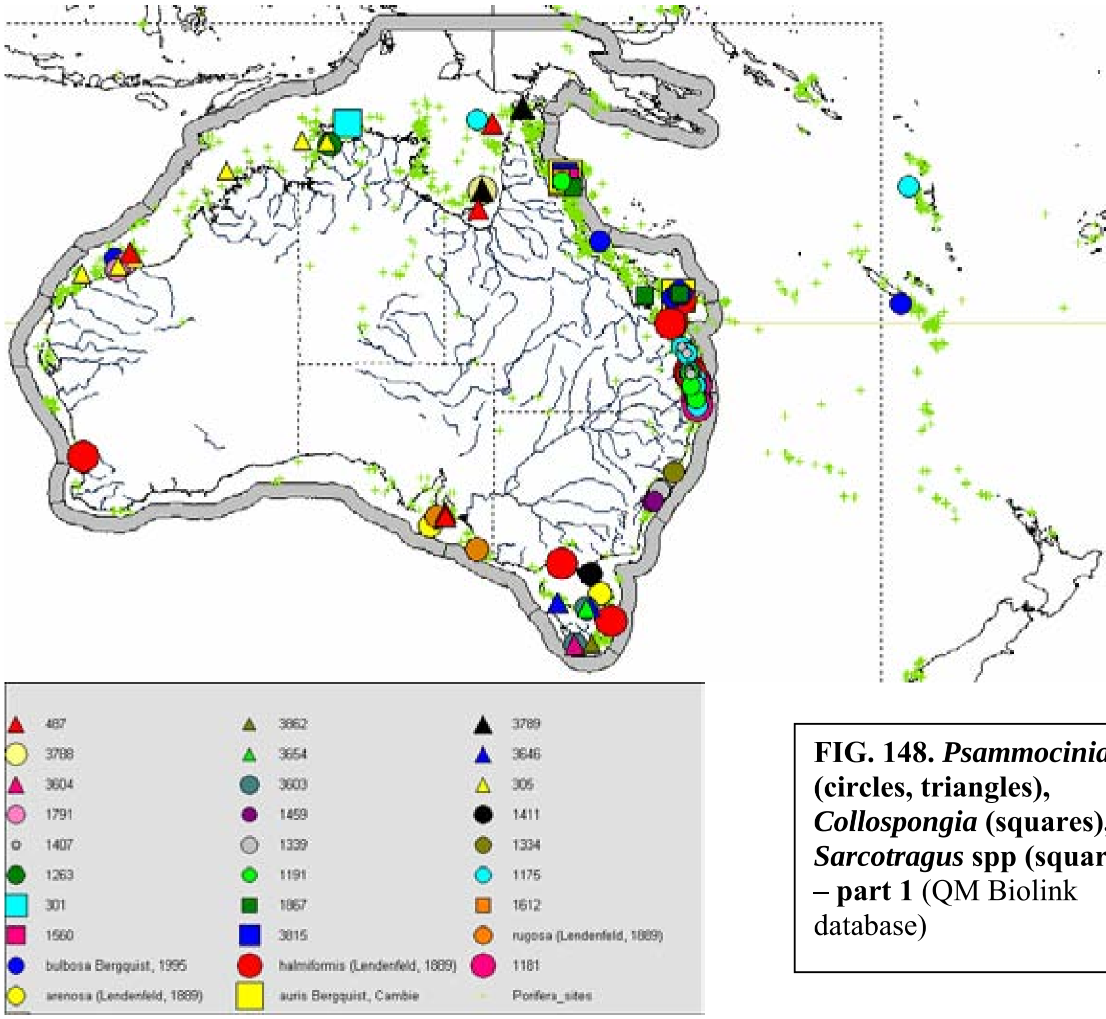
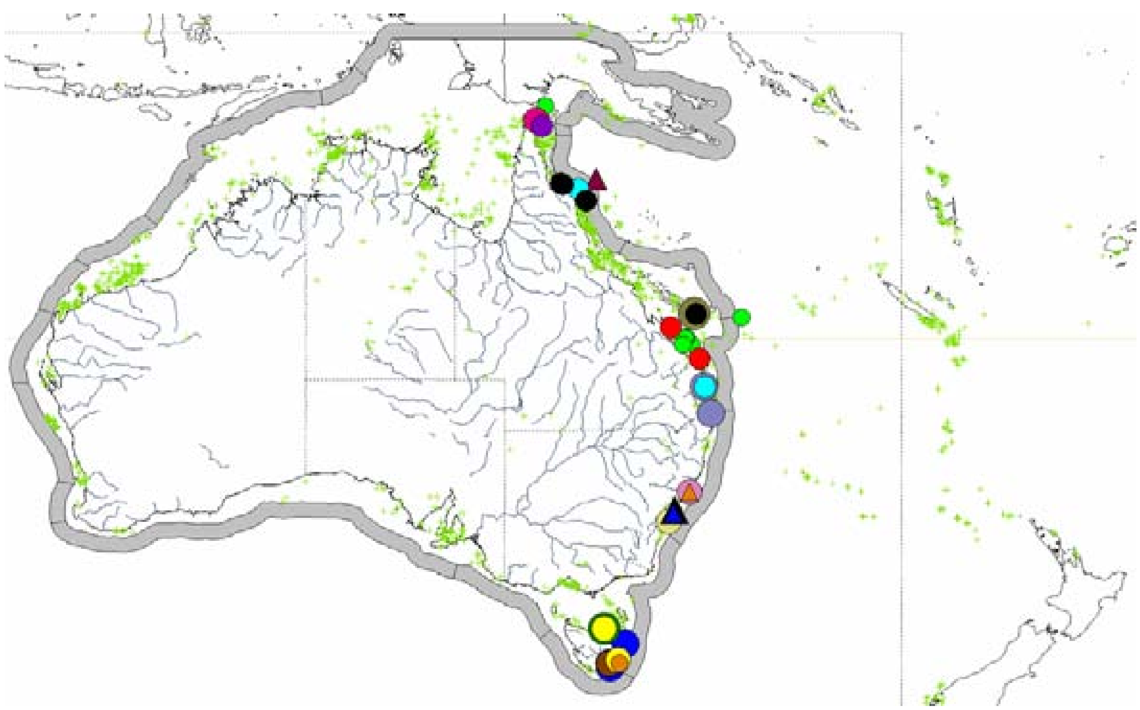


FIG. 148. ***Psammocinia* (circles, triangles), *Collospongia* (squares), *Sarcotragus* spp (squares) – part 1** (QM Biolink database)



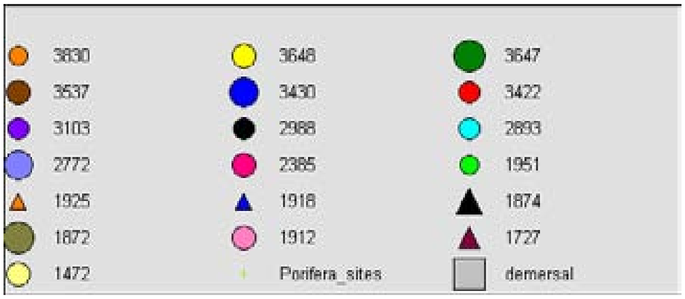


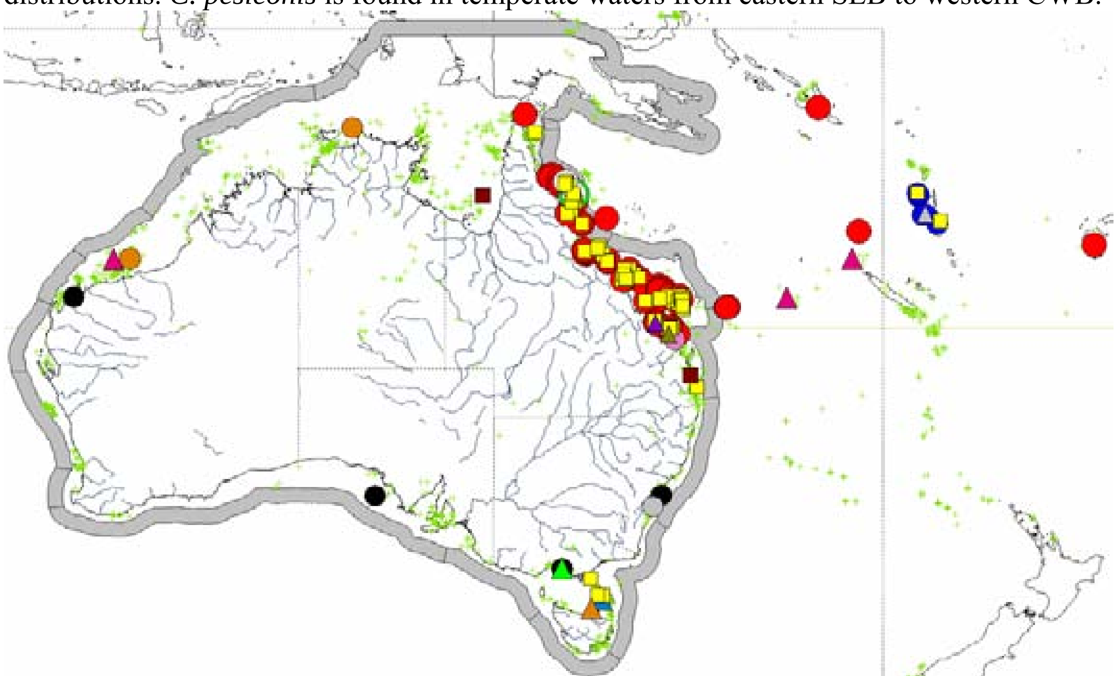
FIG. 149. ***Psammocinia* (circles, triangles) – part 2** (QM Biolink database)

Family Spongiidae Gray, 1867

42. *Coscinoderma*, *Leiosella* and *Rhopaloeides* spp (Demospongiae: Dictyoceratida: Spongiidae) (Fig. 150)

Bioregional trends: Several species characteristic of GBR provinces.

Summary details: *Coscinoderma* (9 species, 2 named), *Leiosella* (7 species, 3 named) and *Rhopaloeides* (2 species, one named) have relatively low species diversity compared to most other genera of Spongiidae, but some species are dominant components of tropical benthic regional faunas. *C. mathewsi* and *R. odorabile* are characteristic of northern, central and southern GBR coral reef habitats (and elsewhere in the tropical western Pacific), with records of the latter outside this region probably representing morphologically similar (cryptic sibling) species distributions. *C. pesleonis* is found in temperate waters from eastern SEB to western CWB.



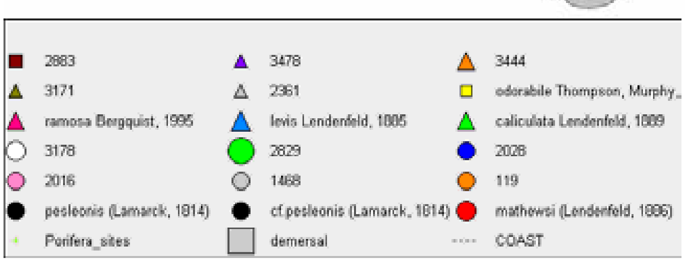
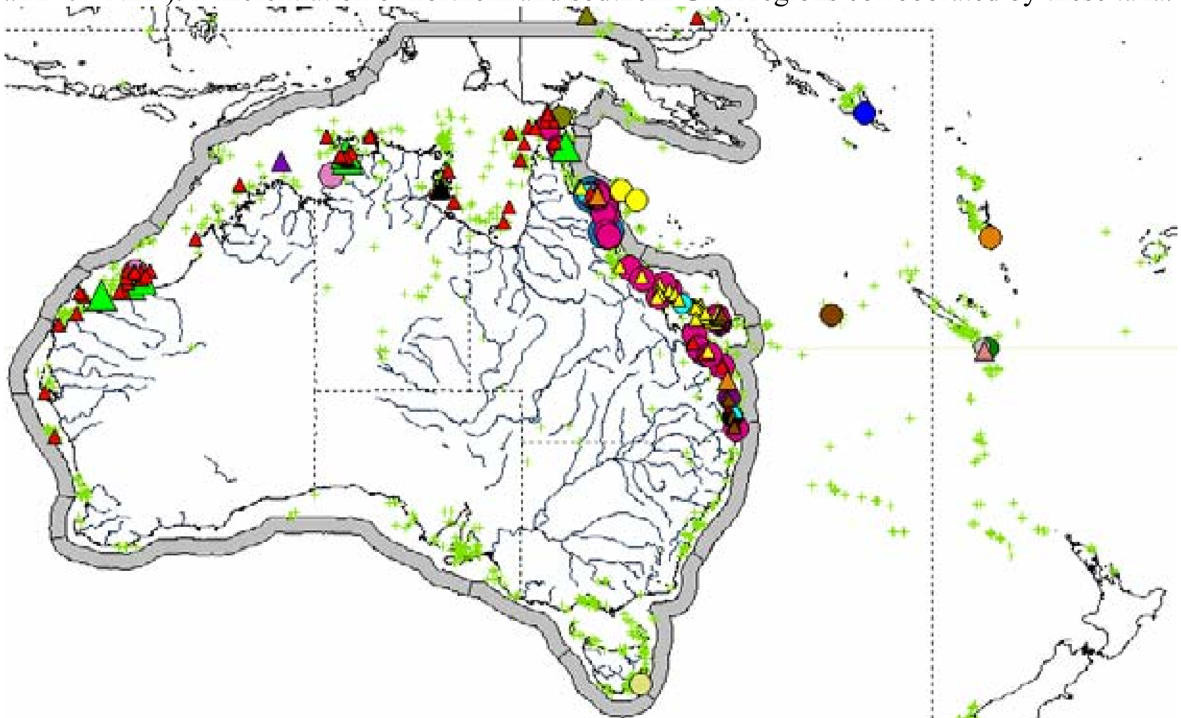


FIG. 150. ***Coscinoderma* (circles), *Leiosella* (triangles) and *Rhopaloeides* spp (squares)** (QM Biolink database)

***Hippospongia* and *Hyattella* spp (Demospongiae: Dictyoceratida: Spongiidae) (Fig. 151)**

Bioregional trends: Several species are markers for boundaries of tropical Australia, north and north west coast (versus northeast coast), entire GBR, and far north and central and southern GBR bioregions.

Summary details: *Hippospongia* (14 species, 4 named) and *Hyattella* (10 species, 2 named) are dominant components of the soft bottom marine benthos in some tropical bioregions, with species exhibiting widespread tropical distributions (*Hy. Intestinalis* - from the mid east CEB to mid west CWP bioregions), or with more restricted distributions: north and northwest coast (*Hy. clathrata* – NP to NWP), widespread GBR (*Hi. elastica* – from CEB to NEB), central and southern GBR (*Hy.* spp #2763, #1366 - CEB, NEP), or far north GBR (*Hi. aphroditella*, *Hi.* sp. #2240 - NEB). Differentiation of northern and southern GBR regions corroborated by these taxa.



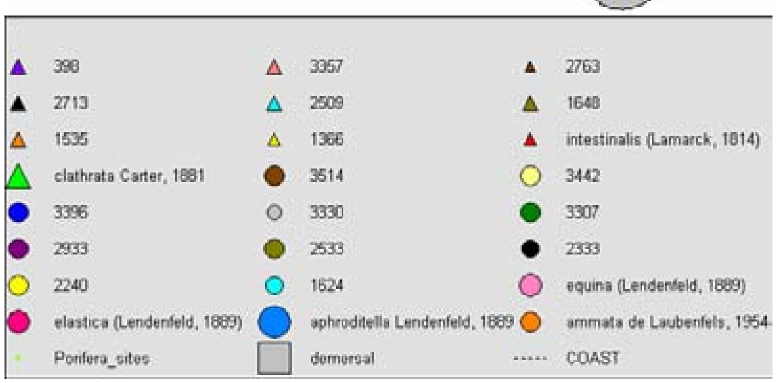


FIG. 151. *Hippospongia* (circles) and *Hyattella* spp (triangles) (QM Biolink database)

***Spongia* spp (Demospongiae: Dictyoceratida: Spongiidae) (Fig. 152)**

Bioregional trends: Distinct tropical and temperate faunas with virtually no overlap. Some bioregions clearly marked by species, including differentiation of GBR into northern and southern regions, splits between GBR and NP, and GBR and south eastern coast.

Summary details: *Spongia* (52 species, only 3 named with confidence) is highly diverse in both tropical and temperate faunas. Few species have apparent widespread tropical and temperate distributions (e.g. *S. hispida*), a couple occur only in the tropics but are widespread (e.g. *Spongia* spp #1983), but several can define particular bioregions:

-northern to southern GBR (NEB to CEB): *Spongia* sp #1990

-northern GBR (NEB): *Spongia* spp #1812, #3193, #3278
-central GBR (NEP): *Spongia* sp. #1364
-southern GBR – southeast Qld (CEB): *Spongia* spp #1815, 2360
-central east coast (CEP): *Spongia* spp #1908, 2831
-southeast Australia (BassP, WBassB, GulfP): *Spongia* spp #869, 542
-Tasmania and Bass Strait (TasP, BassP): *Spongia* spp #3433, 3535, 3428
-Gulf of Carpentaria (NP): *Spongia* spp #3095, 3096
-southwest coast (SWB): *Spongia pyriforme*

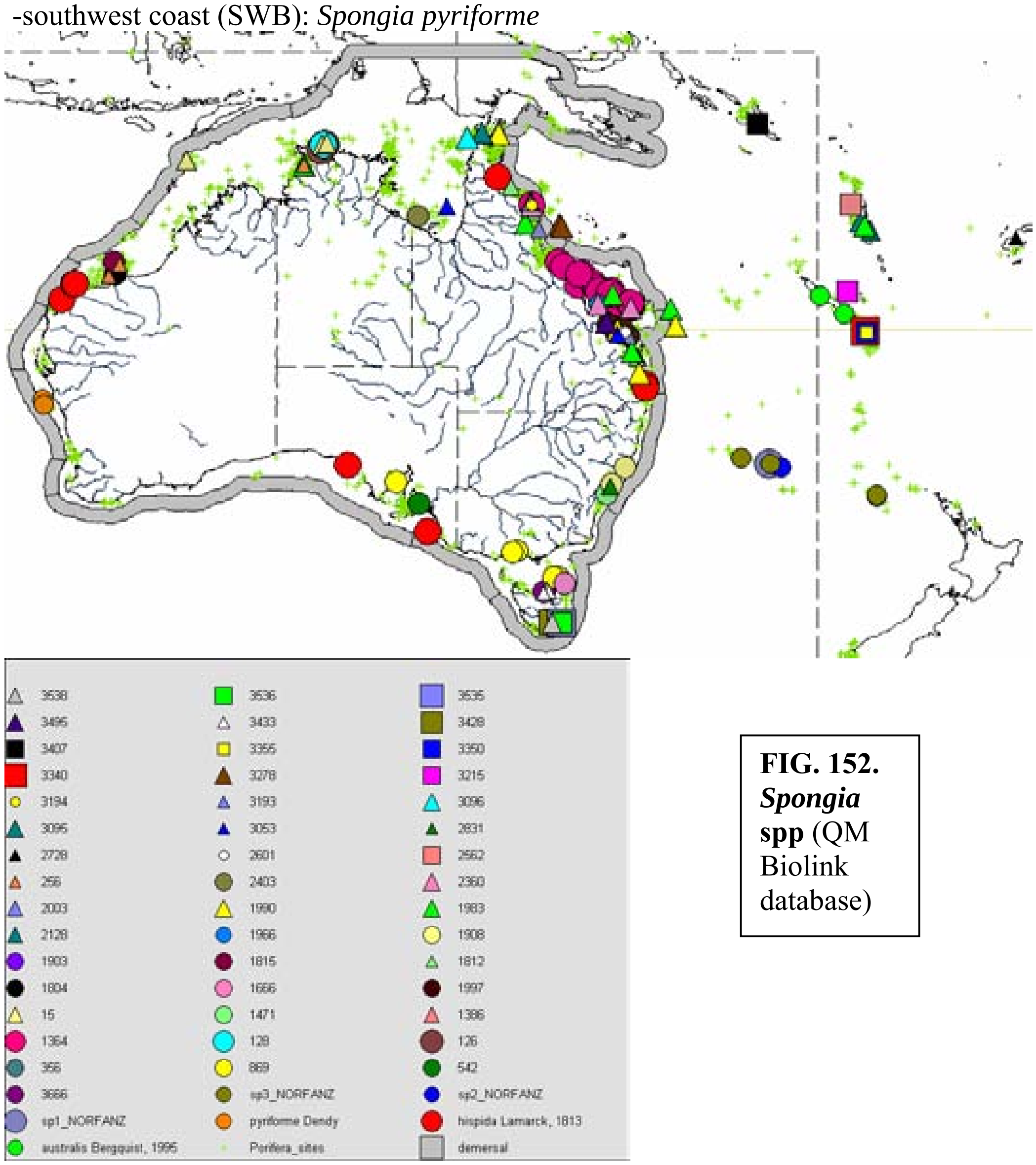


FIG. 152. *Spongia* spp (QM Biolink database)

Family Thorectidae Bergquist, 1978

43. *Aplysinopsis*, *Cacospongia*, *Candidaspongia* and *Narrabeena* spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 153)

Bioregional trends: Predominantly tropical distributions, with some species supporting north-south bioregionalisation of the GBR, and the GulfP region.

Summary details: *Aplysinopsis* (11 species, 3 named), *Cacospongia* (6 species, 1 named), *Candidaspongia* and *Narrabeena* (each with a single named species) are predominantly tropical but with varying distributions. *Candidaspongia flabellata* is widely distributed throughout the GBR but not yet recorded outside this region, nor has it yet been recorded from the very far northern GBR. *Aplysinopsis elegans* appears to occur in both temperate and tropical faunas, although not very commonly; *A. cf. reticulata* and *Aplysinopsis* sp. #330 are restricted to the northwest coasts (NWB-NWP), and several species' distributions support the north-south GBR bioregional split, and a temperate bioregion:

-northern GBR (NEB): *Aplysinopsis* spp #477, #3191, *Cacospongia* sp. #3183

-southern GBR (NEP-CEB): *Narrabeena lamellate*, *Aplysinopsis* sp. #1388, *Cacospongia* sp. #1120

-southern Gulf (GulfP): *Aplysinopsis* spP #477, #538

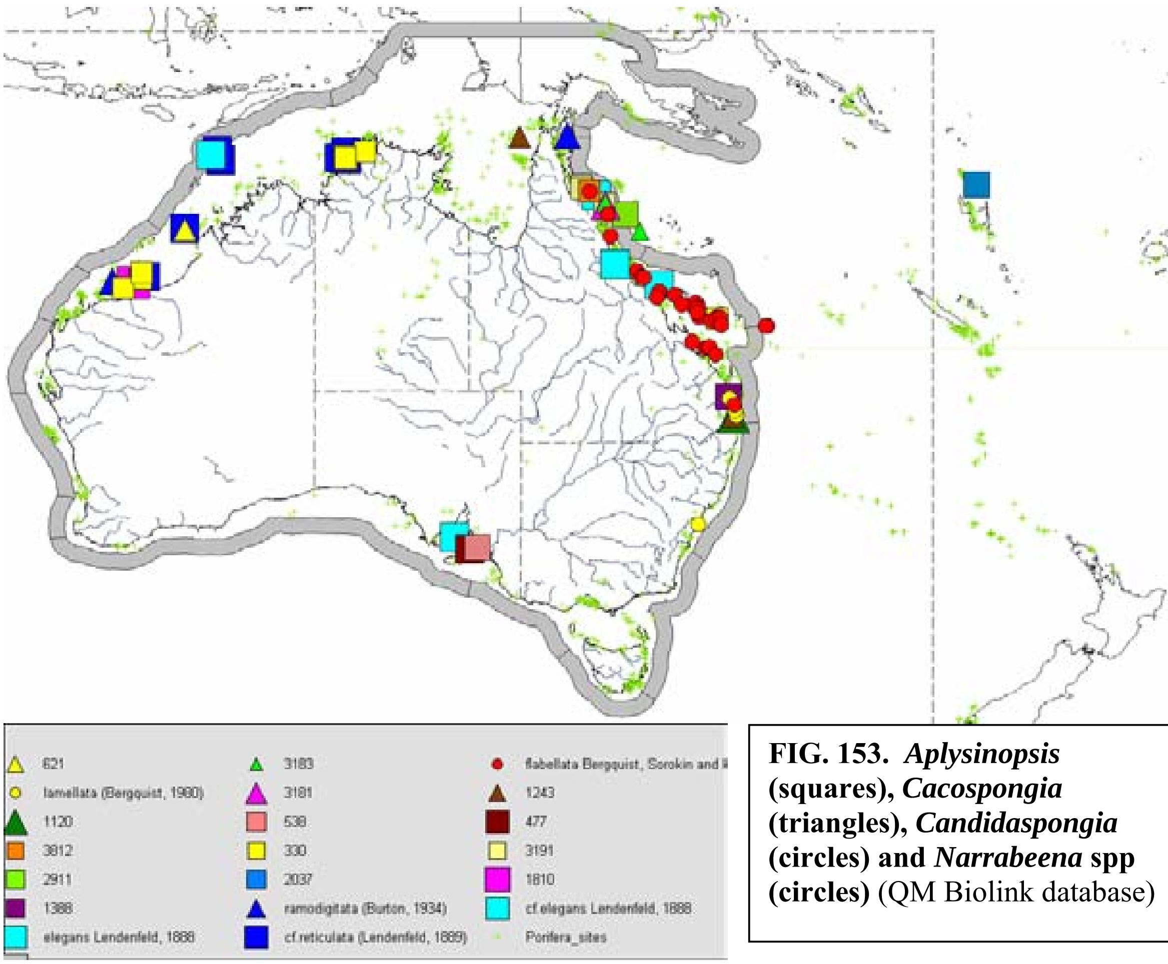


FIG. 153. *Aplysinopsis* (squares), *Cacospongia* (triangles), *Candidaspongia* (circles) and *Narrabeena* spp (circles) (QM Biolink database)

***Carteriospongia* and *Phyllospongia* spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 154)**

Bioregional trends: Predominantly tropical coral reef dwelling species, with similar distributions to the reefs themselves, but a few species restricted to smaller bioregions.

Summary details: *Carteriospongia* (5 species, 3 named) and *Phyllospongia* (8 species, 4 named) demonstrate clear bioregional trends, with several species strongly correlated to the presence/ absence of coral reefs (*P. foliascens*, *P. papyracea*, *C. flabellifera*) and hence mimicking those distributions, one on soft and non-coralline substrata (*P. lamellosa*) and others more restricted to particular bioregions:

-northwest (NWB-NWP): *Carteriospongia* sp. #379, *P. mantelli*

-northeast GBR (NEB): *Phyllospongia* sp. #3202

-southeast GBR (NEP): *Phyllospongia* sp. #2805

Split between northern and southern GBR is not well supported by these taxa.

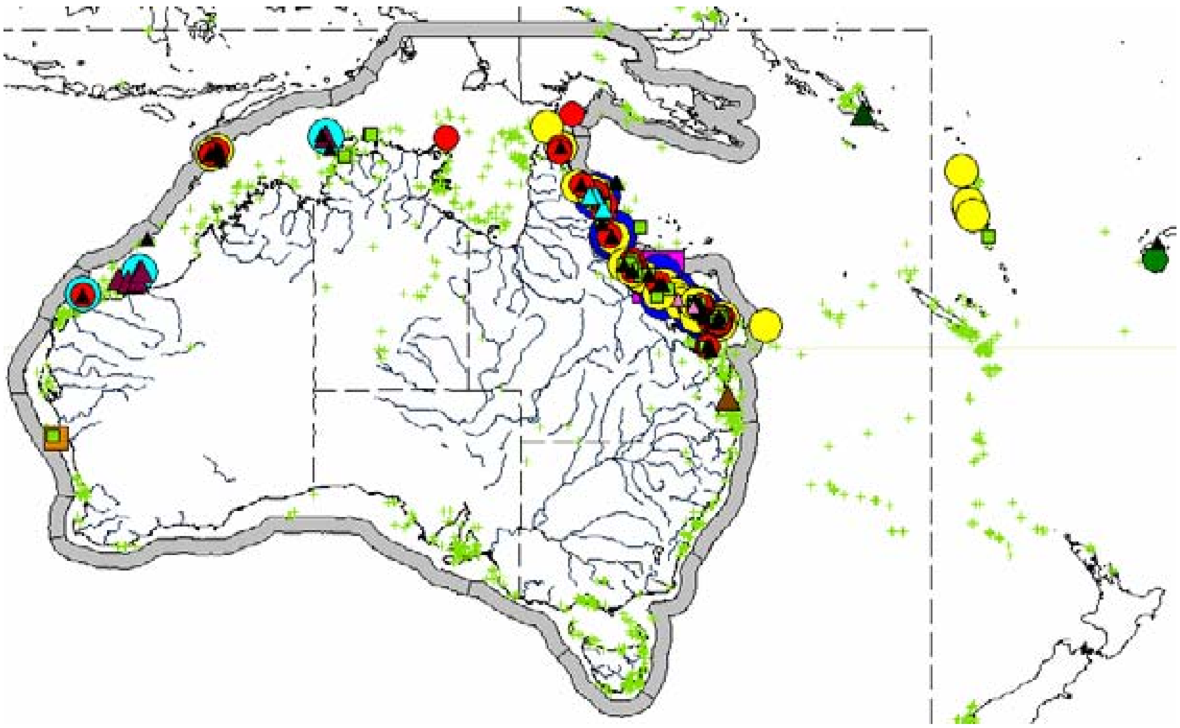


FIG. 154. *Carteriospongia* (circles) and *Phyllospongia* spp (triangles and squares) (QM Biolink database)

Dactylospongia and _Fascaplysinopsis_ spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 155)

Bioregional trends: Predominantly tropical coral reef associated species, with highest diversity by far in the GBR provinces; species distributions support differentiation of northern and southern GBR faunas, distinct from northwest and southeast species compositions.

Summary details: Records of *Dactylospongia* (15 species, only 1 named so far) and *Fascaplyinopsis* (25 species, only 1 named) are predominantly tropical, with highest diversity on the GBR (24 species), and with some (e.g. *D. elegans*, *F. reticulata*) characteristic of coral reef habitats throughout the Indo-west Pacific. Several species support the notion of a north-south split of the GBR fauna and a number of species support few other tropical/ subtropical bioregions:

-entire GBR (NEB – CEB): *D. elegans*, *Fascaplyinopsis* sp. #2170
-northern GBR (NEB): *Dactylospongia* spp #2994, #3244, *Fascaplyinopsis* spp #1538, #2314
-southern GBR (NEP-CEB): *Dactylospongia* spp #2171, #3050, *Fascaplyinopsis* spp #1549, 1824, 1842, 3055
-northwest coast (NWB-NWP): *Dactylospongia* sp. #356, *Fascaplyinopsis* spp #1777, #1798
-central east coast (CEP): *Dactylospongia* spp #1349, #1357, *Fascaplyinopsis* sp #1354

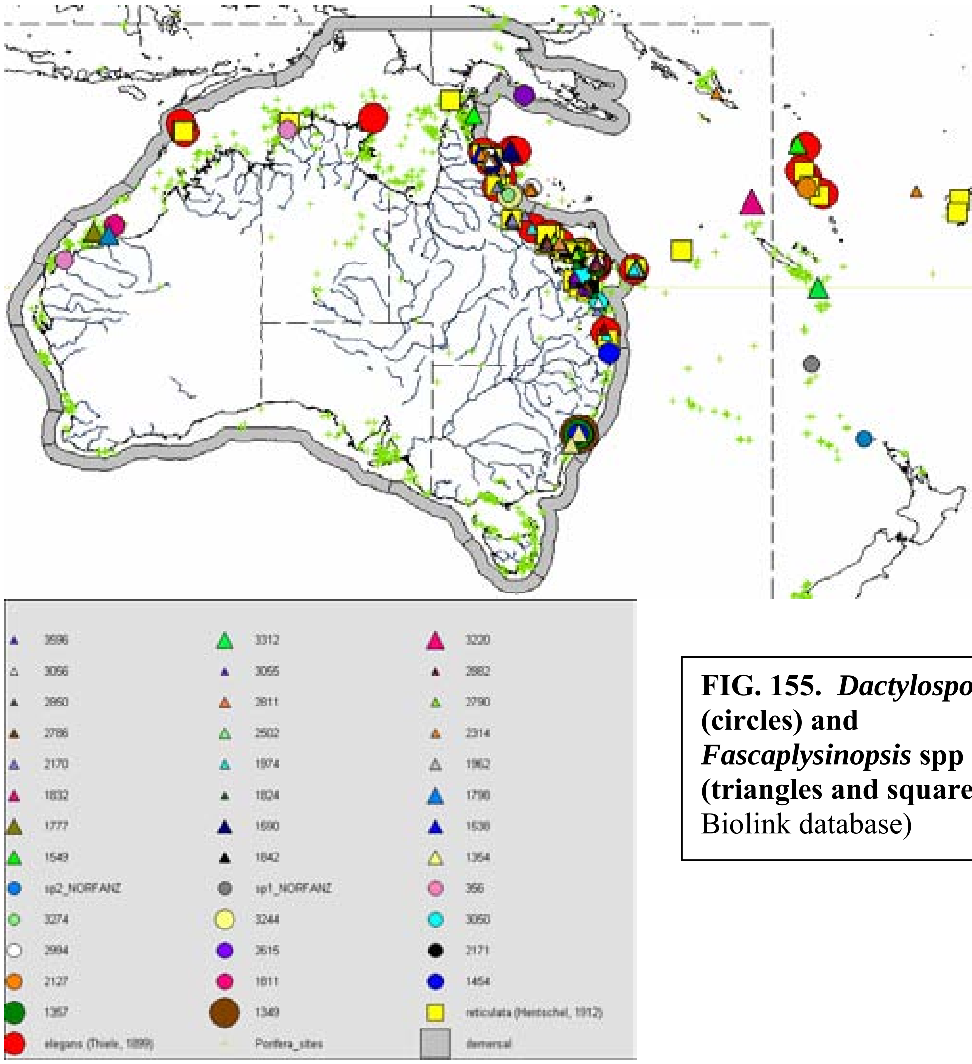


FIG. 155. *Dactylospongia* (circles) and *Fascaplysinopsis* spp (triangles and squares) (QM Biolink database)

***Fasciospongia* and *Hyrtios* spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 156)**

Bioregional trends: Tropical and temperate species, highest diversity on GBR, north-south GBR split supported, few other species useful as bioregional indicators.

Summary details: *Fasciospongia* (14 species, 4 named so far) and *Hyrtios* (18 species, 3 named) are equally diverse in tropical and temperate bioregions. One species (*Fasciospongia* sp. #290) occurs widely throughout Australia whereas most others are more indicative of particular bioregions. Highest diversity occurs on the GBR (17 species). A few species support distinct northern-southern GBR faunas:
-widespread GBR and elsewhere in the tropical Indo-west Pacific (NEB-CEB): *H. erecta*, *H. reticulata*
-northern GBR (NEB): *Hyrtios* spp #2560, #2864, #3271
-southern GBR (NEP-CEB): *Fasciospongia* sp. #2543, *Hyrtios* spp #2693, #2799, #2887
-Gulf of Carpentaria (NP): *Fasciospongia* sp. #1318, #n.sp.
-northwest coast (NWP): *F. pulcherrima*, *Fasciospongia* sp. #49
-central east coast (CEP): *F. australis*, *Fasciospongia* sp. #1476

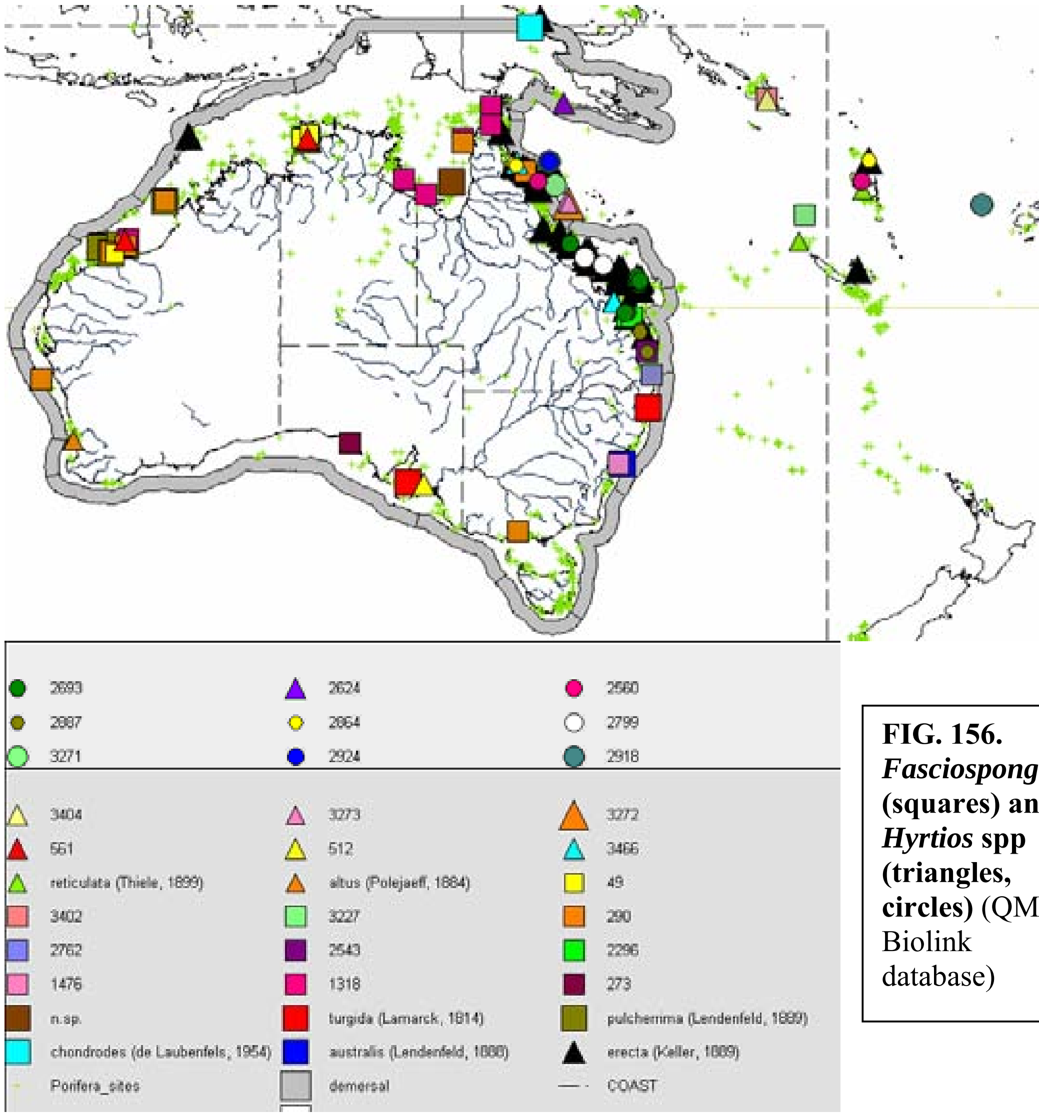


FIG. 156. *Fasciospongia* (squares) and *Hyrtios* spp (triangles, circles) (QM Biolink database)

***Luffariella*, *Fenestraspongia*, *Lendenfeldia, Petrosiaspongia* and *Scalarispongia* spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 157)**

Bioregional trends: Temperate and tropical species, one widely distributed coral reef inter-reef species on whole GBR to NP regions, remainder not abundant but supporting north-south split on GBR, and differences from GBR and southern and western species.

