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Bioregions of the South West Pacific Ocean

Outputs from the Preliminary workshop

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Acknowledgments

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Bioregions of the South West Pacific Ocean

This project has developed sub-regional bioregionalisations for the western-south Pacific Ocean and the Indian Ocean. This combines approaches CSIRO developed in Australia, used in the Bay of Bengal (in collaboration with BOBLME) with similar approaches that have been used throughout the Indian and Pacific Oceans to derive a single combined bioregionalisation. The project has developed an expert derived bioregionalisation in the Indian and Pacific Oceans through expert workshops and novel statistical analysis of physical and biological data.

New bioregionalisations for the western-south Pacific and Indian oceans incorporate understanding of shallow, deep and pelagic species, ecosystems, physical environments and their likely boundaries based on current information. The expert-based bioregionalisations will be supported by development of statistical analysis of datasets of selected species groups to identify bioregions specific for each taxon, with data from the Biologically Significant Marine Areas (EBSA) process and additional regional biogeographies based on new invertebrate and fish collections from CSIRO, University of Tasmania, Museum Victoria and regional partners.

The project draws on experience in CSIRO, GOBI partners, and other collaborators, using approaches currently being trialled in Australia and around the Antarctic margins, and has collaborated with regional and national stakeholders to ensure a consistent approach. The project provides examples of how this information was included and suggest. Outputs have been released in digital format, including a report, the data and analysis used in the process and the final bioregionalisation. This will be provided to all participants, to national CBD focal points and as Documents to CBD meetings.

1.1 Process to Develop Bioregionalisations

The regionalisations of the South West Pacific and Indian Oceans was based on a hierarchical approach that considered the relationships between physical processes, geological and oceanic features, evolutionary processes and ecological communities. The relationships between these different structuring processes is considered at a number of different spatial scales. At the largest scale we have separated the 2 ocean basins. Within the ocean basins we have identified large scale marine regions that define the major oceanographic or geological features and boundaries and define the evolutionary bounds of multiple taxa. Finally, we define provinces within the marine regions that describe areas where the same group of species is expected to occur. The province level will contain unique ecological communities and endemic species that have evolve together over time and may have physical and biological interdependencies.

Table 1 Hierarchical Scales of Biogeographic Classification (Derived from Last et al 2010)

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 and Bathomes	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. These may be broken across depth (bathomes)	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.

This organisation of the classification of biodiversity recognises the spatial hierarchy of biodiversity at a range of scales as detailed in Last et al. (2010).

The hierarchical approach recognises the interplay between process acting at large scales down to processes acting at metre scales and allows the description of biodiversity at each of these scales. However, for this project we are limited to describing biodiversity at the ocean basin, large marine region and province/bathome scale. To move down to the characterisation of geomorphic types and habitats would require additional information and data at smaller scales. Information at this scale is often held by national governments.

To augment the information we relied on biological and ecological information from experts to guide and verify the descriptions of the marine regions and provinces and describe the biophysical interdependencies. For each province, we captured these dependencies through descriptions and concept illustrations that show the defining aspects of the physical drivers, features and processes, and the associated biological communities. These illustrations are useful in understanding the complex biophysical drivers and dependencies, and they also communicate the unique aspects of each province. These illustrations can be used as context to extend the regionalisation to smaller scales in the future.

The participatory approach for the regionalisation involved two workshops and subsequent refinements between CSIRO scientists and local experts. To prepare for the first workshop, CSIRO scientists collated information from literature sources and local experts to map the physical environment, habitats and species distributions. After the approach was explained to workshop participants, the mapped products and local knowledge were used to describe the preliminary regionalisation and to describe the features, processes and interrelationships within each province and between provinces. These relationships were then schematically illustrated by working groups set up for each province. Post-workshop activities refined these draft regionalisations by following up on missing information and ensuring consistency in the descriptions and illustrations. The second workshop reviewed the regionalisations and completed the systems descriptions of each province and linkages between provinces. This latter aspect also facilitated work on trans-boundary issues.

1.2 Data on the Structure of the Pacific Ocean

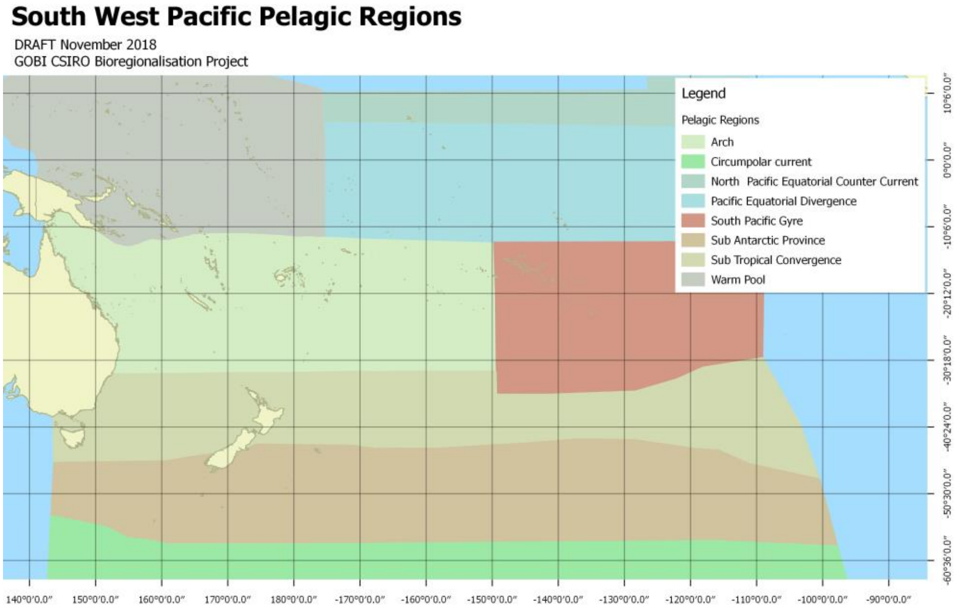
Understanding the ecology and biology of the South West Pacific Ocean requires extensive collections of data to support the analysis and description of the different bioregions with the basin. The South West Pacific Ocean extends from the Eastern Coast of Australia to approximately 100°W Longitude, to the north to 10°N Latitude and extends nominally south the boundary of the CCAMLAR region.

In order to develop an understanding of the Biology, Ecology and Physical structure of the South West Ocean a significant number of data sets were collected. These are shown in Table 1

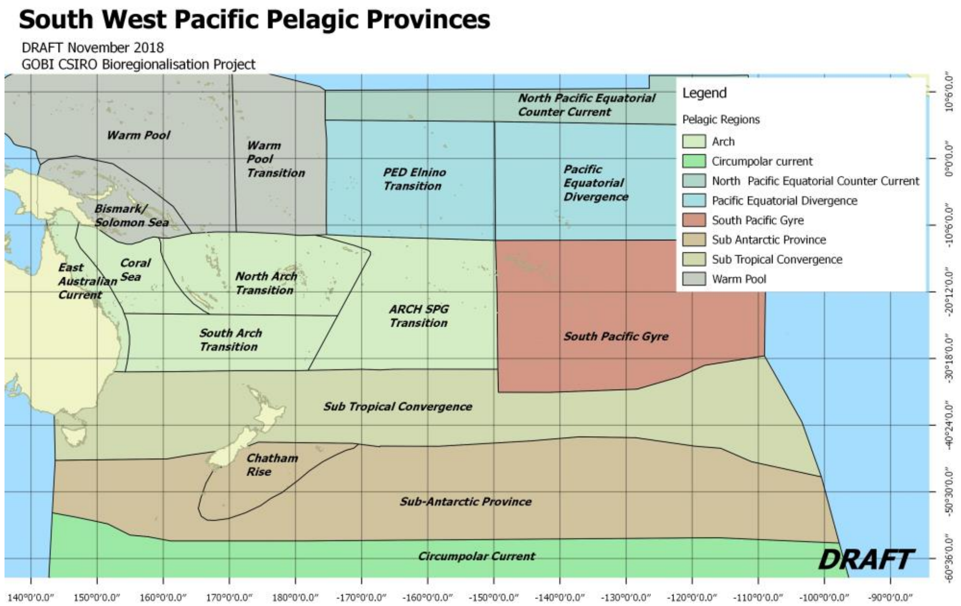
Bological data set	**Biological/Ecological data**	**Previous Bioregionalisations**
Bathymetry (GEBCO 2014) Geomorthology (Harris et al. 2014) Simplified Geomorphology (Harris et al. 2014) Chlorophyll a Concentration June and December Means (NOAA) Sea Surface Temperature June and December Means (NOAA) Nitrate Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018) Oxygen Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018) Temperature Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018) Density Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018) Silicate Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018) Phosphate Decadal Averages – Sea Surface, 200m, 500, 1000m, Seafloor; (WOA 2018)	Squat Lobster Statistical regionalisation – 4 Specie Groups (CSRIO 2018) Ophiuroid Statistical regionalisation – 6Specie Groups (CSRIO 2018) Distribution of Coral Reefs and Species Richness (Bugura and Obura, 2010, CORDIO; UNEP WCMP, World fish centre, WRI, TNC (2010) Distribution of Coral Reefs UNEP WCMP World fish centre, WRI, TNC (2010) Distribution of Seagrass (UNEP WCMC 2005; Short 2017) Distribution of Mangroves (Spalding et al. 2010)	Regional Provincial Provinces (National Marine Bioregionalisation of Australia 2005; Brewer et al. 2015;, Douglas et al. 2015; Holness et al. 2001; Lombard et al. 2004; Sink et al. 2010) Regional Pelagic Regionalisation (National Marine Bioregionalisation of Australia 2005; Lyne and Hayes 2005; Lombard et al 2017; Raymond 2017; Brewer et al. 2017). Surface Ecological Units V1 Pacific Ocean ESRI Ecological Marine Units DepthV1 Pacific Ocean 1000m Esri Bottom Exologica; Units V1 Pacific Ocean Esri Mesopelagic Ecoregions V1 2017. Sutton et al. 2017 Marine Ecosystems of the World (MEOW) WWF Large Marine Ecosystems (LME) NOAA Longhurst Biogeographical Provinces (Longhurst et al. 1995) Global Open Oceans and Deep Seabed (GOODS) Pelagic Provinces. WWF Global Open Oceans and Deep Seabed (GOODS) Bathyal Provinces. WWF

2 Pelagic Bioregions

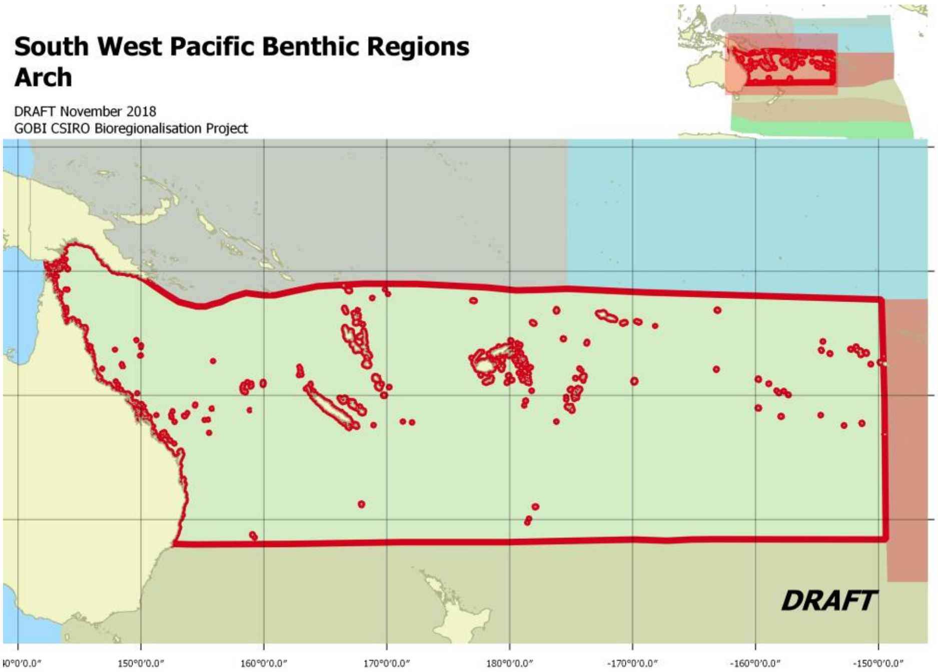
The distribution of the Large Marine Areas – the highest level of classification for the South West Pacific Ocean is shown below.



The distribution of the provinces within the Large Regions is shown below. More detailed descriptions of each of the provinces to given below.


