Regional Biogeographies for the Indian and South Pacific Oceans

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SPREP Secretariat of the Pacific Regional Environment Programme

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Aims of this Project

- To create a harmonised bioregionalisation for the SW Pacific & Indian Ocean that reflects both the existing efforts that have occurred and the new information that is available.
- There have been numerous previous bioregionalisations, which all show different patterns.
- We are aiming to harmonise all these efforts, and align boundaries and descriptions, incorporating all information that is available.
- This project has described the **boundaries, descriptions and conceptual models** for each of the provinces.

Timeline and process

June 2016 to June 2017	• Collation of Data
July 2017	• Expert Workshop on statistical bioregionalisation
April 2017-October 2017	• Development of statistical bioregionalisations
November 2017-February 2018	• Preliminary Regional workshops in Pacific and Indian
March 2018 – October 2018	• Preparation of draft bioregionalisation and review by external stakeholders
November 2018 – April 2019	• Final Regional workshops in Pacific and Indian
April 2019-June 2019	• Preparation of Final Bioregional Outputs

Why are we doing this?

1. There are many different approaches to bioregionalisation and there is a need to harmonise these to reduce confusion
2. Bioregions/Ecoregions form the basis of an ecosystem approach and the results of the workshops will be useful in the management of national jurisdictions and in areas beyond national jurisdictions.
3. Different jurisdictions that share the same bioregion may use this information to cooperate on the management of shared resources.

Boundaries of Bioregions in NAFO

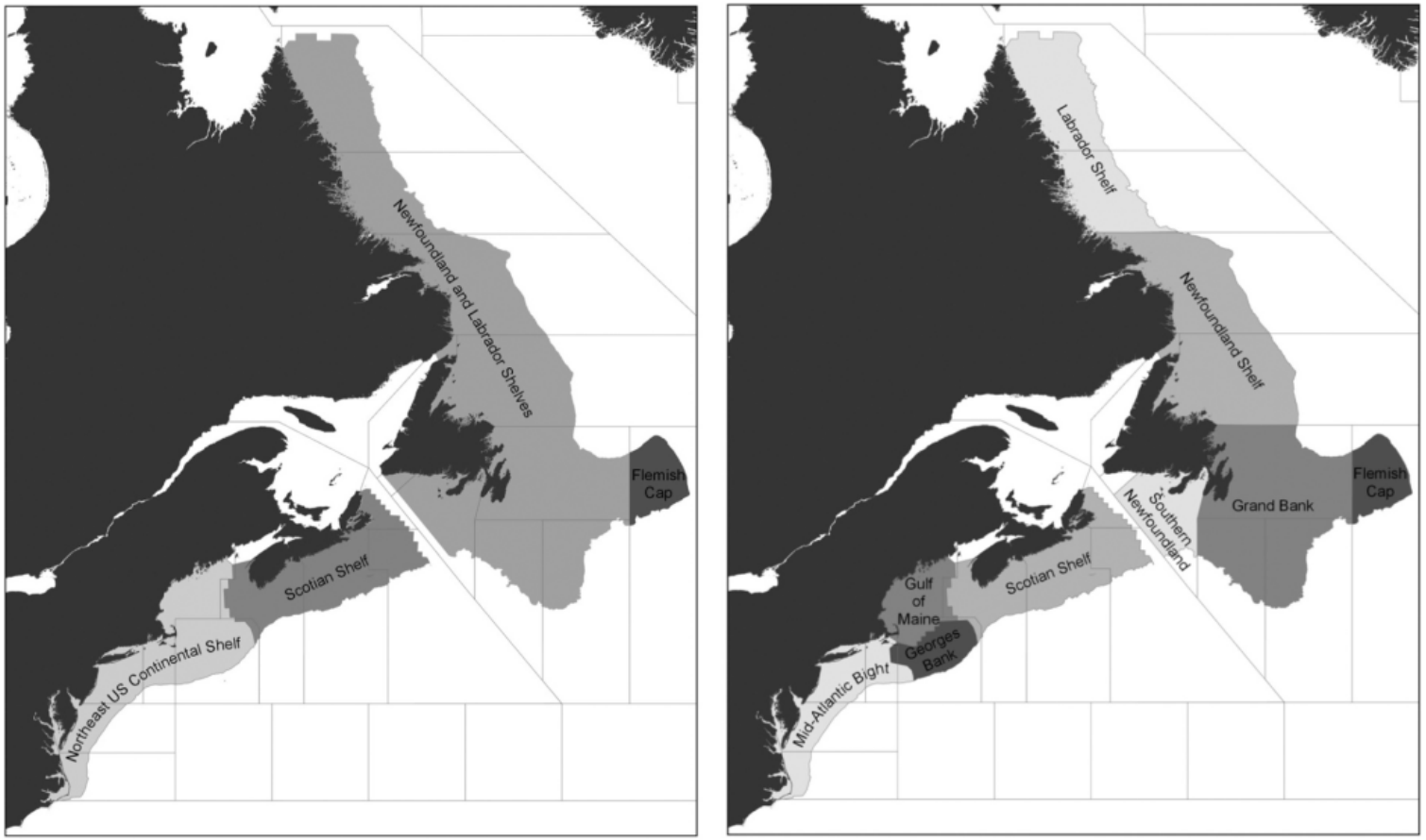


Fig. 4. Bioregions (right) and Ecosystem Production Units (EPUs) (left) currently delineated within the NAFO Convention Area; these spatial units are focused on continental shelf ecosystems where most of the fishing activity takes place.

NAFO Ecosystem Approach to Fisheries

Table 3
Basic spatial scales identified for ecosystem summaries and management plans in the context of developing and implementing Ecosystem Approaches to Fisheries Management.

Name	General operational description	Examples in NAFO Convention Area
Bioregion	Large geographical area characterized by distinct bathymetry, hydrography, and which contains one or more reasonably well defined (but still interconnected) major marine communities/food web systems.	• Newfoundland and Labrador Shelves • Flemish Cap • Scotian Shelf • US Northeast Continental Shelf
Ecosystem Production Unit (EPU)	Within a bioregion, a major geographical subunit characterized by distinct productivity and a reasonably well defined major marine community/food web system.This spatial scale is the one generally considered best suited for the development of integrated ecosystem management plans.	• Newfoundland Shelf (2J3K) • Grand Bank (3LNO) • Flemish Cap (3M) • Georges Bank
Ecoregion	Within an EPU, geographical area with consistent physical and biological characteristics. Often corresponds to a broadly defined seascape and/or major habitat type/class; its precise delineation and extent can vary depending on data availability and the analytical criteria applied. It is within this spatial scale that more precise habitats can be identified (e.g. VMEs).	• Inshore areas in the Northeast Newfoundland Shelf • Northern region of the Grand Bank (~3L) • Top of the bank in Flemish Cap • Slope areas