Summary details: *Luffariella* (20 species, 3 named), *Fenestraspongia* (2 species, 1 named), *Lendenfeldia* (2 species, both named), *Petrosiaspongia* (3 species, 1 named) and *Scalarispongia* (2 unnamed species) comprise distinct tropical and temperate faunas, with a small number of species indicating some bioregional patterns, but species are not abundant. The exception is *Lendenfeldia plicata* which is common throughout the GBR extending to the Darwin region (CEB-NP), mainly associated with soft and silty bottoms in the inter-reef region. Other bioregional faunas indicated are:
-northern GBR (NEB): *Luffariella* spp #2302, #3187, *Fenestraspongia* sp. #3275
-southern GBR (NEP-CEB): *Luffariella* spp #2495, 3057, *Scalarispongia* sp. #3591
-Gulf of Carpentaria (NP): *Luffariella* sp. #1975, #3107
-central east coast (CEP): *Luffariella* sp. #1917
-north west coast (NWP-NWB): *Luffariella* sp. #380
-south east coast (TasP – GulfP): *F. intertexta*
-south west coast (SWB): *Lendenfeldia arenifibrosa*

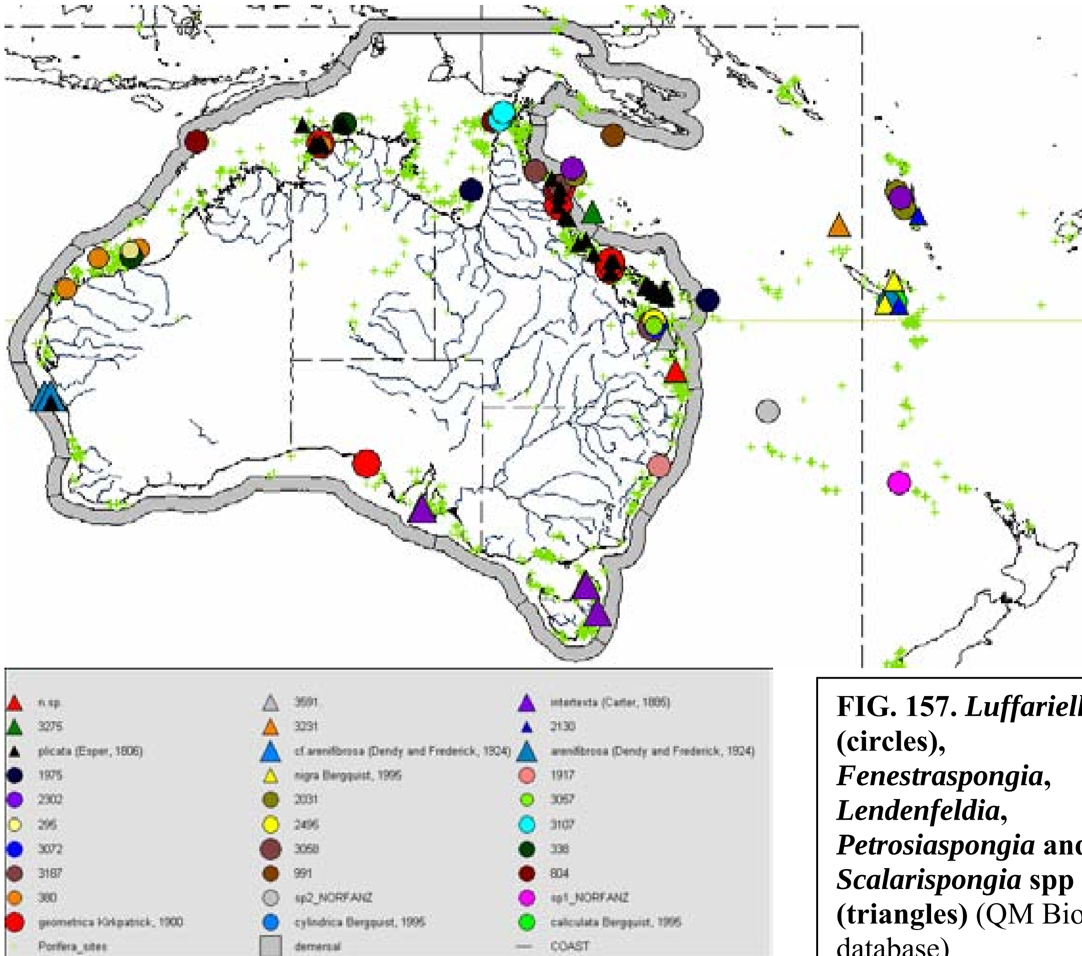


FIG. 157. *Luffariella* (circles), *Fenestraspongia*, *Lendenfeldia*, *Petrosiaspongia* and *Scalarispongia* spp (triangles) (QM Biolink database)

***Thorecta*, *Smenospongia* and *Strepsichordaia* spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 158)**

Bioregional trends: Both temperate and tropical species, not abundant or diverse apart from one widespread GBR species of *Strepsichordaia*, and *Thorecta* most diverse in temperate waters; several groups of species characterize north and south GBR, central east coast, northwest coast and Tasmanian bioregions.

Summary details: *Thorecta* (24 species, 4 named), *Smenospongia* (1 species unnamed) and *Strepsichordaia* (3 species, 2 named) are neither diverse nor abundant apart from the coral reef associated species *Strepsichordaia lendenfeldi* which is found along the length of the GBR (NEB-CEB). Highest diversity is in Bass Strait and Tasmanian bioregions (9 species). Several groups of species characterize other tropical bioregions:
-northern GBR (NEB): *Thorecta* spp #3815, #3232, #3208
-southern GBR (NEP-CEB): *T. vasiformis*, *Thorecta* sp. #3494
-north west coast (NWB-NWP): *Thorecta* spp #11, #38, #44, #146
-central east coast (CEP): *T. freija*, *Thorecta* sp. #1356
-Bass Strait (SEB-BassP): *St. calciformis*
-Tasmania (TasP): *T. cribrocusta*, *Thorecta* sp. #3539

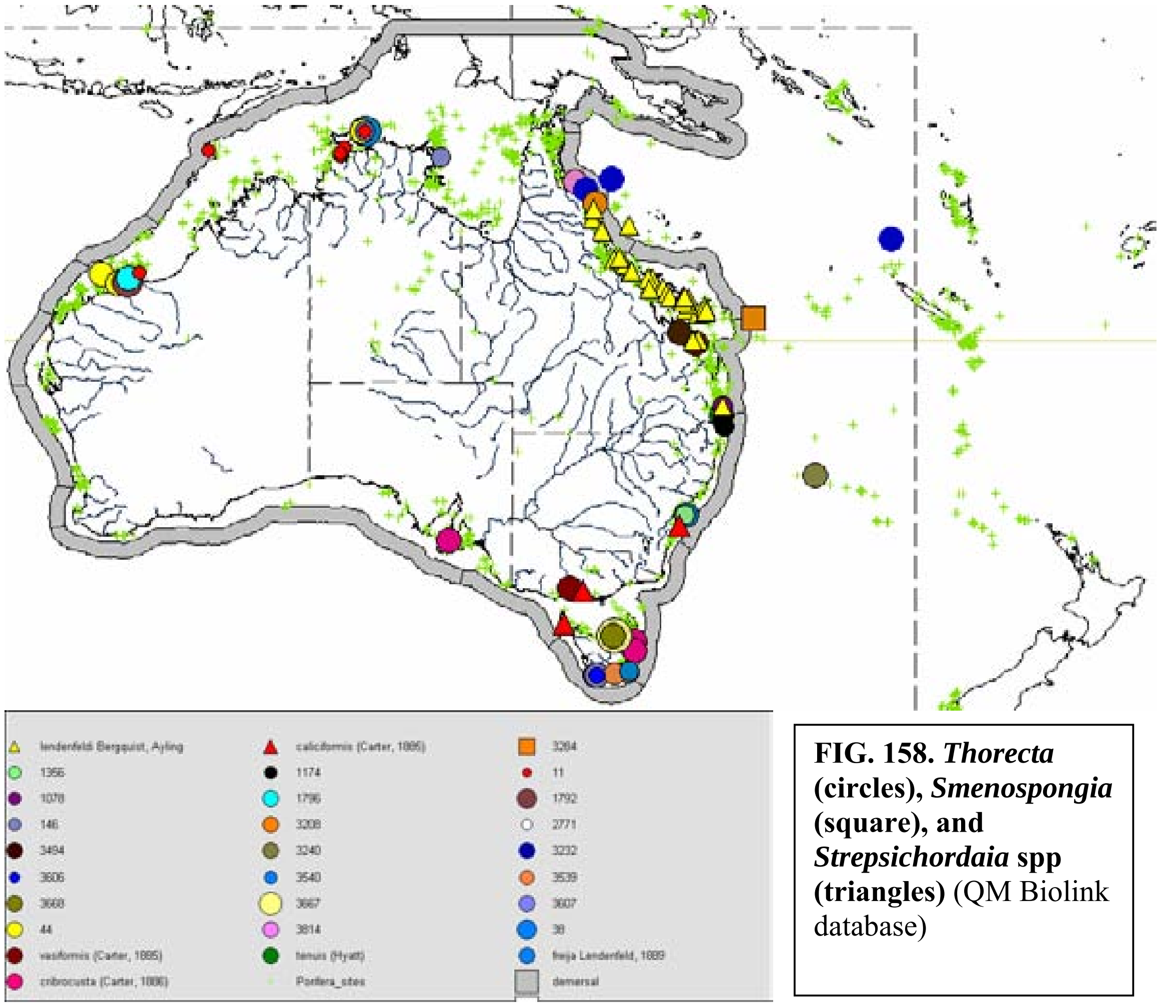
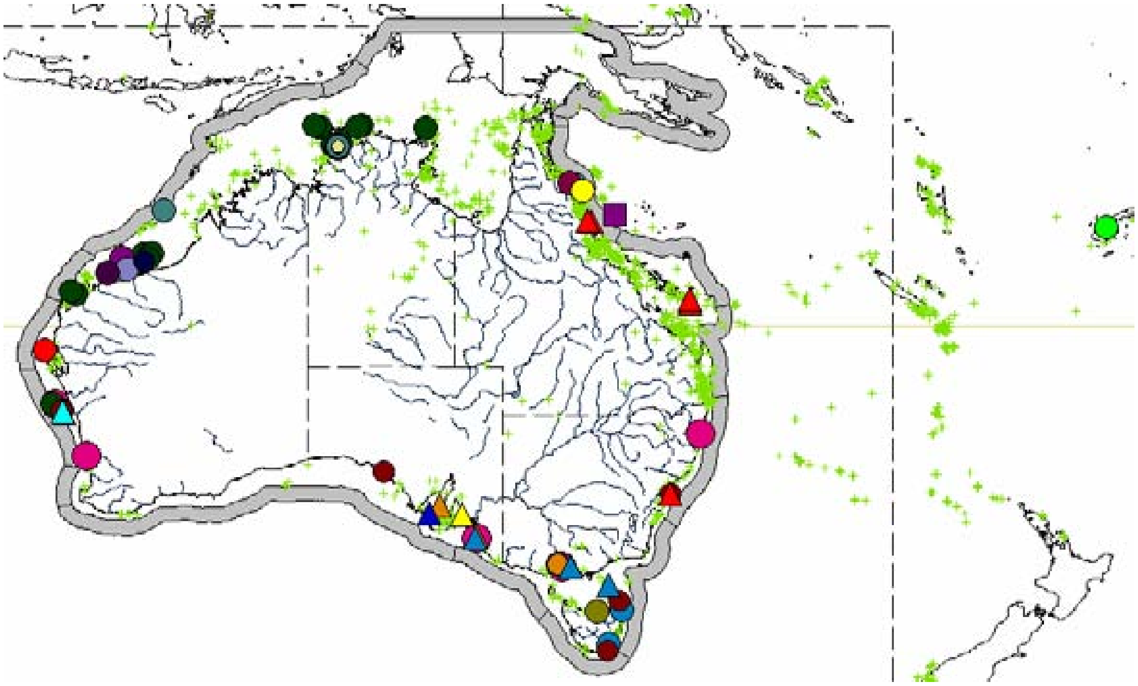


FIG. 158. *Thorecta* (circles), *Smenospongia* (square), and *Strepsichordaia* spp (triangles) (QM Biolink database)

***Thorectandra*, *Taonura* and *Thorectoxia* spp (Demospongiae: Dictyoceratida: Thorectidae) (Fig. 159)**

Bioregional trends: Temperate and tropical groups, characteristic for NP-CWP, TasP-GABB and GulfP.

Summary details: Thorectandra (17 species, 4 named), Taonura (6 species, 3 named), Thorectoxia (1 unnamed species), with one widely distributed temperate species (*Thorectandra choanoides*), and two peaks of diversity in tropical (6 spp) and temperate regions (9 spp):
-northwest and west coasts (NP-CWP): *T. excavatus*
-southeast coastal (Tasp - GABB): *T. corticatus*, *Thorectandra* sp. #491, *Taonura flabelliformis*
-southern Gulf (GulfP): *Taonura colus, T. marginalis, Tanonu* sp.#530,



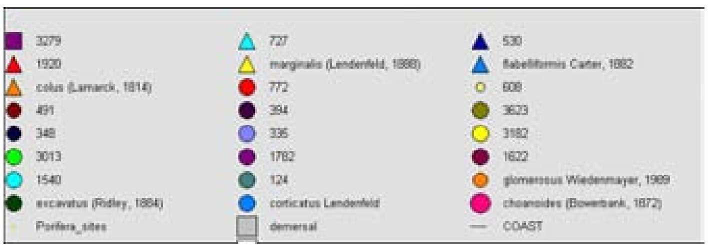


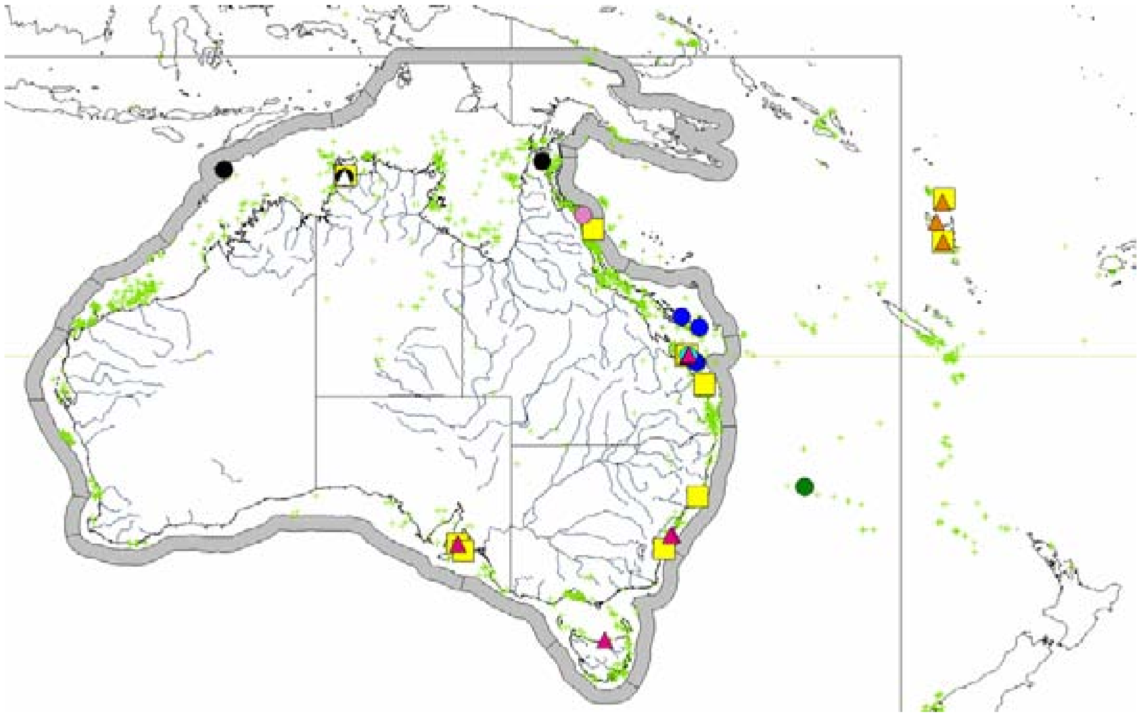
FIG. 159. *Thorectandra* (circles), *Taonura* (triangles) and *Thorectoxia* spp (squares) (QM Biolink database)

Order Dendroceratida Minchin, 1900
Family Darwinellidae Merejkowsky, 1879

44. *Aplysilla* spp (Demospongiae: Dendroceratida: Darwinellidae) (Fig. 160)

Bioregional trends: *Aplysilla* species show useful bioregional trends, indicative of eastern Australian, southeastern Australian, and split between northern and southern GBR faunal distributions.

Summary details: Nine species are recorded with only two presently assigned to a known taxon. Highest species diversity is on the GBR, with three species in the northern sector (NEB) and four in the south (NEP – CEB) with only one species common to both regions (viz. the widely distributed *Aplysilla sulfurea*). Species show distinct bioregionalisation: widely distributed eastern Australia (*A. sulfurea* – GulfP to NP), less widely distributed on southeast coast (*A. rosea* – GulfP to CEB), and more restricted distributions to southern GBR (*Aplysilla* sp. #1999 – CEB), and northern coast and Sahul Shelf regions (*Aplysilla* sp. #688 – NP to NWB).



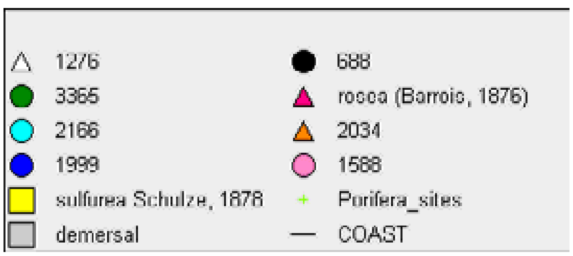


FIG. 160.
***Aplysilla* spp** (QM Biolink dartabase)

***Chelonaplysilla* and *Darwinella* spp (Demospongiae: Dendroceratida: Darwinellidae) (Fig. 161)**

Bioregional trends: Southern GBR differentiated from other tropical regions; two species widely distributed eastern coast.

Summary details: Seven species of *Chelonaplysilla* and five species of *Darwinella* are recorded, with six currently assigned to a known taxon. The highest diversity occurs in the southern sector of the GBR – Coral Sea (nine species – NEP - CEB). All species except (*Chelonaplysilla* sp1 Norfanz) occur in shallow waters (up to 50m depth). Two species (*C. violacea*, *D. gardineri*) are widespread throughout eastern Australia, the former extending into the western Pacific.

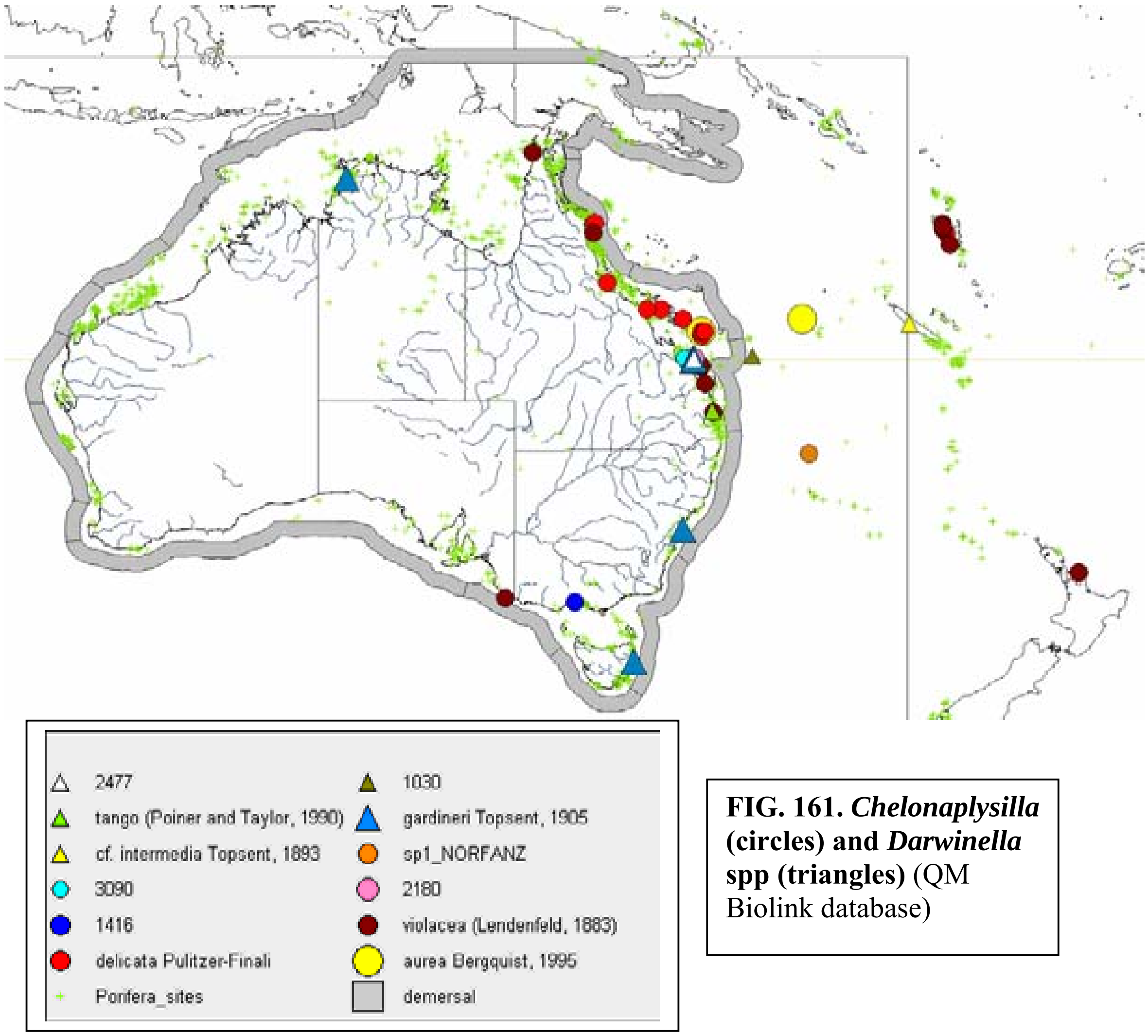


FIG. 161. *Chelonaplysilla* (circles) and *Darwinella* spp (triangles) (QM Biolink database)

***Dendrilla* spp (Demospongiae: Dendroceratida: Darwinellidae) (Fig. 162)**

Bioregional trends: One species characteristic for NWP region.

Summary details: Ten species recorded with only two currently assigned to a known taxon. Highest diversity in the southern GBR sector (NEP). One species widely distributed (*D. rosea*), possibly circum-Australian; one species (*Dendrilla* sp. #159) characteristic of northwest coast (NWP).

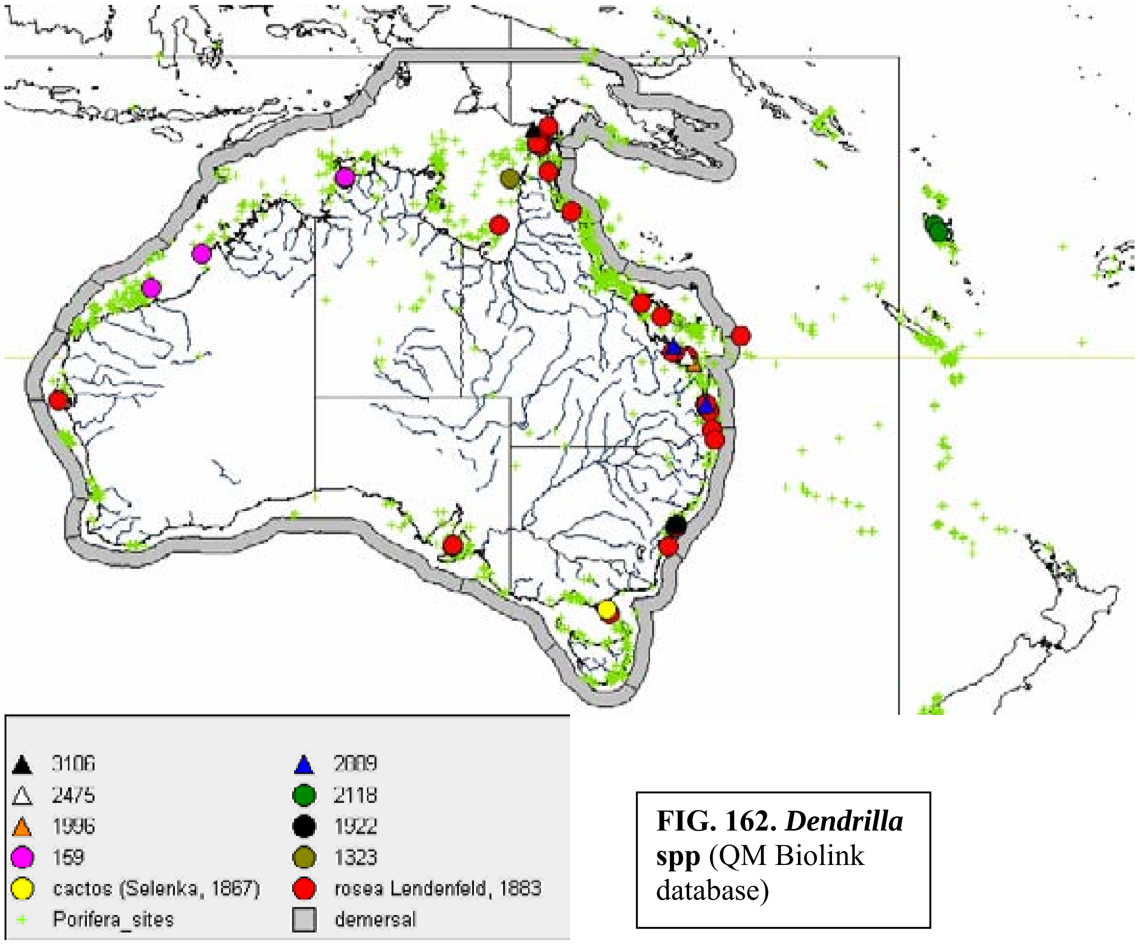


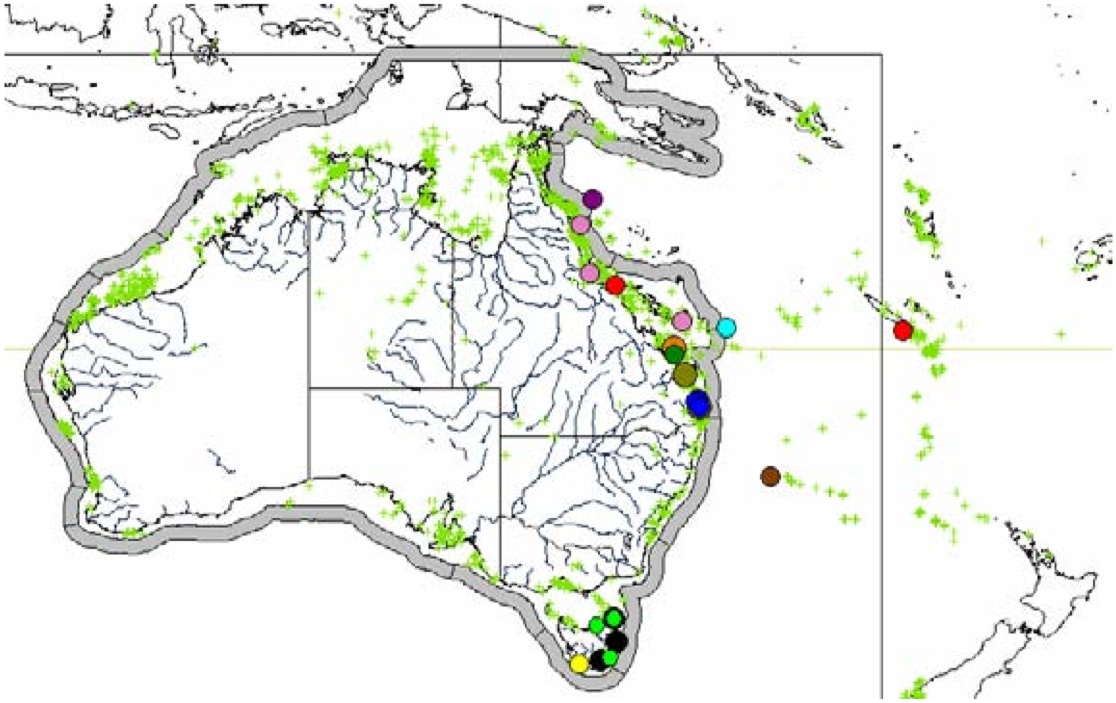
FIG. 162. *Dendrilla* spp (QM Biolink database)

Family Dictyodendrillidae Bergquist, 1980

45. *Acanthodendrilla* spp (Demospongiae: Dendroceratida: Dictyodendrillidae) (Fig. 163)

Bioregional trends: Species composition delineates tropical from temperate east coast faunas.

Summary details: Twelve species, only one of which can be presently assigned to a known taxon. All species occur in shallow waters (<40m depth), with highest diversity in the southern GBR (NEP, CEB), and distinctly different species composition between tropical east coast (8 species – CEB to NEB)) and cool temperate east coast faunas (3 species - TasP).



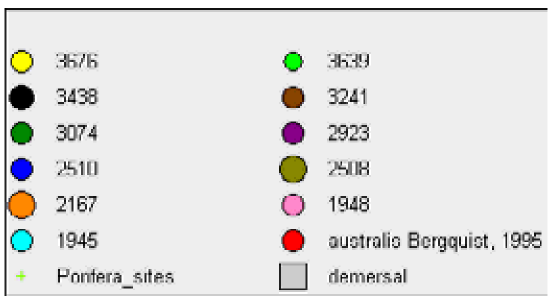
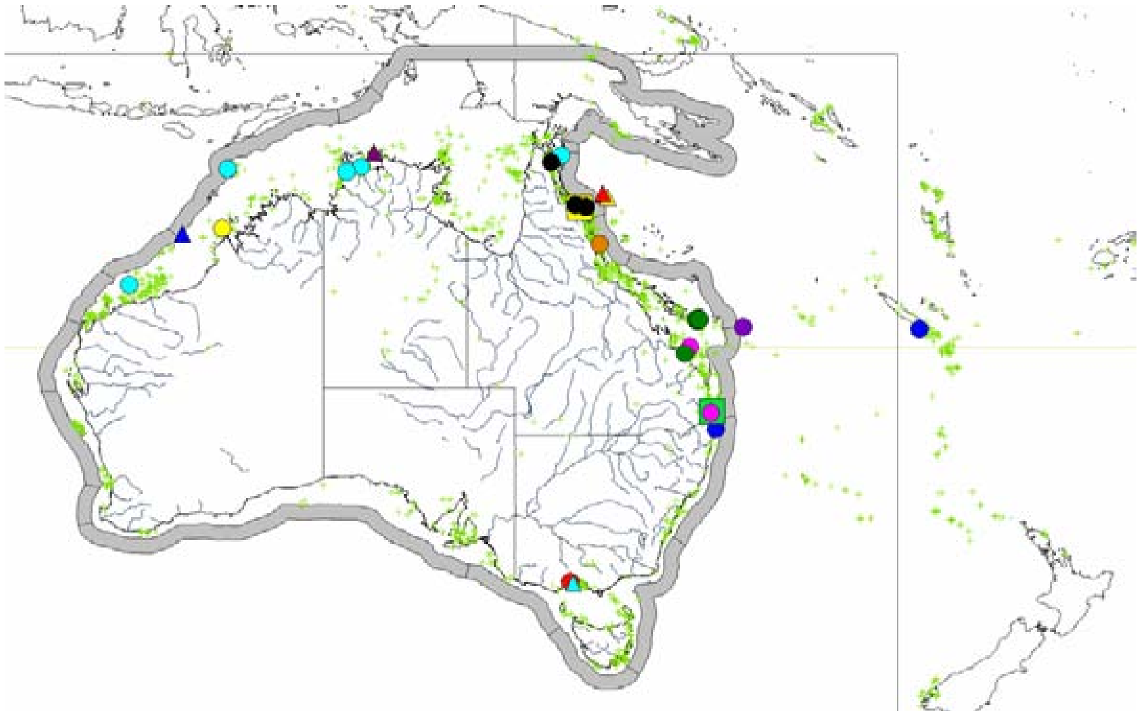


FIG. 163. ***Acanthodendrilla* spp** (QM Biolink database)

***Dictyodendrilla* spp (Demospongiae: Dendroceratida: Dictyodendrillidae) (Fig. 164)**

Bioregional trends: One widespread tropical species; two sets of species groups clearly differentiating northern and southern GBR regions.