South West Pacific Pelagic Provinces
DRAFT November 2018
GOBI CSIRO Bioregionalisation Project
Legend
Pelagic Regions
Arch
Circumpolar current
North Pacific Equatorial Counter Current
Pacific Equatorial Divergence
South Pacific Gyre
Sub Antarctic Province
Sub Tropical Convergence
Warm Pool
Warm Pool
Warm Pool Transition
North Pacific Equatorial Counter Current
PED Elnino Transition
Pacific Equatorial Divergence
Bismark/ Solomon Sea
East Australian Current
Coral Sea
North Arch Transition
South Arch Transition
ARCH SPG Transition
South Pacific Gyre
Sub Tropical Convergence
Chatham Rise
Sub-Antarctic Province
Circumpolar Current
DRAFT
140°0'0.0"
150°0'0.0"
160°0'0.0"
170°0'0.0"
180°0'0.0"
-170°0'0.0"
-160°0'0.0"
-150°0'0.0"
-140°0'0.0"
-130°0'0.0"
-120°0'0.0"
-110°0'0.0"
-100°0'0.0"
-90°0'0.0"
10°6'0.0"
0°0'0.0"
-10°6'0.0"
-20°12'0.0"
-30°18'0.0"
-40°24'0.0"
-50°30'0.0"
-60°36'0.0"

2.1 Western Pacific Archipelagic Deep Basins (ARCHm)



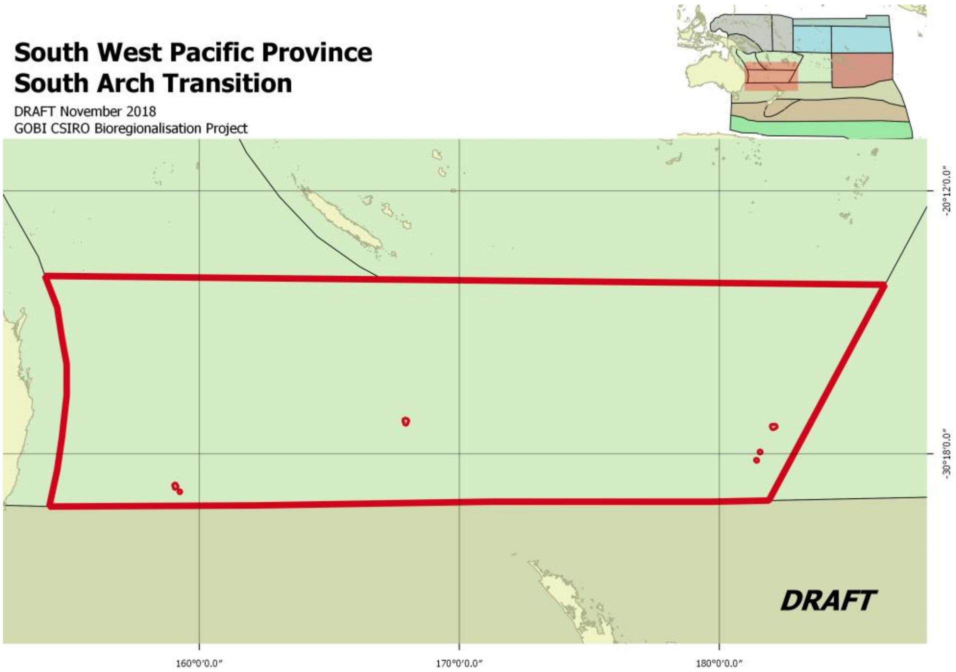
The Western Pacific Archipelagic Deep Basin is characterised by low POM d15N (1.9 ± 3.0‰). Minimum d15N values were recorded in the south-west off New Caledonia, Fiji and Tonga (12.5 ± 1.8‰ and 10.9 ± 2.0‰ for bigeye and yellowfin tuna, respectively)

Mean Trophic Position estimates were the highest in ARCHm compared with other Provinces (5.6 ± 0.8 for bigeye, and 4.8 ± 0.9 for yellowfin). Bigeye tuna are found deeper than in WARMm and PEQD during daytime (300-450m) but shallower than in WARMm and PEQD during nightime; ARCHm biochemical region is characterised by low POM d15N values (2‰) characteristic of high N2 fixation rates (Shiozaki et al., 2014). Additionally, N2 fixation results in the production of organic matter with a d15N value of 0‰ as diazotrophs fix the atmospheric N2 gas (d15N = 0‰) (Minagawa and Wada, 1984; Altabet, 2006).

The influence of N2 fixation is not only observed in New Caledonia but also in Fiji and up to 160 W. This observation extends the ARCHm frontier towards the east compared to the Longhurst ARCH biogeographical province. The presence of picophytoplankton (such as diazotrophs) favours mesozooplankton as an extra step in the food chain (Sommer et al., 2002; Gutiérrez-Rodríguez et al., 2014).

For bigeye, a deeper habitat in the southern regions (ARCHm) was supported by archival tag data, where the mean diving depth of bigeye was higher in New Caledonia (ARCHm) than in the western equatorial Pacific (WARMm, depth difference of 50–90 m according to individuals) (Houssard et al 2017)

2.1.1 Southern ARCH transition



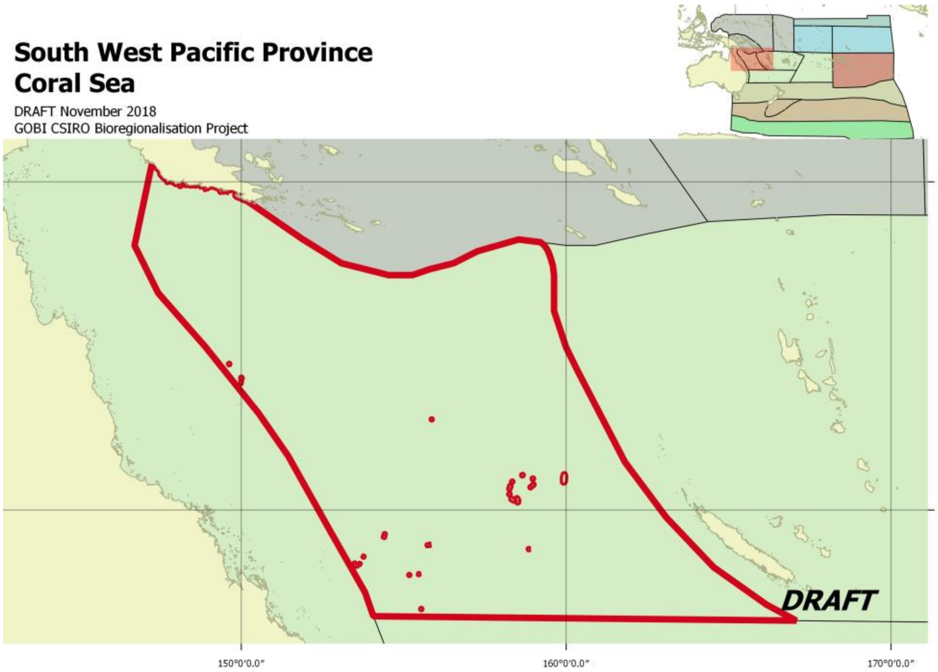
The South ARCH Transition zone extends from South of New Caledonia (~19°S) to 32°S. To the south of New Caledonia, the surface flow returns from the EAC back into the central south Pacific as the South Tropical Counter Current (STCC) (Marchesiello et al., 2010). In this region, the structures of the ocean currents are prone to shear instabilities and high eddy kinetic energy is observed (Qiu et al., 2009). The region is characterised by (Ceccarelli et al., 2013; Dandonneau and Gohin, 1984). South of 19–20°S, waters are characterized by colder temperature, higher salinity, a shallower nitracline, higher nitrate content in the surface layer, higher primary production and higher micronekton biomass estimates and are under the influence of the South Tropical Counter Current branches (Marchesiello et al., 2010)

Within New Caledonia (19S-22S) in the cool season waters were comparatively cooler than in the north, with higher surface salinity, higher concentrations of nitrate (0.13±0.12 µM) and chlorophyll content occurred with more frequent maxima at the surface. Phosphate concentrations varied with an average of 0.067±0.038 µM from the surface to 100 m depth and were occasionally lower than 0.05 µM in the surface layer. The mixed layer was shallower during the hot season, located at 25 m, denoting stronger surface stratification in the water column than during the cool season. The Deep Chlorophyll Maxima (DCM) (0.25–0.3 mg m 3) and the nutricline were located at 90 m depth. The mixed layer was shallower during the hot season, located at 25 m, denoting stronger surface stratification in the water column than during the cool season. During the hot season surface waters were low in nitrate (0.03±0.02 µM) and the DCM was often centred at around 100 m with mean values of 0.41±0.16 mg m3. In general, above the DCM in the top 50 m, chlorophyll concentrations were slightly lower than during the cool season, particularly in the 19S-22S area. Phosphate tended to be lower (0.05±0.03 µM) than in the northern part .

As a consequence of these patterns, during the cool season the Net Primary Production had higher values (350 mgC m^2d) in New Caledonia in the 20S-22S area than in the north. During the hot season the entire region was more oligotrophic, with a weaker north–south gradient, and average values of 200 mgC m ^{2}d . During the cool season, chlorophyll was dominated by picophytoplankton (<3 µm) (mean=75.9%±SD=17.2% in biomass); nano and microphytoplankton represented 12.8%±9.6% and 11.3%±12.6% respectively of chlorophyll biomass. The cyanobacteria Prochlorococcus were the dominant species of the picophytoplankton group (91.9%±6.3% in abundance) with cell abundances of up to 250x103 mL-1. Remaining abundances of picophytoplankton were comprised of Synechococcus (6.3%±6.2%) and picoeukaryotes (1.8%±0.8%). The fractionated chlorophyll and community structure during the hot season was similar; however, cell abundance was much lower during the hot season, with maximum cell counts of Prochlorococcus of 160x103 mL-1.

South of New Caledonia, in the 20 –30 latitudinal band, eddy features are generated due to baroclinic instability of the STCC (Sub Tropical Counter Current) generated by the meeting of two opposite flows: the eastward STCC and the westward South Caledonian Jet (Qiu et al., 2008; Couvelard et al., 2008). The mesoscale eddy field in the south western Pacific and especially in the STCC region is characterized by an eddy life cycle with three dynamic phases depending on the period of the year: growing (August–October), maturing (November–January) and decaying (March–June) phases (Qiu et al., 2008).

2.1.2 Coral Sea Province



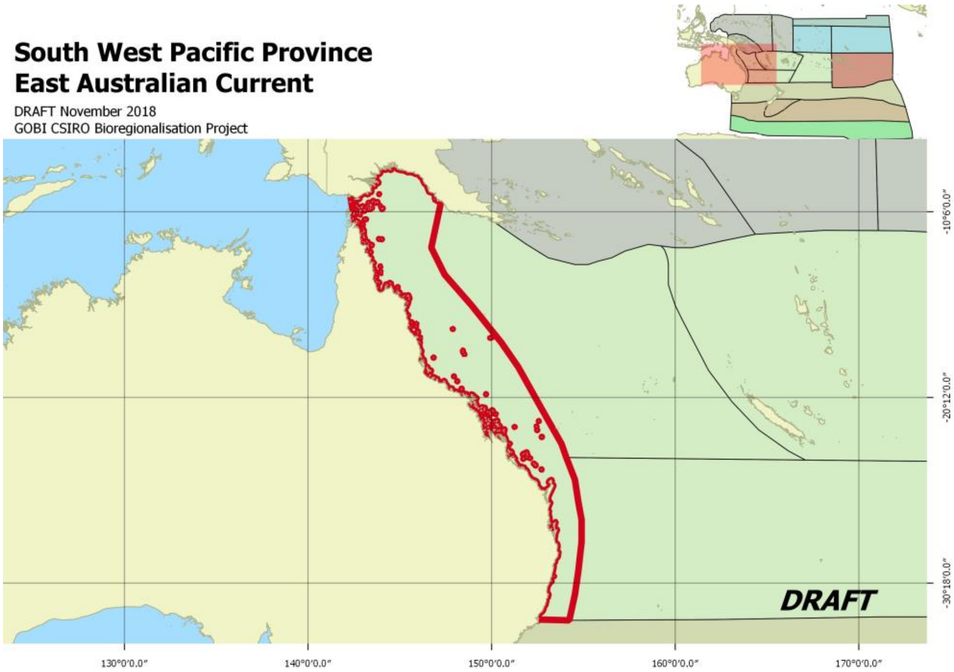
The Coral Sea Province is bounded by the East Australia Current Province, the Bismark Solomon Sea Province and the Northern and Southern ARCH transition provinces. The eddy features within the province are ubiquitous and are generated to the north of New Caledonia, in the Coral Sea, by barotropic instability generated by the north Caledonian and Vanuatu Jets. Eddies in the Coral Sea have radii between 25 and 300 km (Couvelard et al., 2008) and they are generated by a complex topography dominated by several islands and reefs initiating nonlinear currents (Gourdeau et al., 2008; Marchesiello et al., 2010).

North of 19 S–20 S the waters were characterized by warm temperature, low salinity, low nitrate and lower primary production, representative of the Coral Sea oligotrophic regime and largely influenced by the warmer and fresher waters of the South Pacific Convergence Zone; lower overall ADCP-derived zooplankton biomass and clear attenuation of the diel migration in the upper layer (0–100 m) (Smeti et al 2015).

The dominant feature of circulation across 0–150 m is the westward-flowing South Equatorial Current (SEC) from 25°S to the equator. The SEC flow bifurcates at the Australian continental margin (Ridgway and Dunn, 2003) at 15°S, with one branch connecting with the southward flowing East Australian Current (EAC) (Qu and Lindstrom, 2002) and the other forming the Gulf of Papua Current which flows northward along the coast of Queensland. Within the Coral Sea, the SEC comprises narrow filaments and jets created by the complex island, reef, seamounts and ridge topography (Gourdeau et al., 2008) namely the North Vanuatu Jet at around 13–15S, and the North Caledonian Jet at around 17–18°S (Couvelard et al., 2008; Marchesiello et al., 2010)

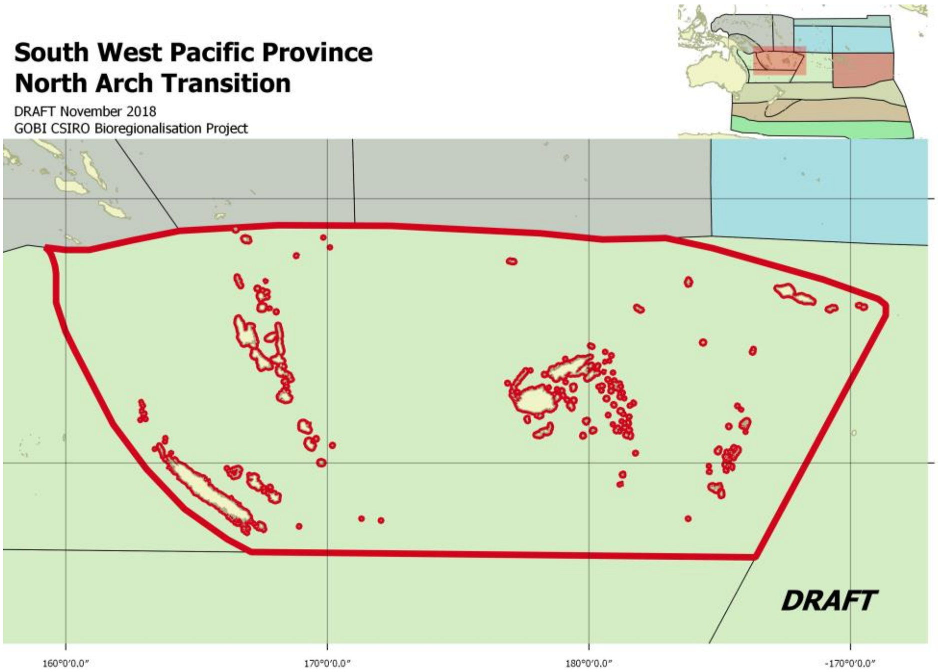
In New Caledonia, tuna catches are dominated by albacore tuna (Thunnus alalunga) and exhibit two seasonal peaks in July–August and December, and the highest catch rates occur in the north-western part of the EEZ (Briand et al., 2011). The influence of temperature, primary production and micronekton density on tuna catch rates has been demonstrated in New Caledonia (Briand et al., 2011)

2.1.3 East Australia Current Province



The East Australia Current Province (AUSE in Longhurst 1995, 1998) is the southward boundary current that moves along the east coast of Australia. It is driven by the Subtropical Gyre and is primarily responsible for warm water transportation down the east coast of Australia to the Tasman Sea. This in turn supports a large fishery and significant biodiversity in the southern extent of the province.