- Koen-Alonso et al. Marine Policy 100 (2019) 342–352

Framework for developing bioregions

Separate workshops

Described in our work

Classification Level	Scale, Key Driver	Characteristics
Ocean Basins	Basin circulation, climate change, water masses, tectonics, terrestrial inputs, continental drift and basin evolution.	Unique ocean-scale composition of environments including tectonics, exchanges with other oceans, paleo-evolution of flora and fauna composition.
Large Marine Regions	Portions of the ocean basin that have evolved through formation or breakdown of barriers and environments. Tectonics (volcanic activity, plate collisions) and ocean circulation are important rivers at this scale.	Unique subset of basin environment caused by changes in drivers and/or physical structure of sub-basin. Environmental and Evolutionary differentiation of faunal compositions and formation or isolation of unique fauna. Contains a collection of provinces.
Provinces	Units within basins with distinct fauna evolved under distinct paleohistoric pathways and processes: barriers (submergence, emergence), circulation, deep water formation and upwelling, mode water formation, water mass renewal and terrigenous inputs	Core provinces contain unique biota within an environment that is differentiated at the sub-basin scale. Speciation aided or hindered by physical processes and moderated by biological adaptive evolutionary processes resulting in a suite of endemics species that adhere to the province unit. Transitional provinces of mixed environments may contain a mix of species from adjoining core provinces.
Geomorphic Types	Distinct geophysical Units (e.g. seamounts, Undersea volcanoes, mudflows, ridges, trenches and channels) that act as surrogates for distinct fauna associated with the unit. Unit provides differential exposure to environment, exchanges and energy flows.	Faunal unit adapted to environment and habitat niches provided by the geomorphic unit and its contained environment.
Habitats/Facies	Hard, soft or mixed substrates formed by various degradation and erosive processes with by-products accumulating within certain areas.	The composition and texture of facies units provide substrates that serve a variety of purposes for flora and fauna.

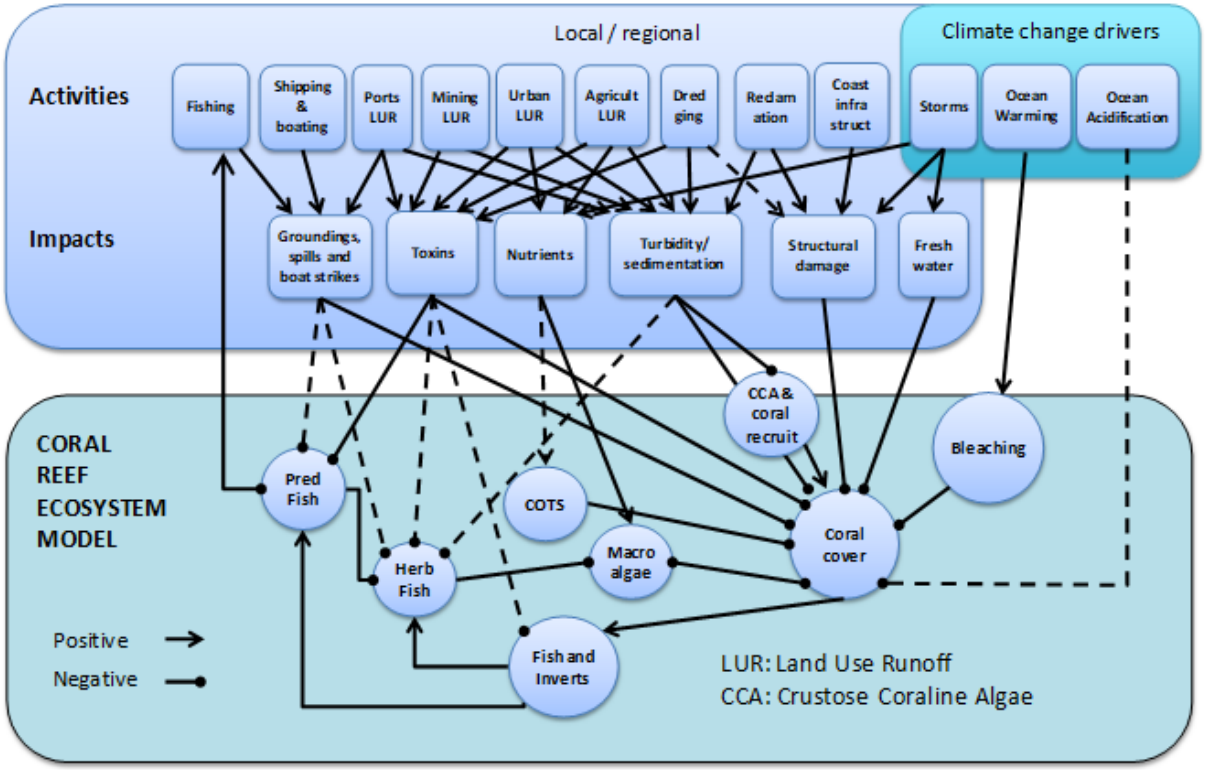
Data sets contributing to the bioregions

Biological data set	Biological/Ecological data	Previous Bioregionalisations
Bathymetry (GEBCO 2014)	Squat Lobster Statistical regionalisation – 4 Specie Groups (CSRIO 2018)	Regional Provincial Provinces (National Marine Bioregionalisation of Australia 2005; Brewer et al. 2015; Douglas et al. 2015; Sink et al. 2010)
Geomorphology (Harris et al. 2014)	Ophiuroid Statistical regionalisation – 6Specie Groups (CSRIO 2018)	Regional Pelagic Regionalisation (National Marine Bioregionalisation of Australia 2005; Lyne and Hayes 2005; Raymond 2017; Brewer et al. 2017).
Simplified Geomorphology (Harris et al. 2014)	Distribution of Coral Reefs and Species Richness (Bugura and Obura, 2010, CORDIO; UNEP WCMP, World fish centre, WRI, TNC (2010)	Surface Ecological Units V1 Ocean ESRI,(Sayre et al 2017)
Chlorophyll a Concentration June and December Means (NOAA)	Distribution of Coral Reefs UNEP WCMP World fish centre, WRI, TNC (2010)	Ecological Marine Units DepthV1 Pacific Ocean 1000m Esri
Sea Surface Temperature June and December Means (NOAA)	Distribution of Seagrass (UNEP WCMC 2005; Short 2017)	Bottom Exologica; Units V1 Pacific Ocean Esri
Nitrate Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)	Distribution of Mangroves (Spalding et al. 2010)	Mesopelagic Ecoregions V1 2017. (Sutton et al. 2017)
Oxygen Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)		Marine Ecosystems of the World (MEOW) Spalding et al. 2007
Temperature Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)		Large Marine Ecosystems (LME) NOAA
Density Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)		Longhurst Biogeographical Provinces (Longhurst et al. 1995)
Silicate Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)		Global Open Oceans and Deep Seabed (GOODS) Pelagic Provinces. WWF
Phosphate Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)		Global Open Oceans and Deep Seabed (GOODS) Bathyal Provinces.

Conceptual Models

- Conceptual models represent a working hypothesis about how an ecosystem works. They should:
- a) identify the important components and processes in the system;
- b) document assumptions about how these components and processes are related;
- c) identify the linkages between these components/processes and anthropogenic pressures; and
- d) identify knowledge gaps or other sources of uncertainty.