Summary details: Sixteen species, only two of which are currently assigned to a known taxon. Only one species (*Dictyodendrilla* sp. #362) widely distributed across northern Australia (NEB to NWP), three informative for meso-regional distributions (*Dictyodendrilla* sp. #648 at NEB, *Dictyodendrilla* spp. #2172, #2989 at CEB), with the remainder rare and known so far from only one or few records. Northern GBR (6 species – NEB) and southern GBR faunas (5 species – CEB, NEP) with different species assemblages with no species in common



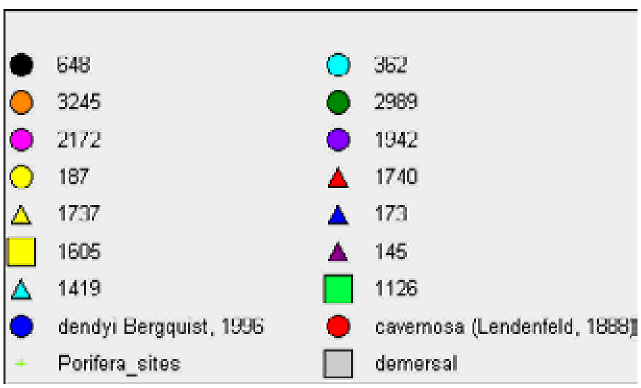


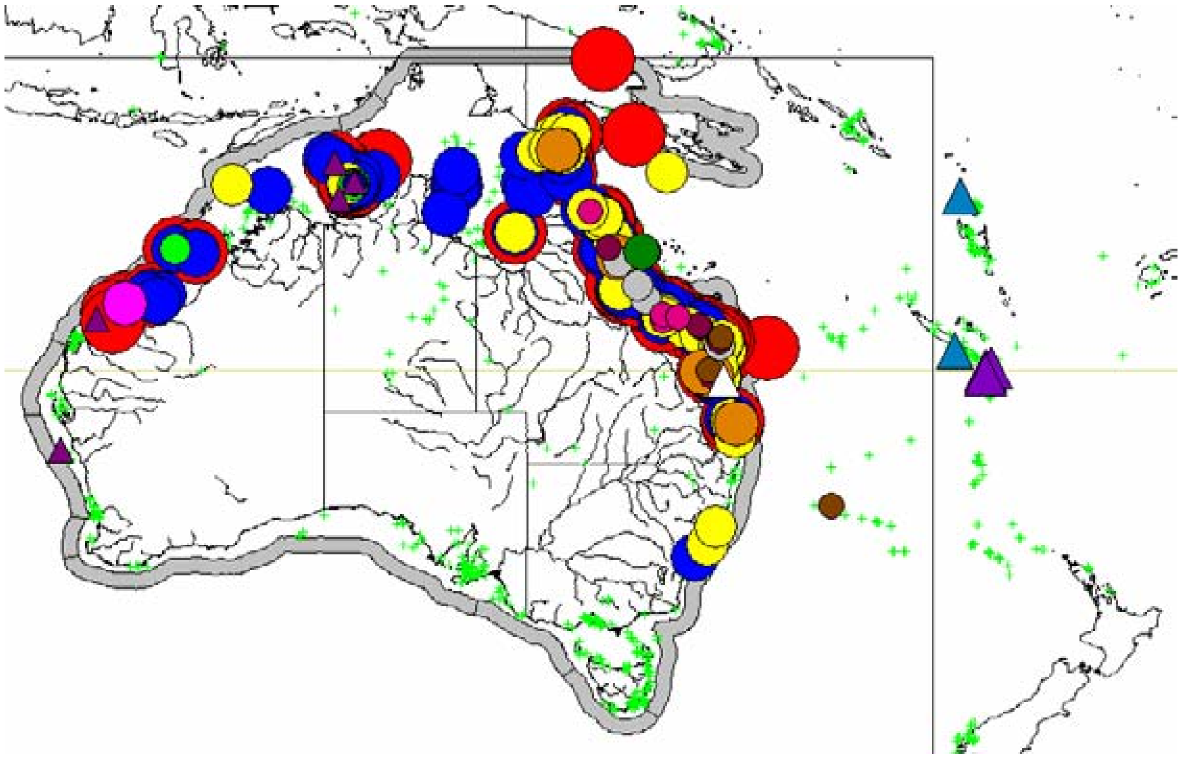
FIG. 164. *Dictyodendrilla* spp (QM Biolink database)

Order Verongida Bergquist, 1978
Family Ianthellidae Hyatt, 1875

46. *Ianthella* and *Anomoianthella* spp (Demospongiae: Verongida: Ianthellidae) (Fig. 165)

Bioregional trends: Predominantly tropical with 3 species spanning the tropical belt; highest diversity on the GBR; north and south GBR and east and west coast faunas not differentiated.

Summary details: *Ianthella* (14 morphospecies spp, 5 named) and *Anomoianthella* (4 spp, 2 named) are not diverse but highly abundant in many habitats, particularly at the base of coral reefs and in the inter-reef region and soft benthos. The fauna is dominated by three species, all showing wide tropical distributions: *I. basta* and *I. flabelliformis* (north west coast to south east Queensland: NWP-CEB), and *I. quadrangulata* (western part of the north coast and Sahul Shelf to the Sydney region: NP–CEP). The highest diversity is on the southern GBR (NEP: 9 spp), north GBR (NEB: 8 spp) and Darwin region (western part of NP: 6 spp). Northern and southern GBR regions and east coast and west coast faunas are not clearly differentiated by this group. *Anomoianthella popeae* is a western and north west coast species (NWP-NP).



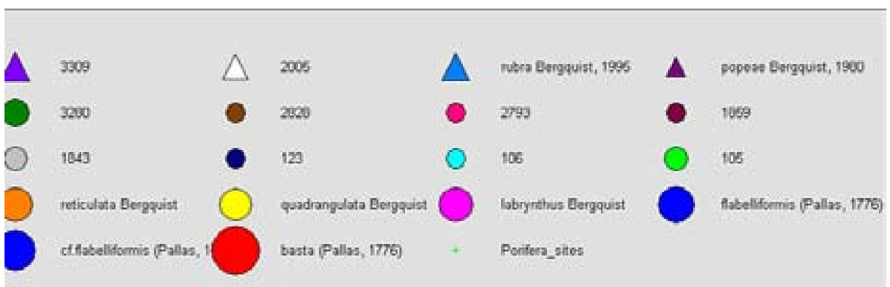


FIG. 165. *Ianthella* (circles) and *Anomoianthella* spp (triangles) (QM Biolink database)

Family Aplysinellidae Bergquist, 1980

47. *Aplysinella, Porphyria, Psammaplysilla* and *Suberea* spp (Demospongiae: Verongida: Aplysinellidae) (Fig. 166)

Bioregional trends: Peak in diversity in the south GBR and south east Queensland regions, with distinct differences between east and west coast faunas changing at Cape York.

Summary details: *Aplysinella* (8 spp, 1 named), *Porphyria* (1 named sp.), *Psammaplysilla* (1 named sp.) and *Suberea* (7 spp, 2 named) are not diverse but one species (*Aplysinella rhax*) can be abundant in coral reef habitats. The southern GBR (NEP) and south east Queensland regions (CEB) have the highest diversity of species (8 spp). There are distinct differences between east coast and west coast species, the latter with *Aplysinella* sp. #143 predominant, with species turnover at the eastern part of NP boundary.

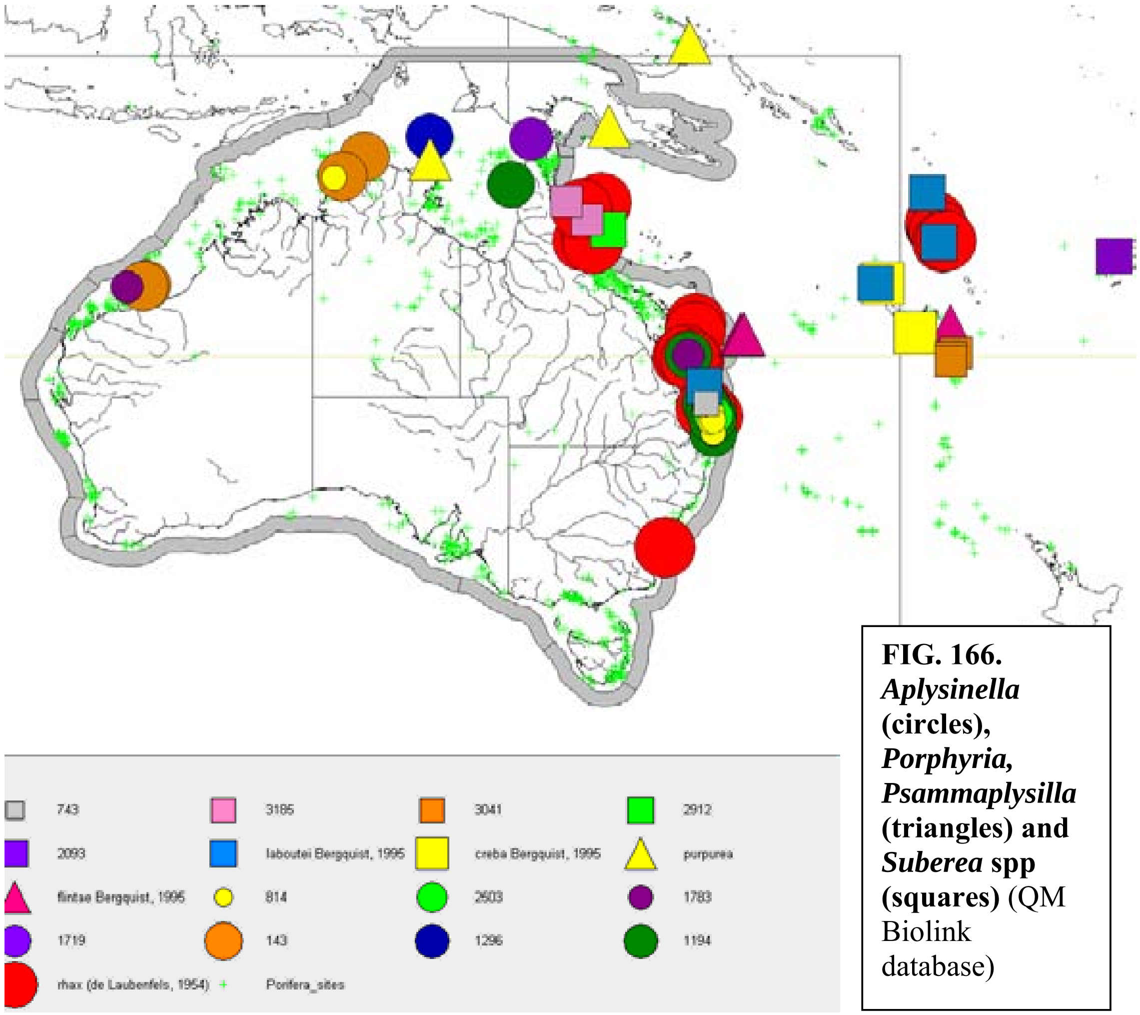


FIG. 166. *Aplysinella* (circles), *Porphyria, Psammaplysilla* (triangles) and *Suberea* spp (squares) (QM Biolink database)

Family Pseudoceratinidae Carter, 1885

48. *Pseudoceratina* spp (Demospongiae: Verongida: Pseudoceratinidae) (Fig. 167)

Bioregional trends: Predominantly tropical Pacific group, with highest diversity in the GBR; north and south GBR bioregions differentiated; distinctinctive east and west coast faunas with species turnover at Cape York (eastern NP).

Summary details: *Pseudoceratina* (36 spp, 4 named) has database records containing extensive tropical and fewer temperate species' distributions, with one widespread western species indicated (*Pseudoceratina* sp. #190), extending from the south west coast to the north coast (SWB-NP), one northern and north eastern species (*Pseudoceratina* sp. #364) extending from the Sahul Shelf (NWB) to south east Queensland (CEB), and and two predominantly southern species (*P. durissima, P. clavata*) that extend into the GBR province. Other species appear to be restricted to one or few adjacent bioregions. Highest species diversity occurs in the southern GBR (NEP: 15 spp), northern GBR (NEB: 14 spp), south east Queensland (CEB: 10 spp) and the north coast (NP: 7 spp). Northern GBR bioregion and south GBR – south east Queensland bioregions differentiated in terms of species composition, and a major species turnover at Cape York (NP) differentiating eastern and western faunas.
-north GBR (NEB): *Pseudoceratina* spp #1773, #2915, #3176
-south GBR and south east Queensland (NEP-CEB): *P. purpurea, Pseudoceratina* sp. #1973, #2462, #3502
-central south east coast (CEP): *Pseudoceratina* sp. #1478
-Tasmania-Bass Strait (TasP-BassP): *Pseudoceratina* spp #3640, #3641

-southern Gulf (GulfP): *Pseudoceratina* sp. #472
-north coast (NP): *Pseudoceratina* spp #145, #2399, #2432

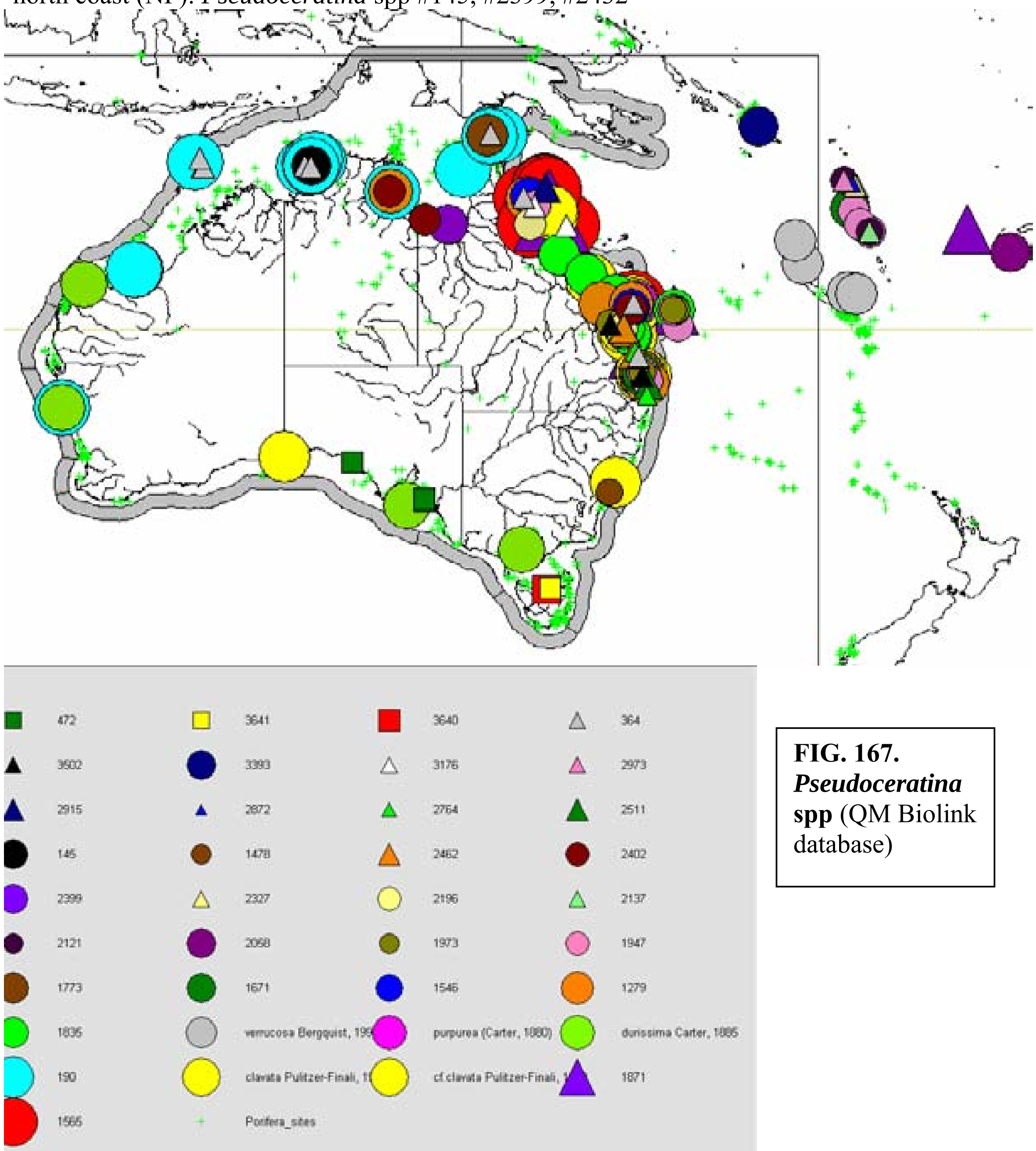


FIG. 167. *Pseudoceratina* spp (QM Biolink database)

Family Aplysinidae Carter, 1875

49. *Aplysina* spp (Demospongiae: Verongida: Aplysinidae) (Fig. 168)

Bioregional trends: One circum-Australian species with remainder restricted to single bioregions; NP region with highest diversity.

Summary details: *Aplysina* (12 spp, 3 named) is not diverse but contains one highly abundant and widely distributed 'morphospecies' (*A. ianthelliformis*) found throughout Australian coastal waters. The Darwin region (western part of NP) contains the highest diversity (6 spp). Several species are markers for particular bioregions:

-south GBR- south east Queensland (NEP-CEB): *Aplysina* sp. #1247
-Tasmania-Bass Strait (TasP-BassP): *A. lendenfeldi*, *Aplysina* sp. #3636
-north coast (NP): *Aplysina* sp. #40, #87, #125, #223
-south west coast (SWB): *A. pedunculata*

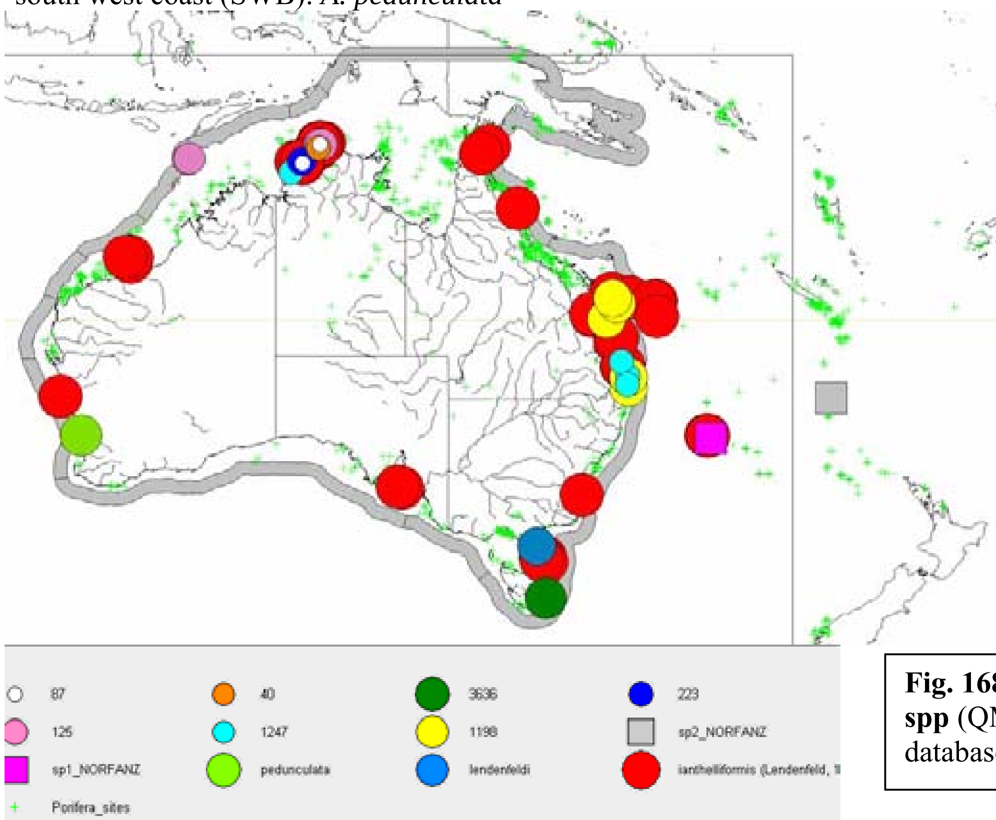


Fig. 168. *Aplysina* spp (QM Biolink database)

Class Calcarea Bowerbank, 1864
Order Clathrinida Hartman, 1958
Family Leucettidae de Laubenfels, 1936

50. *Pericharax* spp (Calcarea: Clathrinida: Leucettidae) (Fig. 169)

Bioregional trends: Highest diversity in the Great Barrier Reef region (CEB to NEB). Two species delineate eastern - northeastern zones (NEB to CEP) from northern - western zones (NP to SWB). Species turnover is dramatic south of the Tweed River (CEB) and west of Torres Strait (NP).

Summary details: Fourteen species of *Pericharax* occur in tropical and warm temperate Australian waters, only one of which can be currently assigned to a named taxon with any certainty. The greatest species diversity (ten species) occurs in the Great Barrier Reef provinces (NEB, NEP & CEB), predominantly associated with coral substratum. Nine species occur in the northern zone (NEB) and six in the southern zone (NEP & CEB), with five species common to both zones. Two of these species are shared with New Caledonia.

There is one species distributed widely along the length of the east Australian coast (*Pericharax* sp. #1187), extending from TasP to NEB. There is a marked species turnover (biotone) at the southern end of the CEB, with only two species occurring south of the Tweed River region (one unique to the southern region).

There is a fundamental east-west differentiation at Torres Strait (NEB-NP), delineated primarily by the predominant distributions of two widespread tropical taxa (*Pericharax heterorhaphis* and *Pericharax* sp. #58). To date no species have yet been discovered within the Gulf of Carpentaria.

On the north and west coasts of Australia only four species occur, two of which concern the widely distributed tropical *Pericharax* species.

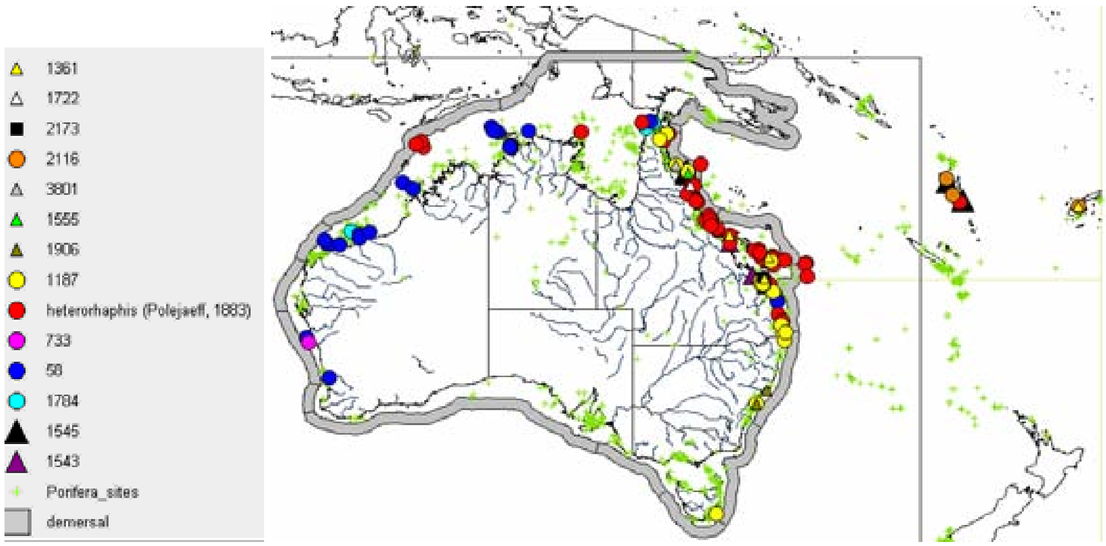
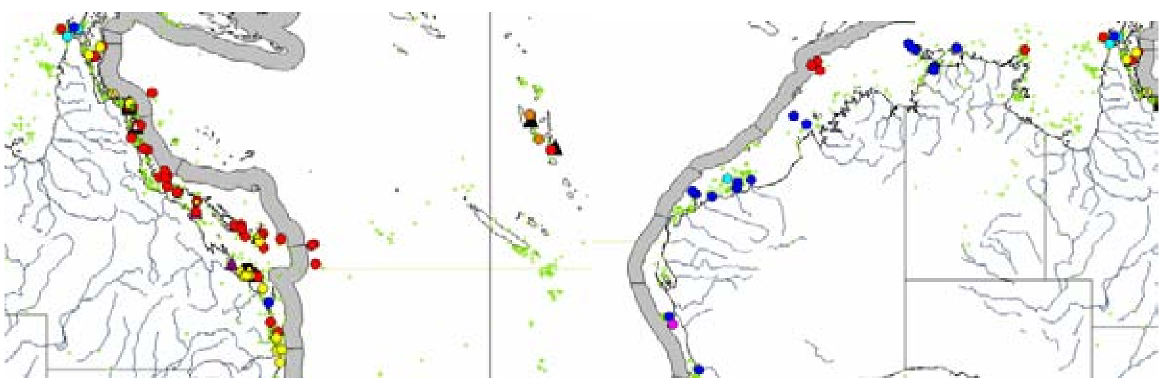


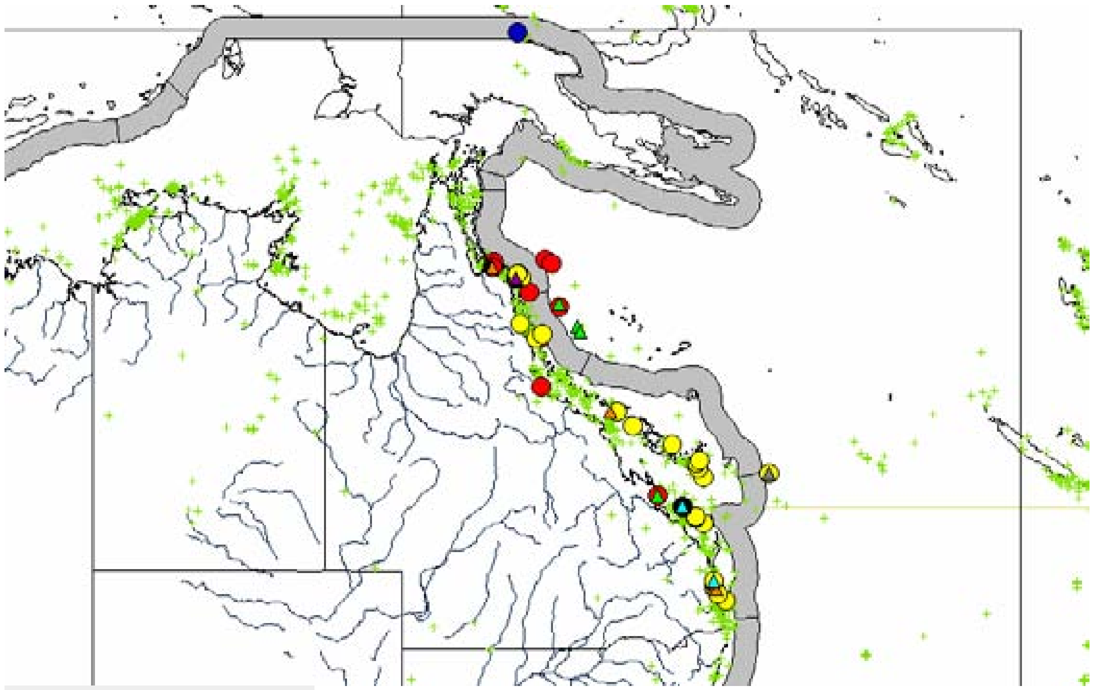
FIG. 169. *Pericharax* species, with enlargements of east and west coast species distributions (QM Biolink database)



***Leucetta* spp (Calcarea: Clathrinida: Leucettidae) (Fig. 170)**

Bioregional trends: Only recorded so far from the GBR region (NEB to CEB). Species diversity and composition differentiate northern and southern faunas, corresponding to genetic data.

Summary details: Ten species of *Leucetta* were recorded for tropical Australian waters, several of which have been recently described, and all of which occur in the Great Barrier Reef and Coral Sea provinces. One species (*L. chagosensis*) is widely distributed throughout the GBR and the Indo-west Pacific in general, although there is empirical evidence to show that there are two distinct 'haplotypes' within the GBR and Coral Sea populations (Woerheide et al. 2001). The far northern region of the GBR (NEB) has six species, the southern regions have eight species (NEP & CEB), with two species unique to each of these northern and southern regions, and none so far recorded south of the Tweed River or west of the Torres Straits.



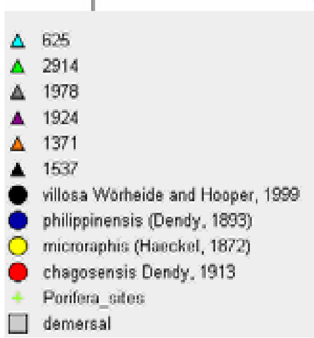


FIG. 170. ***Leucetta*** **species** (QM Biolink database)

Family Levinellidae Borojevic & Boury-Esnault, 1986 &
Order Leucosolenida Hartman, 1958
Family Sycettidae Dendy, 1892

51. *Levinella* (Calcarea: Clathrinida: Levinellidae) and *Sycon* spp (Calcarea: Leucosolenida: Sycettidae) (Fig. 171)

Bioregional trends: Species presence/absence is indicative of coral reefs, but no differentiation of northern or southern reef provinces.

Summary details: Two other calcarean species are common in both the northern and southern-central GBR region associated with coralline substrate, extending from NEB to CEB. Neither have yet been collected extensively, but probably have geographically sympatric distributions and occur elsewhere in the Coral Sea and Pacific Island regions. Both species are indicative of coral substrate. The record of *Sycon* cf. *gelatinosum* from the Sydney region likely concerns a non-conspecific morphologically similar (sister) species.

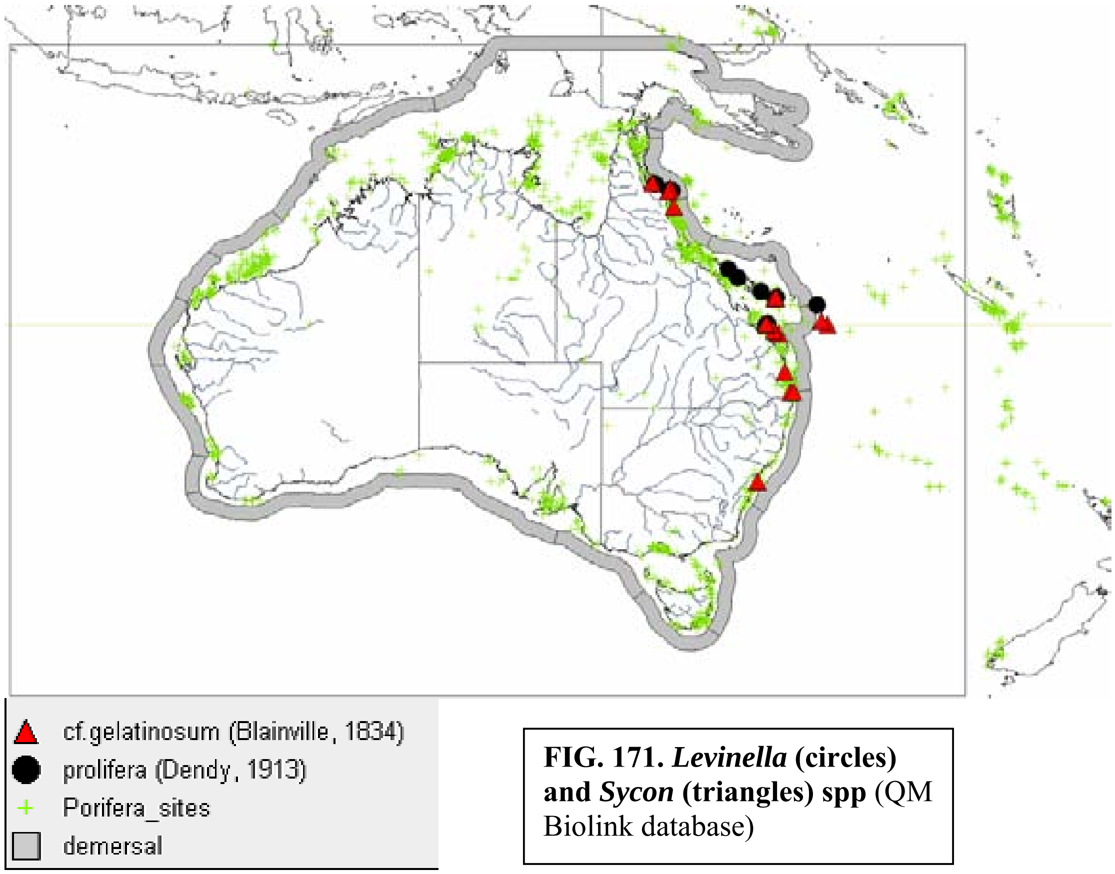


FIG. 171. *Levinella* (circles) and *Sycon* (triangles) spp (QM Biolink database)

APPENDIX 7. Modeled CAAB distributions and 'mudmaps' of surrogate species used for GIS and numerical analysis. Refer to Appendix 1 for list of taxonomic names that refer to each of these CAAB modelled distributions (ordered by species number).

CAAB distributions: surrogate species

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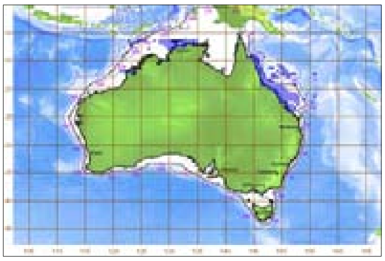

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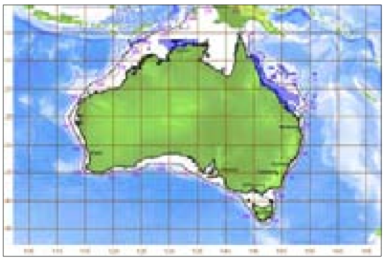

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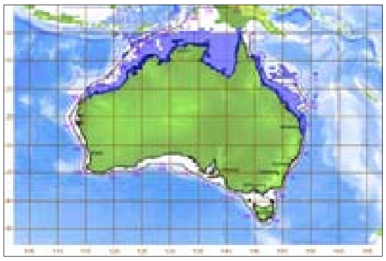

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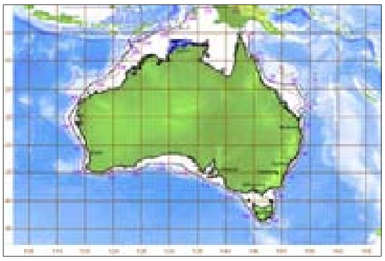

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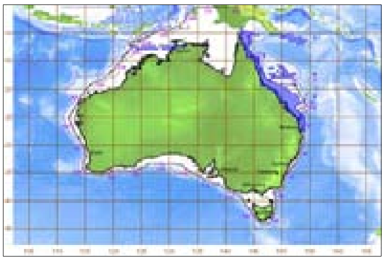

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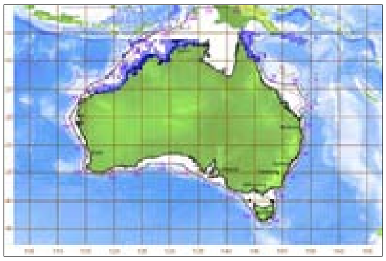

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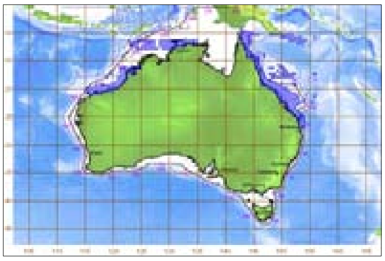

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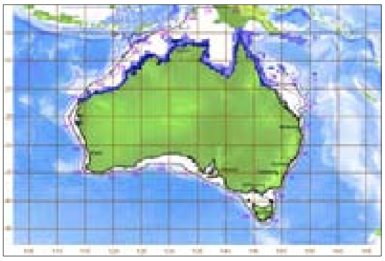

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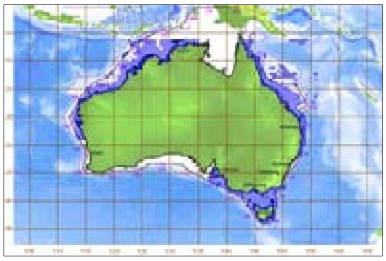

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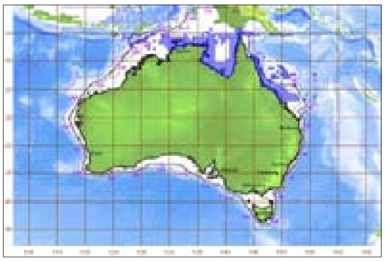

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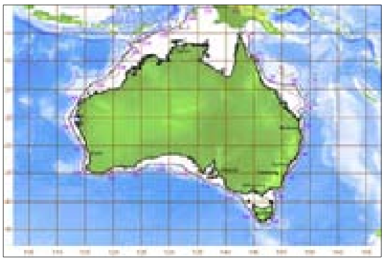

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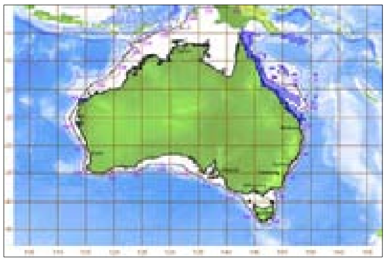

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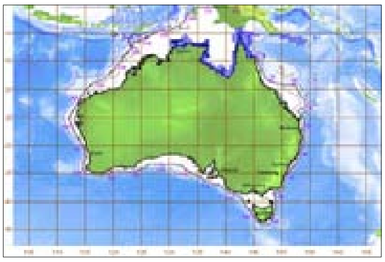
CAAB distributions: surrogate species



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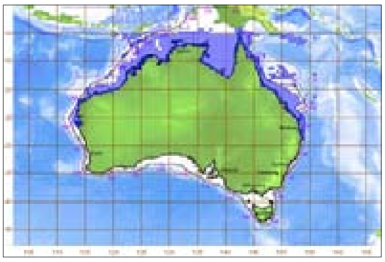

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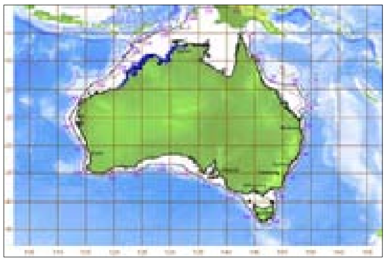

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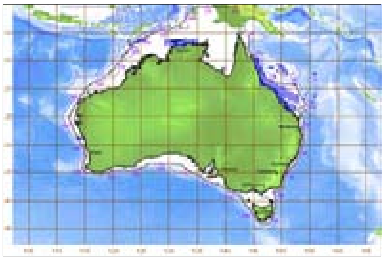

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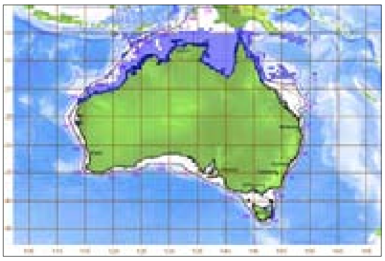