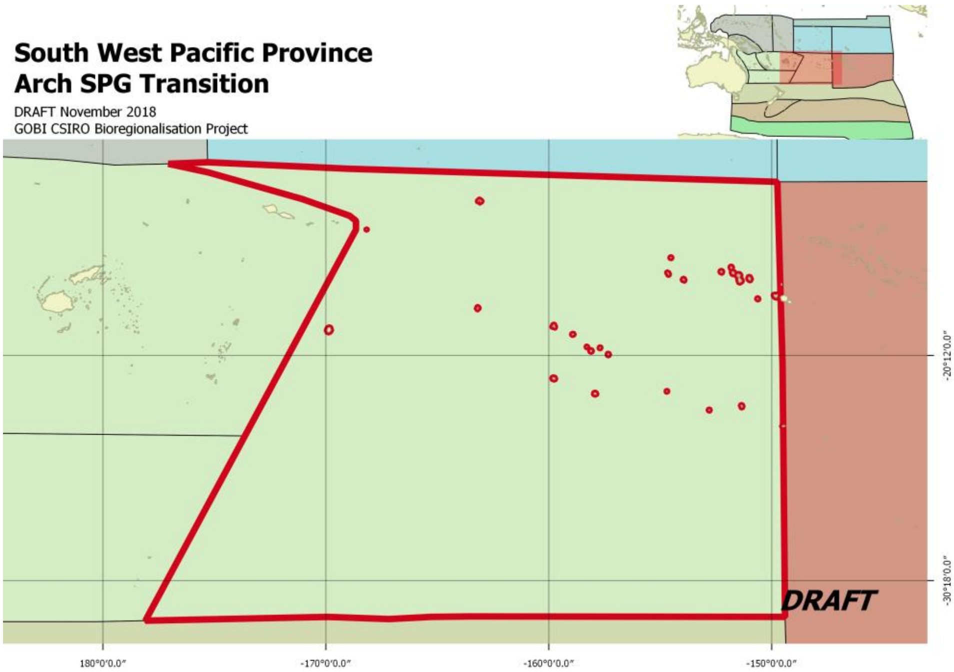
2.1.4 Northern ARCH Transition Province



In contrast to the Southern ARCH Province, the ocean around New Caledonia (17°S-19°S) were characterised by relatively warm, low salinity waters with a mixed layer depth of 60 meters and low values of nitrate (0.05±0.07 µM) to a depth of 90 meters. This province extends eastwards from the Coral Sea Province and includes New Caledonia, Fiji, Tonga, Samoa.

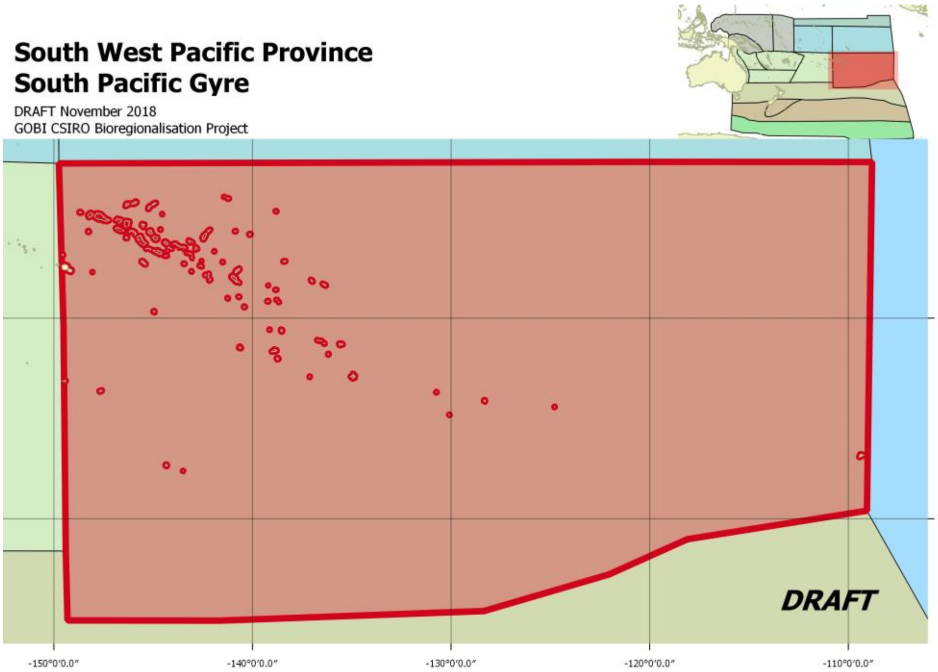
The stable nitrogen isotope ratio δ15N in the mesozooplankton from the upper 100 m of the water column were 1.5%lower to the east of New Caledonia (Northern ARCH) compared to the Coral Sea in the west, with a separation around 163.5E. There was evidence that the east–west difference in mesozooplankton δ15N values was transferred into the macrozooplankton and micronekton communities (Hunt et al 2015). The δ15N values of the primary consumer zooplankton were consistently lower east of New Caledonia (=middle ARCH) (average=3.79‰ ±0.52) than to the west (coral sea) (average=5.62‰ ±0.26). A similar pattern was observed in the macrozooplankton/micronekton (Hunt et al 2015). Amongst the nekton species a significant (negative) relationship between δ15N and longitude was only detected for *T. alalunga*. For the species of micronekton with significant longitudinal correlations, there was a mean increase in δ15N of 2.9% between 157E and 170E.

2.1.5 ARCH-SPG Transition



Pelagic species in the ARCH-SPG transition zone show a noticeable transition from the POM d15N seen the ARCH provinces to the lower values seen in the SPSG province. In this region the values are between 3-6‰ (Houssard et al. 2017).

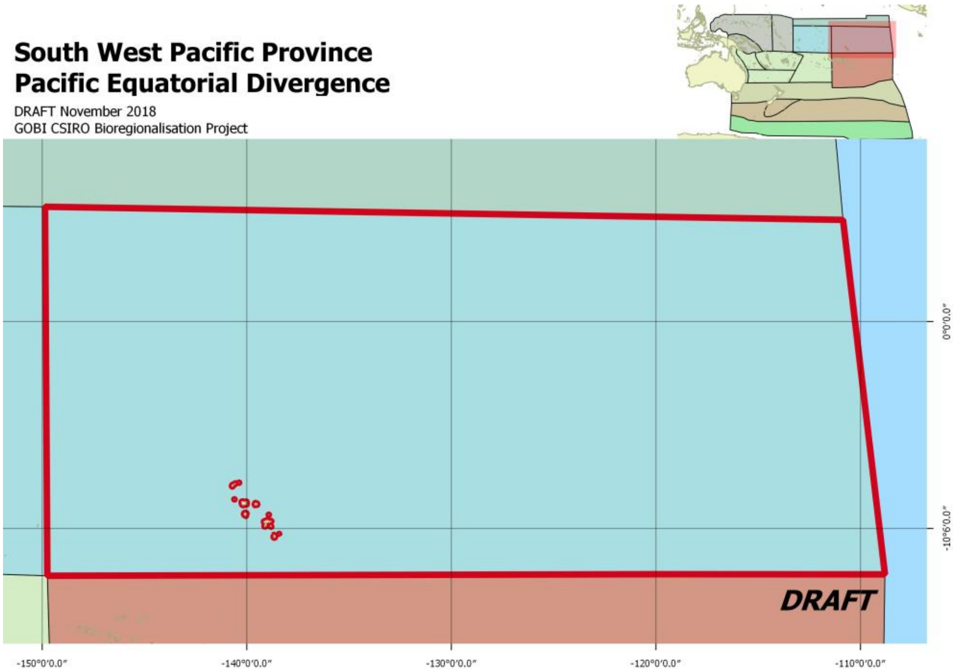
2.2 South Pacific Subtropical Gyre (SPSG)



The South Pacific Gyre can be found south of 10-14°S (down to 20°S) in French Polynesia and northern boundaries of this region is the south equatorial counter current (SECC) around 8-14°S. The waters in this region are influenced by the great southern gyre and present oligotrophic characteristics less favourable to micronekton development. The waters of the south pacific central gyre south of 13S are oligotrophic (Rougerie & Rancher 1994). The region is characterised by high POM d15N (11.1 ± 2.9‰). Maximum d15N values were found in the south-east in SPSGm (19.4 ± 2.5‰ and 17.2 ± 2.6‰ for bigeye and yellowfin tuna, respectively). The mean Trophic Position estimates were high in SPSGm (5.4 ± 1.1 for bigeye , and 4.6 ± 1.1 for yellowfin). In regions of SPSGm that exhibited the highest POM d15N values (11‰), the nitrate pool would be completely utilized resulting in no isotope fractionation effect (Rafter et al., 2013).

N2 fixation is low (e.g., SPSGm; Deutsch et al., 2001; Shiozaki et al., 2014) in regions where new primary production is fuelled by nitrate, large phytoplankton such as diatoms are directly grazed by macrozooplankton, leading to a ‘’shorter” food chain (Le Borgne et al., 2011).

2.3 Pacific Equatorial Divergence (PEQD)



The Pacific Equatorial Divergence is similar to the region describe by Longhurst (1995, 1998) but extends further south based on information from migratory fish species. Both bigeye and yellowfin tuna showed low d15N values in PEQD (12.1 ± 1.6‰ and 13.0 ± 2.6‰, respectively) and the mean Trophic Position estimates were the lowest in PEQD compared with other regions (3.7 ± 0.8 for bigeye, and 3.7 ± 0.9 for yellowfin). Bigeye tuna are shallower than in ARCHm during the day (250-350m) but deeper than in ARCHm during the night. The d15N values could occur due to incomplete and low levels of nutrient utilization driven by Rayleigh fractionation (Altabet, 2001,Yoshikawa et al., 2006, Graham et al., 2010).

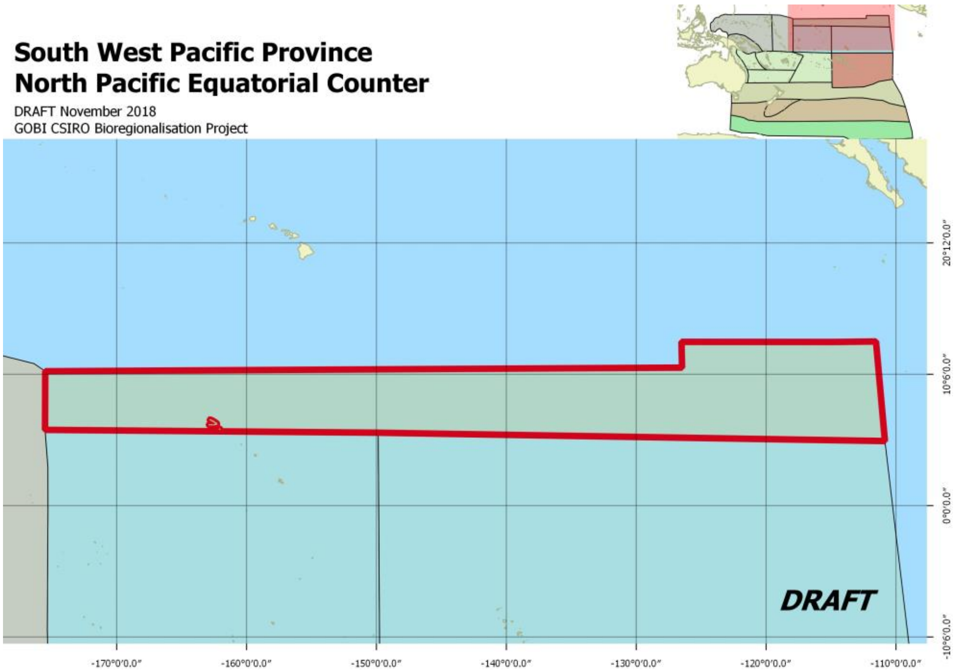
Within the PEQD micronekton abundance was higher (than in regions to the north and south) in an area between Marquesas Archipelagos (8S-10°S) and a west-northwest/east-southeast oriented line stretching between 11°S and 14°S, i.e. in a weak convergence, favourable to micronekton development due to the concentration of lower trophic levels with no oxygen limitation in the deep layers (Houssard et al 2017).

To the north (up to 4S), waters are enriched by the equatorial upwelling, but intense organic matter remineralisation limits oxygen availability under the thermocline.

The equatorial upwelling north of the Marquesas supports high biomass and biomass is known to decrease as latitude increases (Vinogradov 1981). The same patterns emerge for primary productivity which is maximal between 2°N and 2°S (Lindley et al. 1995, Barber et al. 1996, Chavez et al. 1996, Vinogradov et al. 1997). However the mesozooplankton maximum is shifted several degrees south to between 2°S and 5°S (Vinogradov 1981, White et al. 1995) at 140°W). Although

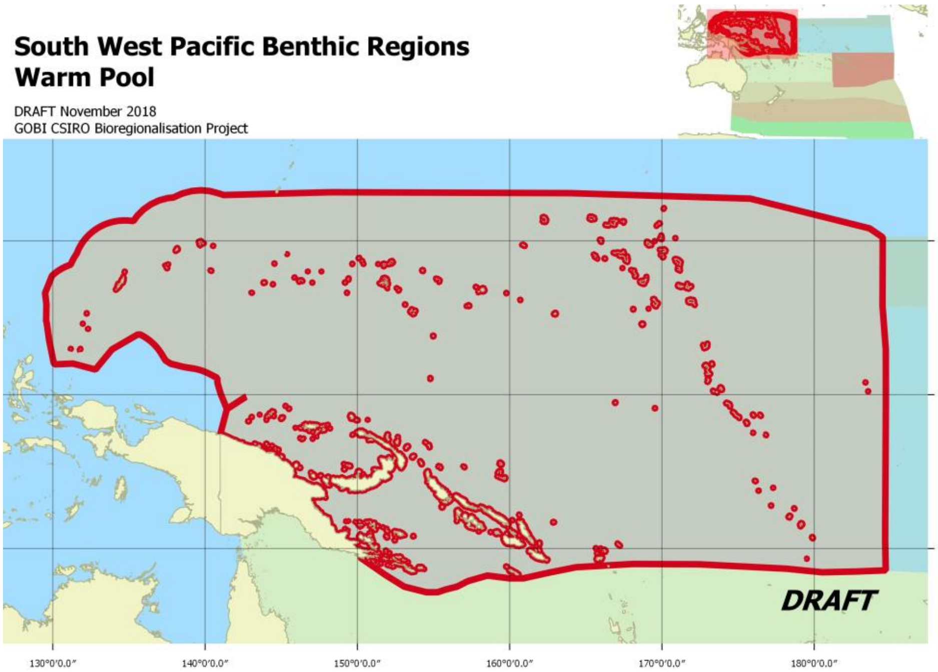
Vinogradov (1981) and Lehodey et al. (1998) predict a tuna forage biomass maximum at the same latitude as that of the zooplankton, ECOTAP results locate it more to the south. In the equatorial upwelling, occurrence of macronutrients (such as nitrate or orthophosphate) in the photic layer allows production of larger phytoplanktonic cells than in oligotrophic areas which are nutrient-limited (Le Bouteiller et al. 1992). As a result, mesozooplankton diet consists of a greater proportion of phytoplankton, leading to a closer relationship between phytoplankton and mesozooplankton.