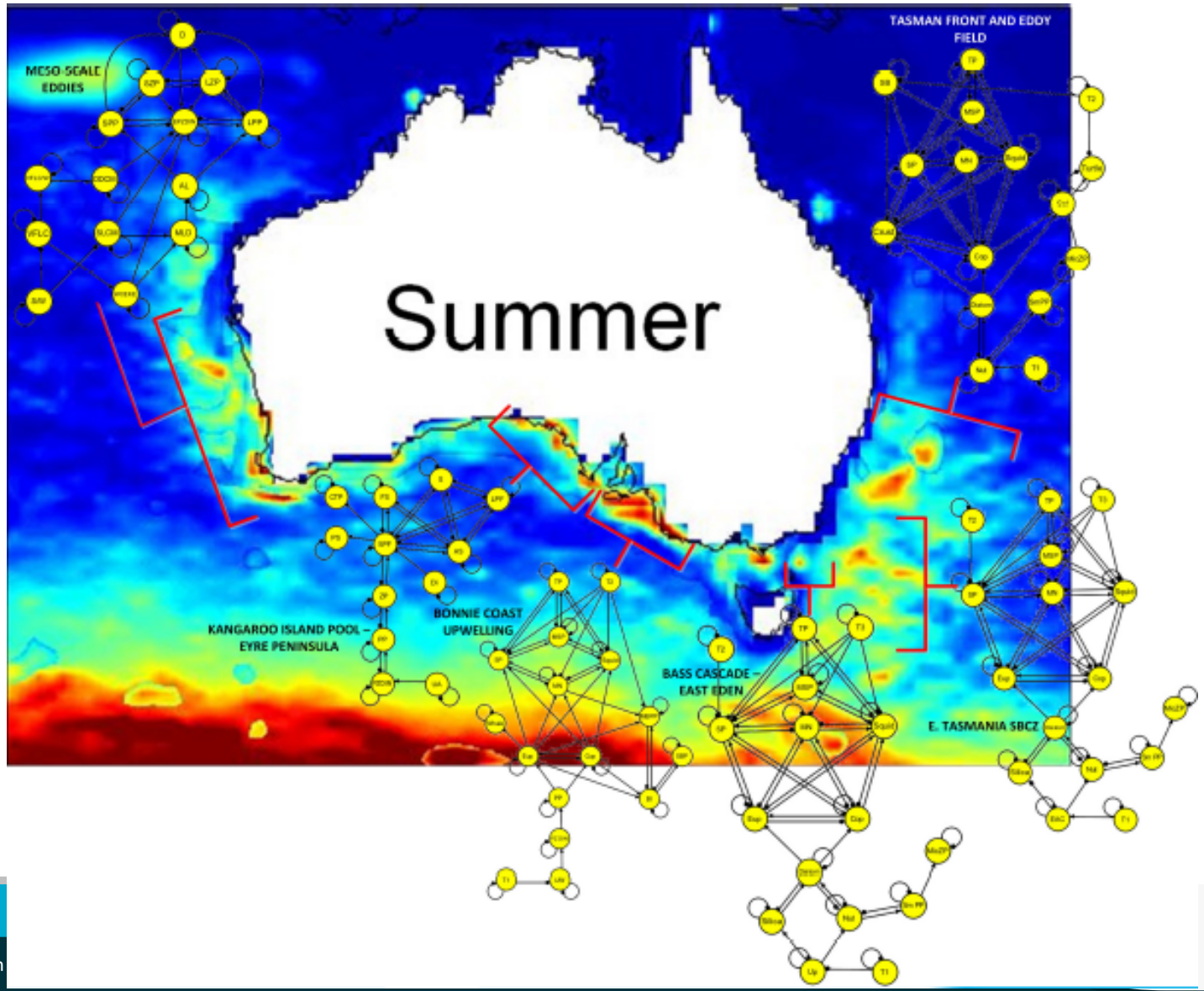
Coral Reef Example



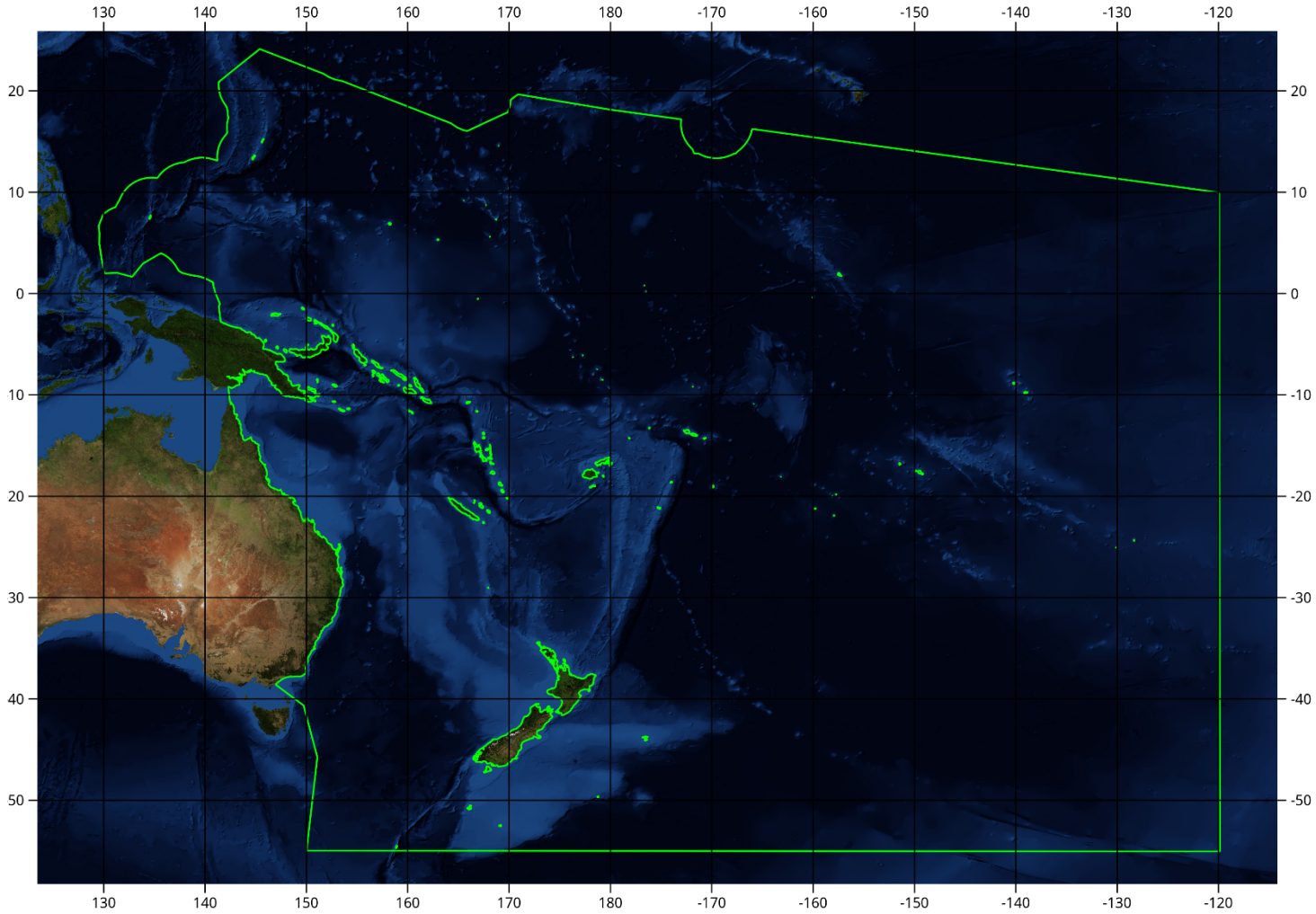
- Conceptual model illustrating how coral reefs are affected by multiple impacts that result from various activities and drivers. It details the main variables and effects at a relatively general (aggregated) level of resolution, and excludes minor (rare) species groups and weak effects. Links describe direct positive or negative effects of one node on another. There were a number of links that were uncertain or contentious. These are represented by dashed-lines links and provide the basis to consider alternative model structures in subsequent analyses.