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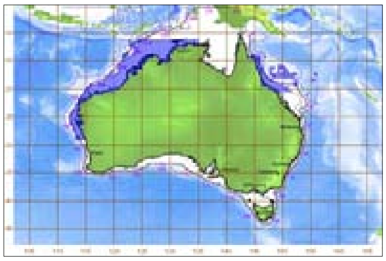

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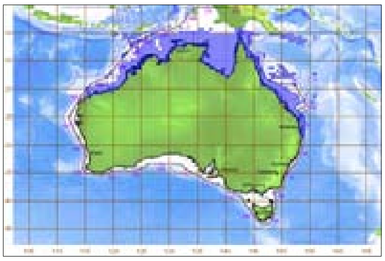

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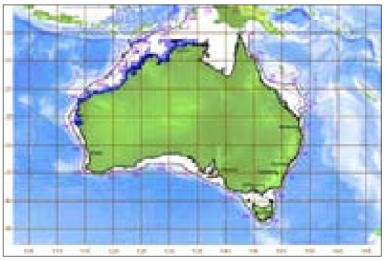

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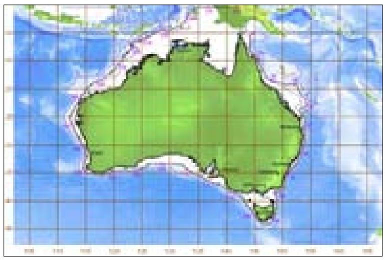

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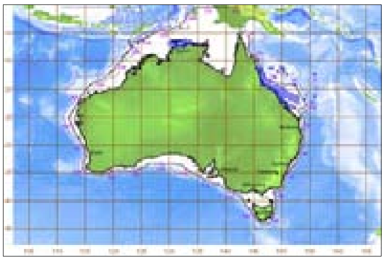

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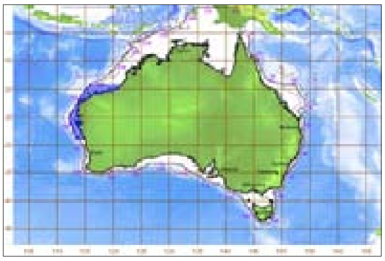

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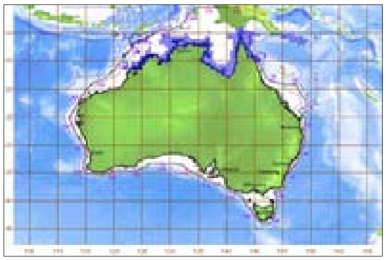

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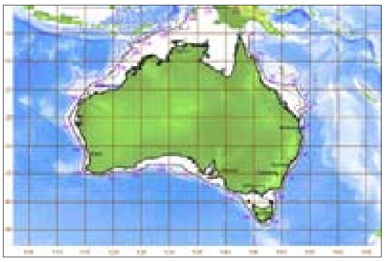

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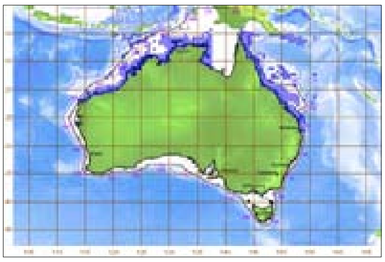

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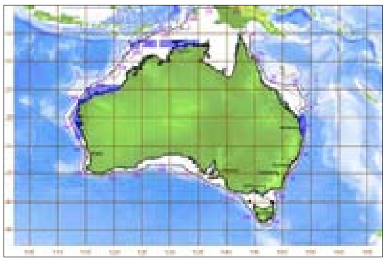

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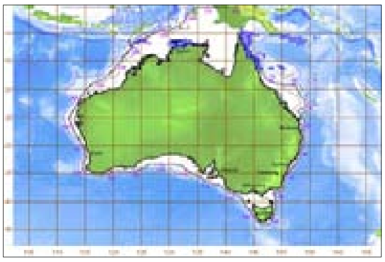
CAAB distributions: surrogate species



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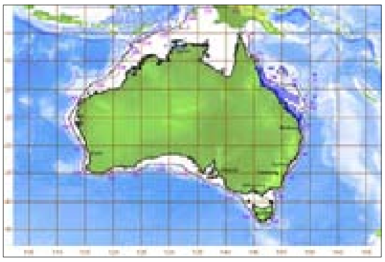

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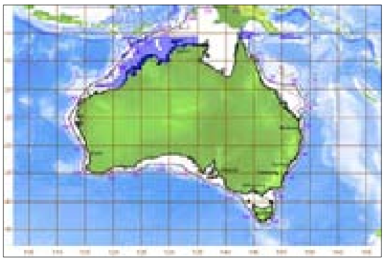

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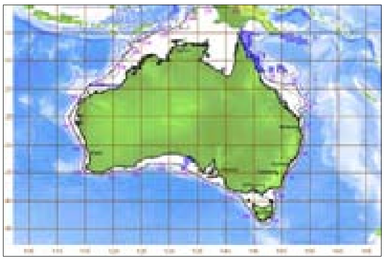

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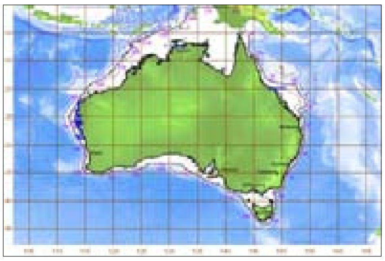

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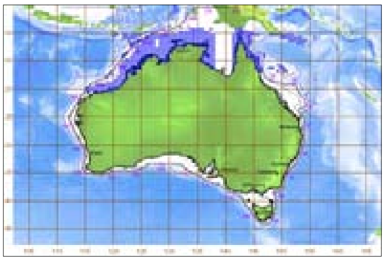

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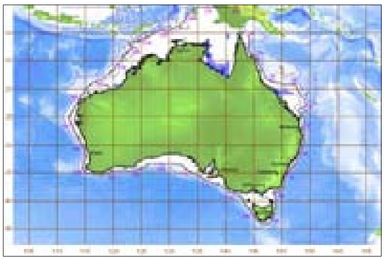

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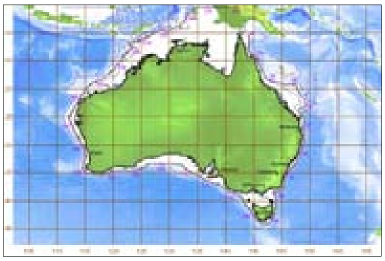

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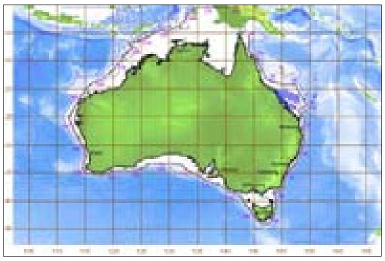

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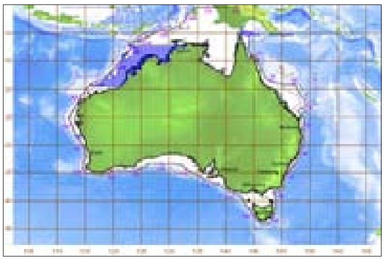

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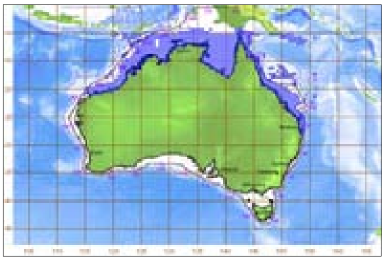

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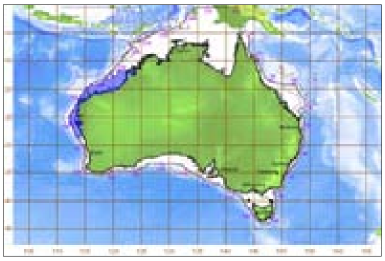

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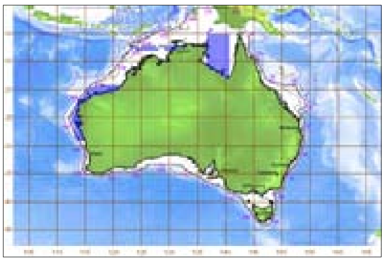

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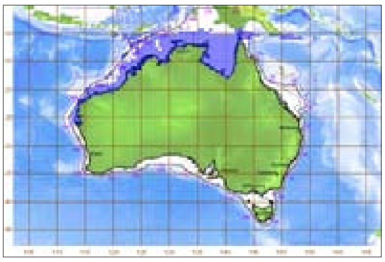

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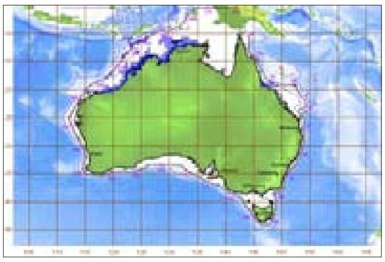

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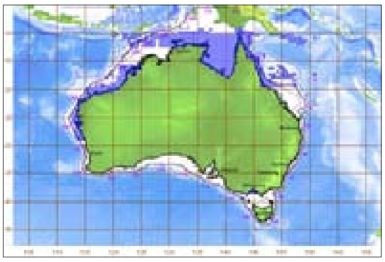
CAAB distributions: surrogate species



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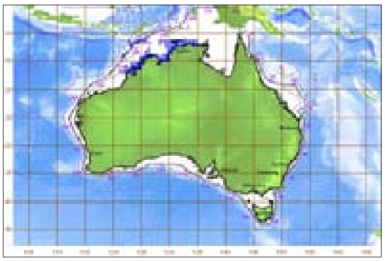

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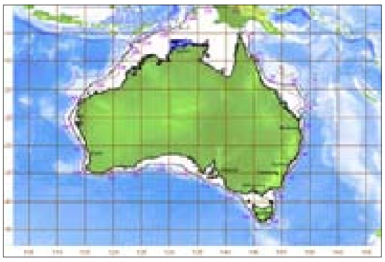

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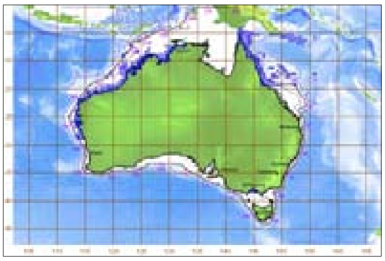

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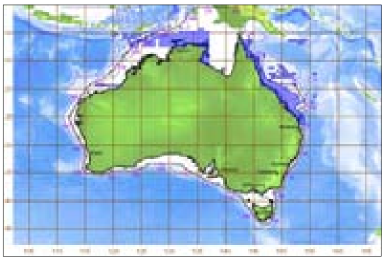

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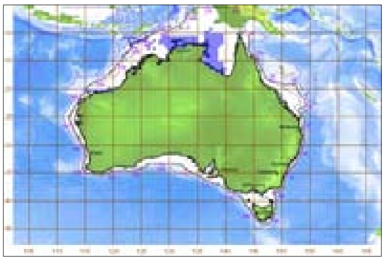

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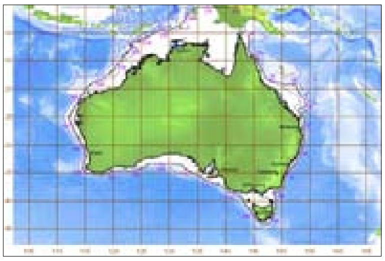

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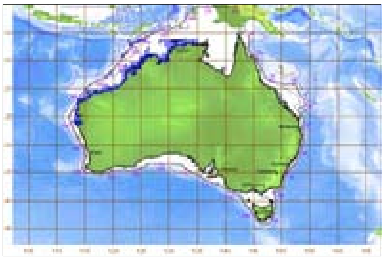

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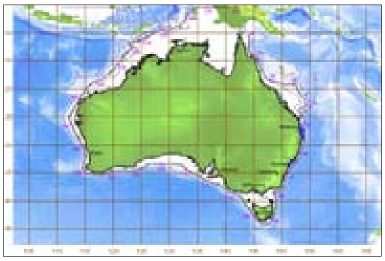

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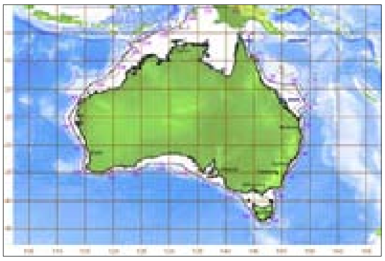

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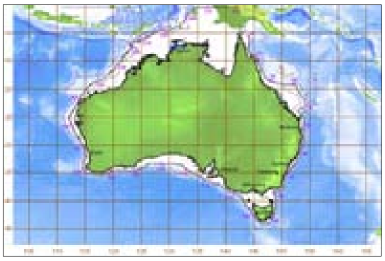

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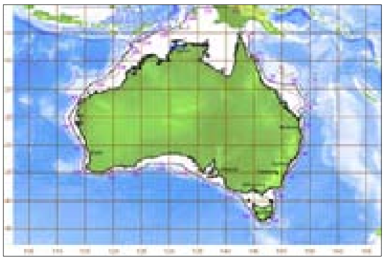

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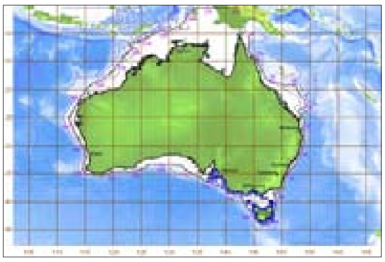

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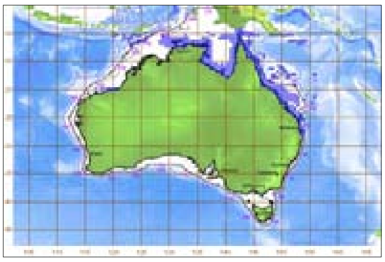

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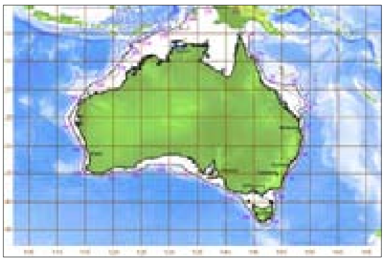

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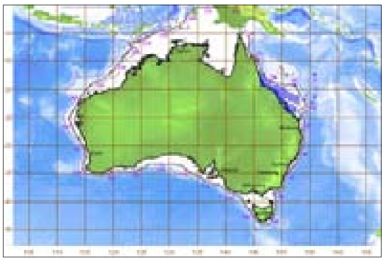
CAAB distributions: surrogate species



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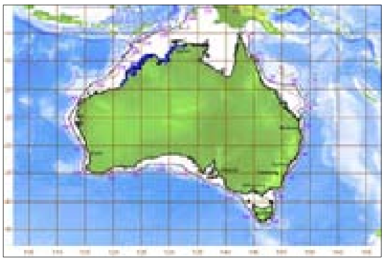

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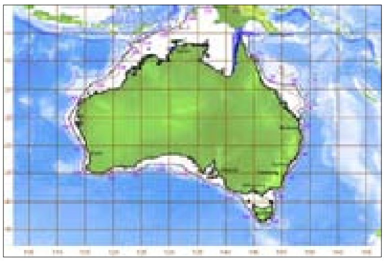

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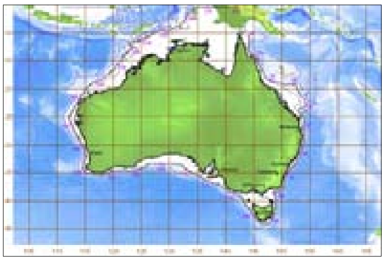

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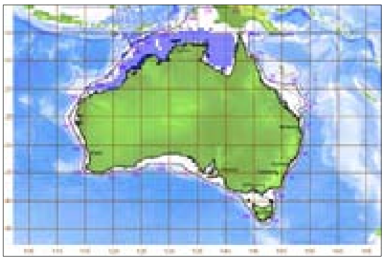

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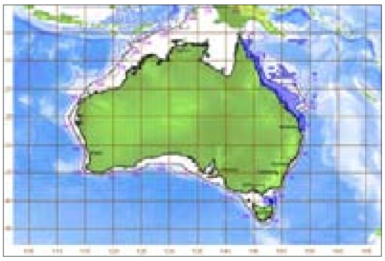

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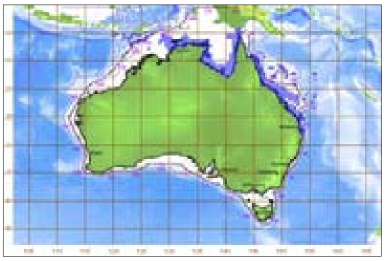

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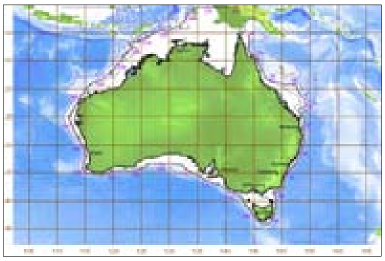

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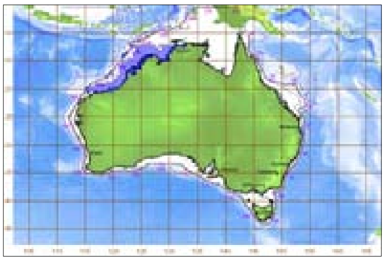

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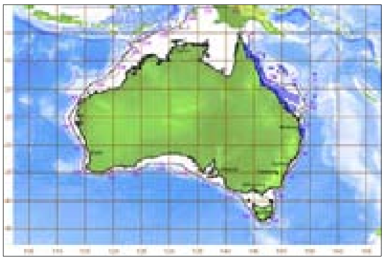

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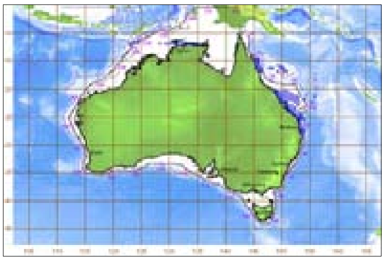

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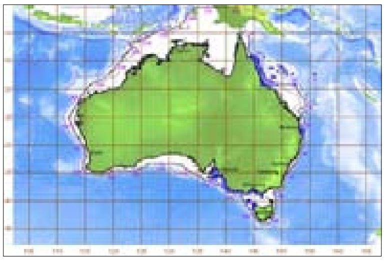

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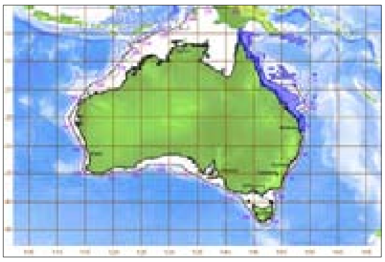

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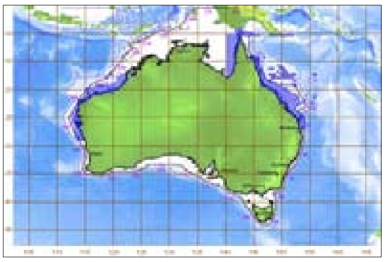

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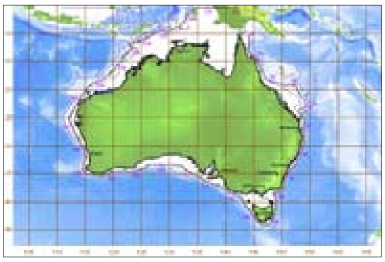

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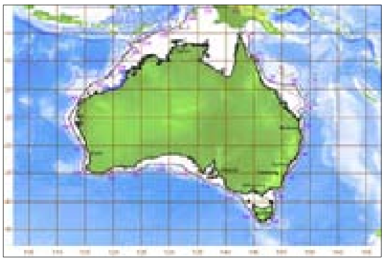
CAAB distributions: surrogate species



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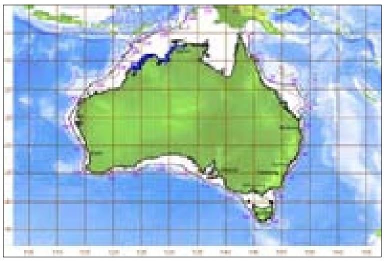

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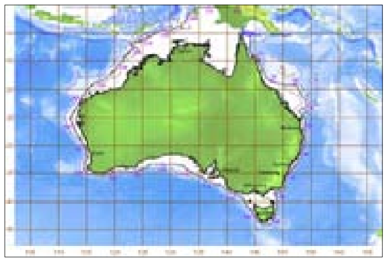

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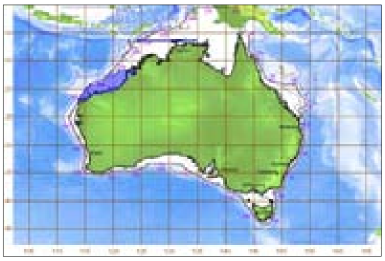

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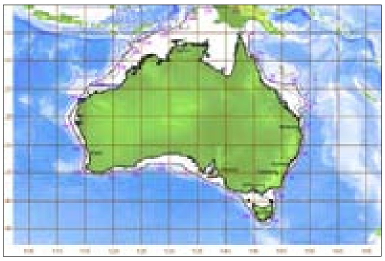

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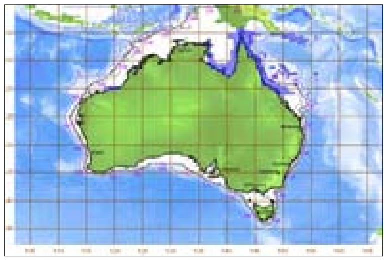

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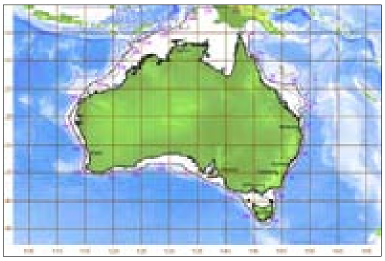

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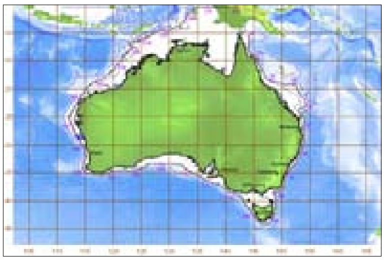

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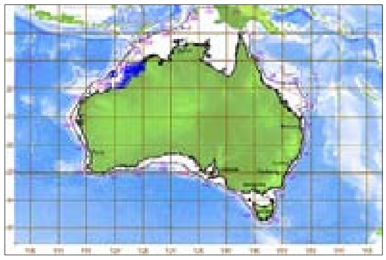

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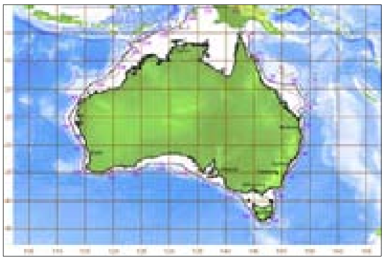

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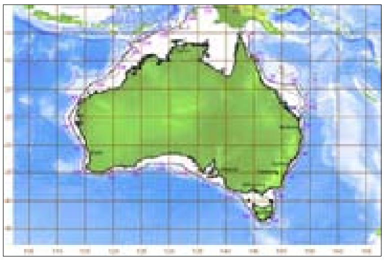

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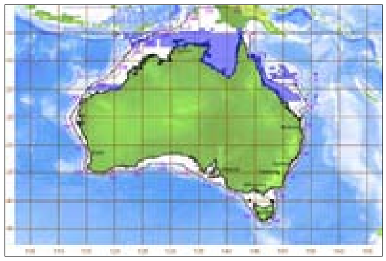

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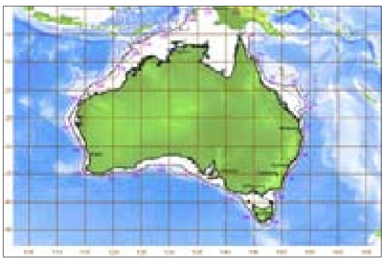

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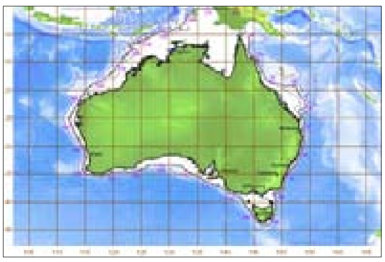

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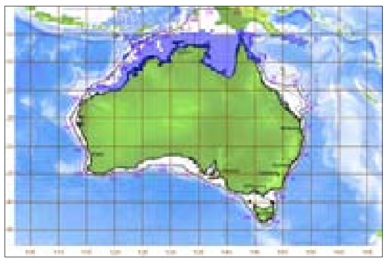

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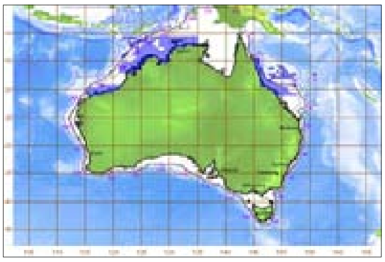
CAAB distributions: surrogate species



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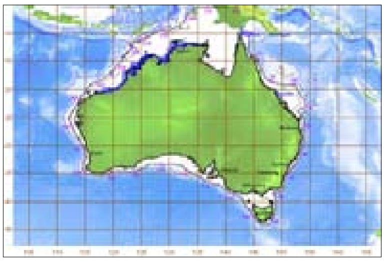

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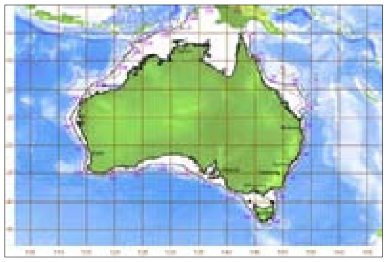

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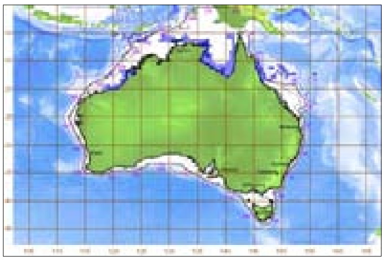

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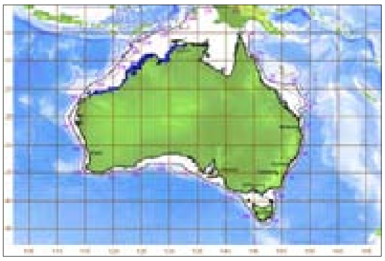

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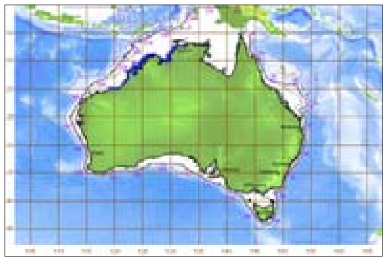

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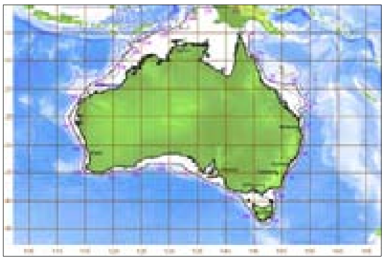

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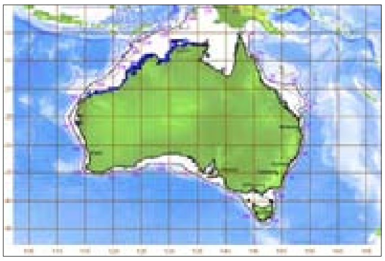

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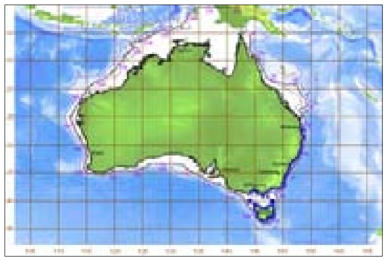

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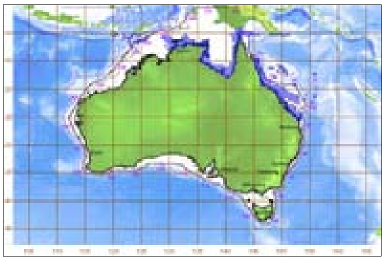

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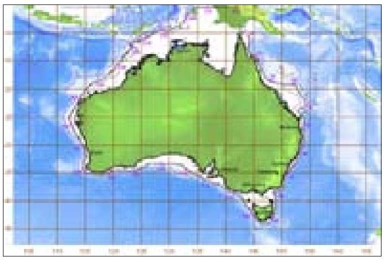

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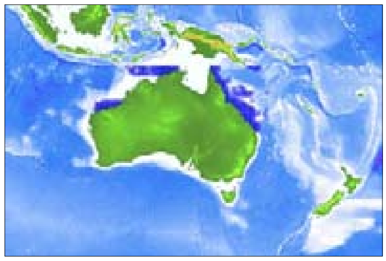

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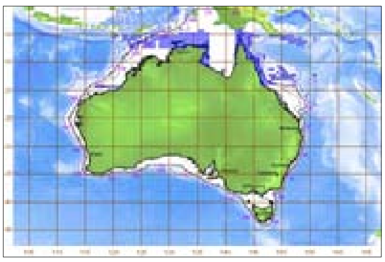

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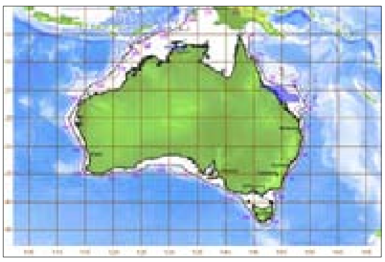

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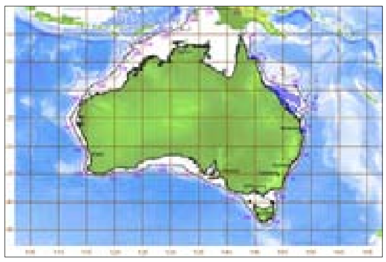

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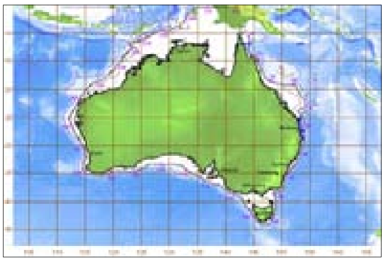
CAAB distributions: surrogate species



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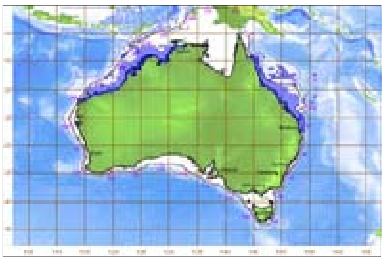

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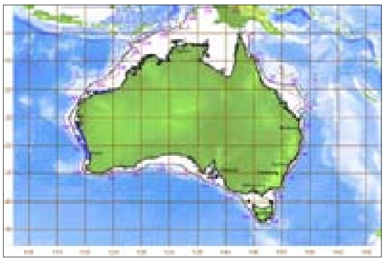

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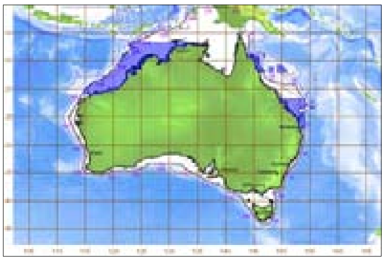

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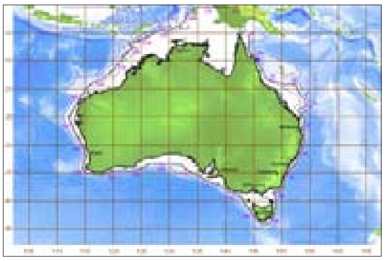

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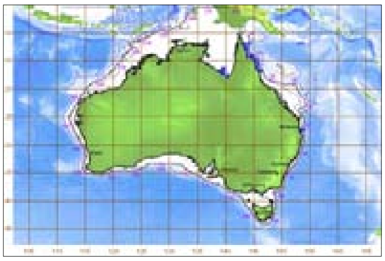

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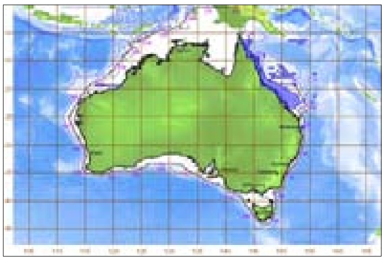

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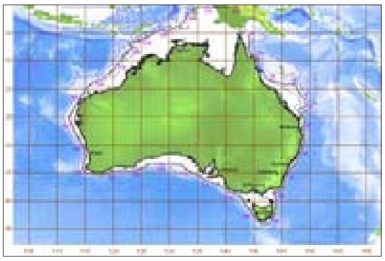

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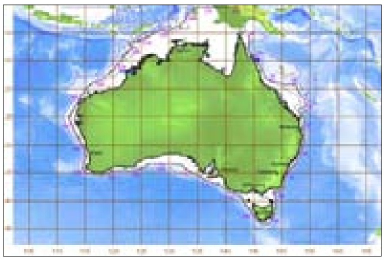

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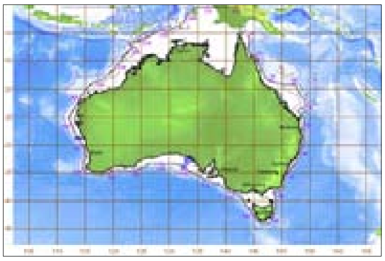

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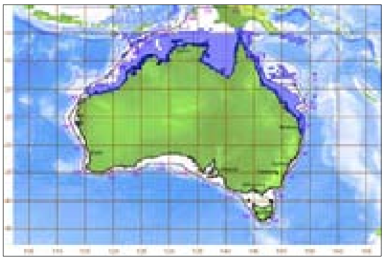

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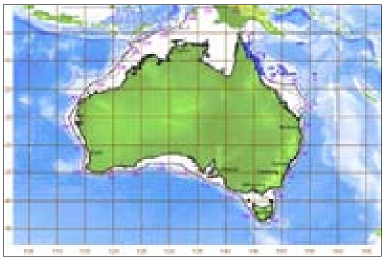

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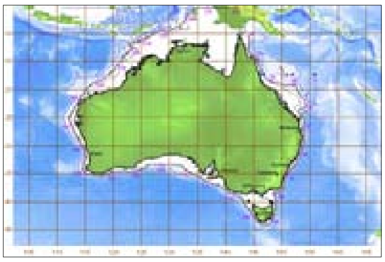

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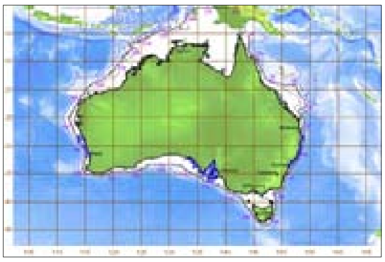

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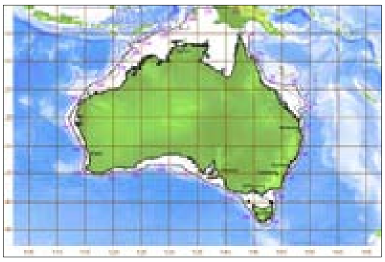

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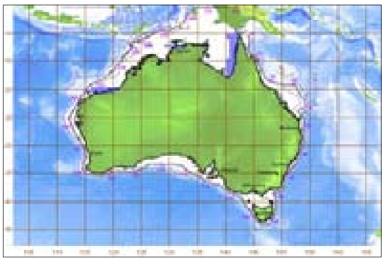
CAAB distributions: surrogate species



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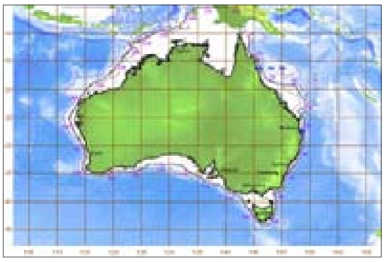

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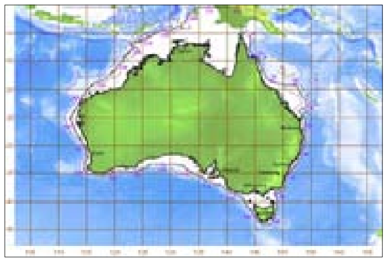

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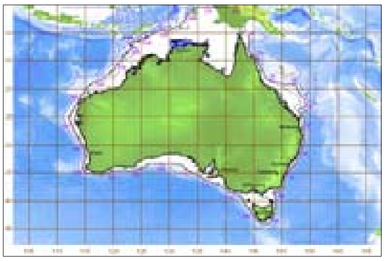

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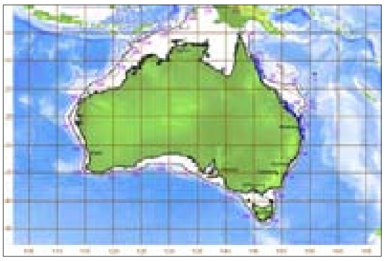