2.4 North Pacific Equatorial Countercurrent (PNEC)



This region is identical to the area described in Longhurst (1995,1998). Houssard et al. (2017) found medium-high POM d15N (7.7 ± 1.6‰), however no tuna were sampled in PNEC.

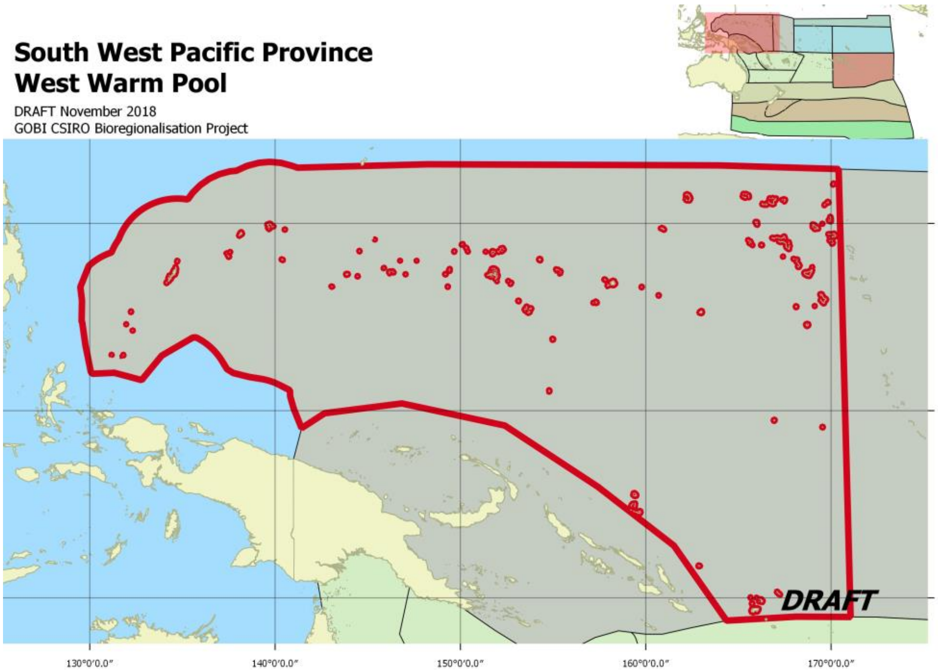
2.5 Western Pacific Warm Pool (WARM)



Large migratory fish species in the Western Pacific Warm Pool have medium-high POM d15N (7.5 ± 2.7‰) and moderate d15N values were found at the equator in WARMm (15.5 ± 1.7‰ and 14.1 ± 2.5‰ for bigeye and yellowfin tuna) since new primary production is mainly fuelled by nitrate (Yoshikawa et al., 2006; Rafter and Sigman, 2016). The mean trophic position estimates were low to intermediate in WARMm (4.1 ± 0.8 for bigeye and 3.6 ± 1.1 for yellowfin). Bigeye tuna shallower than in ARCHm during the day (250-350m) but deeper than in ARCHm during the night

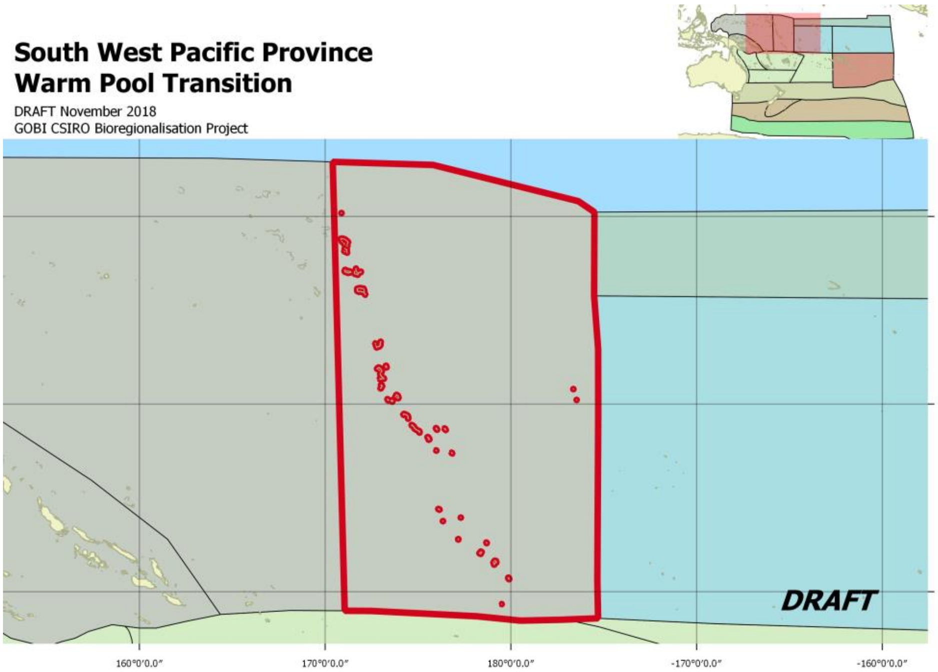
The depth of the 20°C isotherm around 140 meters deep in the western equatorial Pacific (WARMm). For bigeye tuna, a deeper preferred habitat in the southern regions (ARCHm) was indicated by archival tag data, where the mean diving depth of bigeye was deeper in New Caledonia (ARCHm) than in the western equatorial Pacific (WARMm, depth difference of 50–90 m according to individuals) (Houssard et al 2017)

2.5.1 Pacific Warm Pool



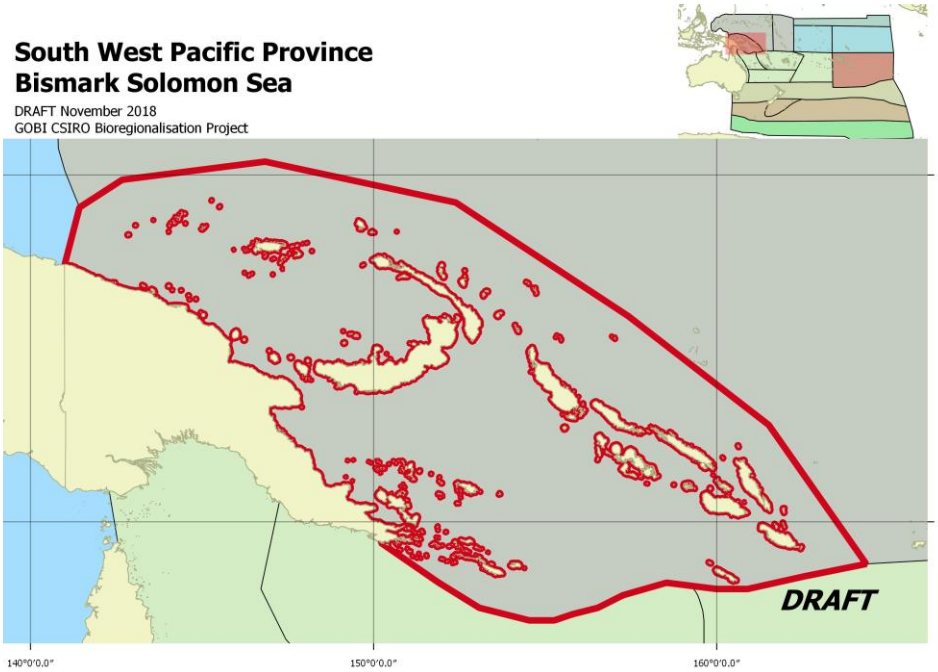
The Pacific Warm Pool is well described in Longhurst (1995, 1998) and is strongly influenced by the North Equatorial Counter Current (From the Equator to 10°N) with micronekton composition different from micronekton composition of other norther areas to the east (Hidaka etal 2013)

2.5.2 Warm Pool La-Nina Transition Province



The Warm Pool La-Nina Transition Province encompasses the transition region where the Pacific Warm pool extend to in La-Nina years. When the Pacific is in a La-Nina phase surface temperatures in this region rise and large migratory fish (e.g. Tunas) move eastwards from the Pacific Warm Pool province to this region. In an El-Nino phase, the reverse is true and there are much fewer Tunas and similar species in this Province.

2.5.3 Bismarck-Solomon Sea Province



The dominant biogeographic forcing agents defining this ecoregions vary from location to location but generally include isolation, upwelling, nutrient inputs, freshwater influx, temperature regimes, exposure, sediments, currents, and bathymetric or coastal complexity. In ecological terms, these are strongly cohesive units, large enough to encompass ecological or life history processes for most sedentary species (Green et. al 2014).

The Bismarck-Solomon Sea Province is 2 semi-enclosed tropical marginal seas (after McKinnon et al 2014) with associated reefs and islands. The ecoregion includes an important deep-sea features such as the New Britain Trench, which is just south of the island of New Britain, south west of Solomon Archipelago. This seas are located in the western part of the so-called warm pool region and, as such, have some of the warmest waters in the global ocean comprising predominately of oligotrophic seas (McKinnon et al 2014). It is around annual mean Sea Surface Temperature (SST) ranges within 28 °C–29.5°C.

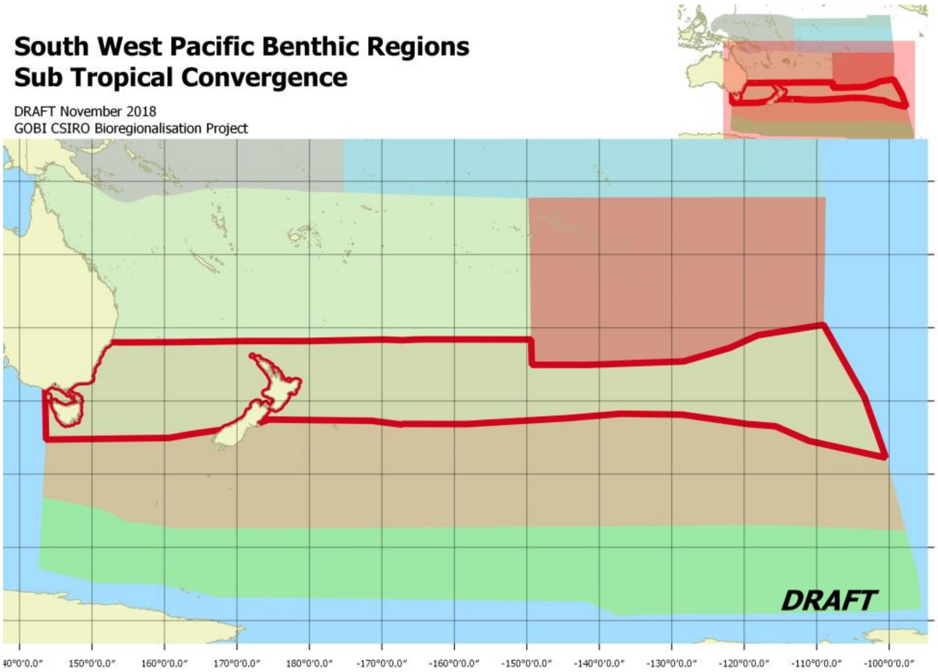
Analysis of mean and seasonal change of Sea Surface Temperature (SST) and Salinity (SSS) in the Solomon and Bismarck Seas (Delcroix *et al* 2014*)* shows large annual oscillations in the Solomon Sea, with the coldest and saltiest waters occurring in July/August mainly due to horizontal advection.

The mean ocean surface circulation flow know to enter the Solomon Sea from both its northern and southern parts. From the north, the flow is southward through Solomon Strait; one part flows along the New Britain coast and exits northward through Vitiaz Strait; the other part flows southward into the Solomon Sea, exiting through its southern limit.

With western current and upwelling generally contribute to richness of nutrient and species in the region apart coral (within the CTI). McKinnon et al (2014) indicated the region as part of the global center of marine biodiversity primarily defined by high species diversity of corals (almost 600) and reef fish (>2,000) (Veron et al. 2011), and it contains 76% of the world’s coral species and a number of endemics of various coral reef taxa.

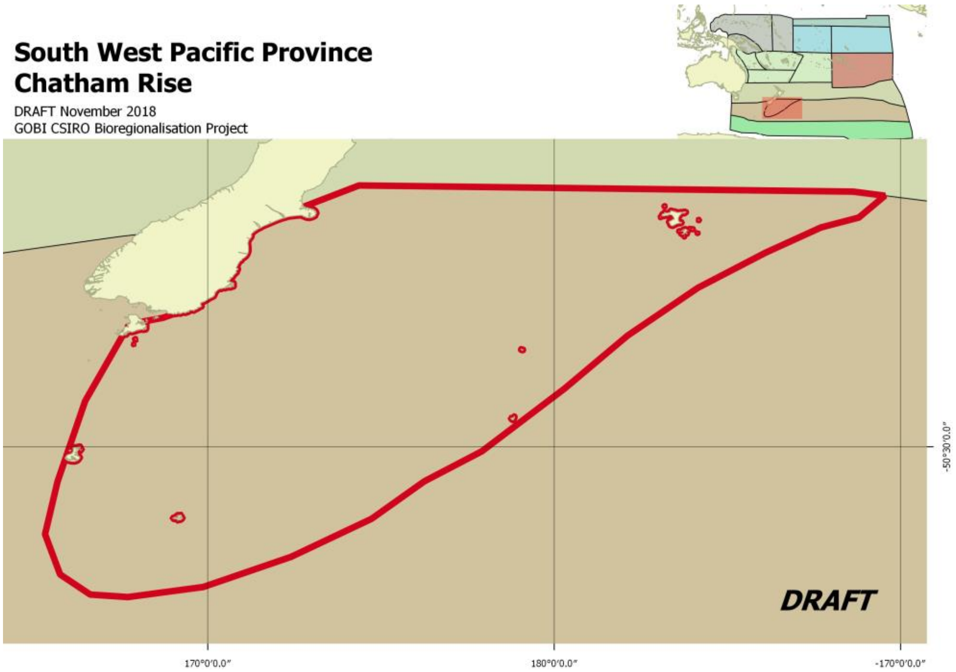
At pelagic level, the occurrence of species such as tuna and charismatic species has been a focus for conservation in region (BSSE initiative). Bismarck Solomon sea region characterised with deep water habitats, off shore reef with low pressure, unique land and reef types. It is rich reproduction and aggregation sites for Tuna compare to east, whale passage, dolphins, Leatherback nesting, turtle migratory path, feeding habitats for green and hawksbill turtle etc. has certainly characterised the region.