Going further to simple ecosystem conceptual models

Simple ecosystem models provide opportunity to identify and evaluate monitoring and management priorities



Boundary for Consideration



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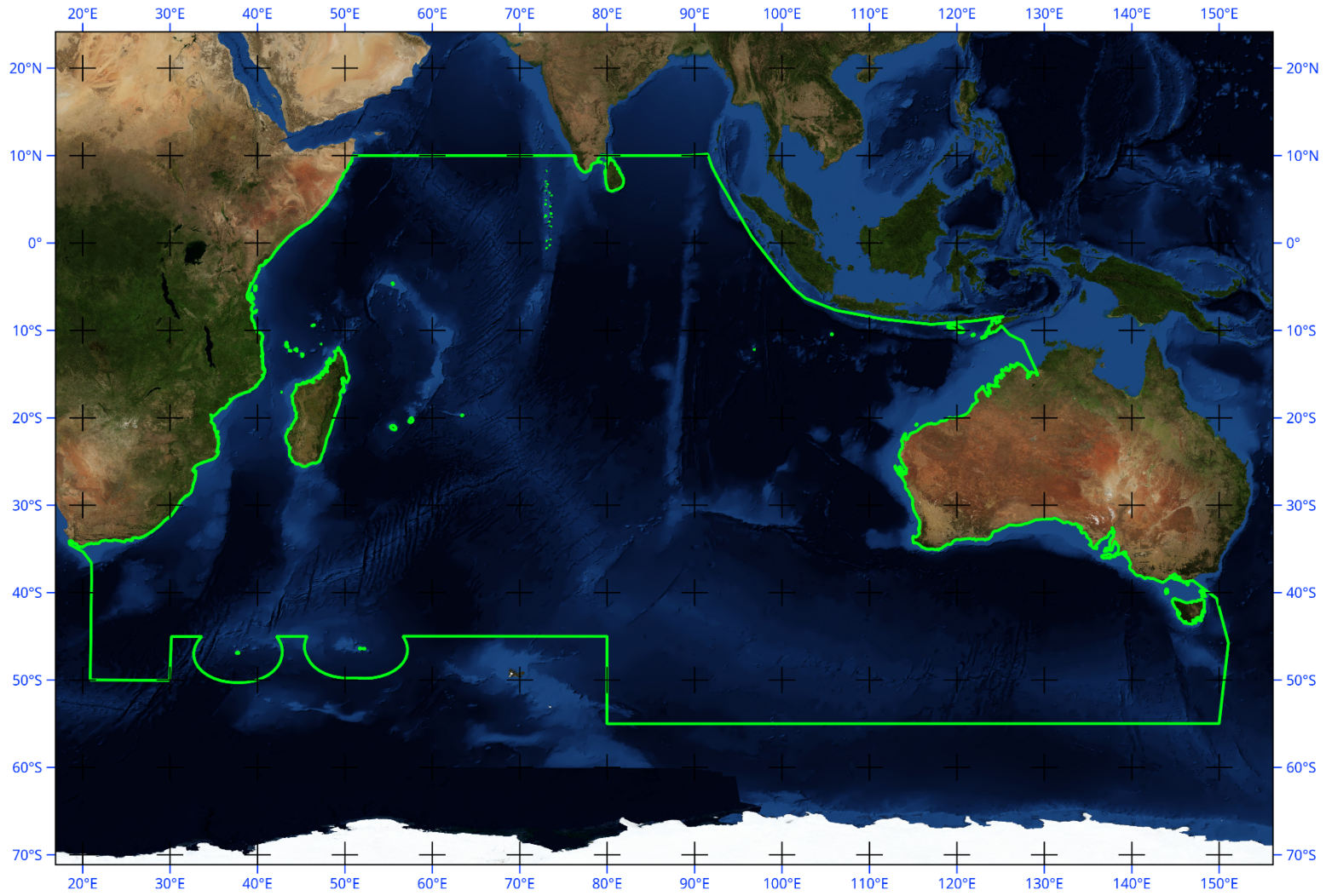


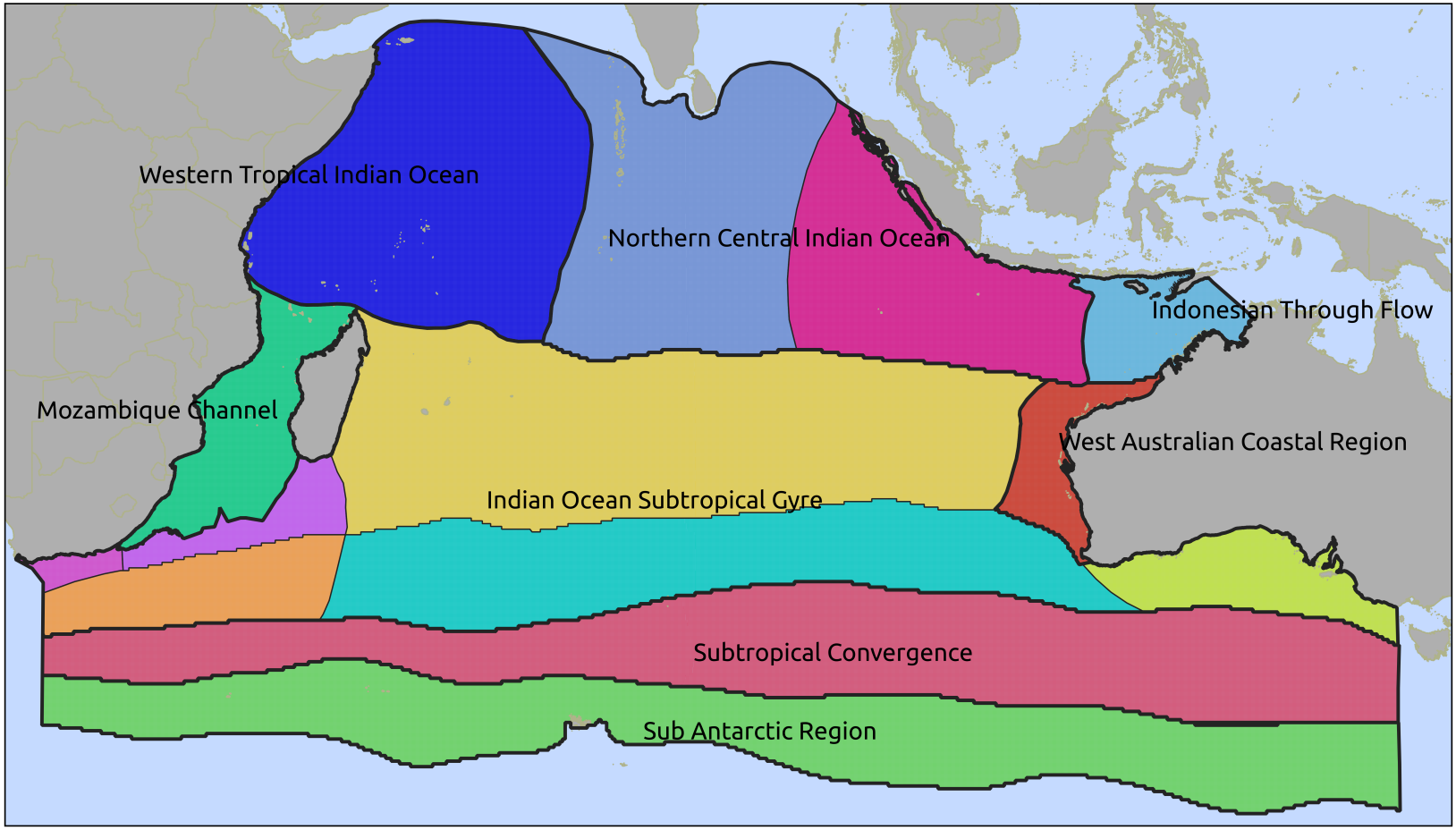
Bioregions of the Indian and South West Pacific