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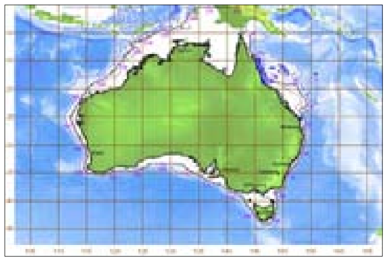

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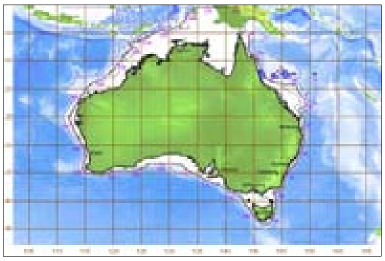

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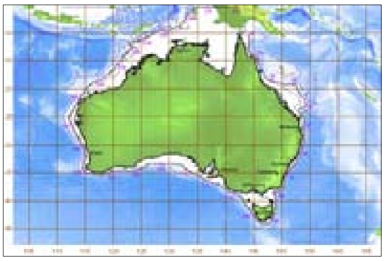

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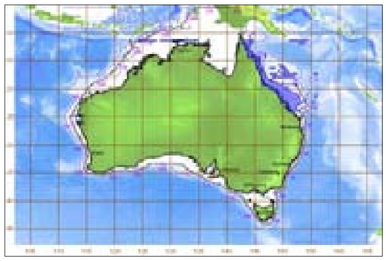

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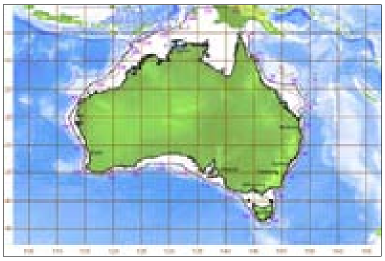

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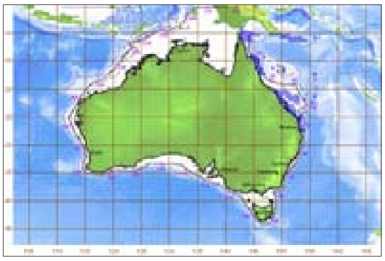

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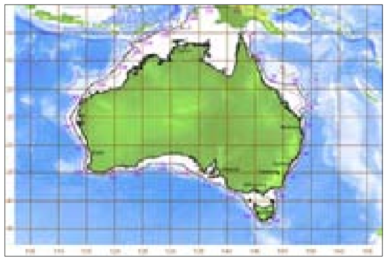

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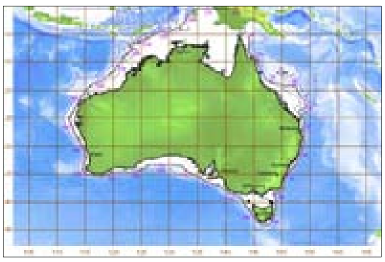

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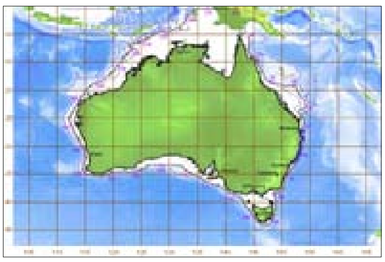

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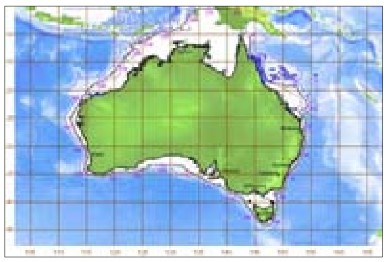

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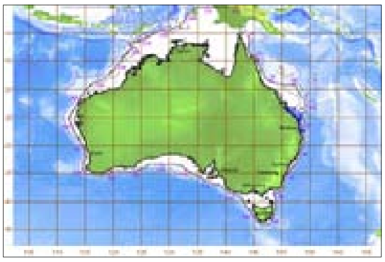
CAAB distributions: surrogate species



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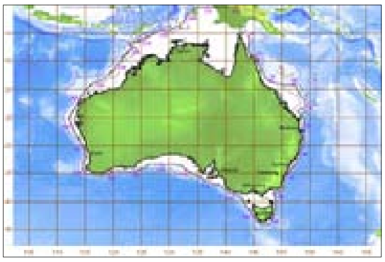

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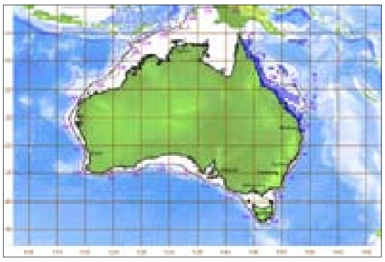

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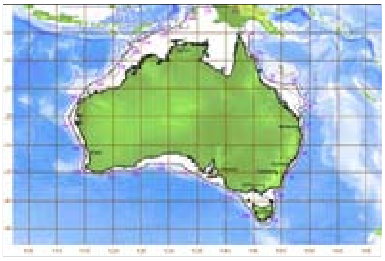

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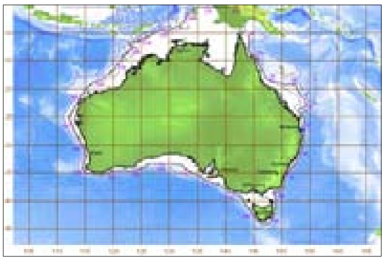

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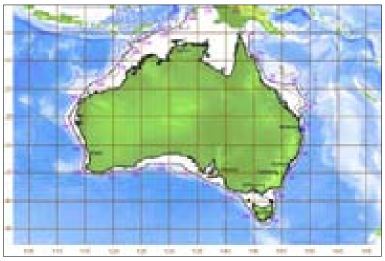

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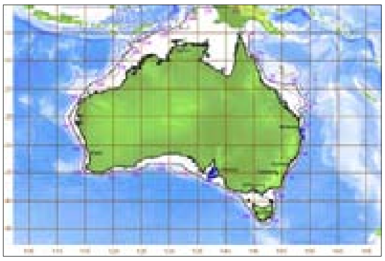

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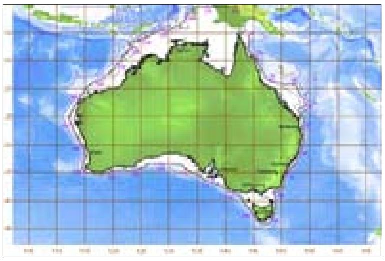

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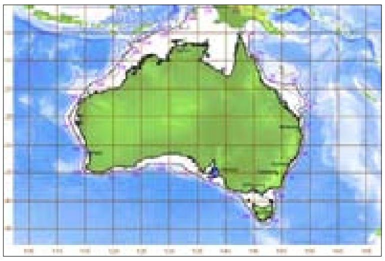

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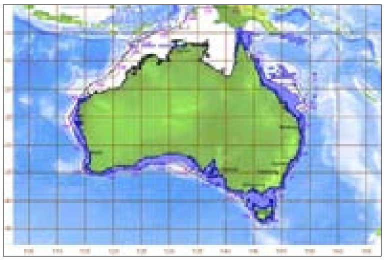

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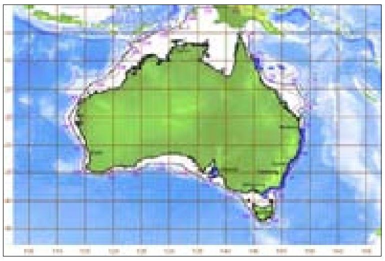

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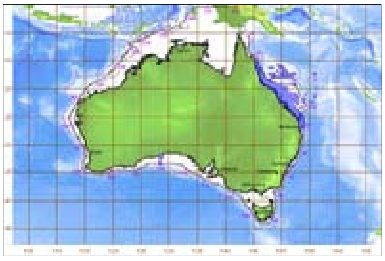

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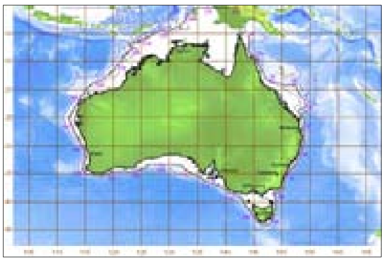

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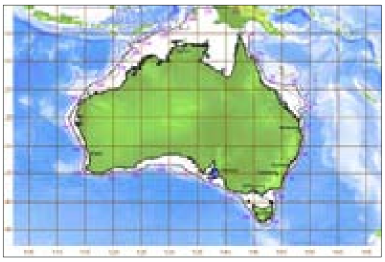

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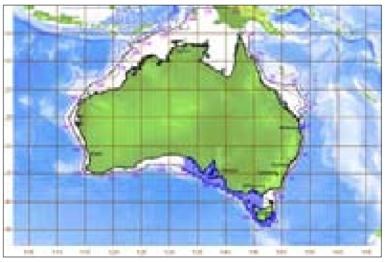

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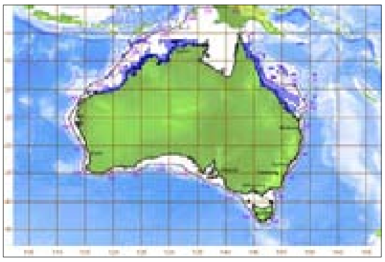
CAAB distributions: surrogate species



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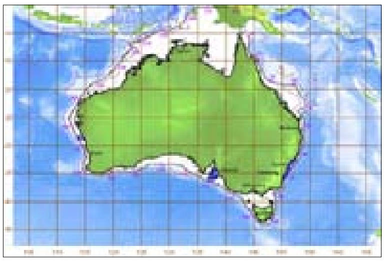

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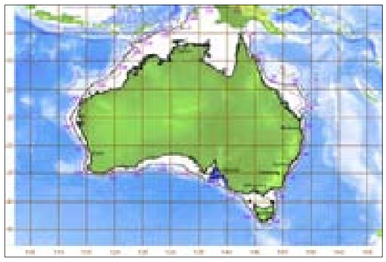

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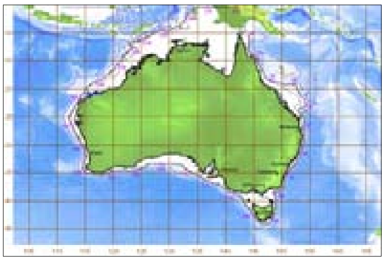

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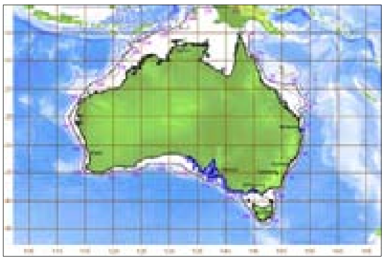

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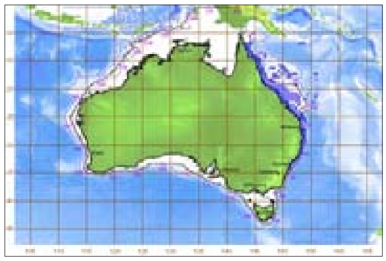

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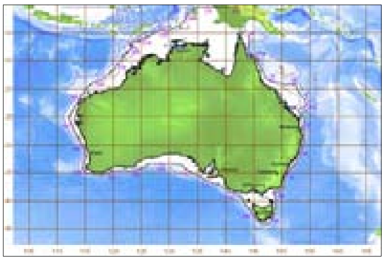

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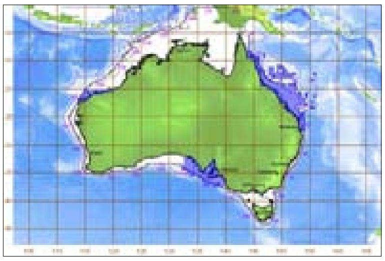

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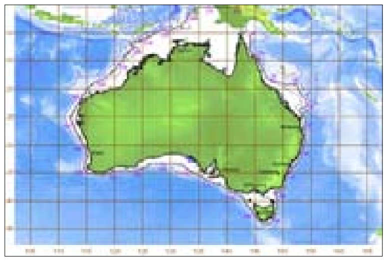

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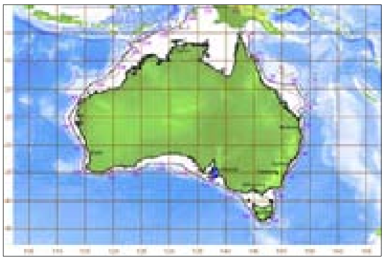

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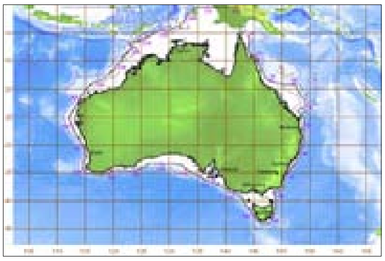

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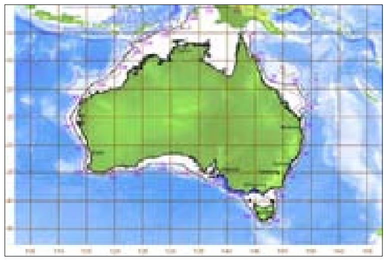

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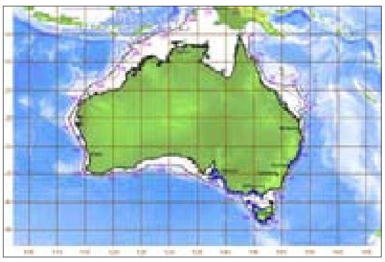

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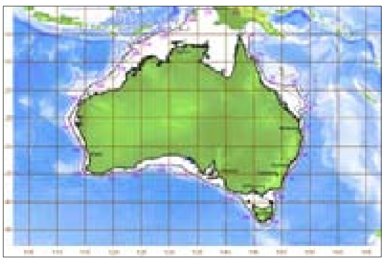

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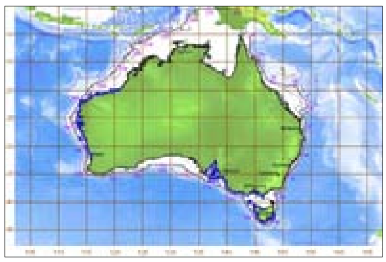

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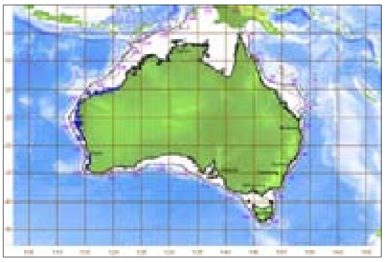
CAAB distributions: surrogate species



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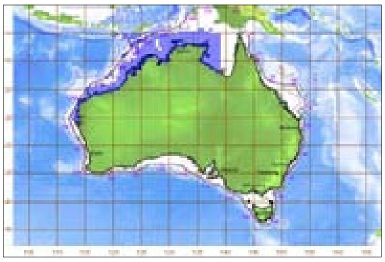

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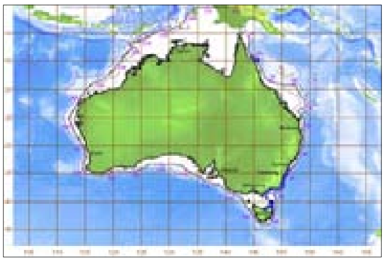

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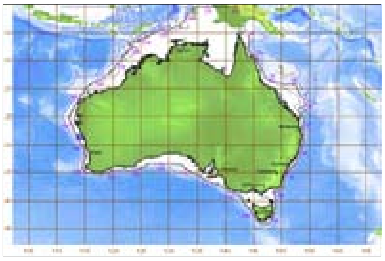

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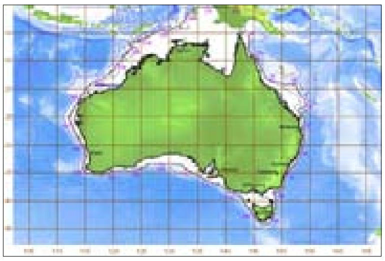

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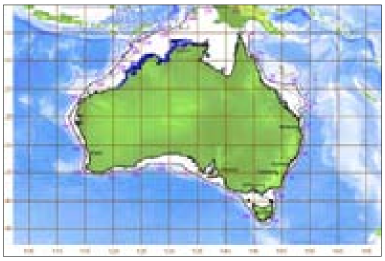

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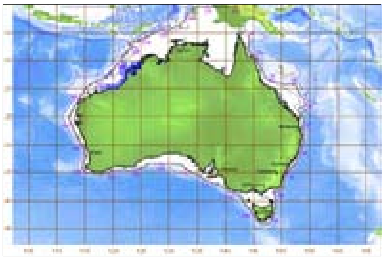

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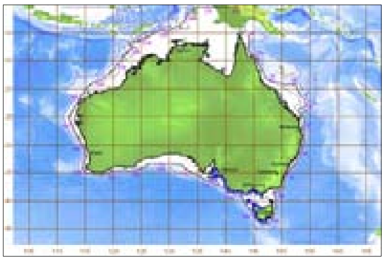

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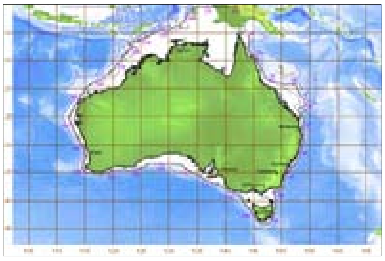

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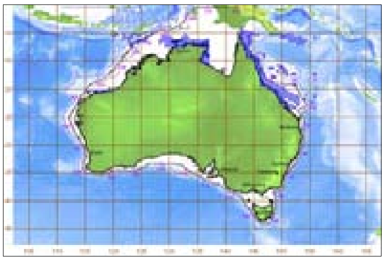

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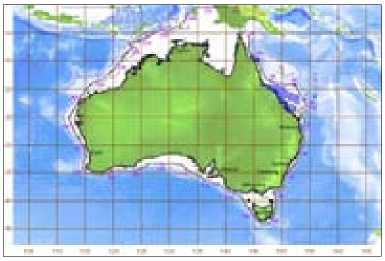

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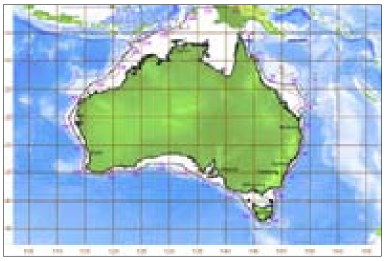

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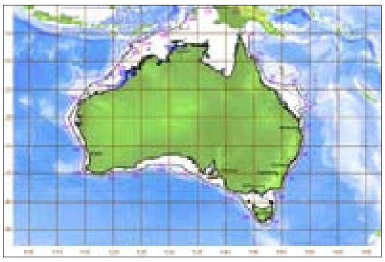

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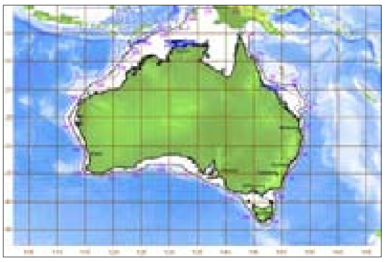

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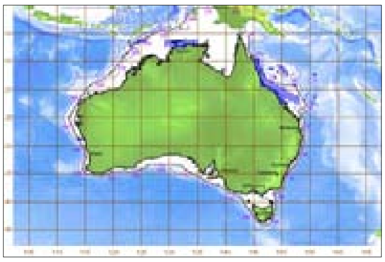

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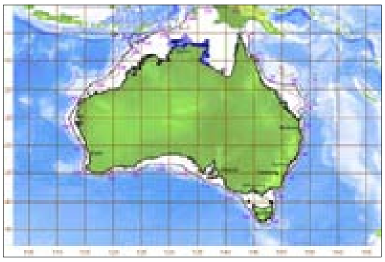
CAAB distributions: surrogate species



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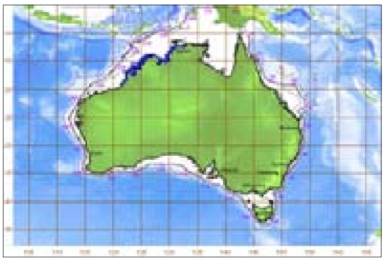

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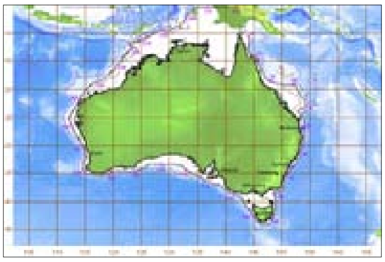

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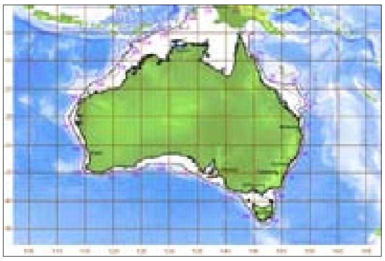

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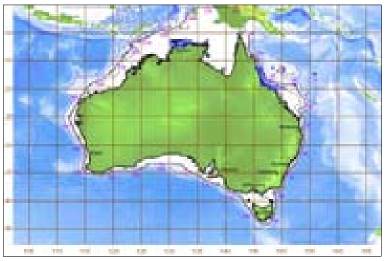

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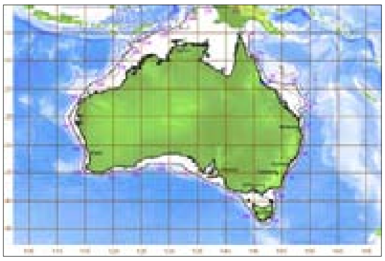

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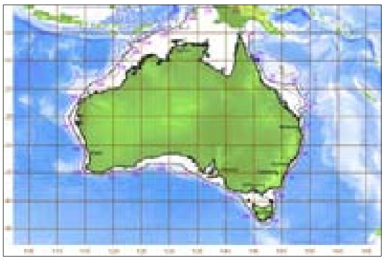

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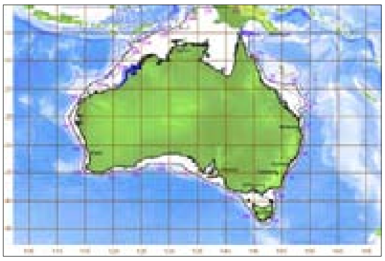

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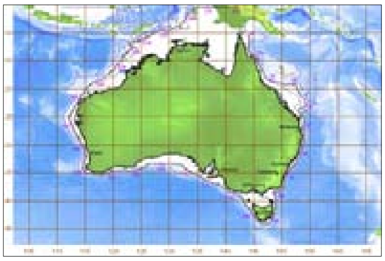

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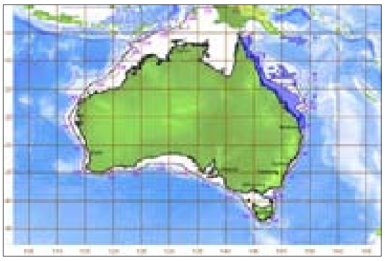

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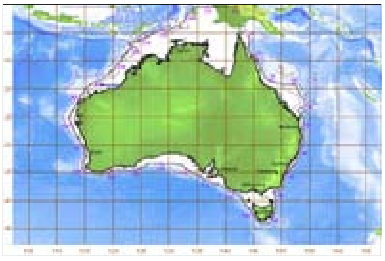

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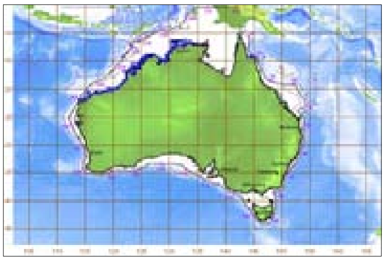

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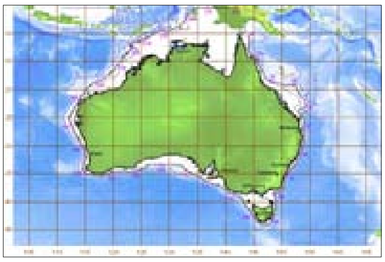

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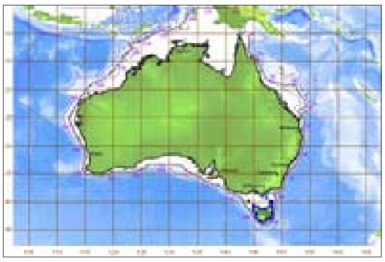

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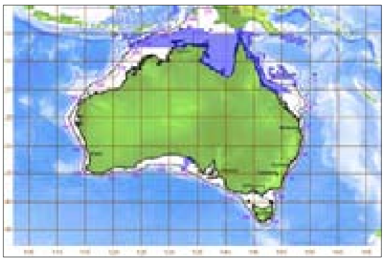

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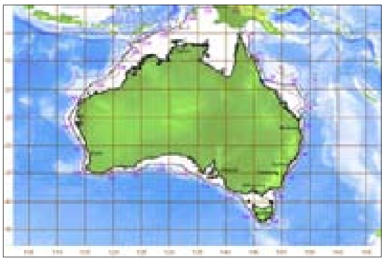
CAAB distributions: surrogate species



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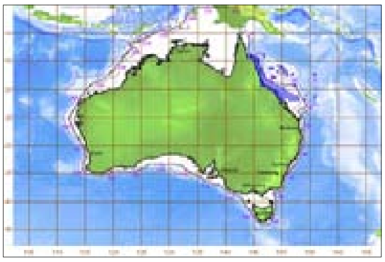

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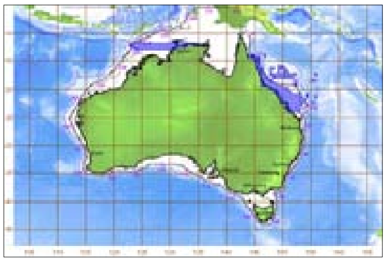

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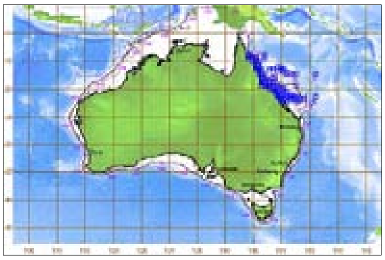

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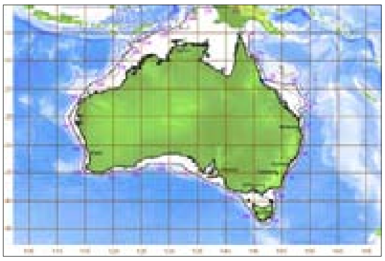

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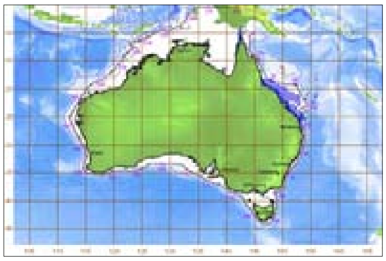

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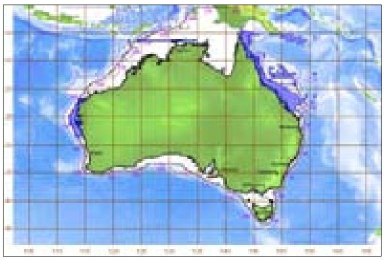

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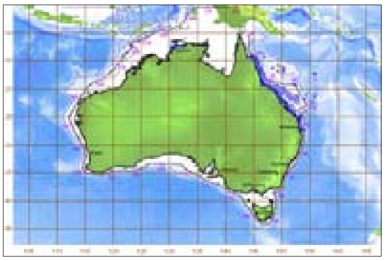

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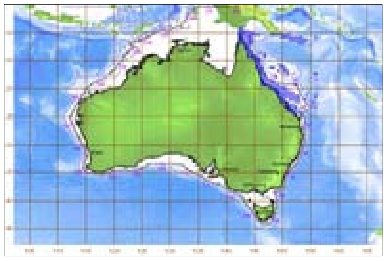

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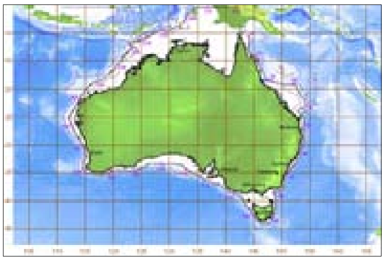

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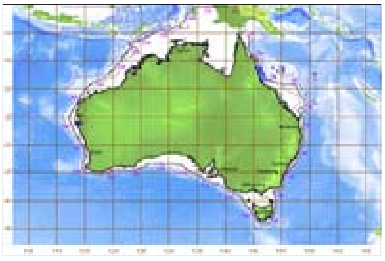

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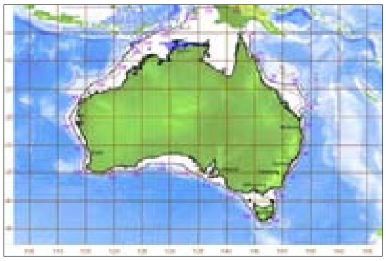

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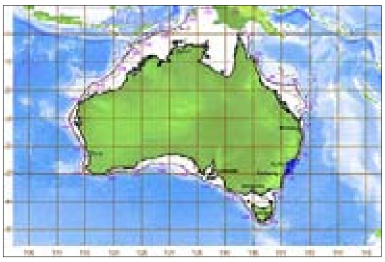

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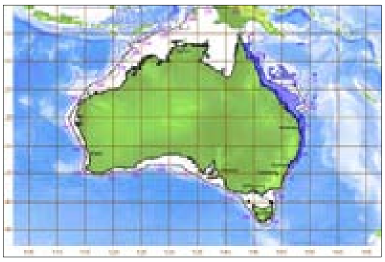

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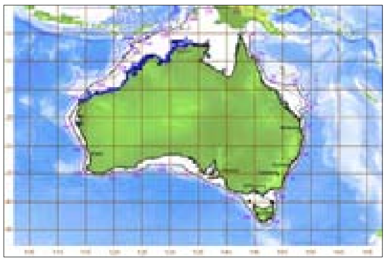

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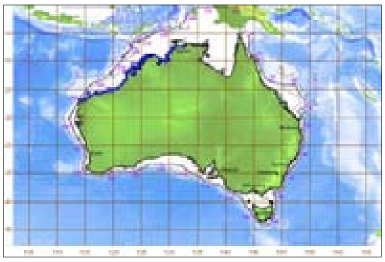
CAAB distributions: surrogate species



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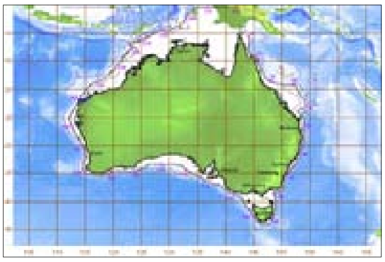

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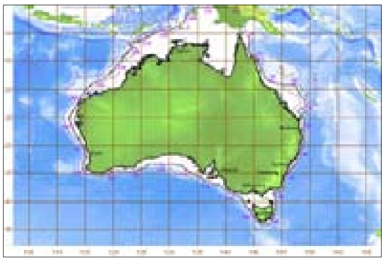

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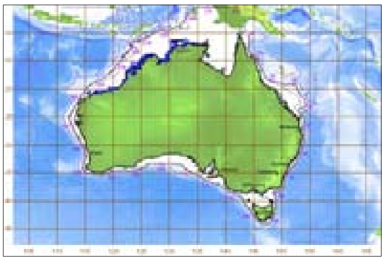

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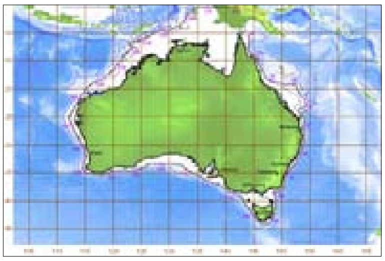

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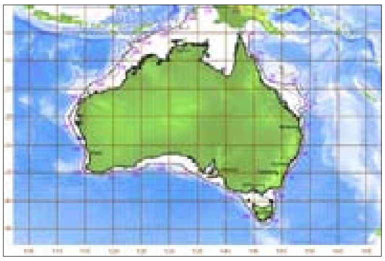

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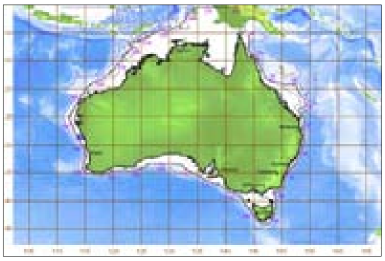

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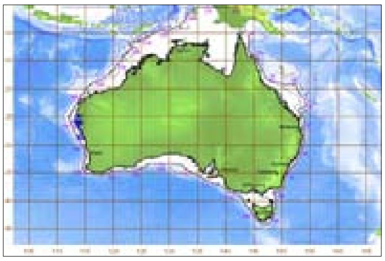

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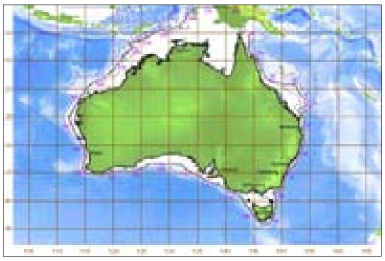

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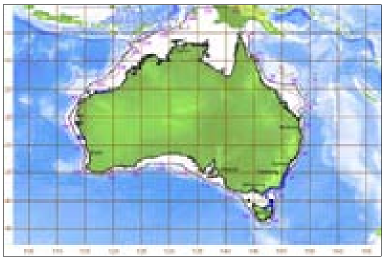

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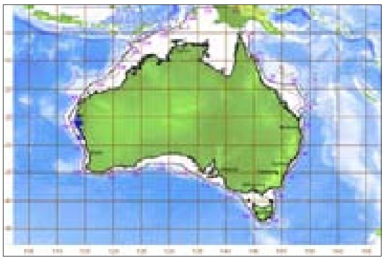

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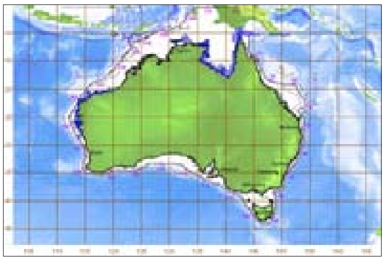

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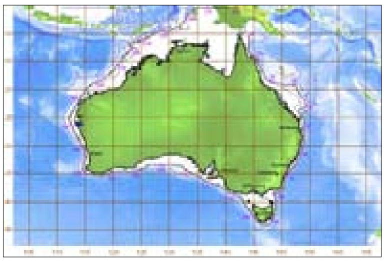

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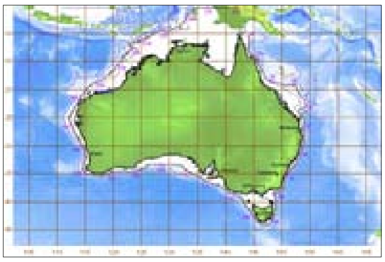

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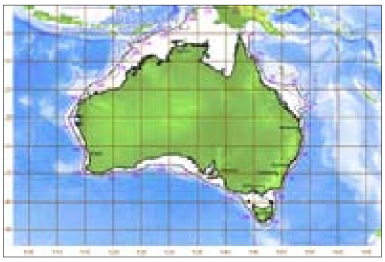

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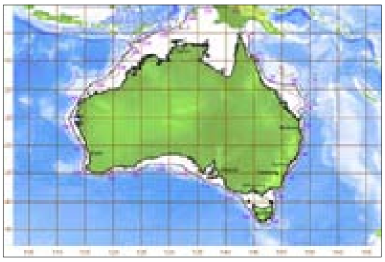
CAAB distributions: surrogate species



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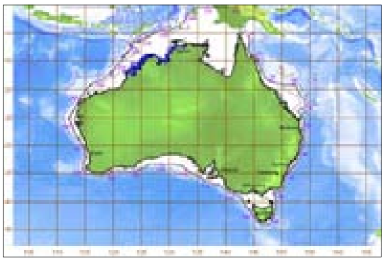

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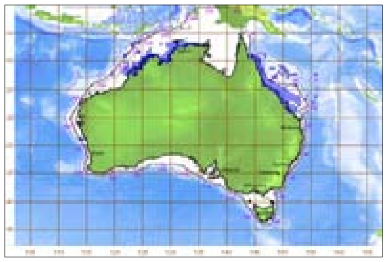

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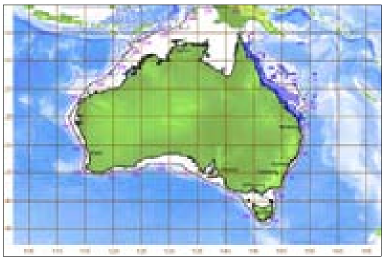

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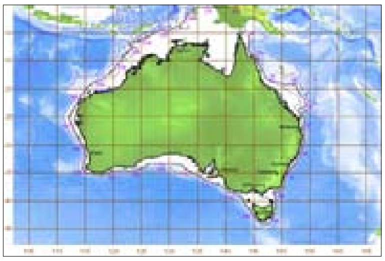

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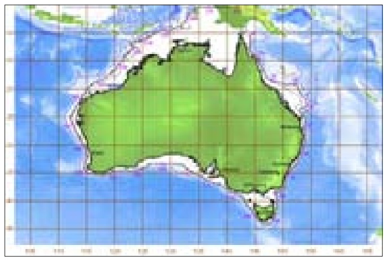