2.6 South Subtropical Convergence (SSTC)



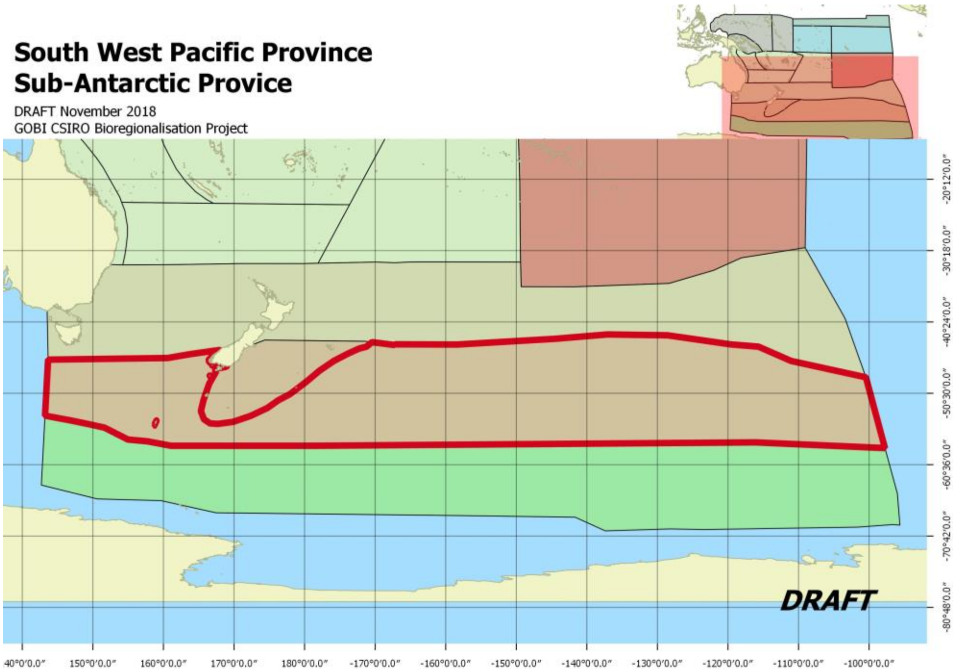
The South Subtropical Convergence is very similar to the region identified in Longhurst (1995, 1998). This is the frontal zone that marks the intersection of colder sub Antarctic waters with warmer tropical waters and is a region that supports substantial fisheries.

2.6.1 Chatham Rise (NEWZ)



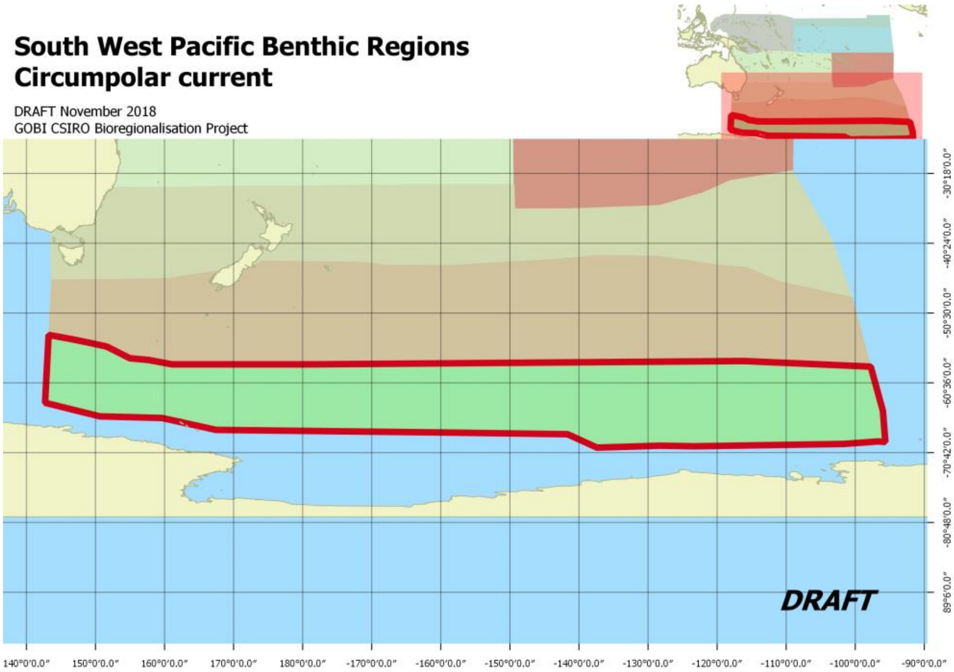
This region is similar to the region identified in Longhurst (1995, 1998) as New Zealand Coastal (NEWZ). However, it does not include the western or norther coastal areas. The Antarctic circumpolar current wraps around the southern extend of New Zealand and rises over the Campbell Plateau and Chatham Rise. This water mass intersects with warmer waters from the Subtropical convergence to generate a series of fronts over the rise (Hadfield et al. 2007). This area support a highly productive fishery.

2.6.2 Subantarctic Province (SANT)



This region extend from the South Subtropical Convergence south to the Antarctic Polar Front. It is an extension of a similar region identified in the Indian Ocean and is strongly influenced by Antarctic waters.

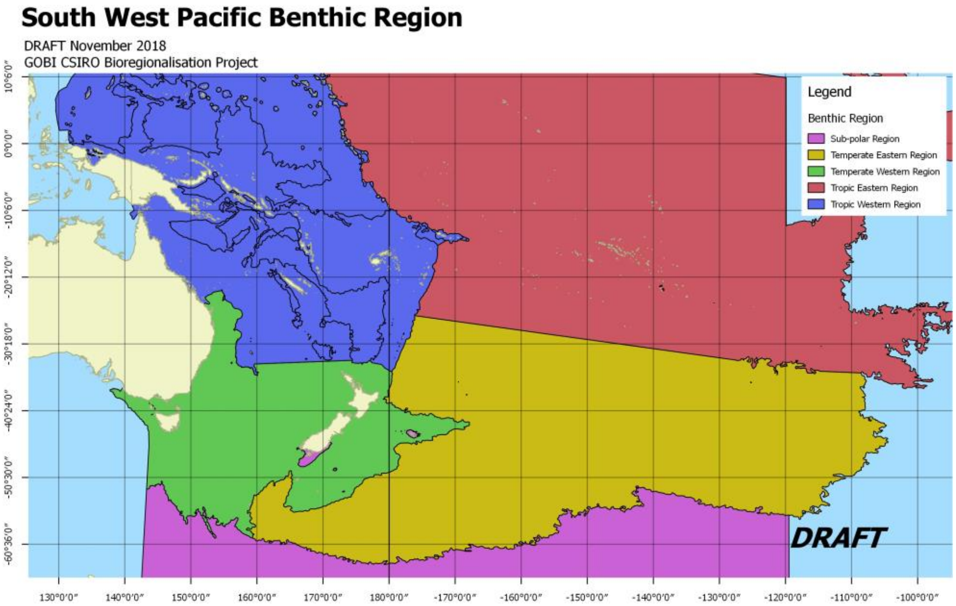
2.7 Circumpolar Current



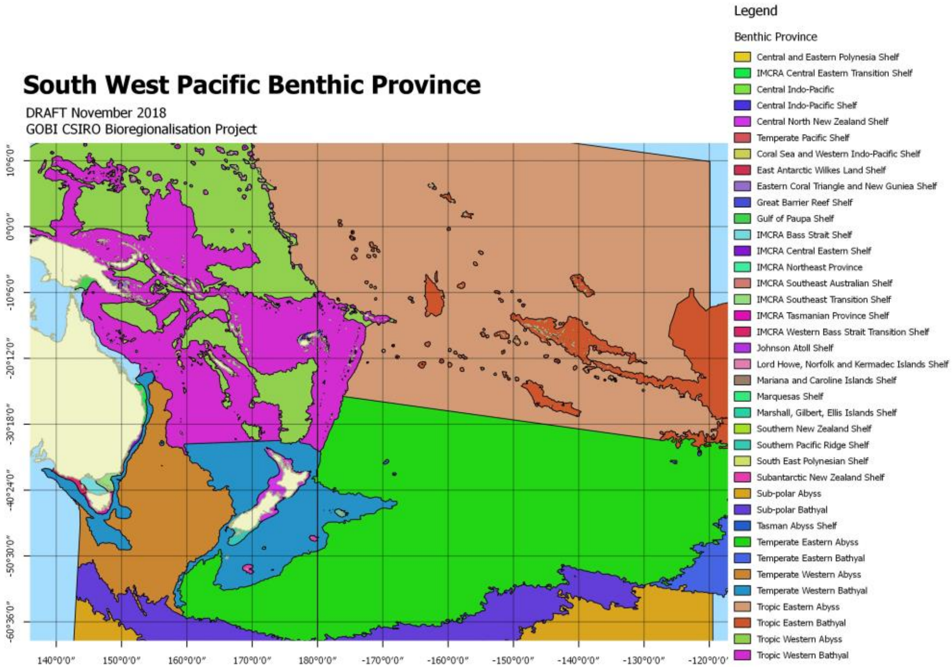
The Circumpolar Current Province contains the Antarctic Circumpolar Current which flows clockwise from west to east around Antarctica. The current is circumpolar due to the lack of any landmass connecting with Antarctica and this keeps warm ocean waters away from Antarctica, enabling that continent to maintain its huge ice sheet. The colder water temperatures of Circumpolar Current Province dictates a different fauna, as the region transitions into a polar fauna.

3 South Western Pacific Benthic Bioregions

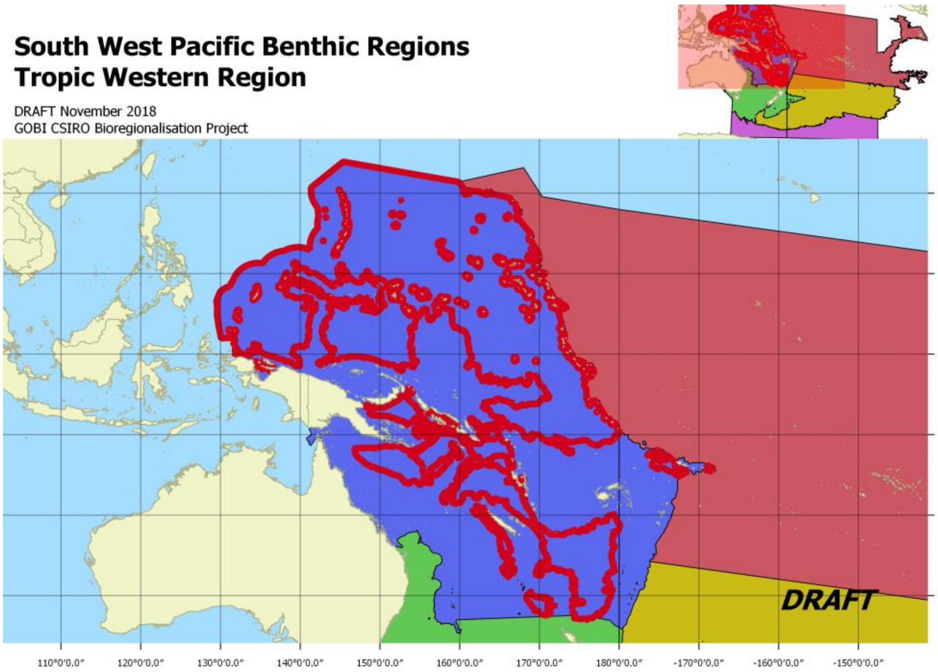
The distribution of the Large Marine Areas – the highest level of classification for the South West Pacific Ocean is shown below.



The distribution of the provinces within the Large Regions is shown below. More detailed descriptions of each of the provinces to given below.

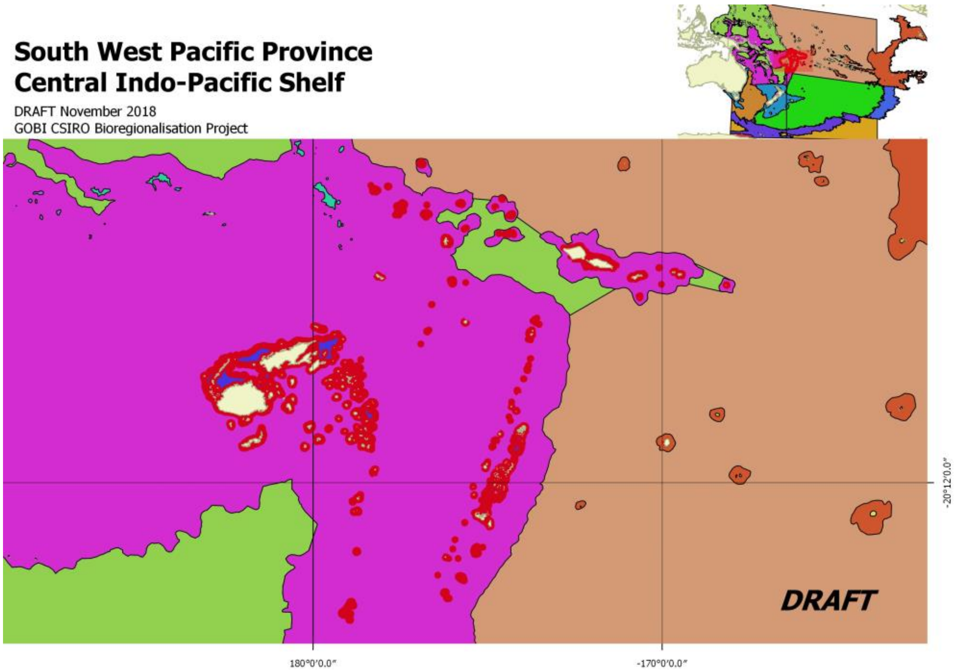

South West Pacific Benthic Province
DRAFT November 2018
GOBI CSIRO Bioregionalisation Project
Legend
Benthic Province
Central and Eastern Polynesia Shelf
IMCRA Central Eastern Transition Shelf
Central Indo-Pacific
Central Indo-Pacific Shelf
Central North New Zealand Shelf
Temperate Pacific Shelf
Coral Sea and Western Indo-Pacific Shelf
East Antarctic Wilkes Land Shelf
Eastern Coral Triangle and New Guniea Shelf
Great Barrier Reef Shelf
Gulf of Paupa Shelf
IMCRA Bass Strait Shelf
IMCRA Central Eastern Shelf
IMCRA Northeast Province
IMCRA Southeast Australian Shelf
IMCRA Southeast Transition Shelf
IMCRA Tasmanian Province Shelf
IMCRA Western Bass Strait Transition Shelf
Johnson Atoll Shelf
Lord Howe, Norfolk and Kermadec Islands Shelf
Mariana and Caroline Islands Shelf
Marquesas Shelf
Marshall, Gilbert, Ellis Islands Shelf
Southern New Zealand Shelf
Southern Pacific Ridge Shelf
South East Polynesian Shelf
Subantarctic New Zealand Shelf
Sub-polar Abyss
Sub-polar Bathyal
Tasman Abyss Shelf
Temperate Eastern Abyss
Temperate Eastern Bathyal
Temperate Western Abyss
Temperate Western Bathyal
Tropic Eastern Abyss
Tropic Eastern Bathyal
Tropic Western Abyss
Tropic Western Bathyal
10°6'0"
0°0'0"
-10°6'0"
-20°12'0"
-30°18'0"
-40°24'0"
-50°30'0"
-60°36'0"
140°0'0"
150°0'0"
160°0'0"
170°0'0"
180°0'0"
-170°0'0"
-160°0'0"
-150°0'0"
-140°0'0"
-130°0'0"
-120°0'0"