The number of Large Marine Regions and provinces described in the Indian and South West Pacific Oceans

South West Pacific	Large Marine Regions	Provinces
Pelagic	9	21
Benthic	4	35

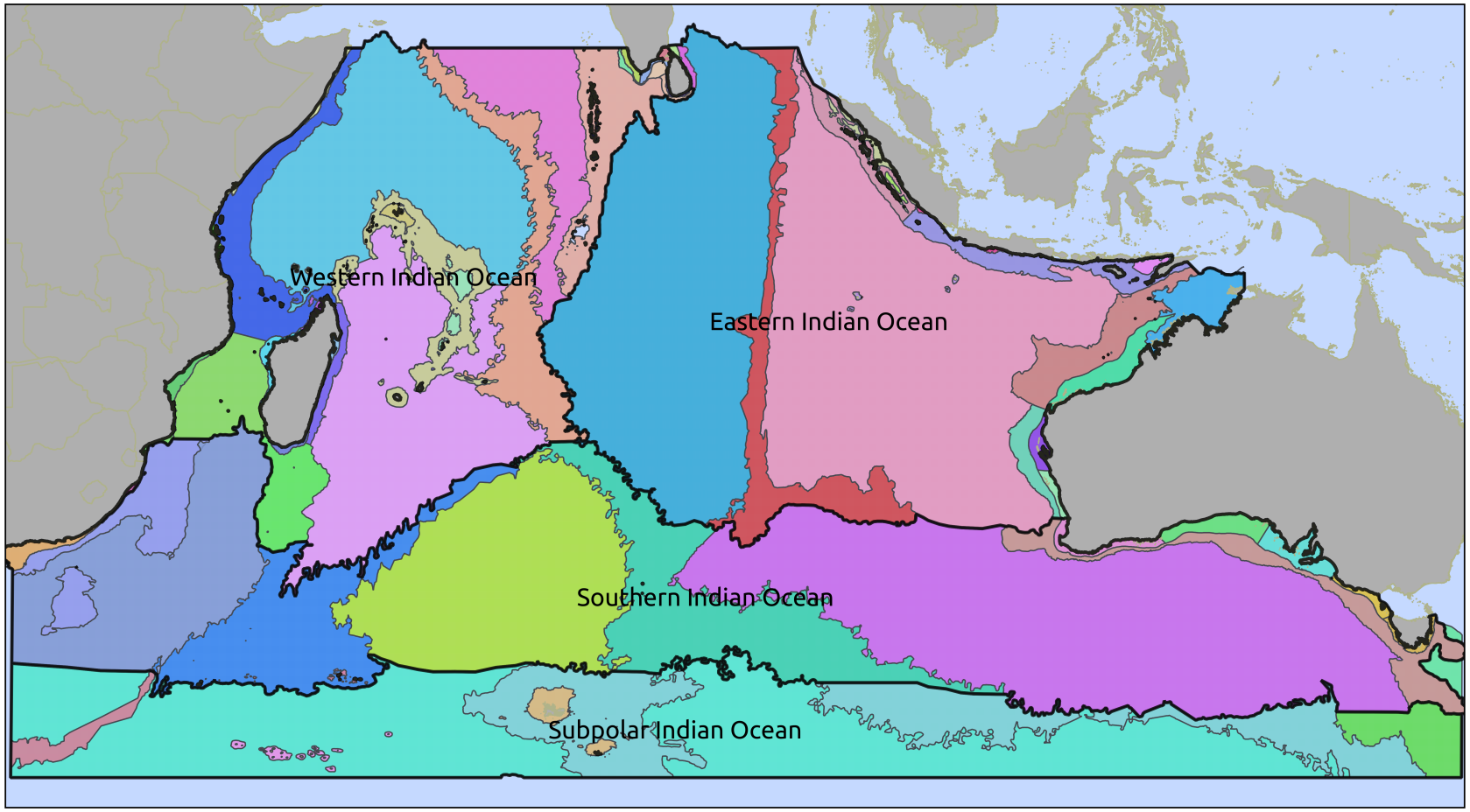
Indian	Large Marine Regions	Provinces
Pelagic	8	14
Benthic	5	76