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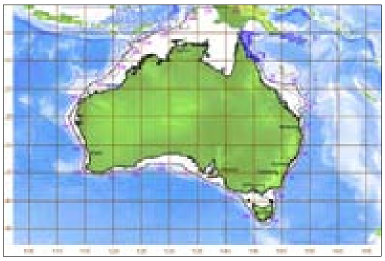

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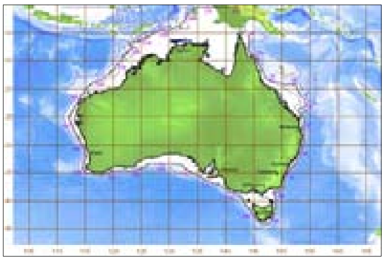

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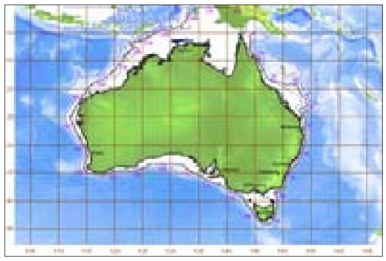

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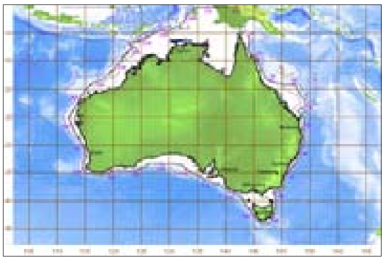

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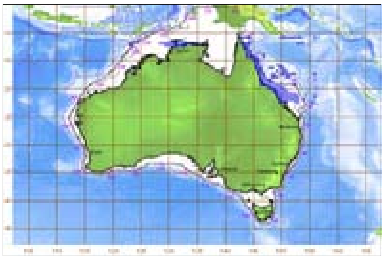

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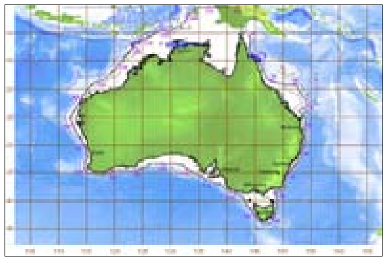

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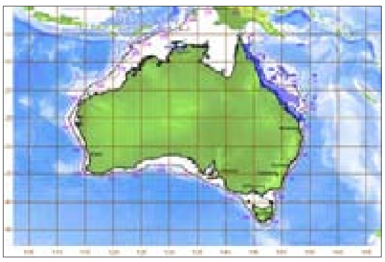

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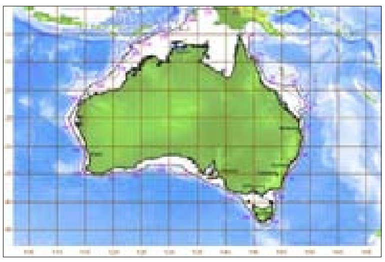

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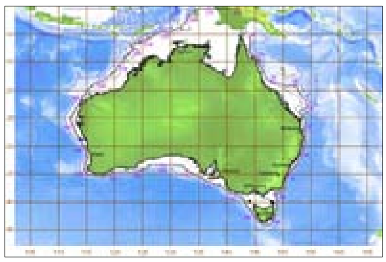

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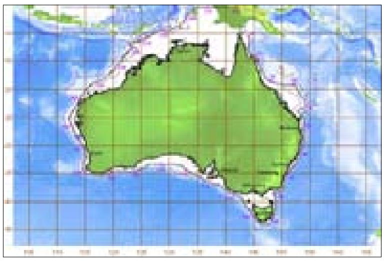
CAAB distributions: surrogate species



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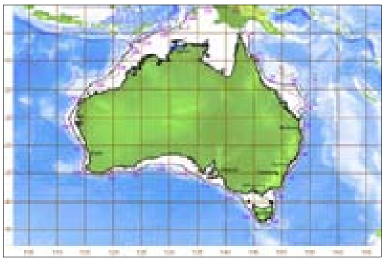

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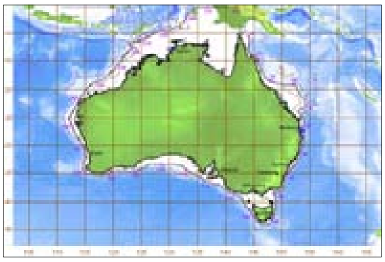

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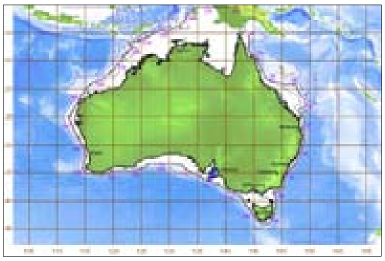

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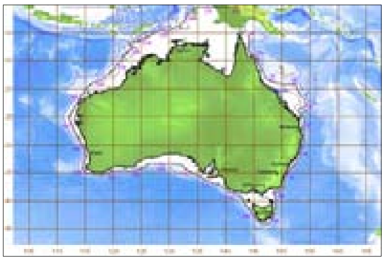

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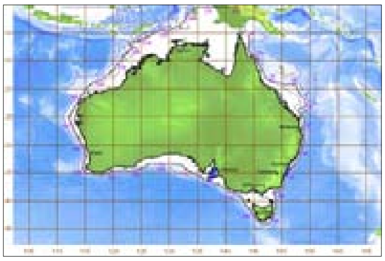

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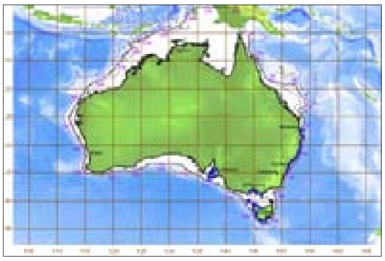

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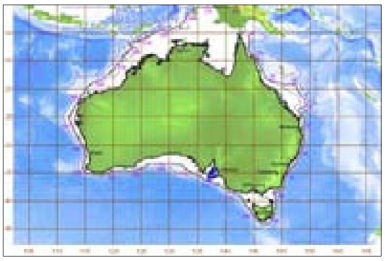

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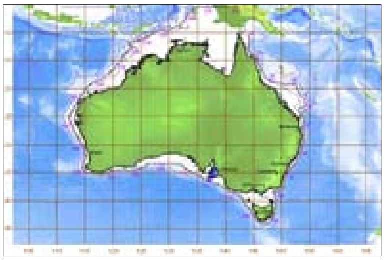

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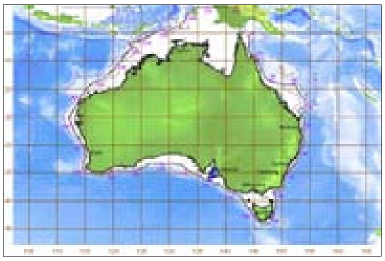

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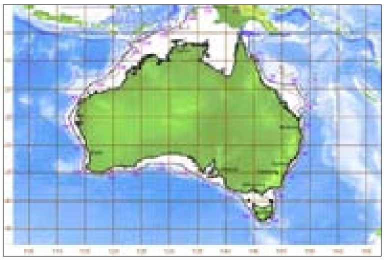

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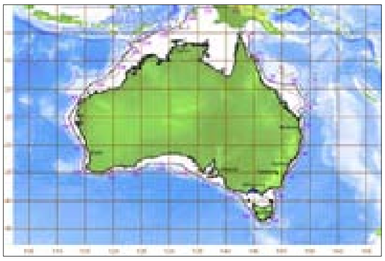

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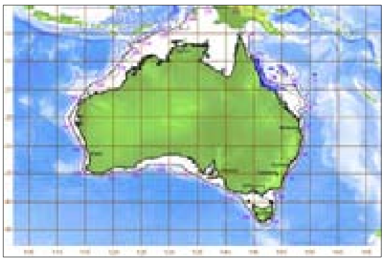

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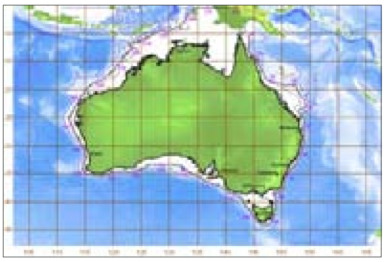

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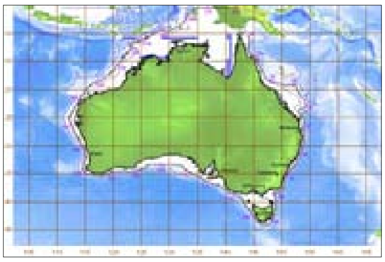

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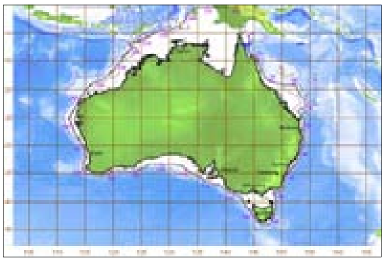
CAAB distributions: surrogate species



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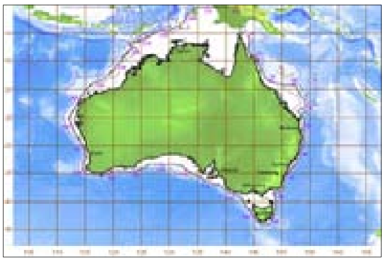

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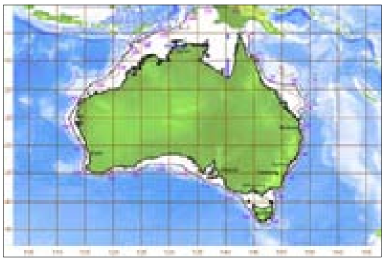

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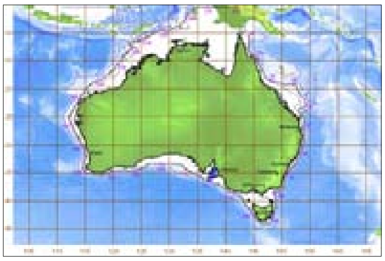

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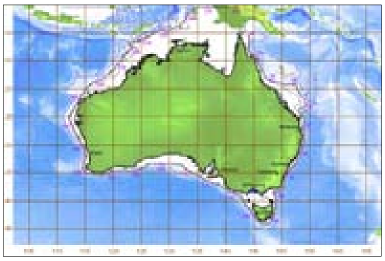

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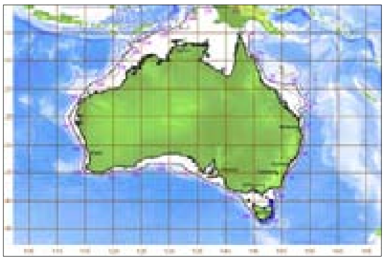

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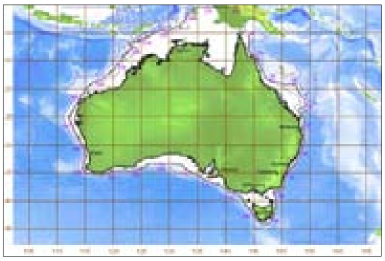

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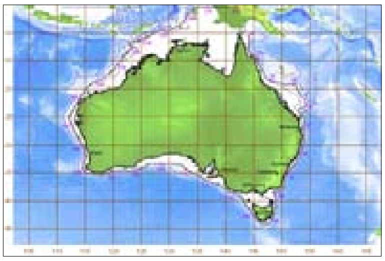

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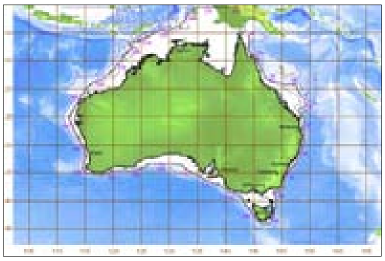

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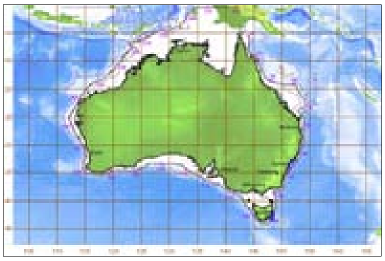

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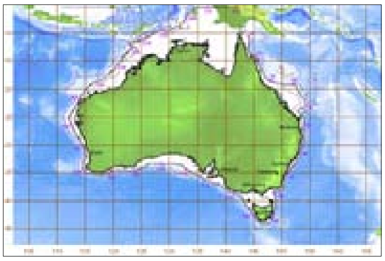

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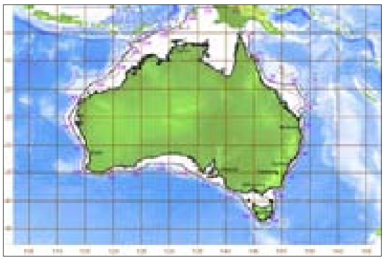

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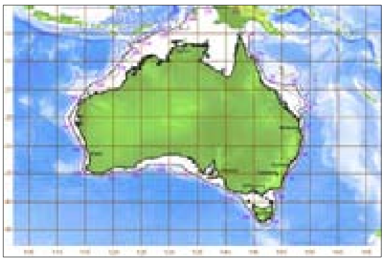

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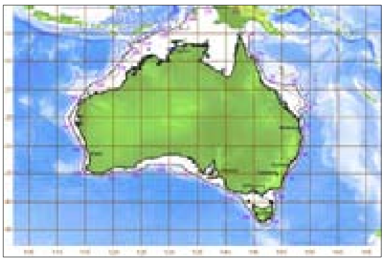

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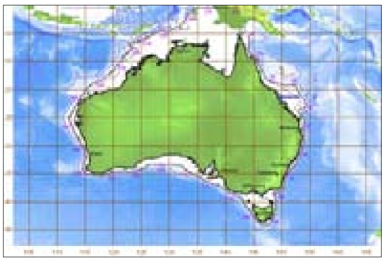

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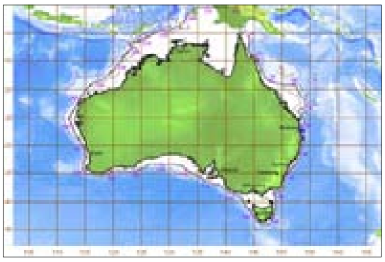
CAAB distributions: surrogate species



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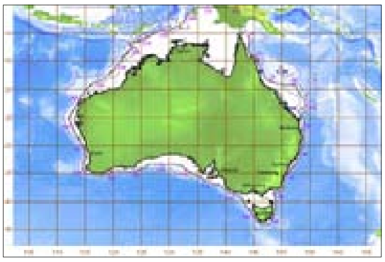

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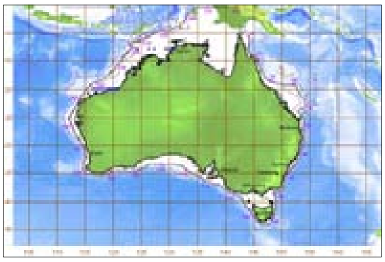

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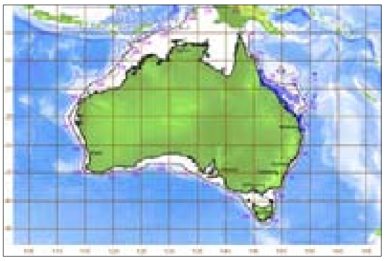

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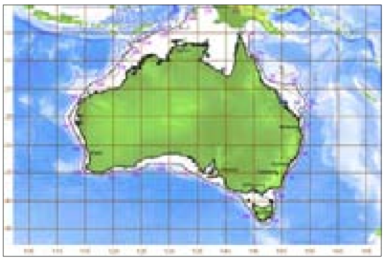

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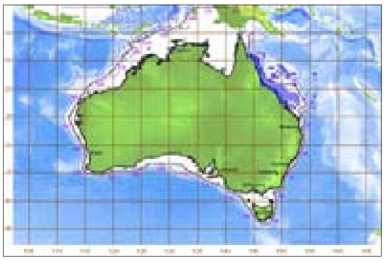

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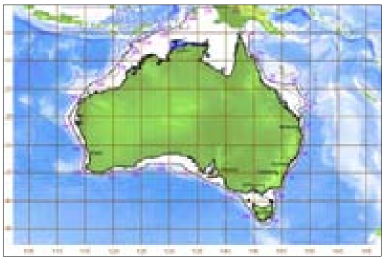

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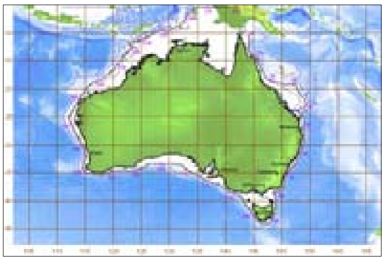

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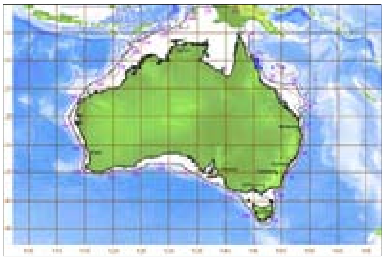

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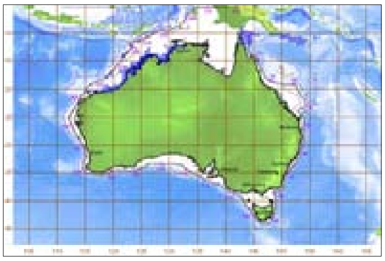

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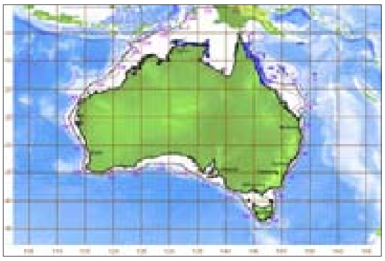

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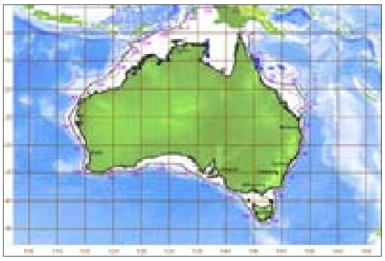

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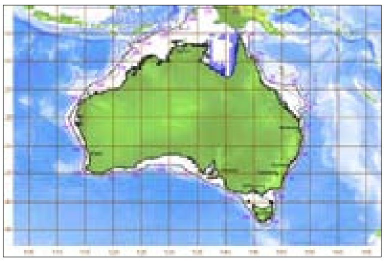

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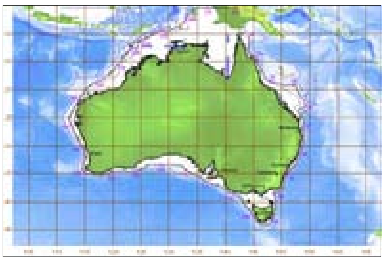

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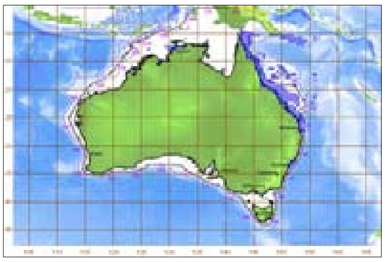

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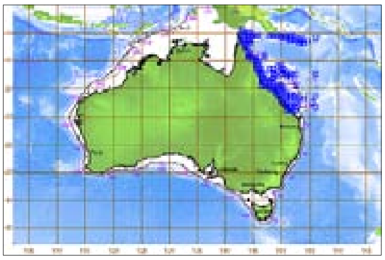
CAAB distributions: surrogate species



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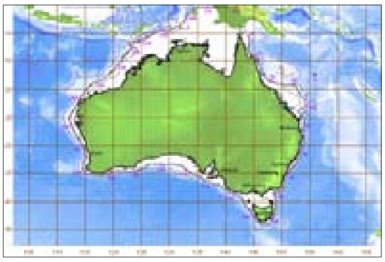

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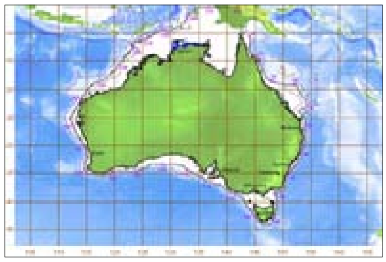

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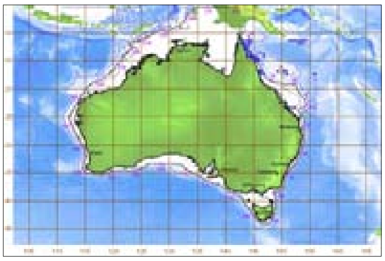

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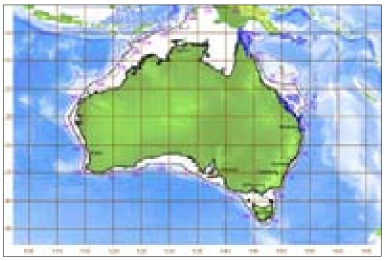

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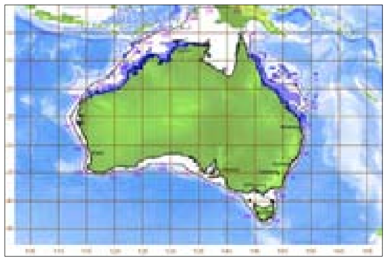

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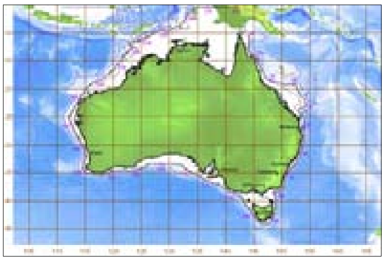

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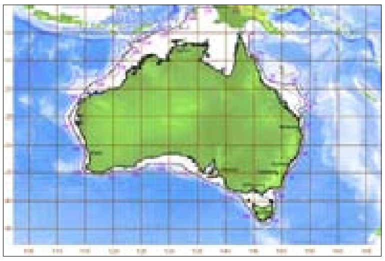

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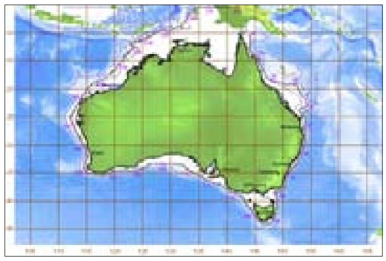

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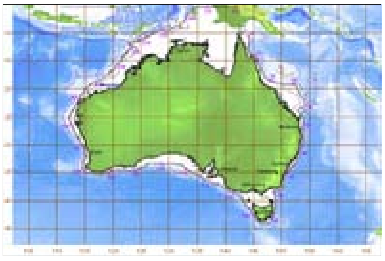

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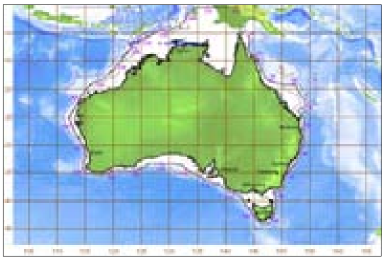

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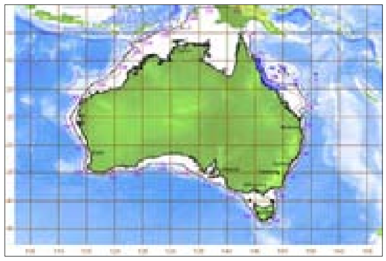

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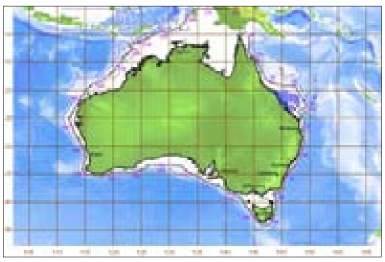

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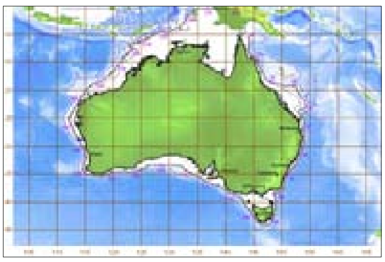

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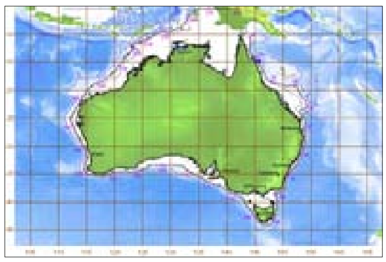

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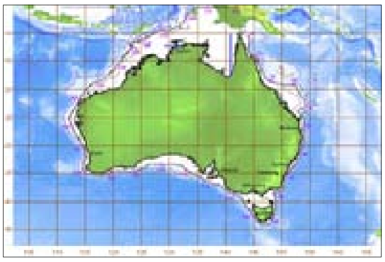
CAAB distributions: surrogate species



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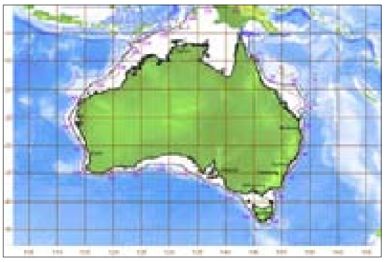

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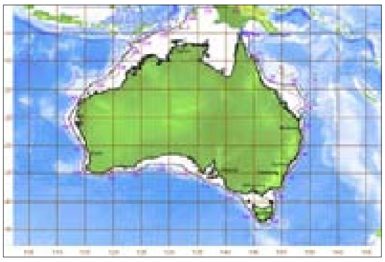

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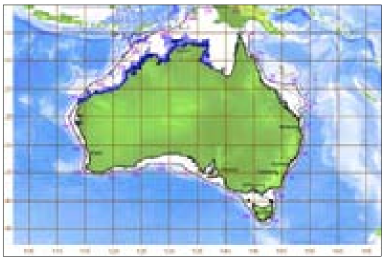

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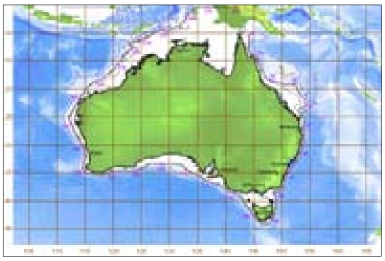

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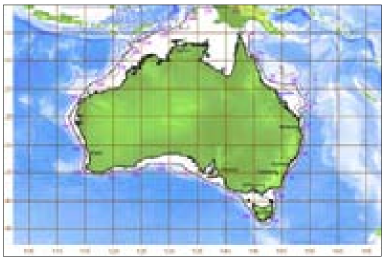

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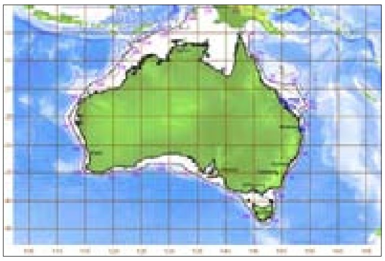

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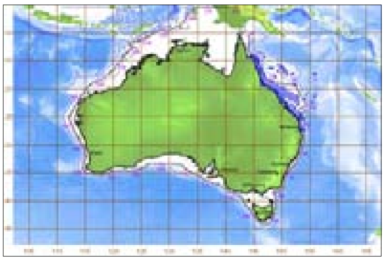

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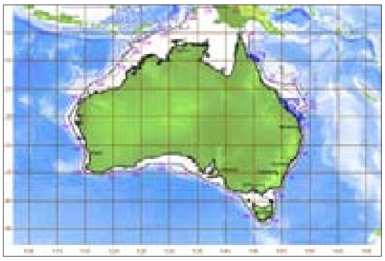

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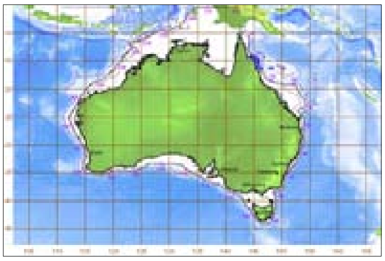

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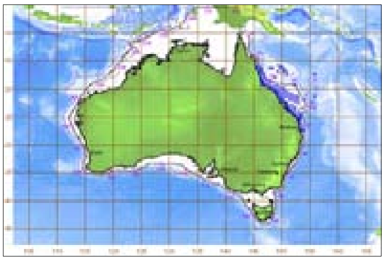

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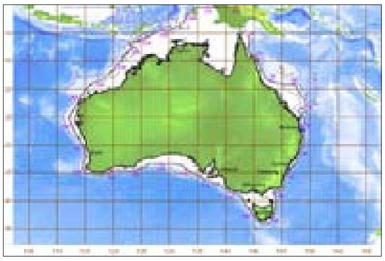

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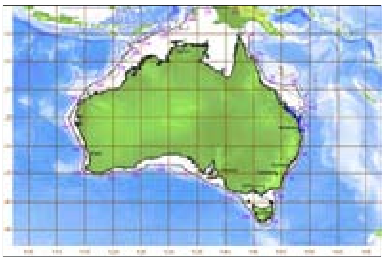

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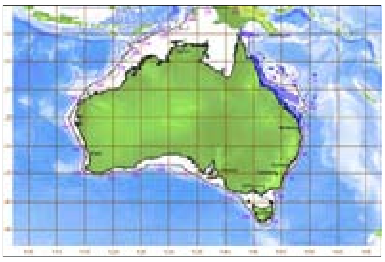

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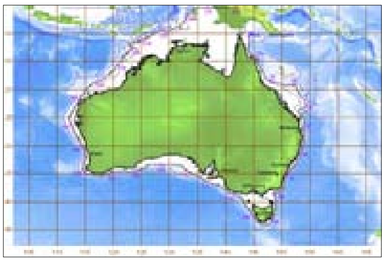

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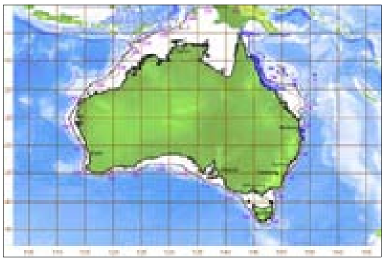
CAAB distributions: surrogate species



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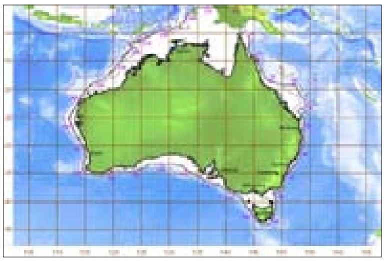

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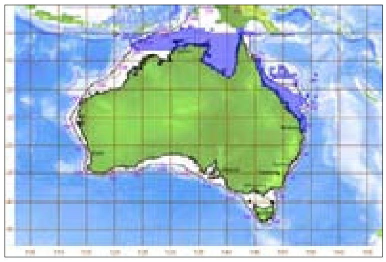

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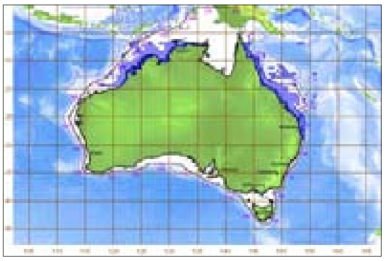

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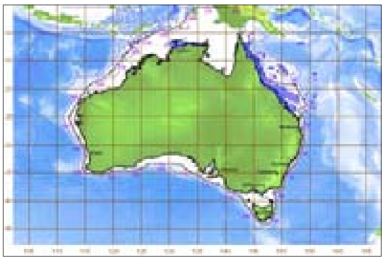

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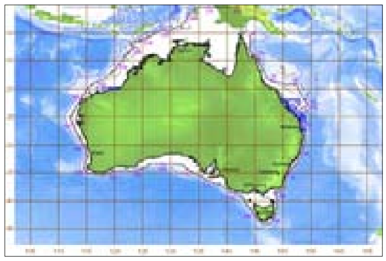

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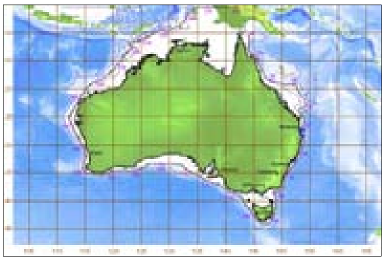

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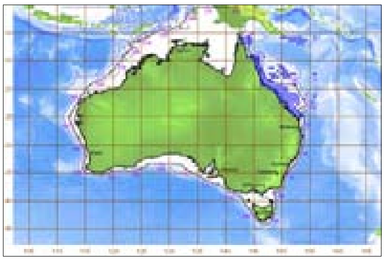

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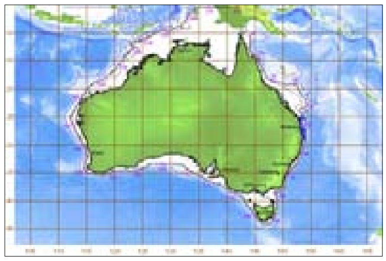

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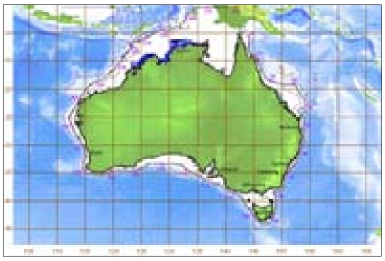

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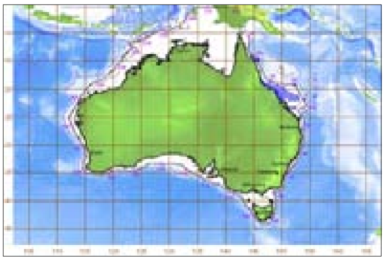

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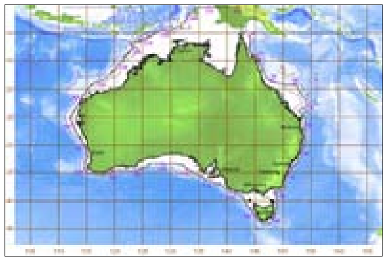

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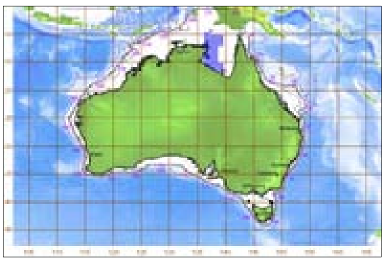

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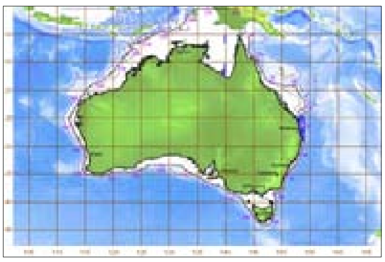

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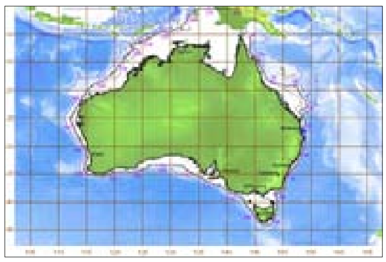

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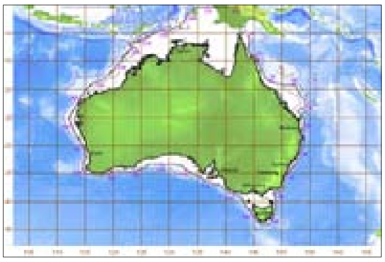

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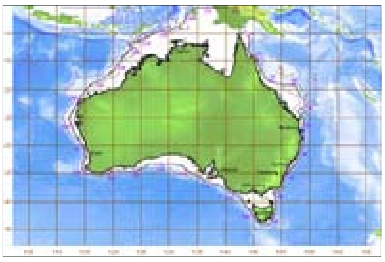

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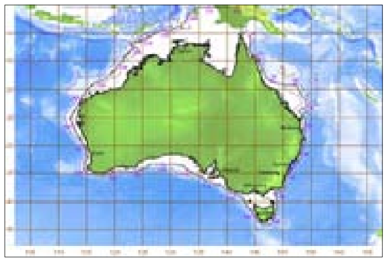

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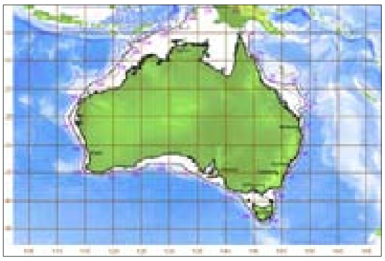

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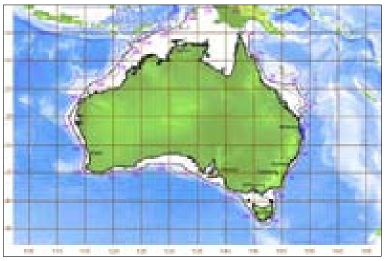

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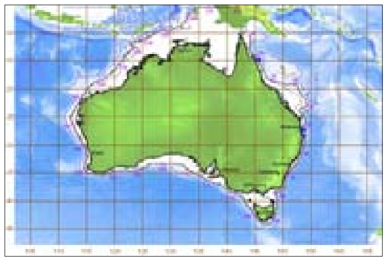

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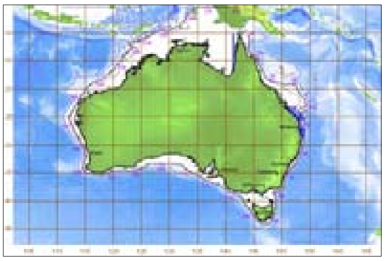