3.1 SW Pacific Tropic Western Region



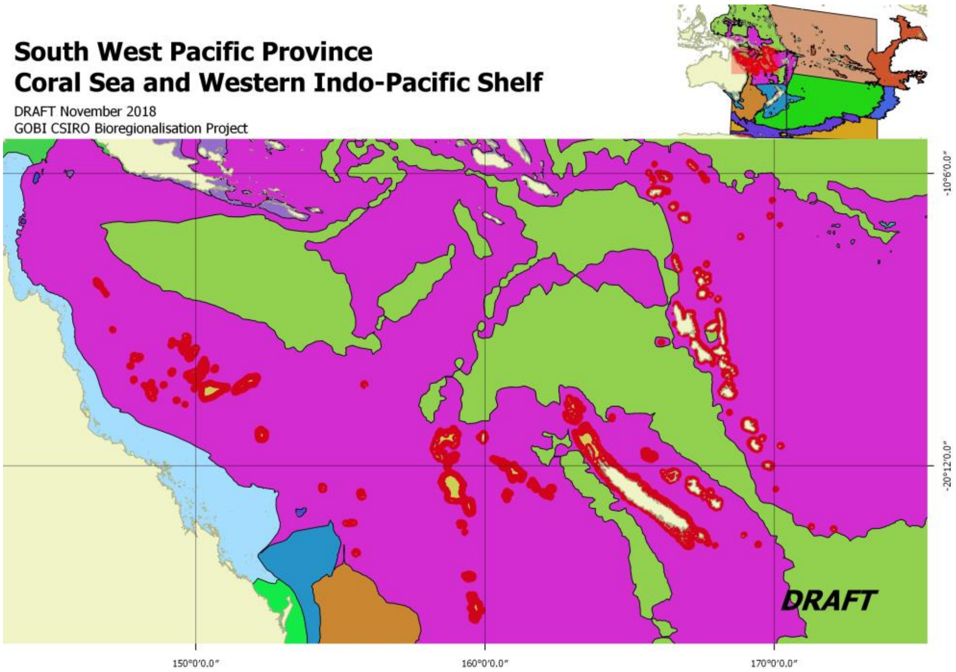
Large encompassing bioregion for the western tropic shelf, slope and abyssal fauna/flora, bounded to the east of the Marshal Islands and Kiribati. The southern latitudinal boundary which sits below the Lord Howe, New Caledonia and Kermedecs and cuts slightly north up the eastern coast of Australia to match the distribution of Australia's IMCRA regions. On the Australian coastline the southern boundary reflects the latitudinal break in the middle of the Central Eastern IMCRA transition province (IMCRA 4). The eastern boundary is defined by a decrease in coral diversity and turnover of both shallow water coral and fish species (Kulbicki e al., 2013, Veron et al ., 2015). The eastern boundary is also bounded by the abyssal Kermedec trench to the east of the Kermedec archipelago. The eastern boundary also kinks around the eastern side of American Samoa and Tonga, but remains west of Niue, this reflects the distribution of fishes in the this area, which has a dramatic change across this region (Kulbicki et al., 2013). Western and northern extents are bounded by the distribution of the bioregional project, but they reflect the edge of the Coral-Triangle on the west the central Pacific towards the north.

3.1.1 Central Indo-Pacific Shelf



The Central Indo-Pacific Shelf province contains the islands of Tonga, Tavula, Samoa, American Samoa and Fiji. This region has is differentiated from surrounding areas for both corals and fishes (Kulbicki et al., 2013, Veron et al., 2015). The species seen in this area have are relatively similar to the species seen in New Caledonia and Vanuatu. We have grouped Fiji and the other islands based on the distribution of fishes (Kulbicki et al., 2013), rather than the split seen in the coral ecoregions (Veron et al., 2015). The shelf region is constrained to shelf areas as defined by Harris *et al.,* (2008), which equates to depth approximately less than 200 meters.

3.1.2 Coral Sea and Western Indo-Pacific Shelf



The Coral Sea and Western Indo-Pacific Shelf Province includes the Coral Sea, New Caledonia and Vanuatu Shelf region. The regionalisation is based on the ecoregionalisations of reef fish and corals (Kulbicki et al., 2013, Veron et al., 2015). This area is a geographically distinct region, but it shares similar species to Vanuatu, which is geographically separated to the north by the New Hebrides Trench. The coral species also share an affinity with the species found around Fiji. Like other ecoregions based on shallow water fauna we constrained the Coral Sea and Western Indo-Pacific Shelf Province to shelf habitats (approximately 200 meters depth) to reflect the biogeographic distribution of these shallower water species.

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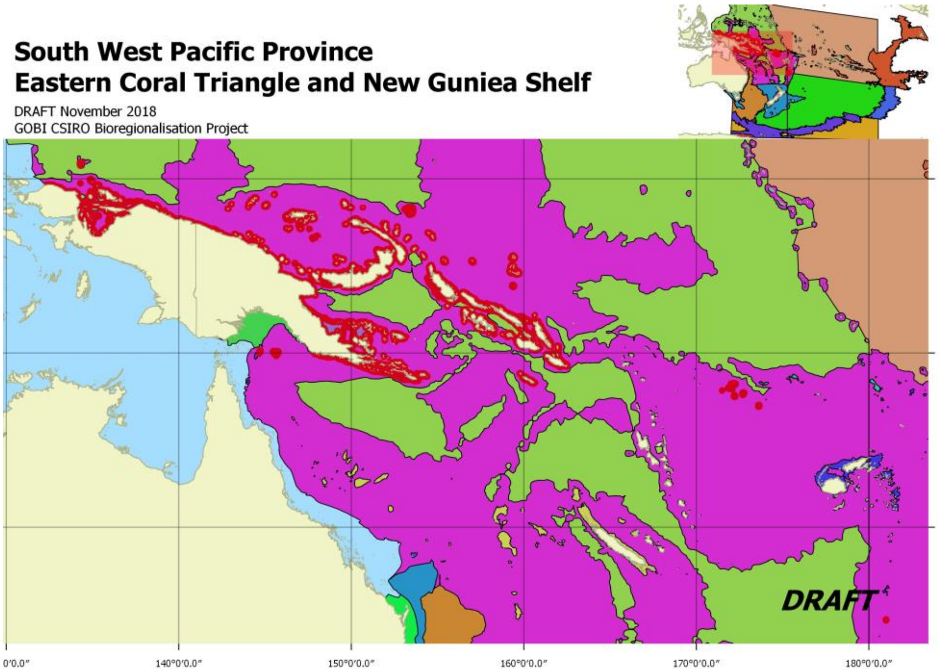
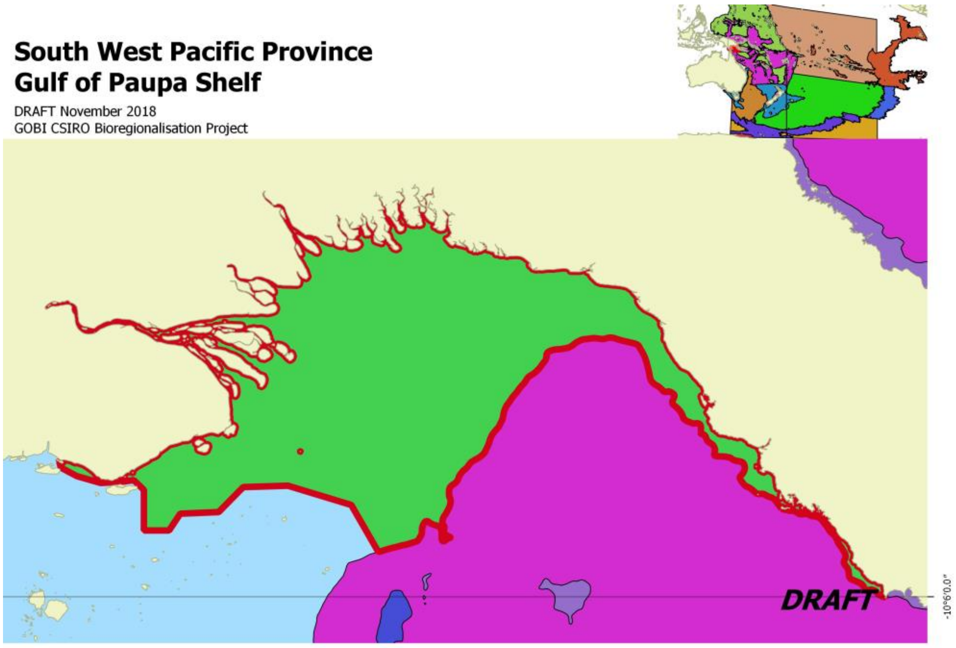
3.1.3 Eastern Coral Triangle and New Guinea Shelf



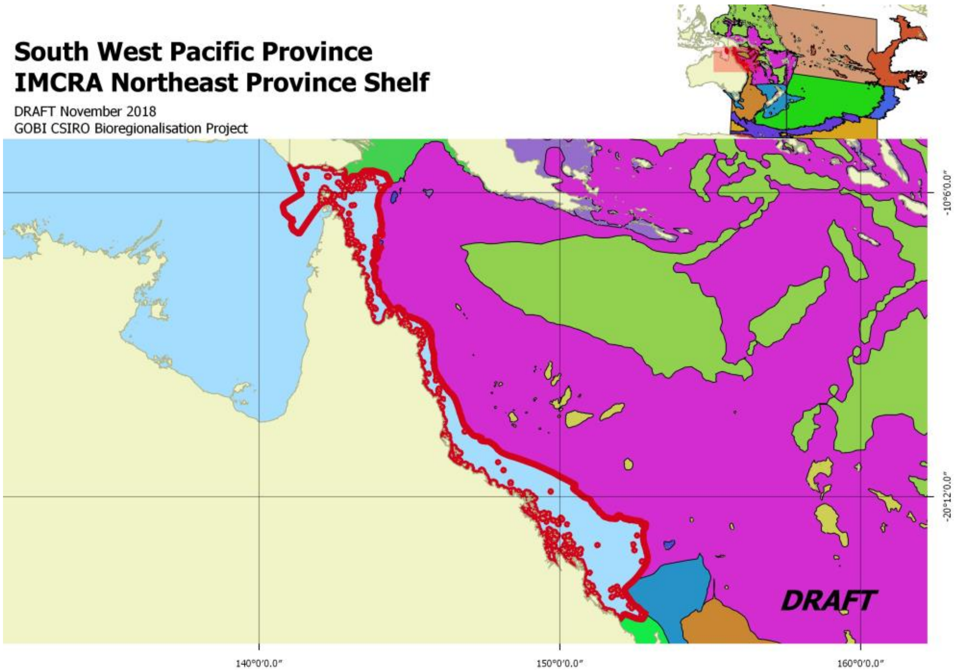
The Eastern Coral Triangle and New Papua New Guinea Shelf is an important area of corals and reef fish (Kulbicki et al., 2013; Veron et al., 2015). The delineation of this region is based on coral (Veron et al., 2015) and reef fishes (Kulbicki et al., 2013) ecoregions. However, we have merged multiple smaller, but biologically similar ecoregions into our province size region. Our Eastern Coral Triangle and New Guinea Shelf contains the Solomon Archipelago, the Solomon Shelf and the Bismarch Sea Shelf ecoregions. We did this because the corals found in the Solomon Archipelago, Bismarck Sea Shelf, Solomon Sea and Milne Bay areas all share a close affinity. This bioregion form a coherent group with only distant affinity to other western Pacific ecoregions (Veron et al., 2015). We constrained the Eastern Coral Triangle and New Guinea Shelf region to shelf habitats (approximately 200 meters depth) to reflect the biogeographic distribution of these shallower water species.

3.1.4 Gulf of Papua Shelf



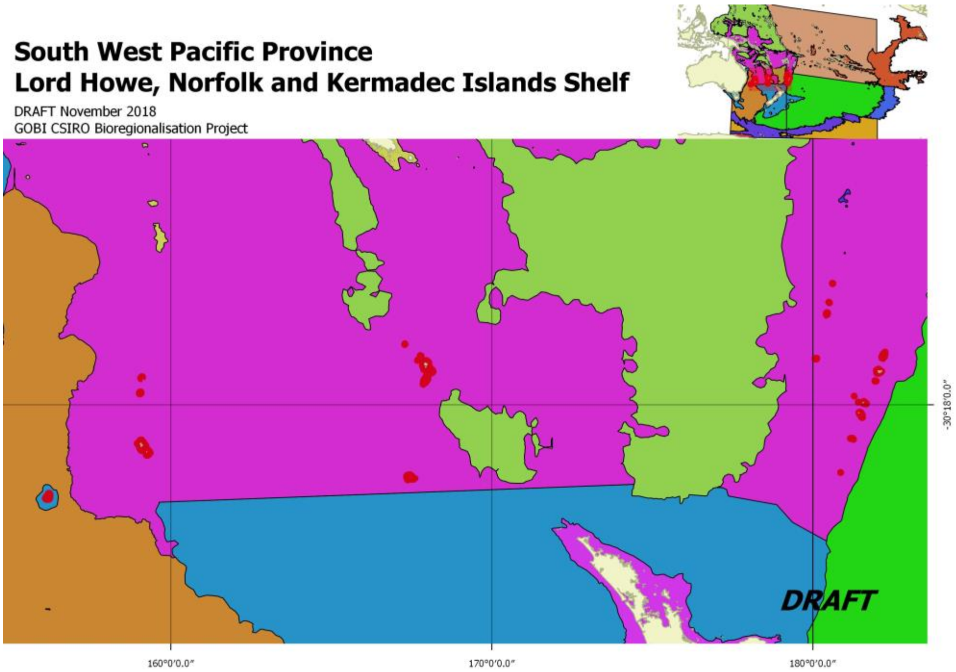
The Gulf of Papua Shelf is just north of Australia's IMCRA Northeast Province. It is separated out from the IMCRA region to the south and the Easter Coral and New Guinea Shelf to the east and north, due to a decline in coral and fish diversity driven by the proximity to Port Moresby and the increase in mangrove habitat and sedimentation (Veron *et al.,* 2015; Kulbicki *et al.,* 2013). This is a shelf province and contains habitats which are approximately less than 200 meters deep.