Pelagic Bioregions - Indian



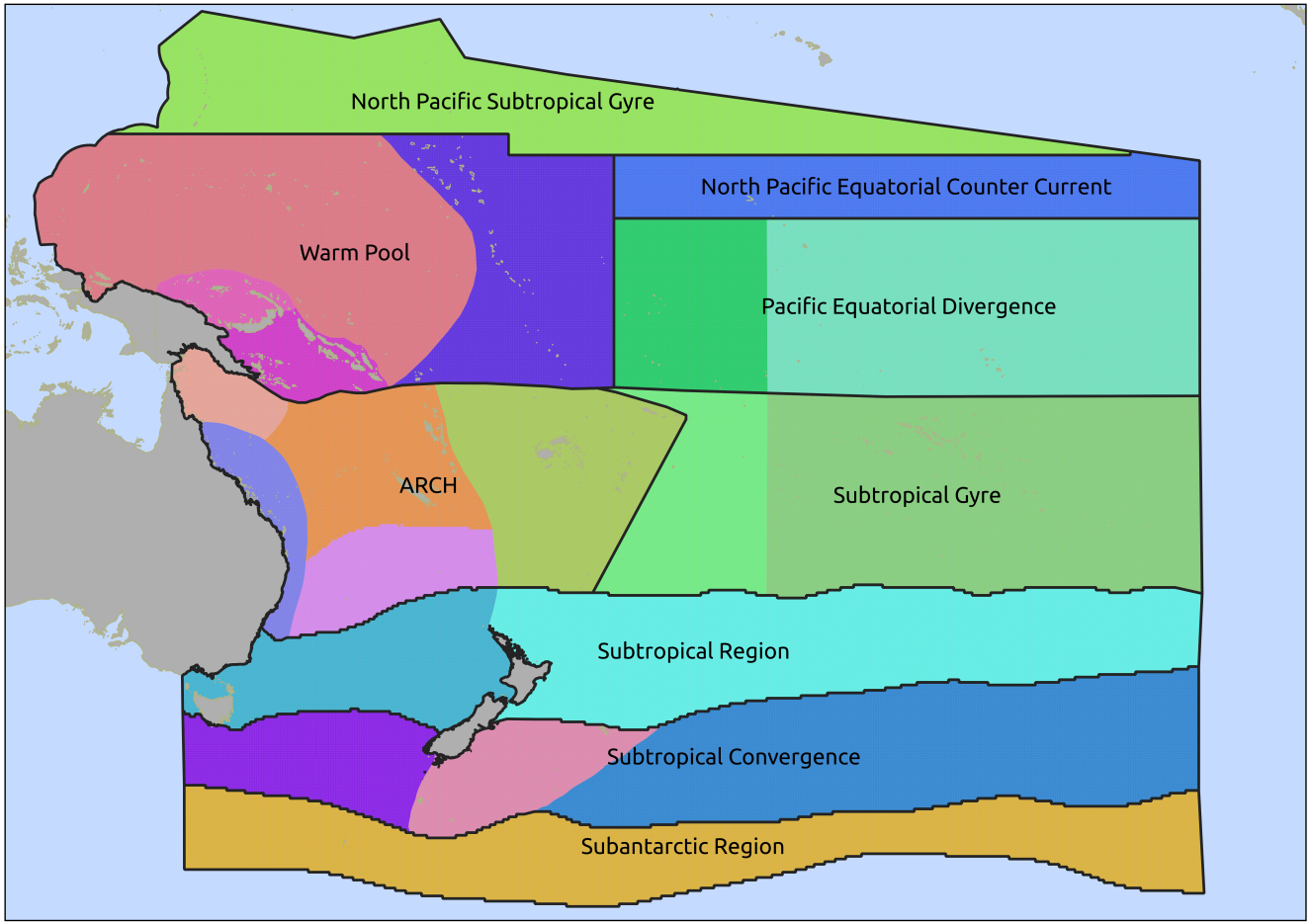
The pelagic Large Marine Regions (outlined and named) and provinces (coloured) in the Indian Ocean.

Benthic Bioregions - Indian



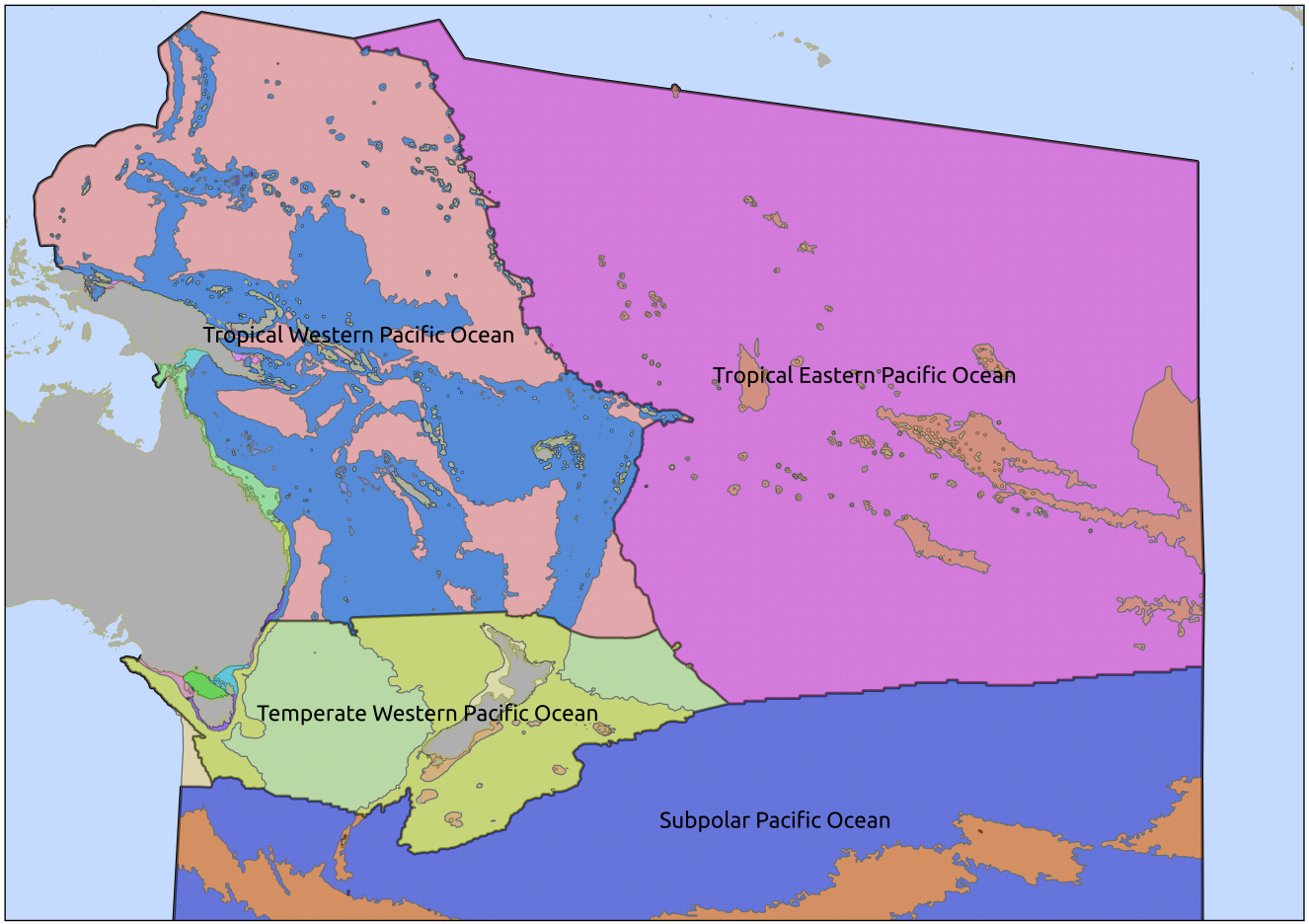
The benthic Large Marine Regions (outlined and named) and provinces (coloured) in the Indian Ocean.

Pelagic Bioregions - Pacific



The pelagic Large Marine Regions (outlined and named) and provinces (coloured) in the South West Pacific Ocean.