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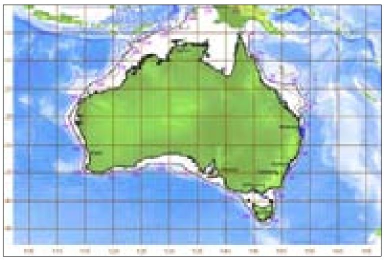

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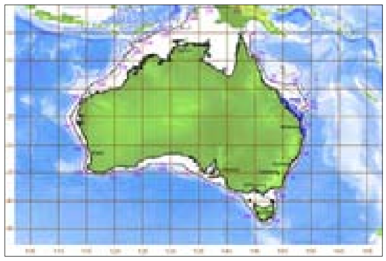

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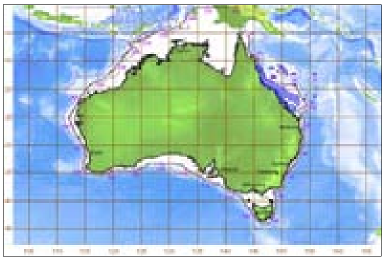

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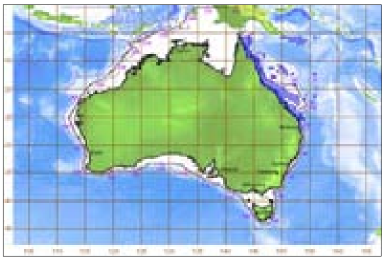

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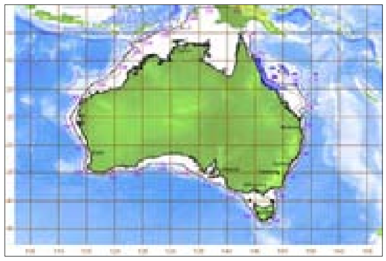

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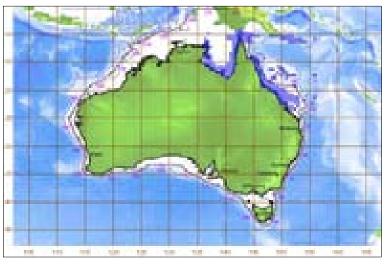

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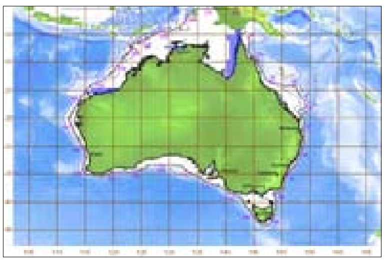

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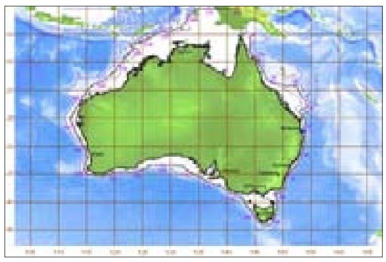

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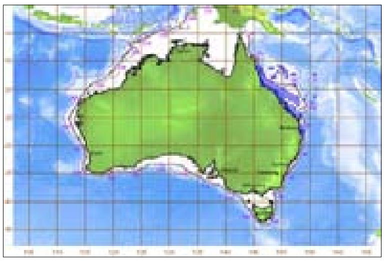
CAAB distributions: surrogate species



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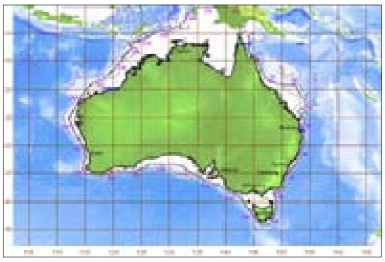

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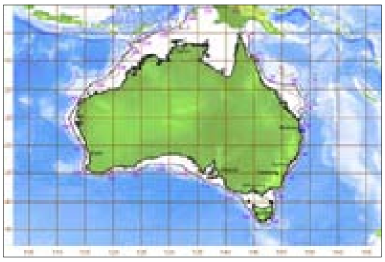

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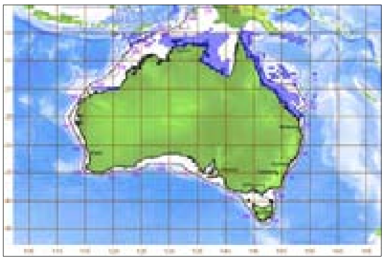

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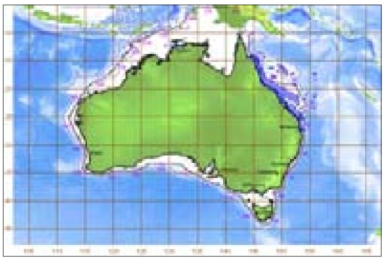

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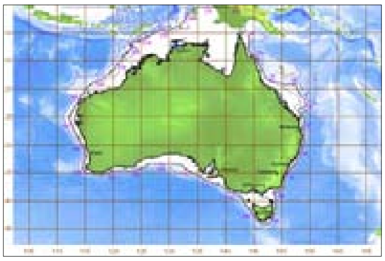

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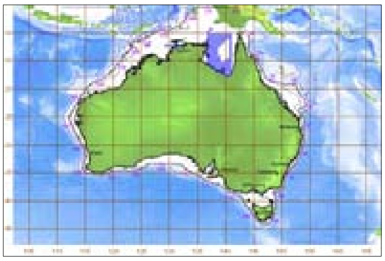

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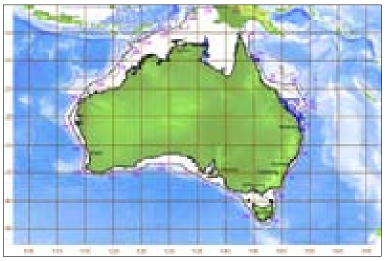

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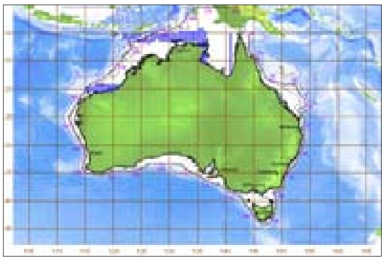

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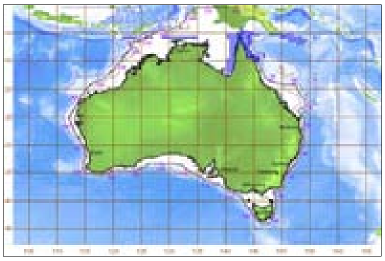

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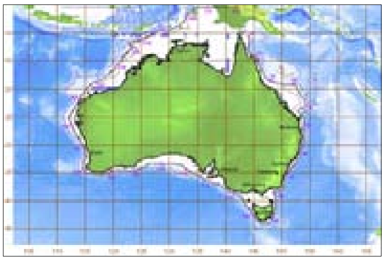

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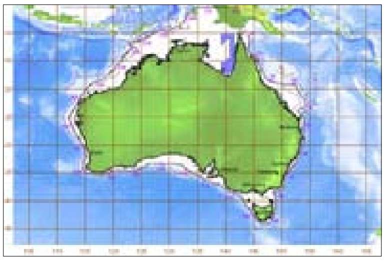

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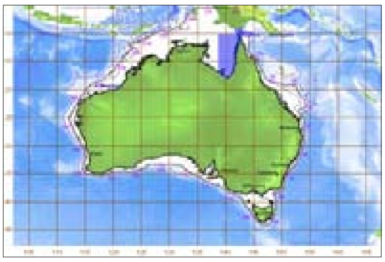

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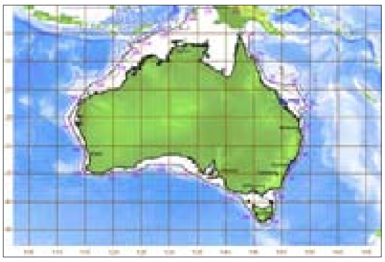

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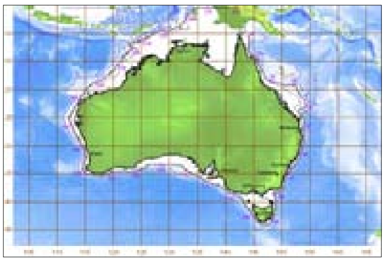

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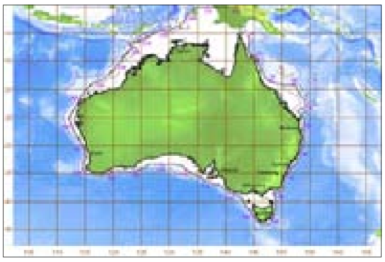
CAAB distributions: surrogate species



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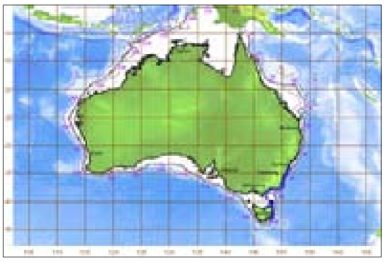

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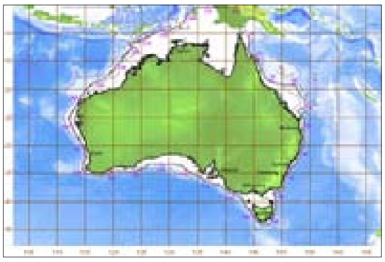

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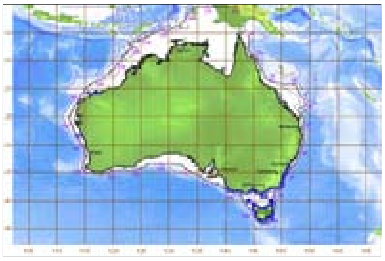

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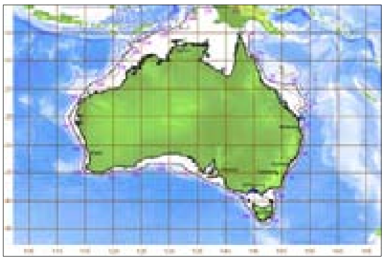

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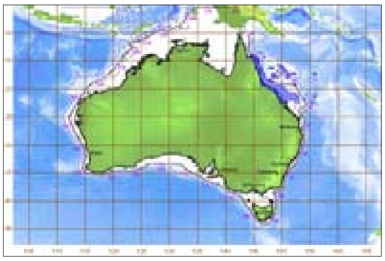

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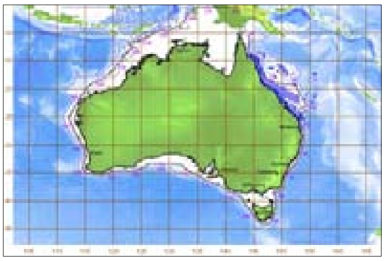

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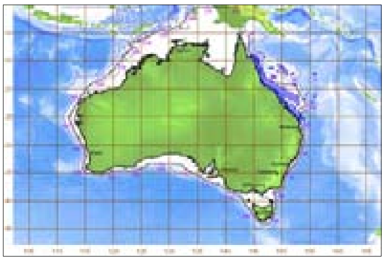

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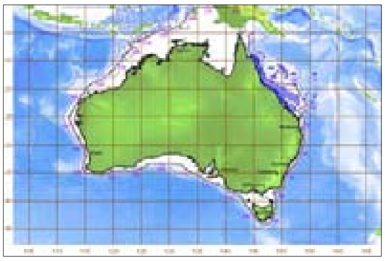

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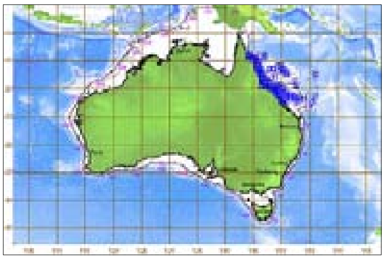

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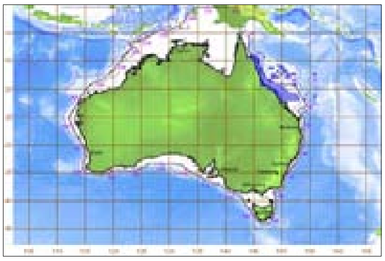

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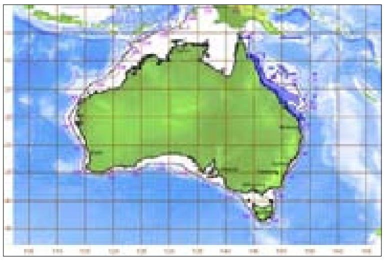

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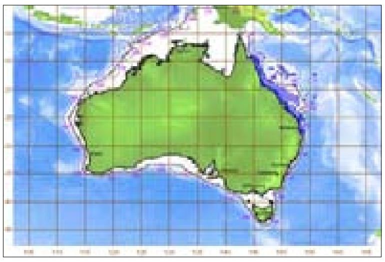

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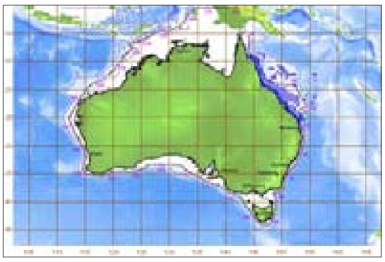

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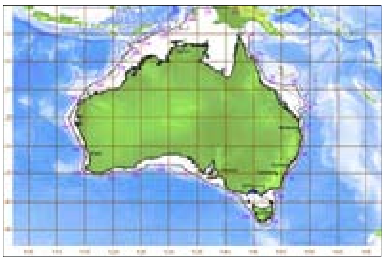

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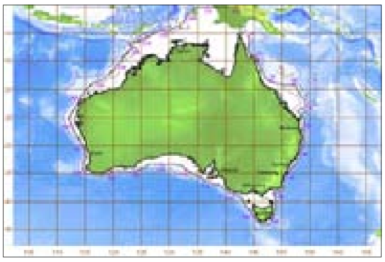
CAAB distributions: surrogate species



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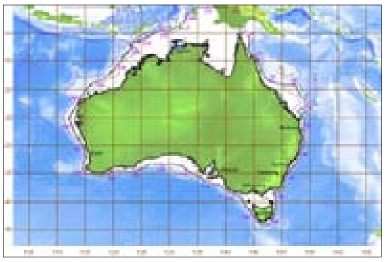

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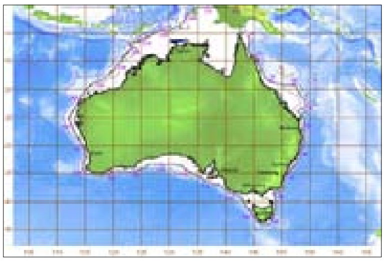

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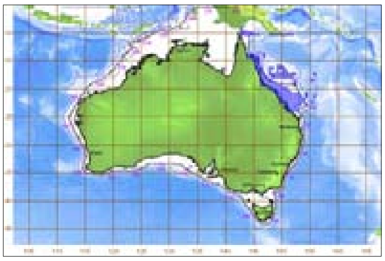

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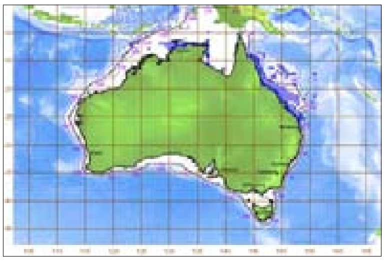

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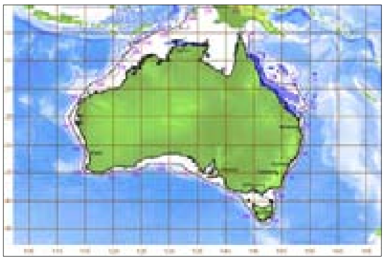

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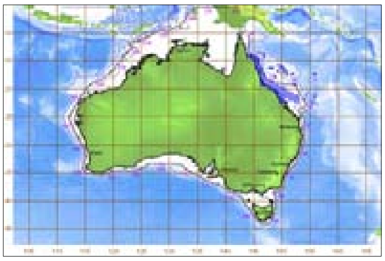

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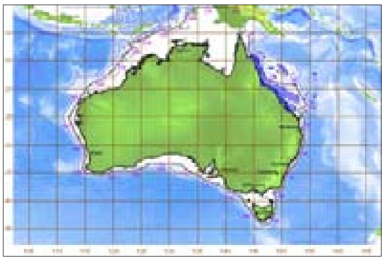

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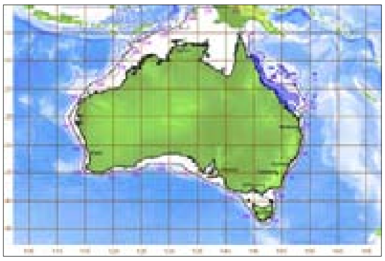

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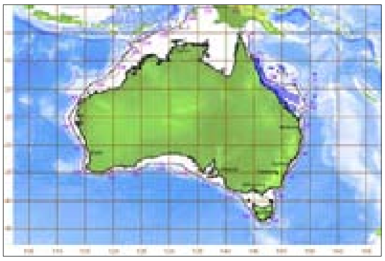

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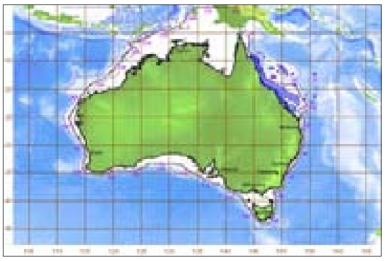

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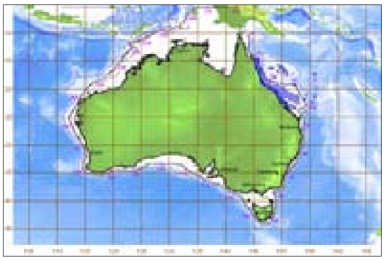

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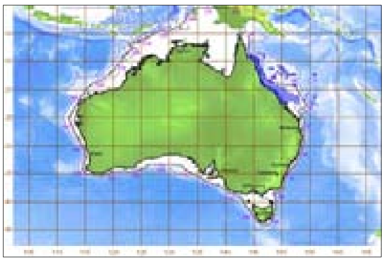

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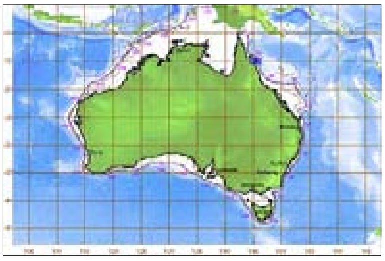

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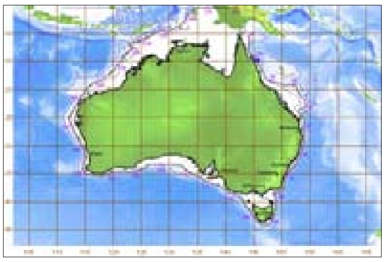

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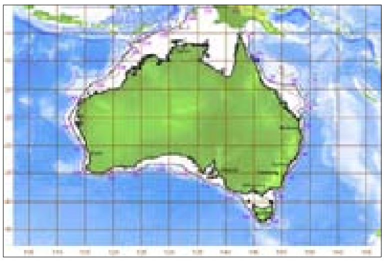
CAAB distributions: surrogate species



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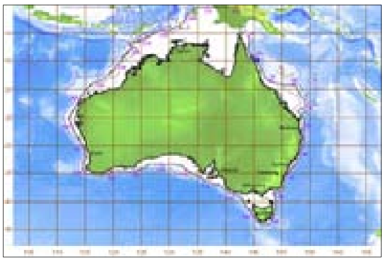

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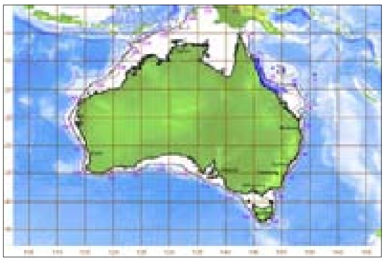

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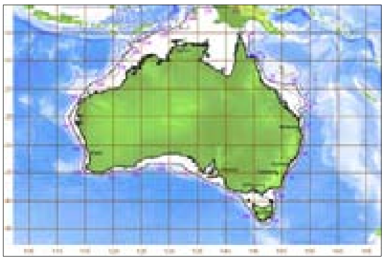

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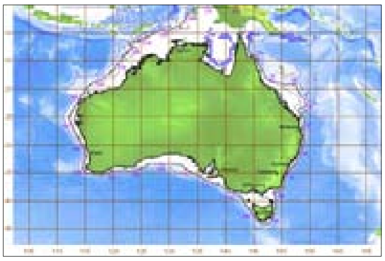

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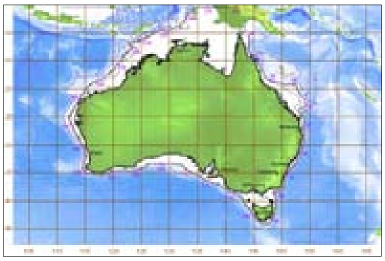

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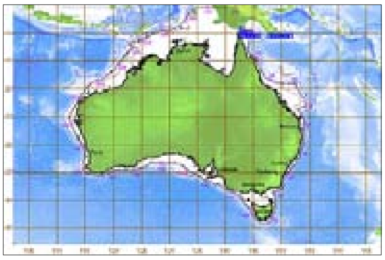

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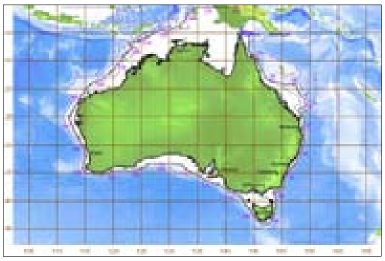

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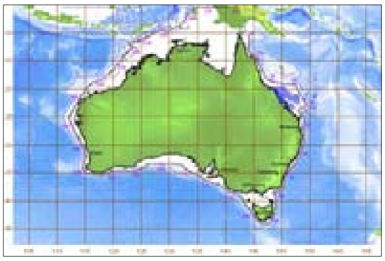

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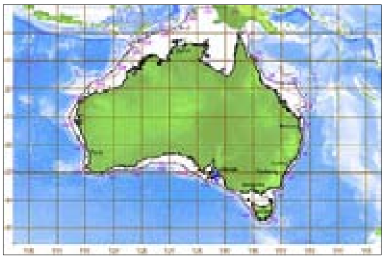

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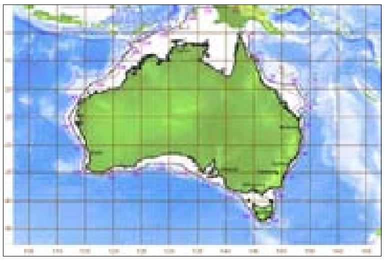

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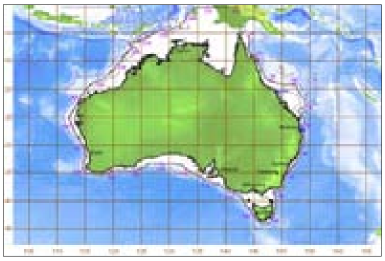

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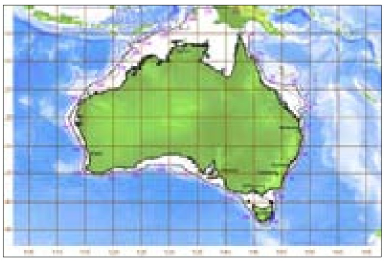

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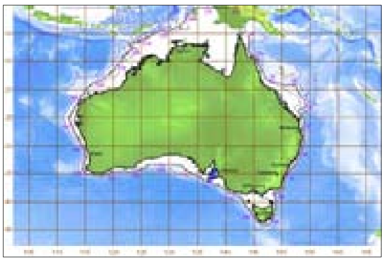

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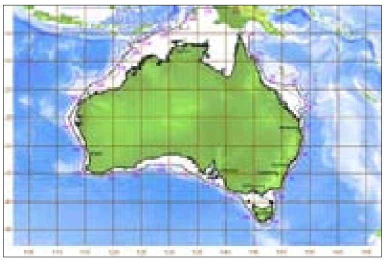

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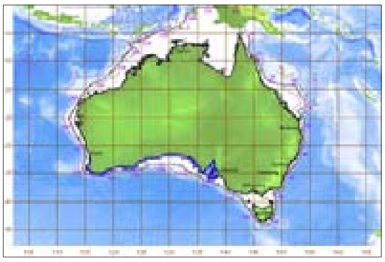
CAAB distributions: surrogate species



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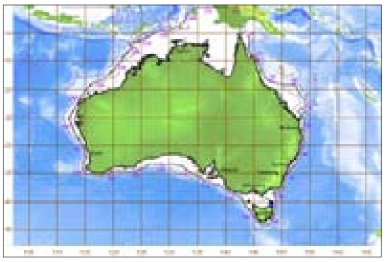

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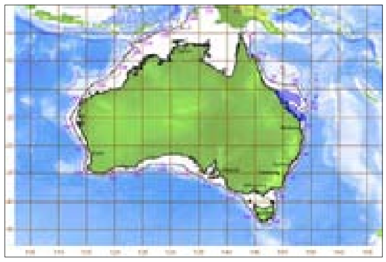

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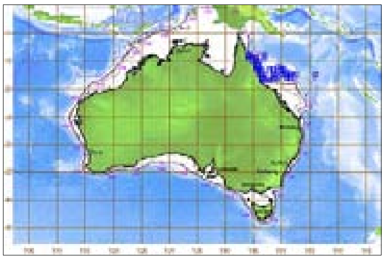

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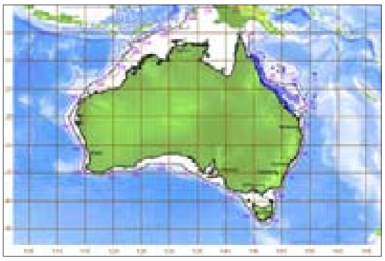

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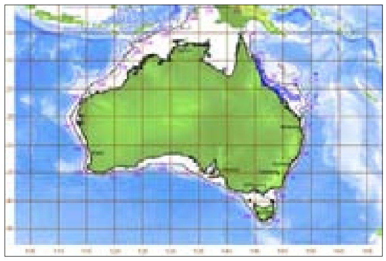

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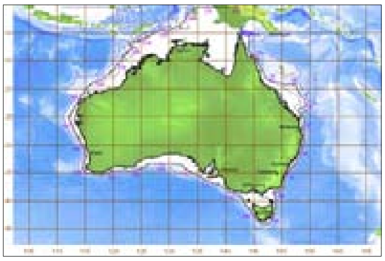

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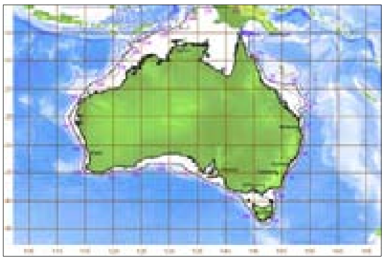

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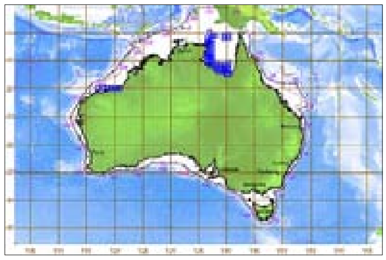

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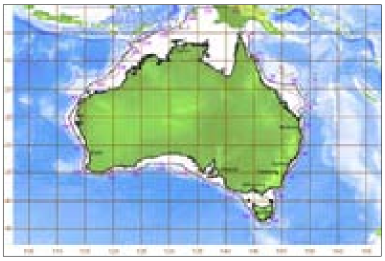

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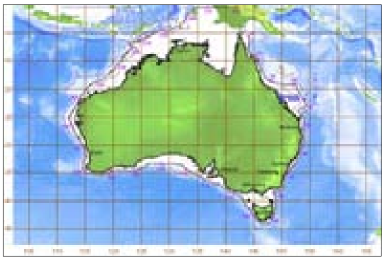

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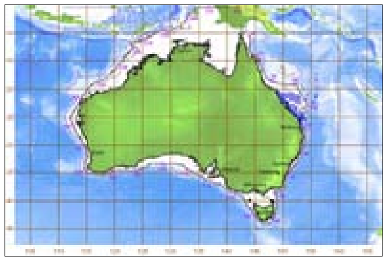

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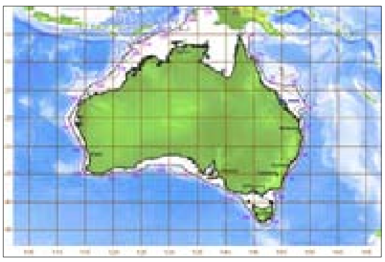

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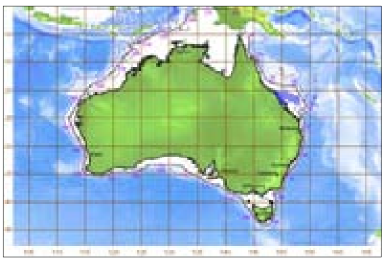

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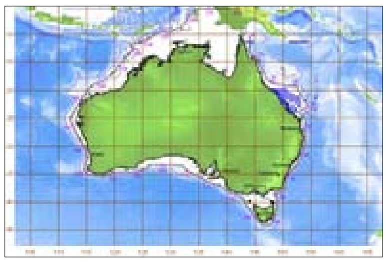

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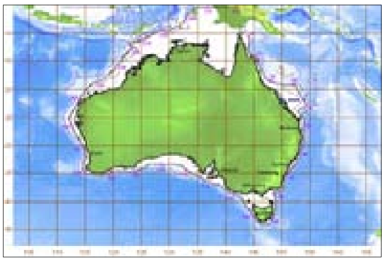
CAAB distributions: surrogate species



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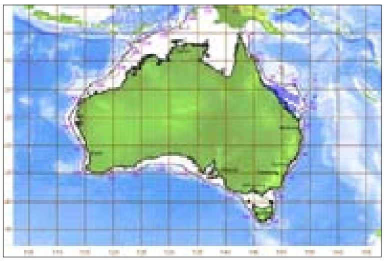

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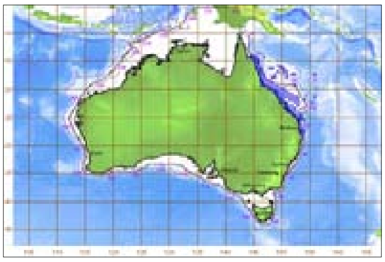

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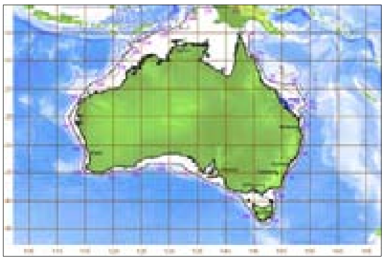

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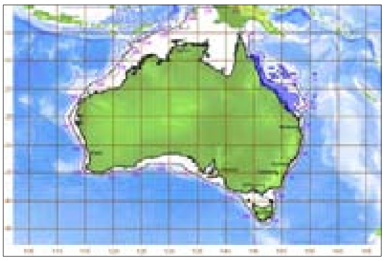

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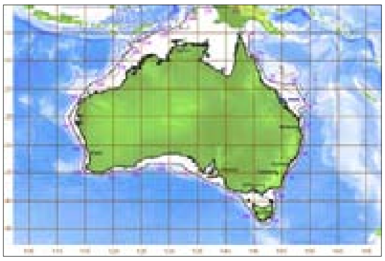

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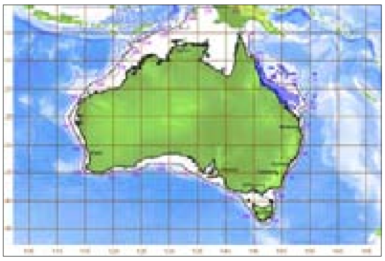

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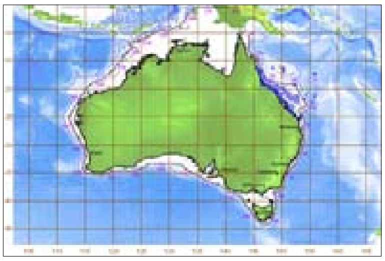

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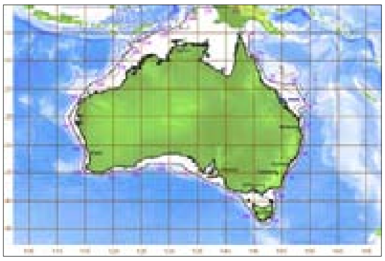

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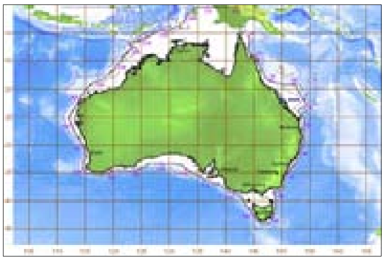

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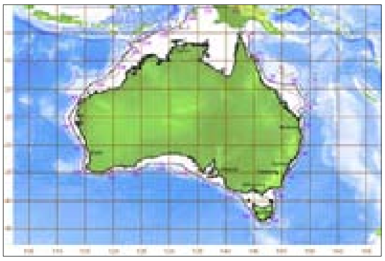

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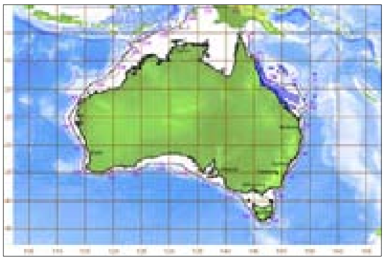

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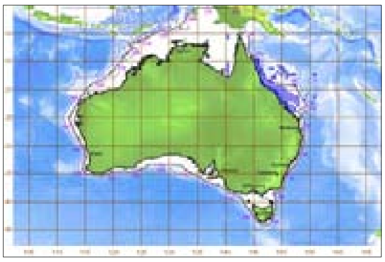

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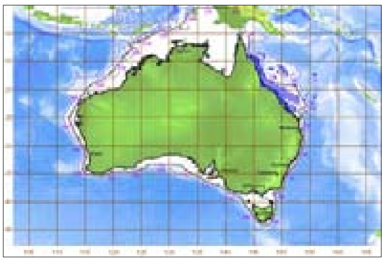

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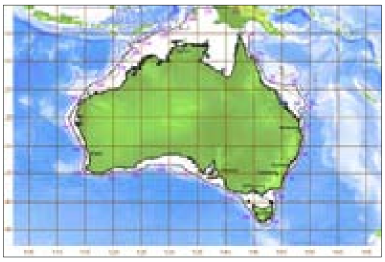

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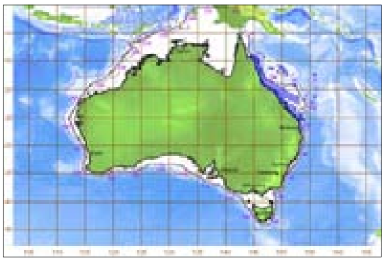
CAAB distributions: surrogate species



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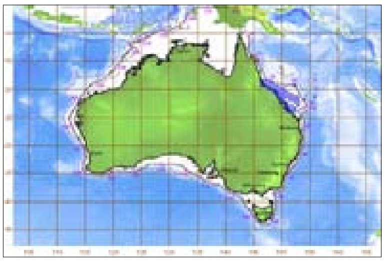

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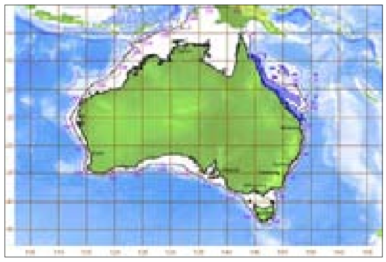

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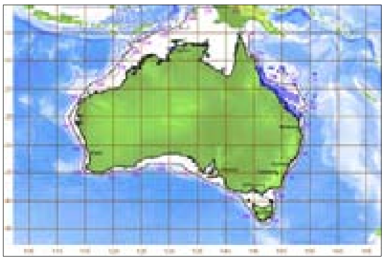

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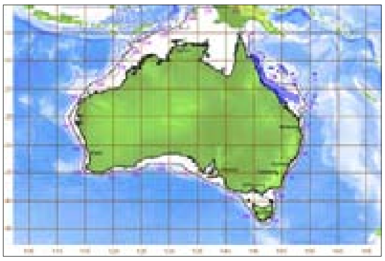

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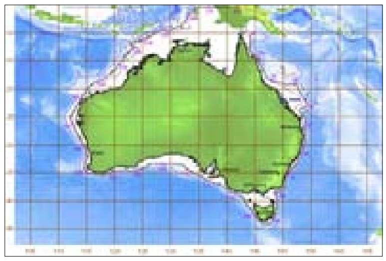

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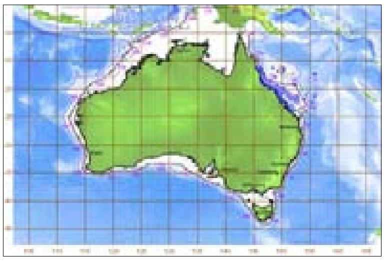