3.1.5 IMCRA Northeast Shelf



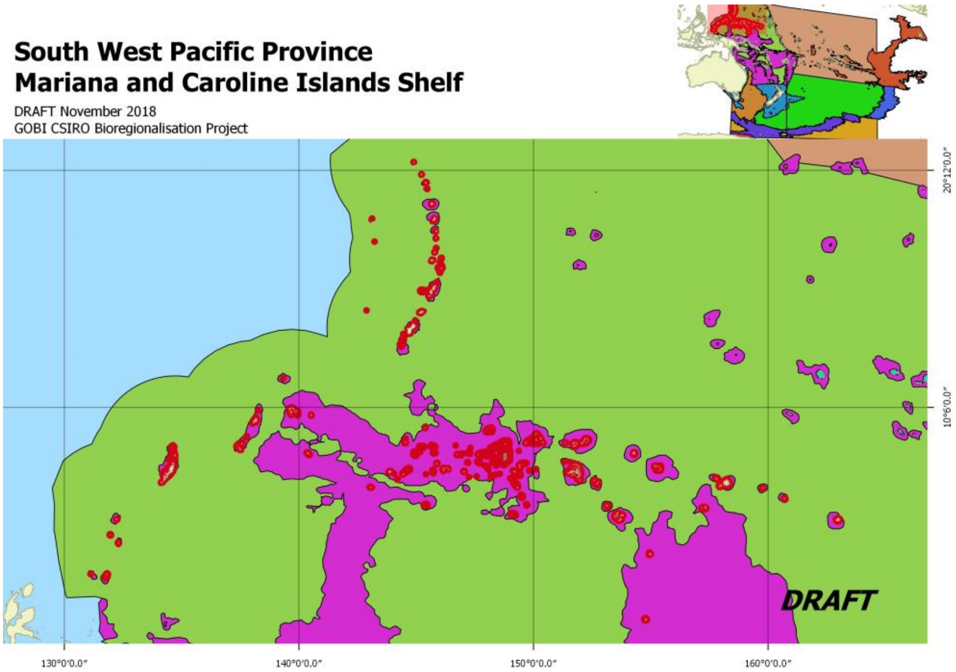
The IMCRA Northeast Province contains the Great Barrier Reef shelf is based on Australia's IMCRA bioregionalisation. It is separated out due to the unique nature of the GBR and the fauna within. This classification is also supported by corals, fish and other groups (Veron *et al.,* 2015; Kulbicki *et al.,* 2013). This is a shelf province and contains habitats which are approximately less than 200 meters deep.

3.1.6 Lord Howe, Norfolk and Kermadec Islands Shelf



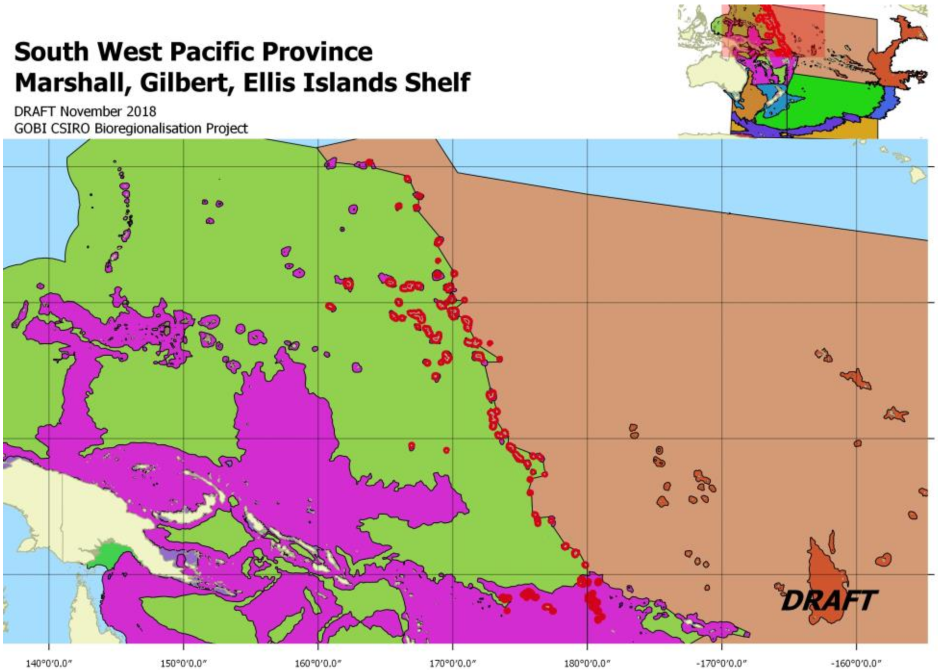
This region is based on a band of similar species of coral, fish and other invertebrates distributed across this narrow band of islands, which are approximately at the same latitude (O'Hara *et al.,* 2011; Veron *et al.,* 2015; Kulbicki *et al.,* 2013). They represent the southern boundary of the tropical western shelf fauna. But are also unique and need to differentiate from the New Caledonia (Coral Sea and Western Indo-Pacific Shelf province) and the Central Indo-Pacific Shelf fauna to the north. This region is a shelf province and is constrained depths less than approximately 200 meters.

3.1.7 Marianas and Caroline Islands Shelf



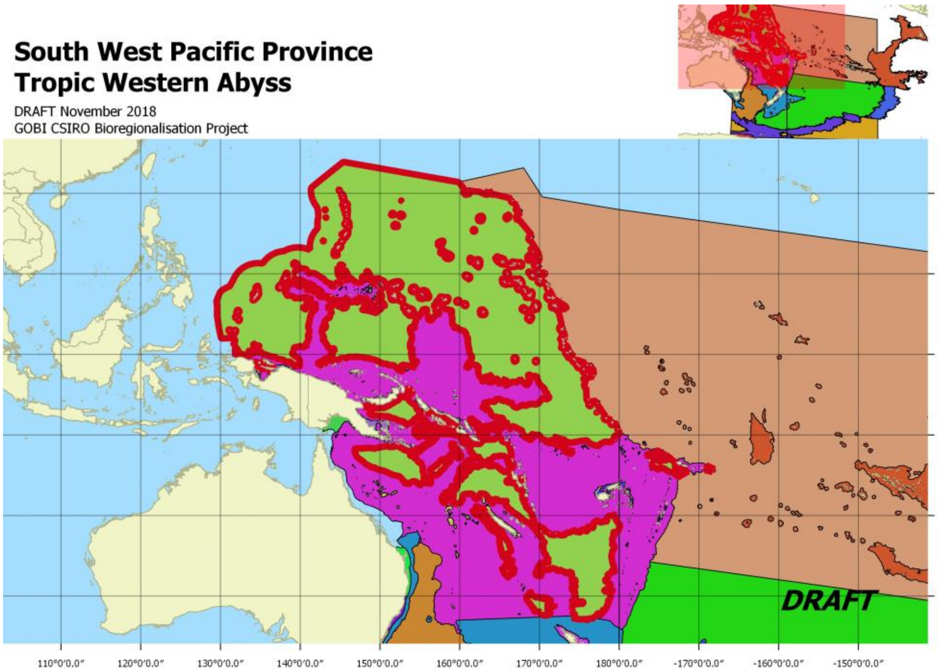
The Marianas and Caroline Islands Shelf region are a large group of volcanic islands and seamounts. The Marianas and Caroline Islands are separated from neighbouring region by deep oceanic waters. The classification of this province is based on the grouping of the Marianas and Caroline coral ecoregions (Veron *et al.,* 2015), but also, the distribution of reef fish species which appear to have a close affinity across these islands (Kulbicki *et al.,* 2013). Like other provinces based on shallow water fauna we constrained the Marianas and Caroline Islands province to shelf habitats (approximately 200 meters depth) to reflect the biogeographic distribution of these shallower water species.

3.1.8 Marshall, Gilbert, Ellis Islands Shelf



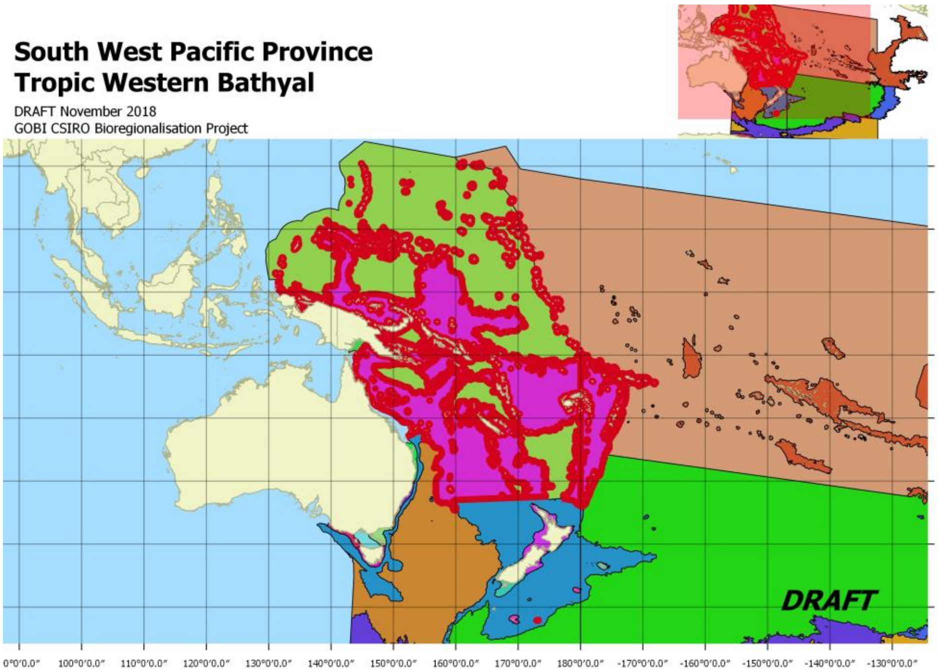
The Marshall, Gilbert and Ellis Islands Shelf region is based on the ecoregionalisations of reef fish and corals (Kulbicki et al., 2013, Veron et al., 2015). This regions is separated from the neighbouring Micronesia islands to the west by deep oceanic waters. The Marshall, Gilbert and Ellis islands are combined into a single large province because the of the distribution of reef fish in this area, and the close affinity between the composition of corals Gilbert Islands of West Kiribati (Veron et al., 2015). Like other provinces based on shallow water fauna we constrained Marshall, Gilbert, Ellis Islands Shelf province to shelf habitats (approximately 200 meters depth) to reflect the biogeographic distribution of these shallower water species.

3.1.9 Tropic Western Abyss



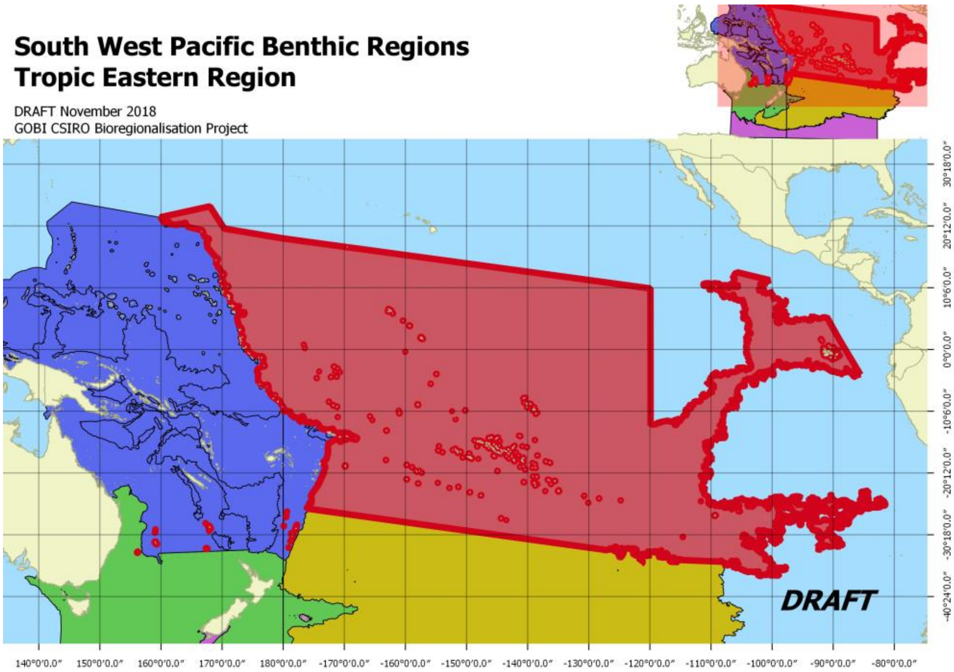
The Tropical Abyssal Province is based on the modelled distribution of ophiuroids and squat lobsters using the Regions of Common Profile Method (Foster *et al.,* 2013), see the Appendix 'Statistical Bioregionalisations' for details. This approach separated out the abyssal province at about 3500 meters deep and beyond. This is slightly different form other regionalisation's which made this boundary at 2000 meters (O'Hara *et al.,* 2011). But it does conform to other benthic classifications which draw his boundary at 3500 meters (e.g. GOODS classification and Watling et al., 2013).