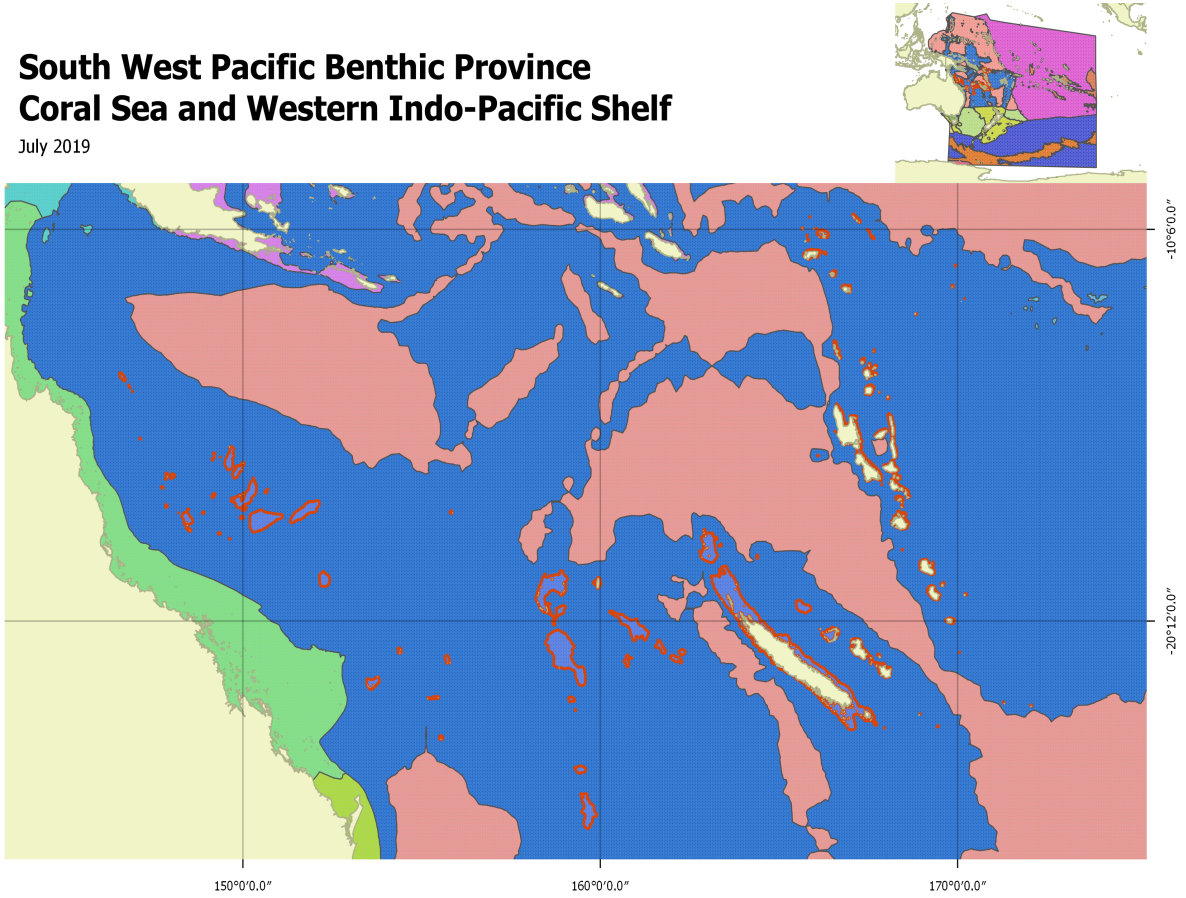
Benthic Bioregions - Pacific



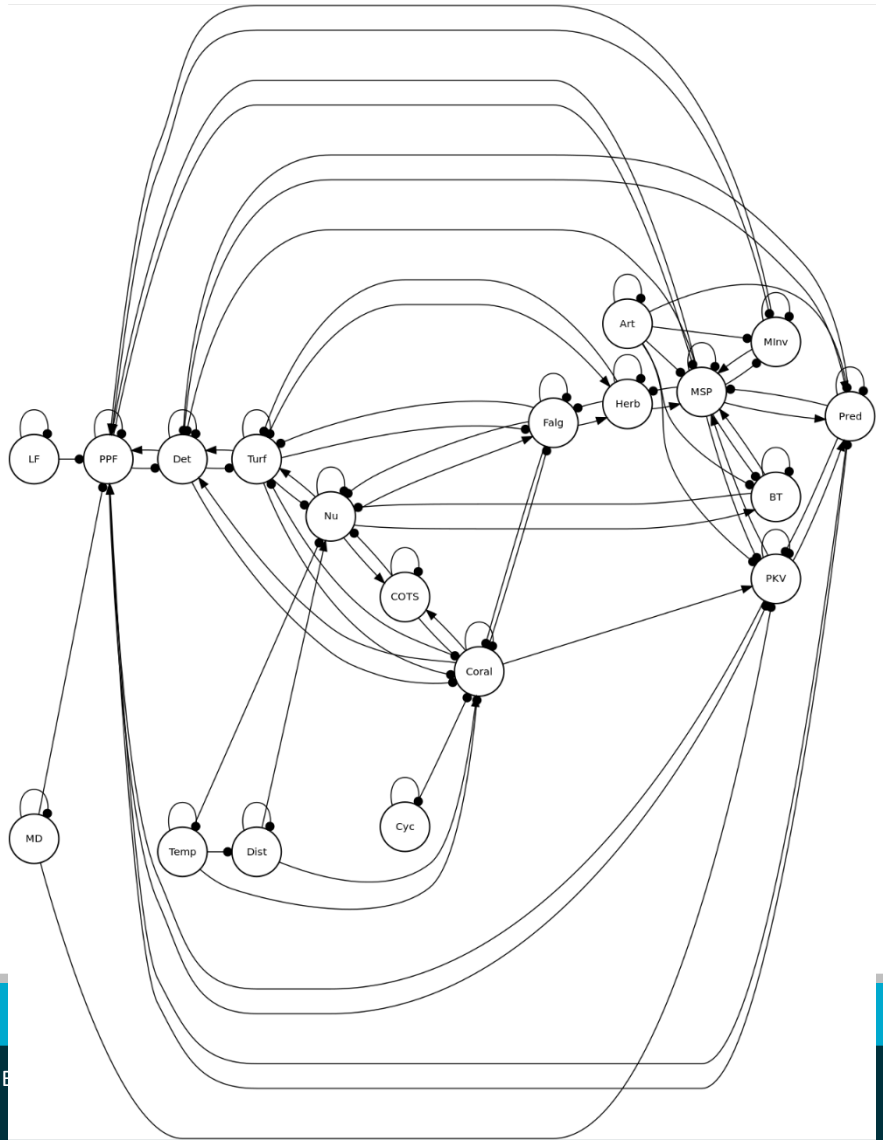
The benthic Large Marine Regions (outlined and named) and provinces (coloured) in the South West Pacific Ocean

Details on Provinces

- Description of spatial boundaries
- Description of species and ecosystems found in the region
- Description of qualitative model of dominate ecosystem
- Analysis of potential impacts of pressures found in those provinces