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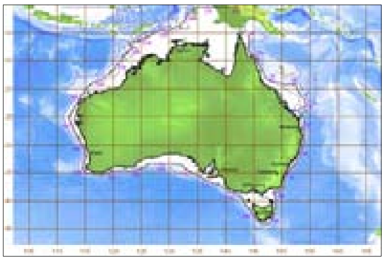

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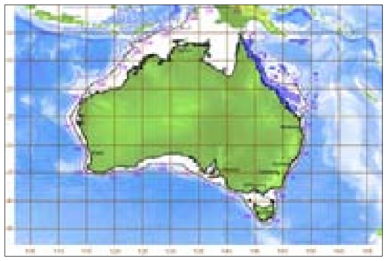

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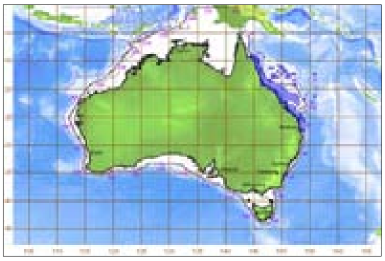

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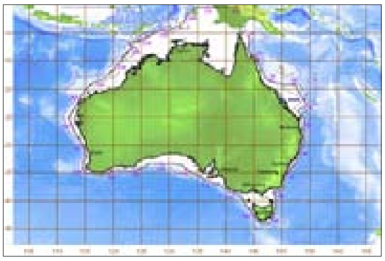

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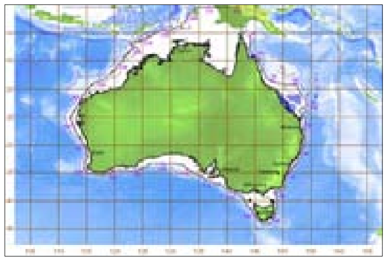

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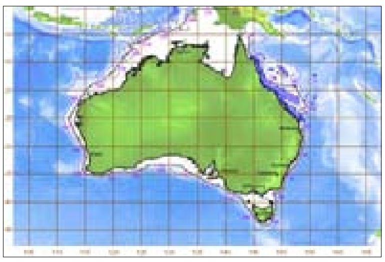

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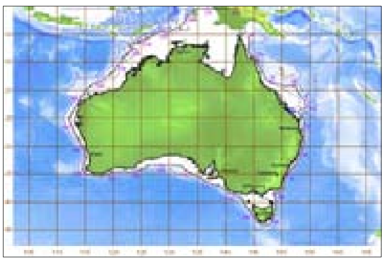

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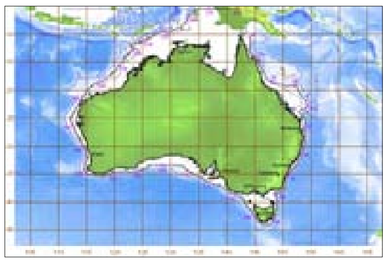

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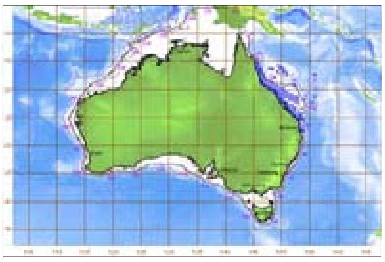
CAAB distributions: surrogate species



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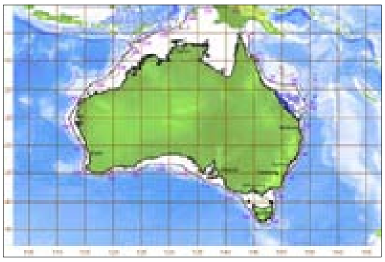

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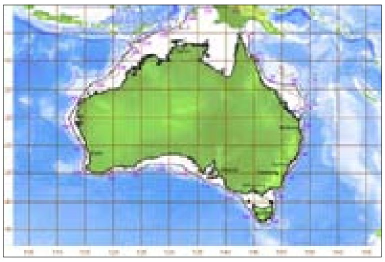

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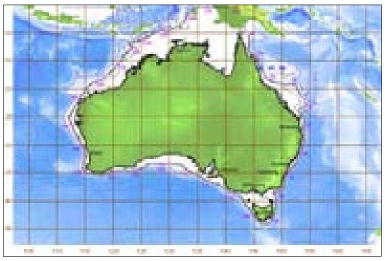

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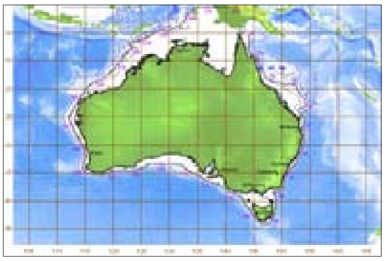

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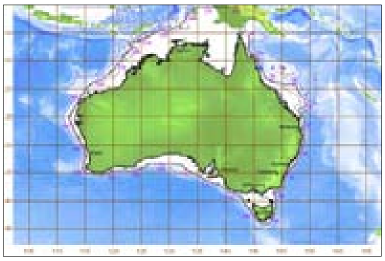

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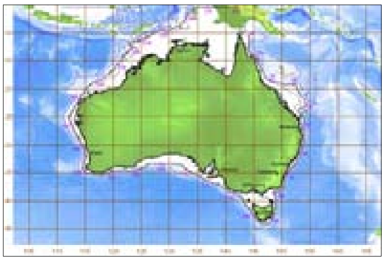

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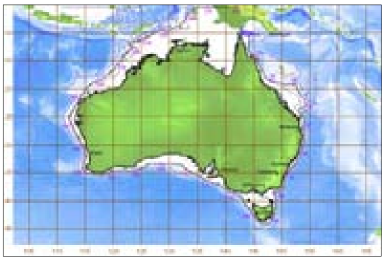

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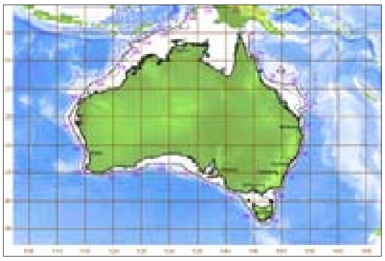

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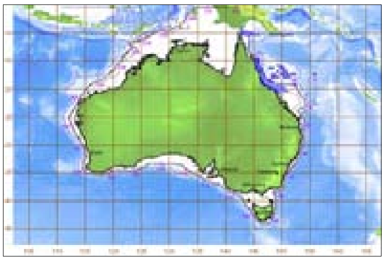

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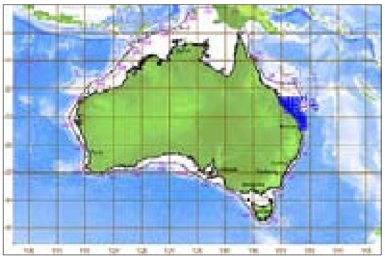

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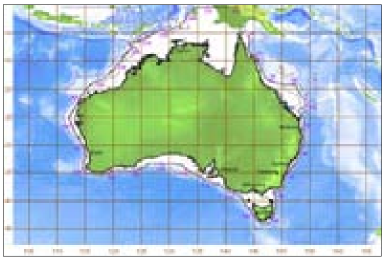

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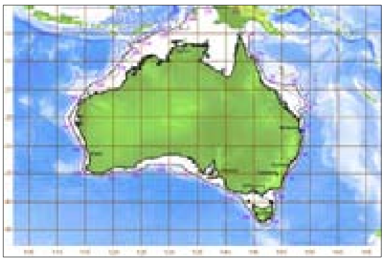

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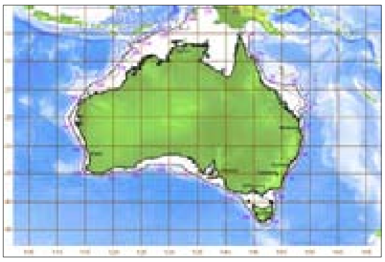

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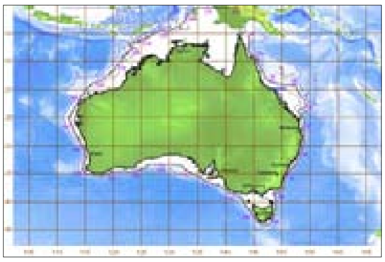

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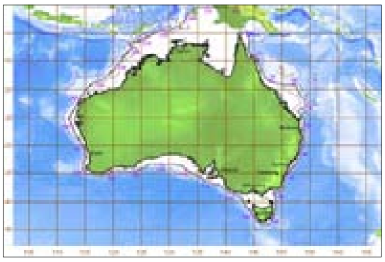
CAAB distributions: surrogate species



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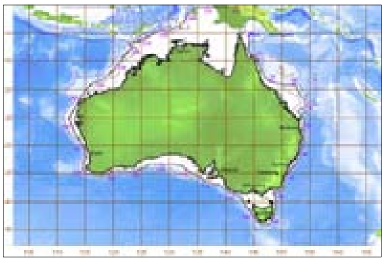

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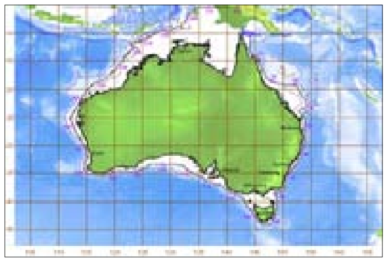

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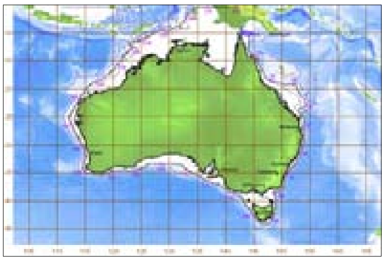

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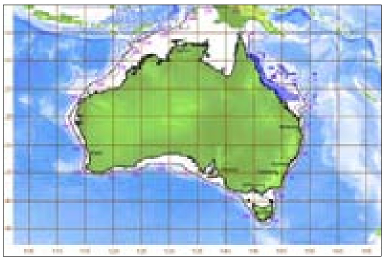

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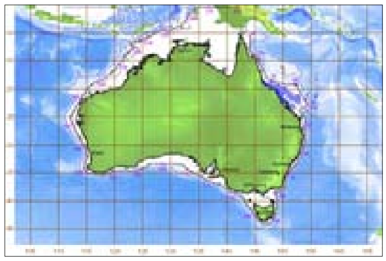

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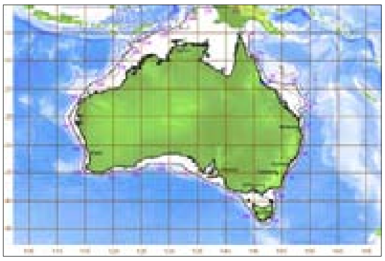

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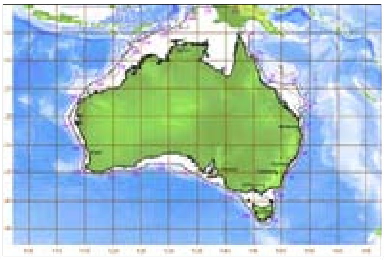

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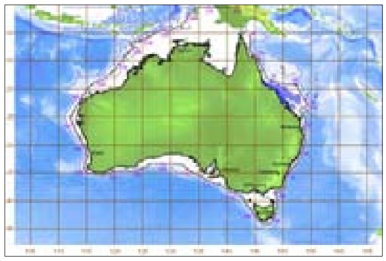

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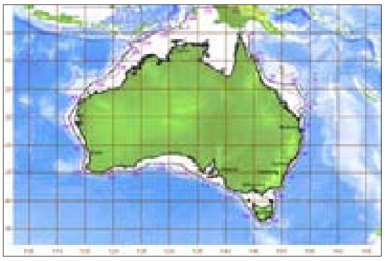

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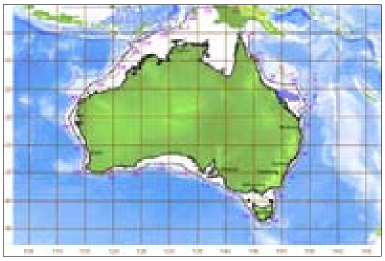

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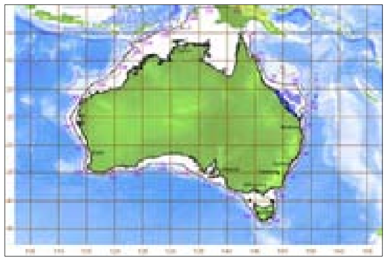

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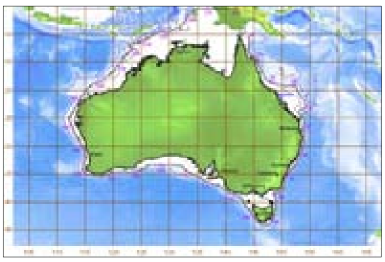

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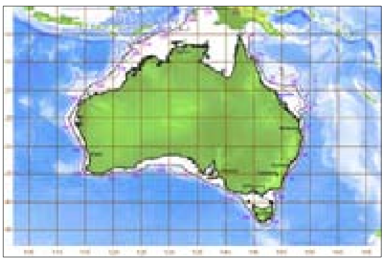

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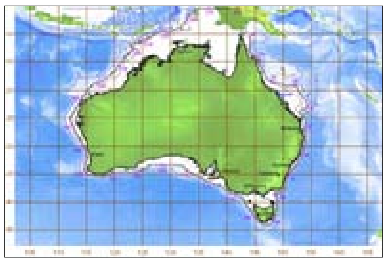

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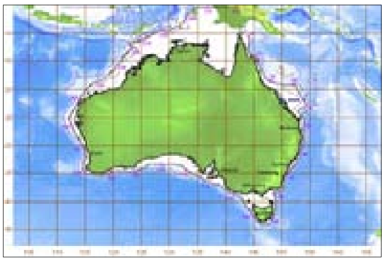
CAAB distributions: surrogate species



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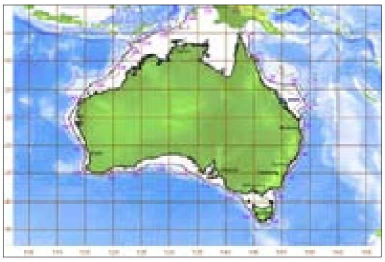

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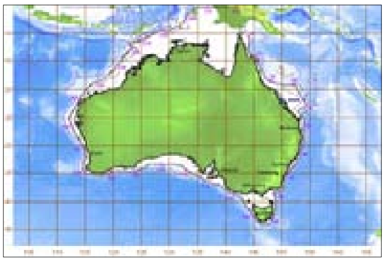

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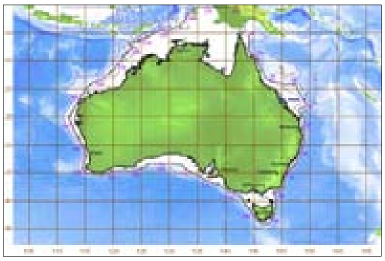

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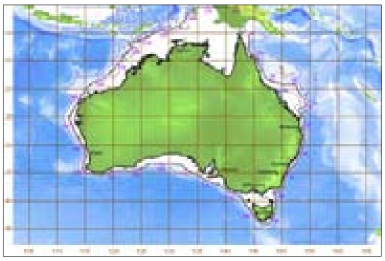

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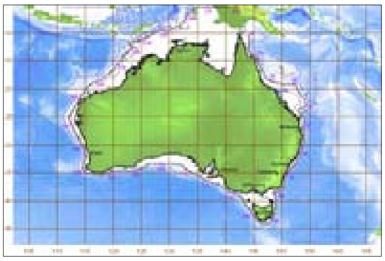

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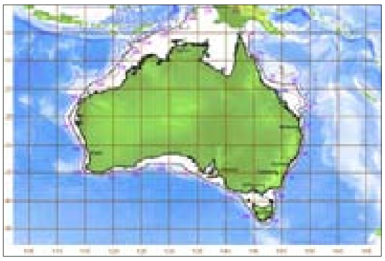

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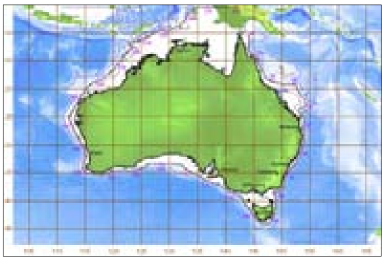

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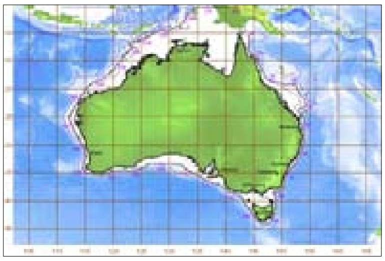

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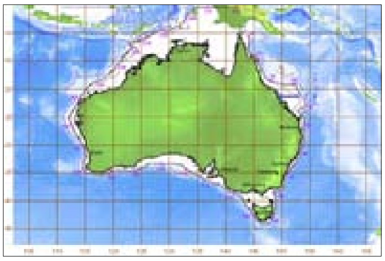

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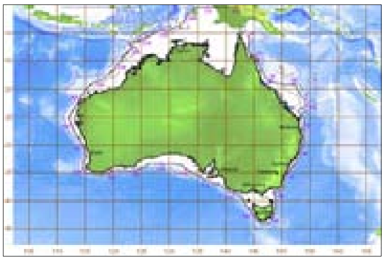

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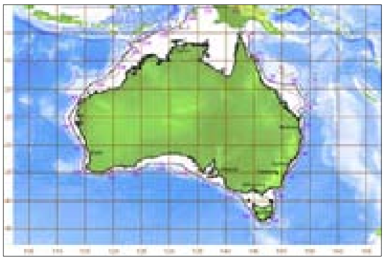

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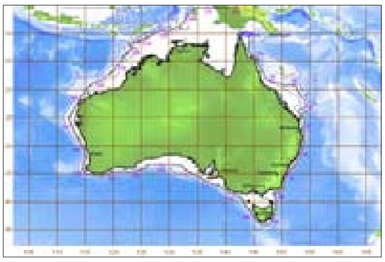

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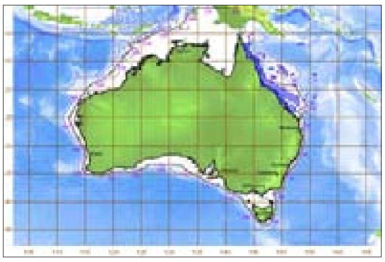

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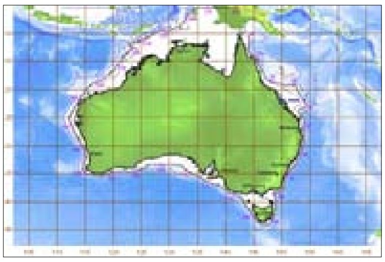

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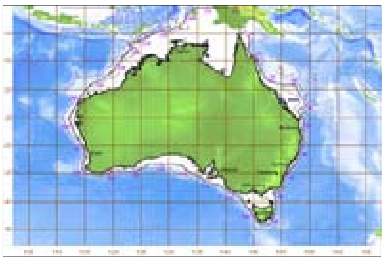
CAAB distributions: surrogate species



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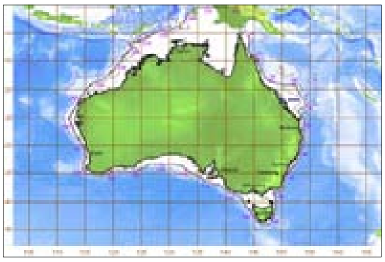

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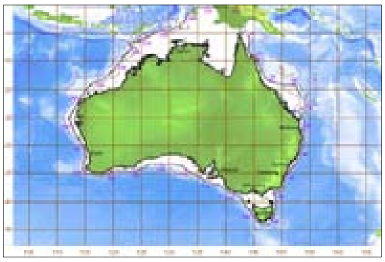

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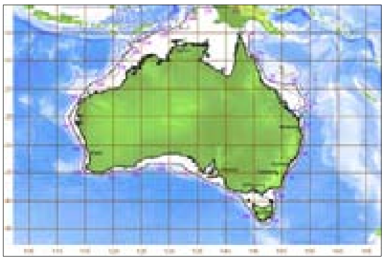

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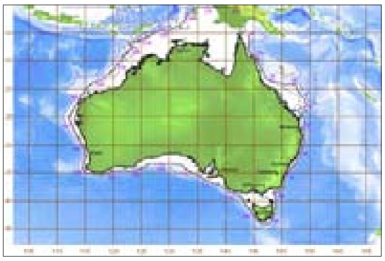

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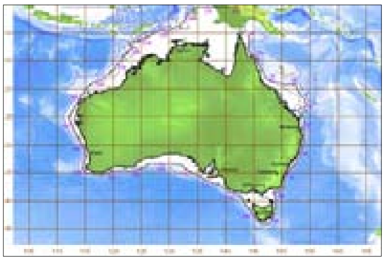

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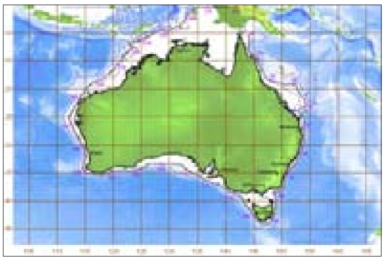

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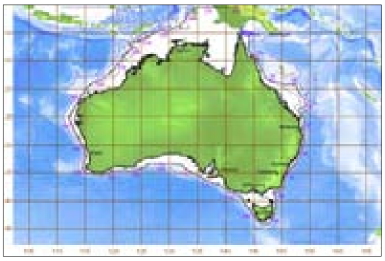

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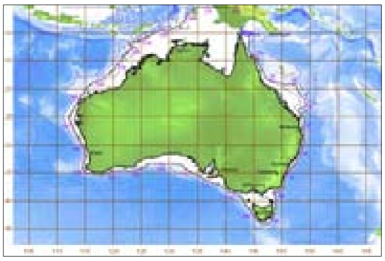

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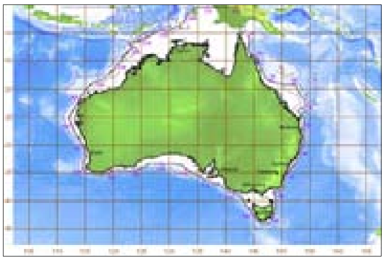

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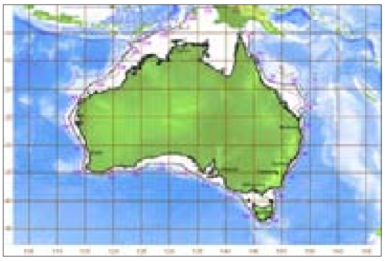

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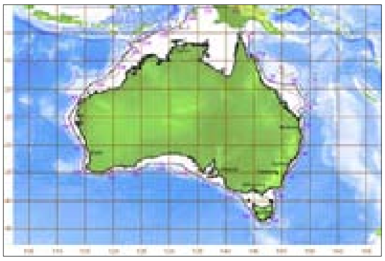

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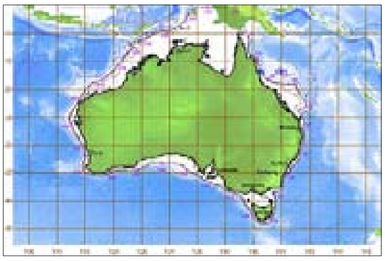

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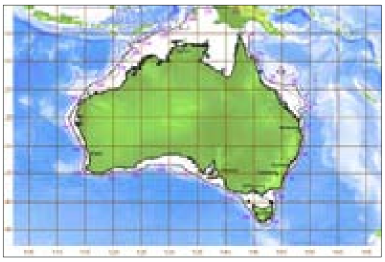

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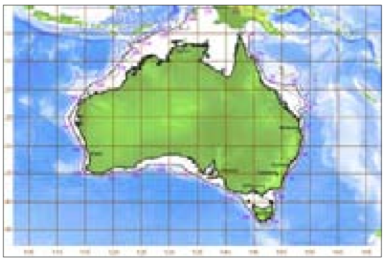

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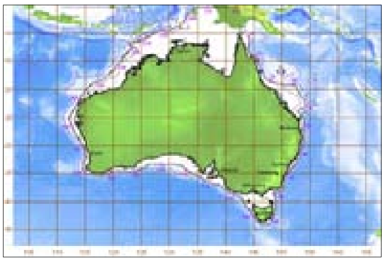
CAAB distributions: surrogate species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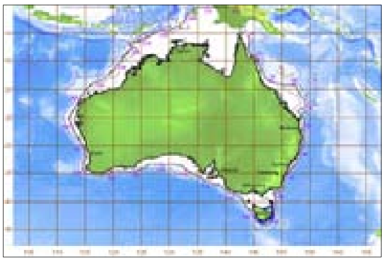
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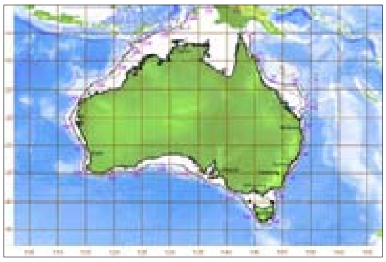
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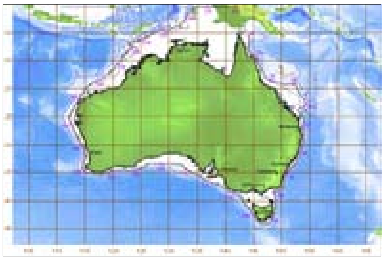
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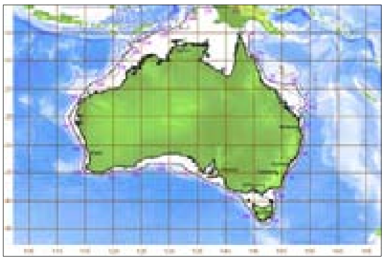
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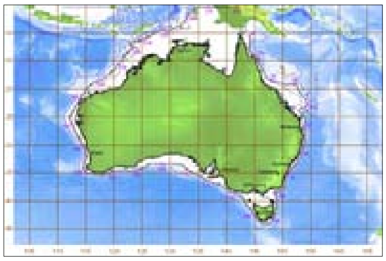
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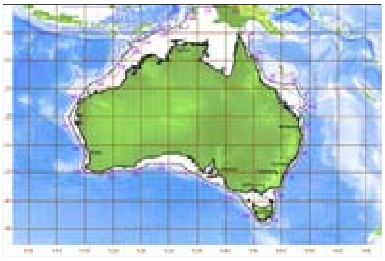
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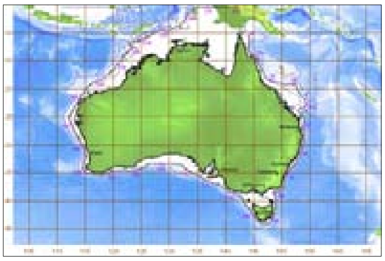
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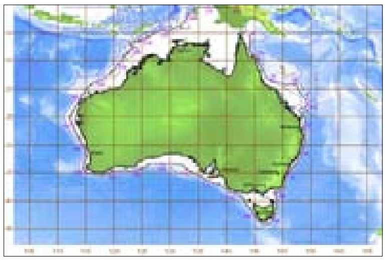
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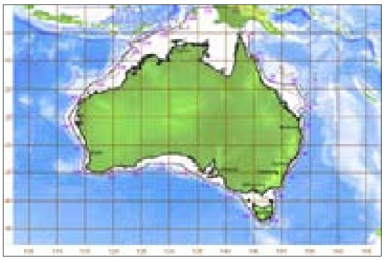
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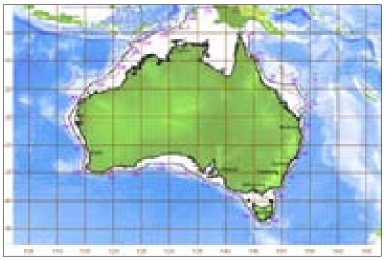
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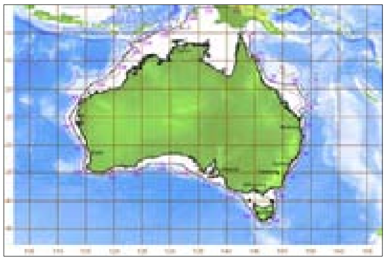
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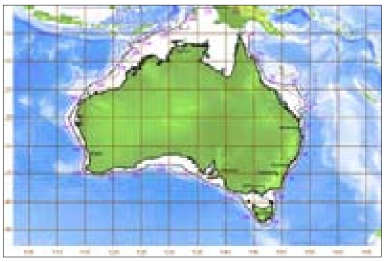
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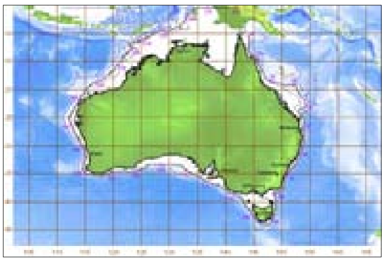
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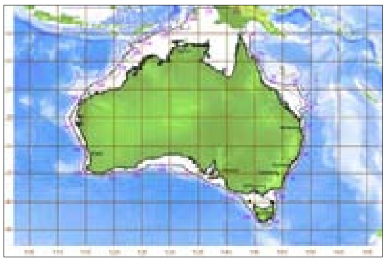
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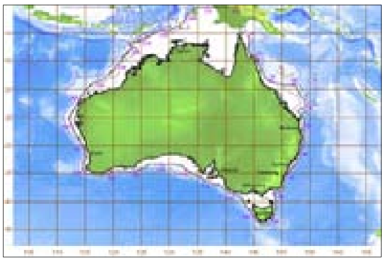
CAAB distributions: surrogate species



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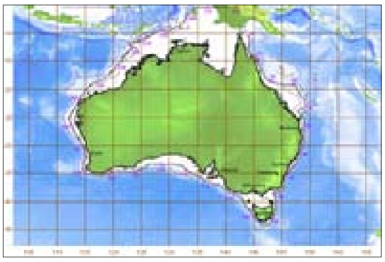

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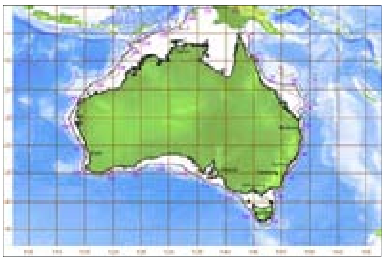

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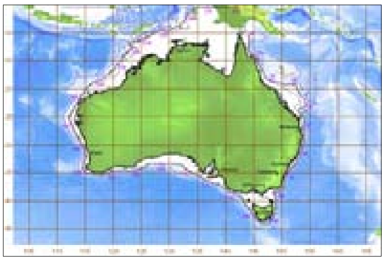

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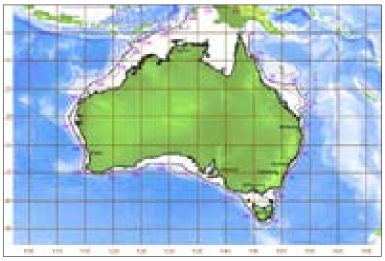

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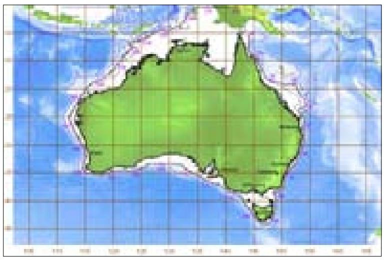

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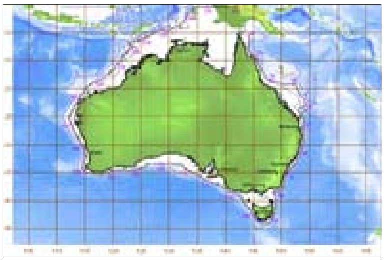

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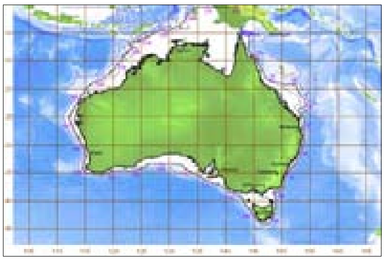

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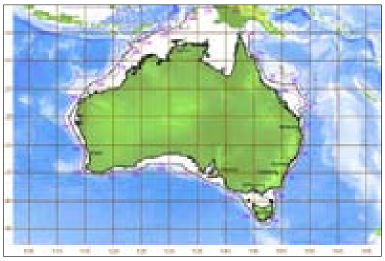

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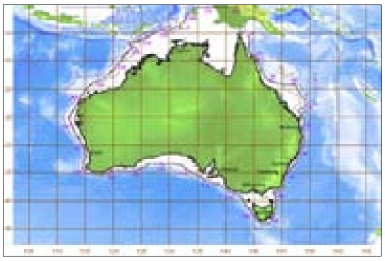

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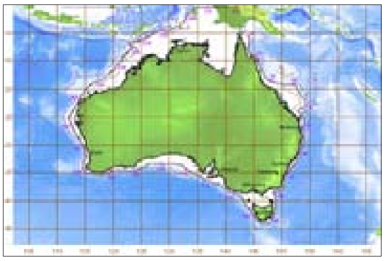

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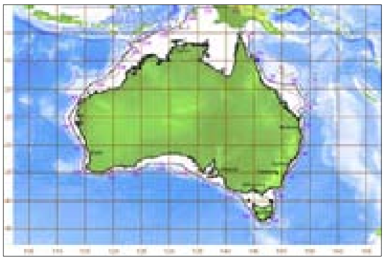

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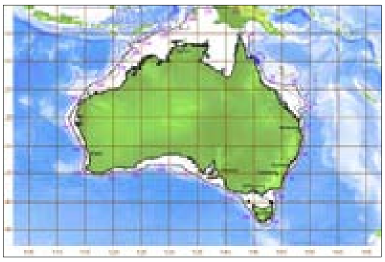

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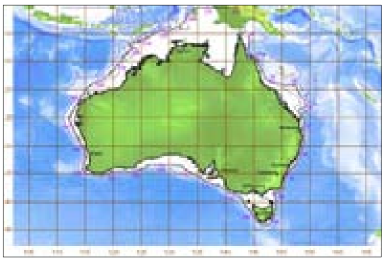

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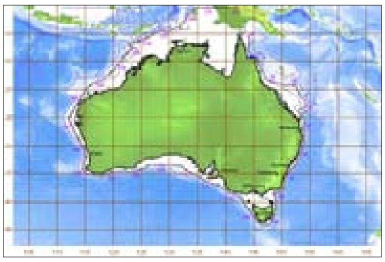

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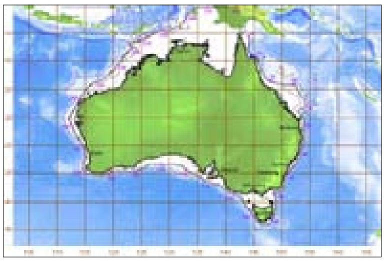
CAAB distributions: surrogate species



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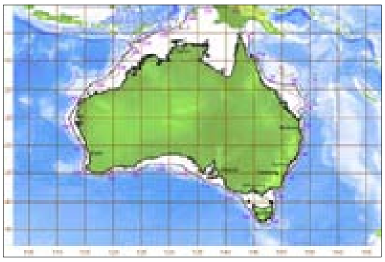

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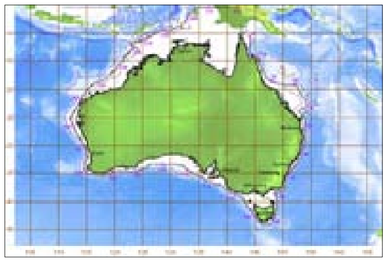

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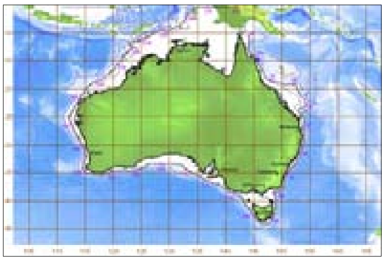

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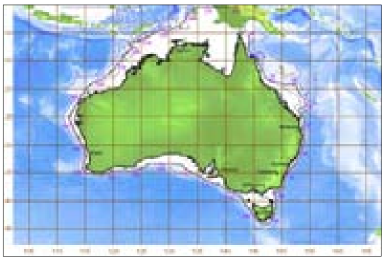

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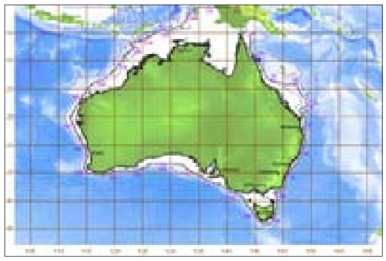

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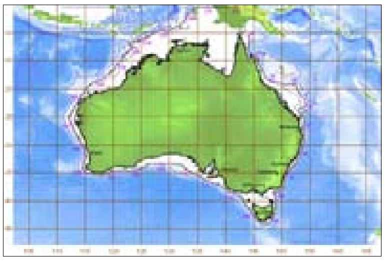

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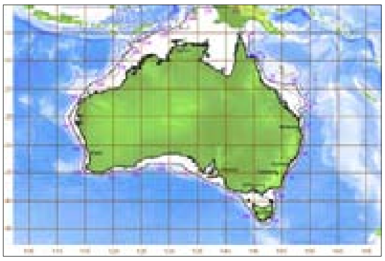

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