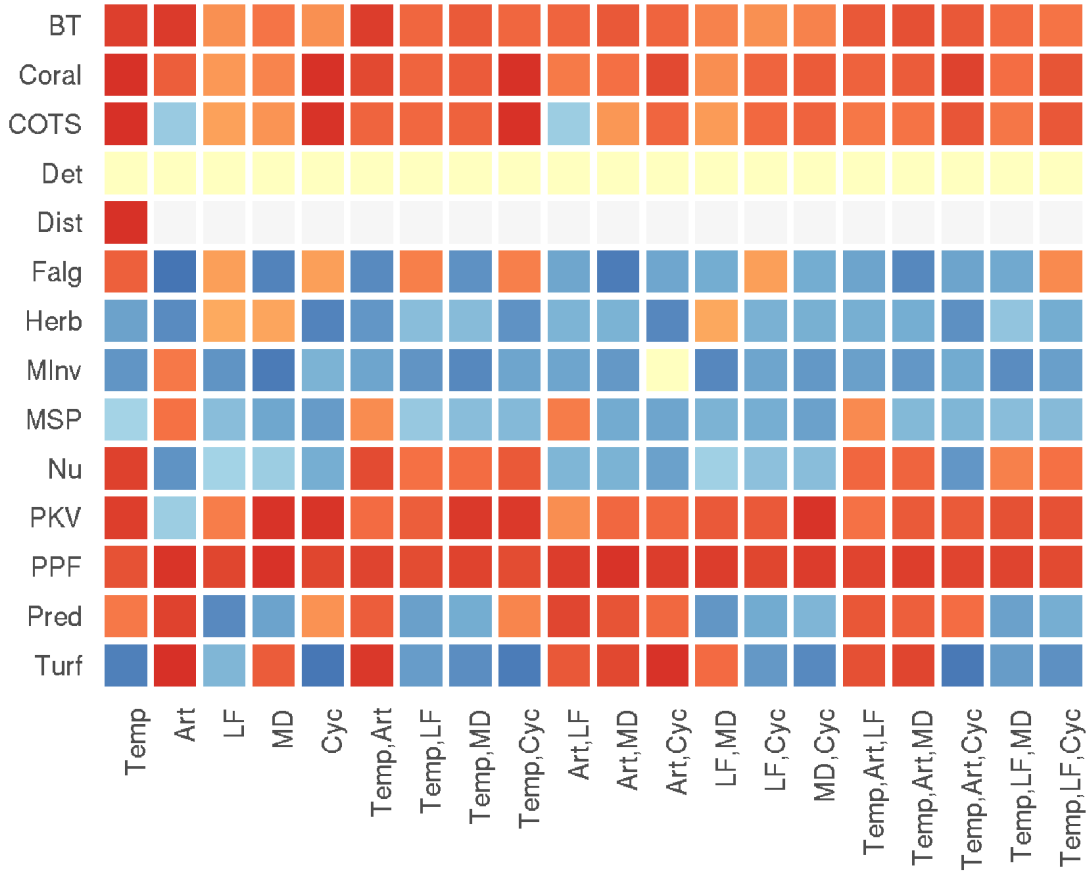
Qualitative model for Coral Sea and Western Indo-Pacific Shelf

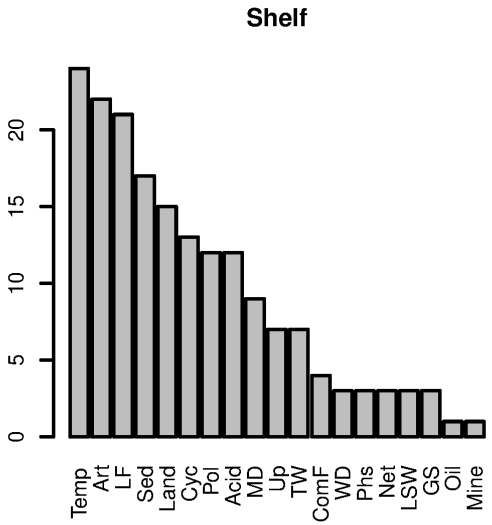


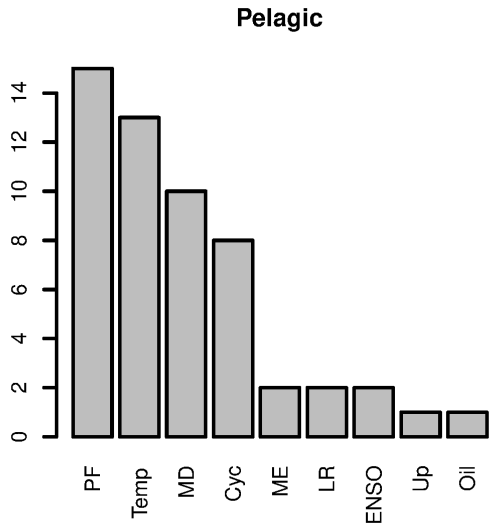
- Ecosystem components in the qualitative model are: Pelagic Predatory Fish (PPF), Detritivore (Det), Predatory Fish (Pred), Medium Sized Predators (MSP), Mobile Invertebrates (MInv), Herbivorous Fish (Herb), Coral (Coral), Planktivores (PKV), BioTurbators (BT), Nutrients (Nu), Fleshy Algae (Falg), Turf Algae (Turf), Coral Predators (COTS), Distance to deep water (Dist) .
- Pressures acting on the system are: Temperature (Temp), Artisanal Fisheries (Art), Line Fishing (LF), MarineDebris (MD), Cyclones (Cyc)

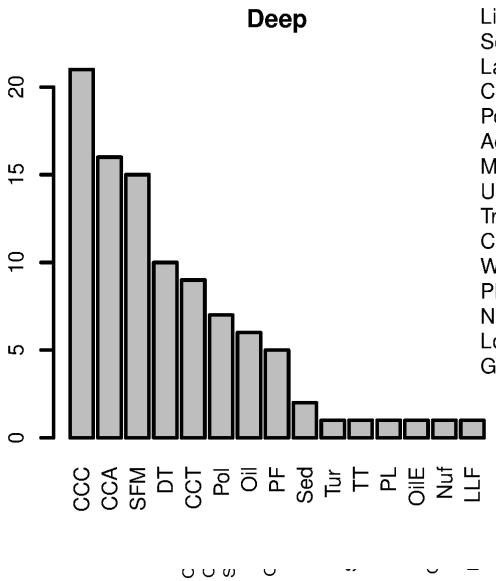
Responses of ecosystem to pressures

- Identification of high risk activities and combinations of activities.
- Identification of indicators for ecosystem health and impact assessments









Temperature = Temp
Artesinal Fisheries = Art
Line Fishing = LF
Sediment = Sed
Land Use Change = Land
Cyclone = Cyc
Pollution = Pol
Acidification = Acid
MarineDebris = MD
Upwelling = Up
Trawl = TW
Commercial Fisheries = ComF
Waste Discharge = WD
Physcial Disturbance = Phs
Net Fisheries = Net
Low Saline Water = LSW
Grounding Ships = GS

OilSpills = Oil
Mine Tailings = Mine
Pelagic Fishing = PF
Mesoscale Eddies = ME
Land Runoff = LR
ENSO = ENSO
Climate Change Chlorophyll = CCC
Climate Change Acidification = CCA
Seafloor Mining = SFM
Demersal Trawling = DT
Climate Change Temperature = CCT
Turbitity Increase = Tur
Targeted Fishing = TT
Pelagic Longlining = PL
Oil Extraction = OilE
Nutrification = Nuf
Longling Fishing = LLF

essures identified on shelf
(0-200m), Deep ecosystems (200-
l Pelagic ecosystems.

Where to from here?

- Publication of results in a peer reviewed journal
- Engagement with Governments and IGOs on use of these methods and outputs
- Developing projects in the Indian Ocean
- Utility in Planning and Environmental Impact Assessment
  - Work with ISA on cumulative impact
  - Work with FAO on cumulative impact
- Potential for using outputs to plan MPA and other forms of management in the Indian and Pacific Ocean

Thank you

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