3.1.10 Tropic Western Bathyal



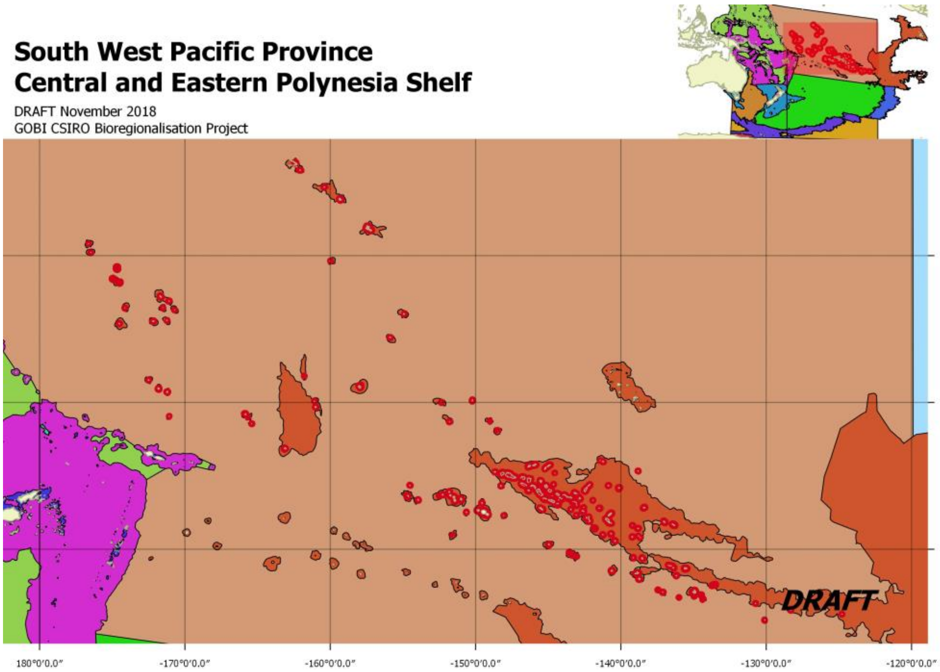
The Tropical Bathyal Province is based on the modelled distribution of ophiuroids and squat lobsters using the Region of Common Profile Method (Foster *et al.,* 2013), see the Appendix 'Statistical Bioregionalisations' for details.. This approach separated out the bathyal province between 200 and 3500 meters depth. This is slightly different form other regionalisation's which made this boundary at 2000 meters (O'Hara *et al.,* 2011). The 2000 to 3500 meter region could be viewed as the lower bathyal and a more reduced subset of the shallower bathyal region. We however, do not define an upper and lower bathyal region, but recognise that there will be an affinity between these two bathomes (e.g. GOODS classification and Watling et al., 2013).

3.2 Tropic Eastern Region



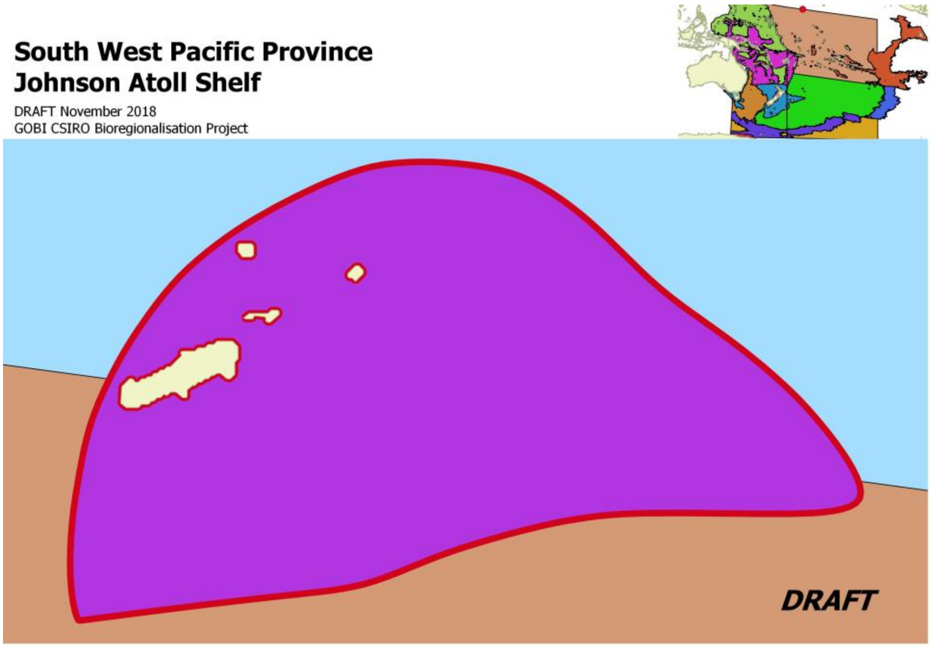
Large bioregional province for eastern tropic shelf, slope and abyssal depth regions. Bounded to the west by Marshall Islands, Gilbert Islands and Kiribati. The western boundary is also bounded by the by the Kermadec archipelago and abyssal trench and wraps around American Samoa. The eastern boundary ends at approximately at the longitudinal location of the Pitcairn Islands. The southern boundary sits at a higher latitude than the Tropic Western Pacific southern boundary, and reflects southern boundary of the tropical coral, fishes and other tropical species.

3.2.1 Central and Eastern Polynesia Shelf



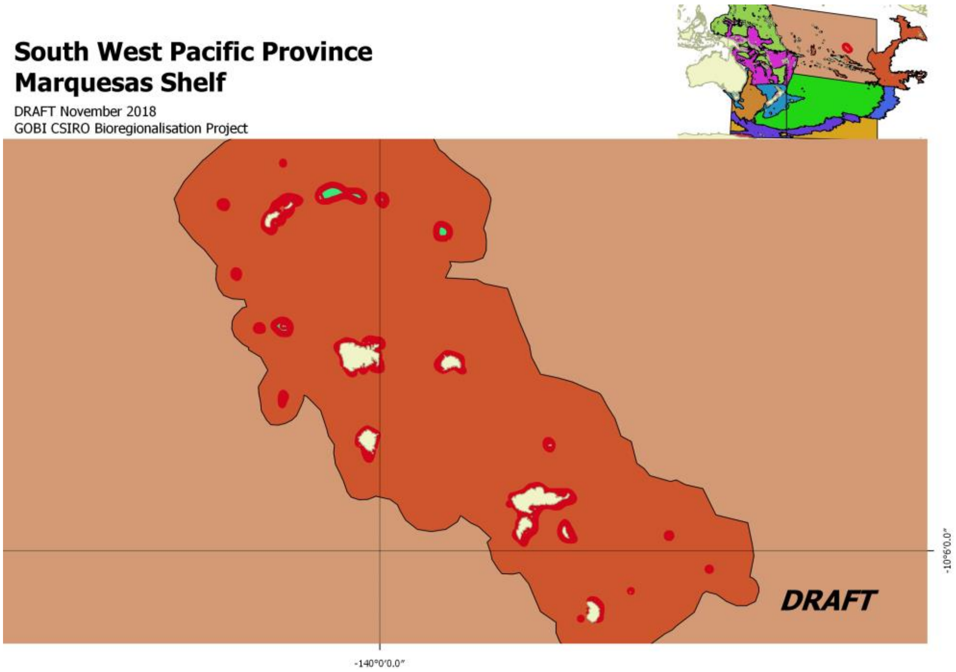
The broad longitudinal province contains the Phoenix, Central Kitribati, South Line, Society, Tuamotu, Pitcairn Islands and French Polynesia. This region is based on the broad group of coral ecoregions (Veron *et al.,* 2015) and also the distribution of fishes (Kulbicki *et al.,* 2013). Although this province is an amalgamation of a few coral and fish ecoregions, there was consensus at the workshop that all these ecoregions shared a close affinity. This province are constrained to approximately 200 meters deep.

3.2.2 Johnson Atoll Shelf



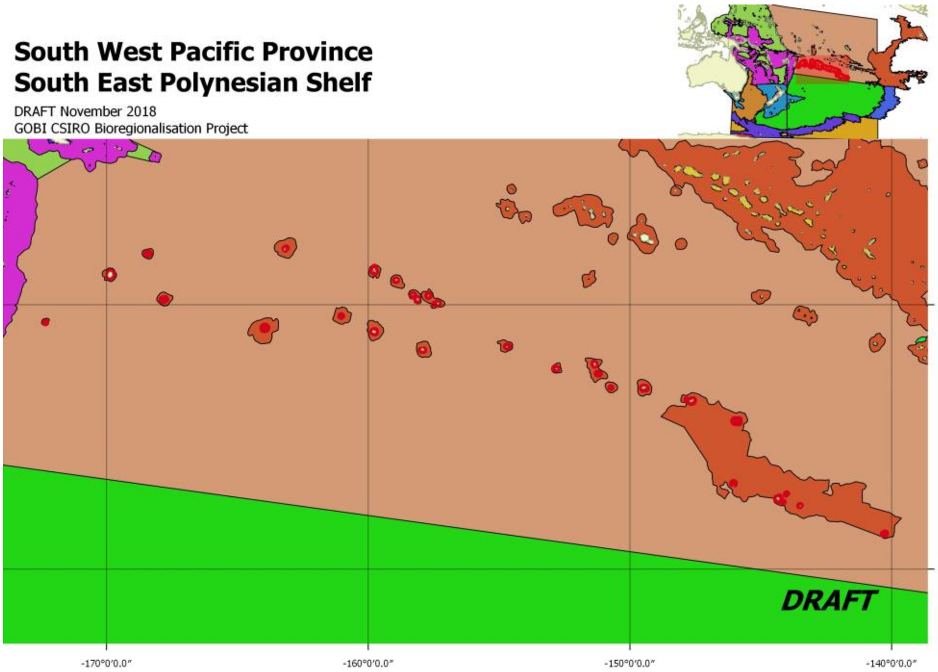
The Johnson Atoll Shelf Province is on the very northern edge of our bioregional scheme, it is a small geographically distinct province which contains corals and fish that are related to those seen in Hawaii (Veron *et al.,* 2015). This region is constrained to the shelf (approximately 200 meters).

3.2.3 Marquesas Shelf



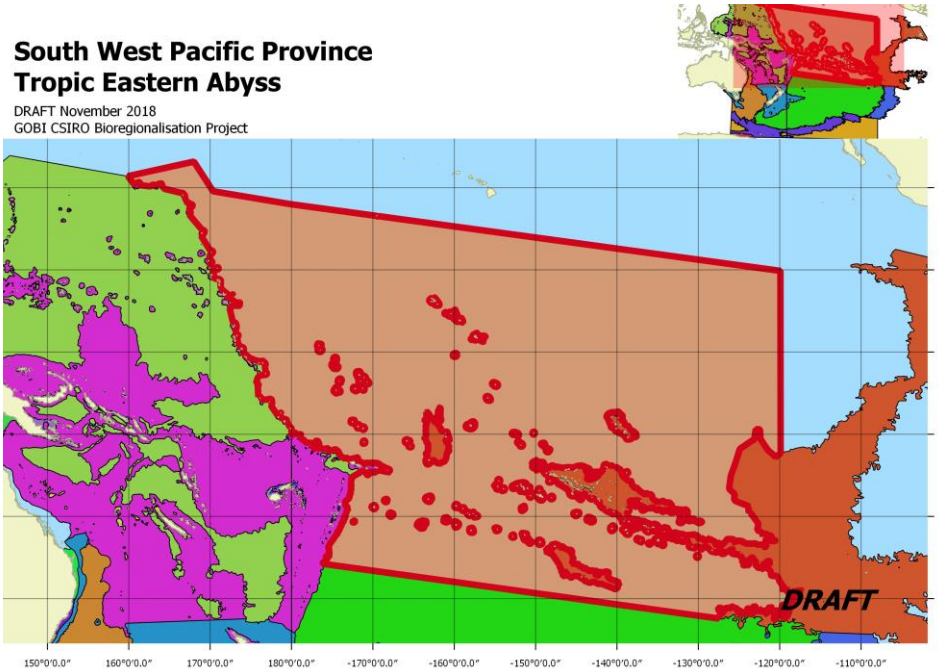
The Marquesas Islands are a unique and geographically distinct region. These islands are the most eastern extent of coral distributions and many reef fishes in the pacific. They share no close affinity to any neighbouring regions. The classification of the Marqueses Shelf Province is based on corals and fishes (Kulbicki et al., 2013, Veron et al., 2015). This province is constrained to approximately 200 meters depth.

3.2.4 South East Polynesian Shelf



The South East Polynesia Shelf Province includes the Cook and Astral Islands. This province is based on a merger of two coral ecoregions (Cooks and Astral) and the distribution of fishes (Kulbicki et al., 2013, Veron et al., 2015). This region is distinct from the Central and Eastern Polynesian Shelf Province to the north and Niue to the west. This province is constrained to approximately 200 meters depth.

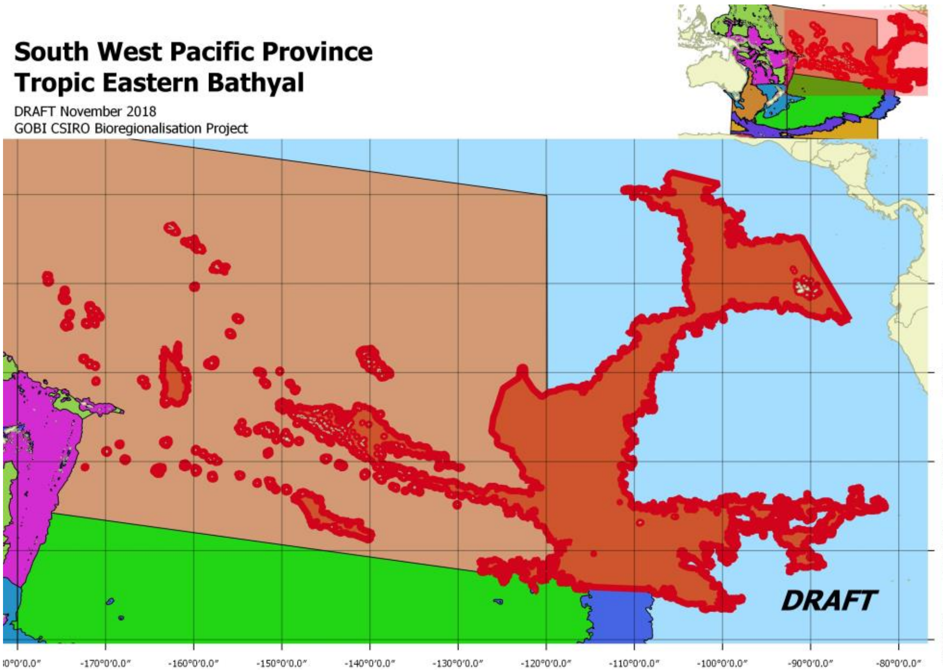
3.2.5 Tropic Eastern Abyss



The Tropic Eastern Abyssal Province is based on the modelled distribution of ophiuroids and squat lobsters using the Regions of Common Profile method (Foster *et al.,* 2013), see the Appendix 'Statistical Bioregions' for details. This approach separated out the abyssal province at about 3500 meters deep and beyond. This is slightly different form other regionalisation's which made this boundary at 2000 meters (O'Hara *et al.,* 2011). But it does conform to other benthic classifications which draw his boundary at 3500 meters (e.g. GOODS classification and Watling et al., 2013).

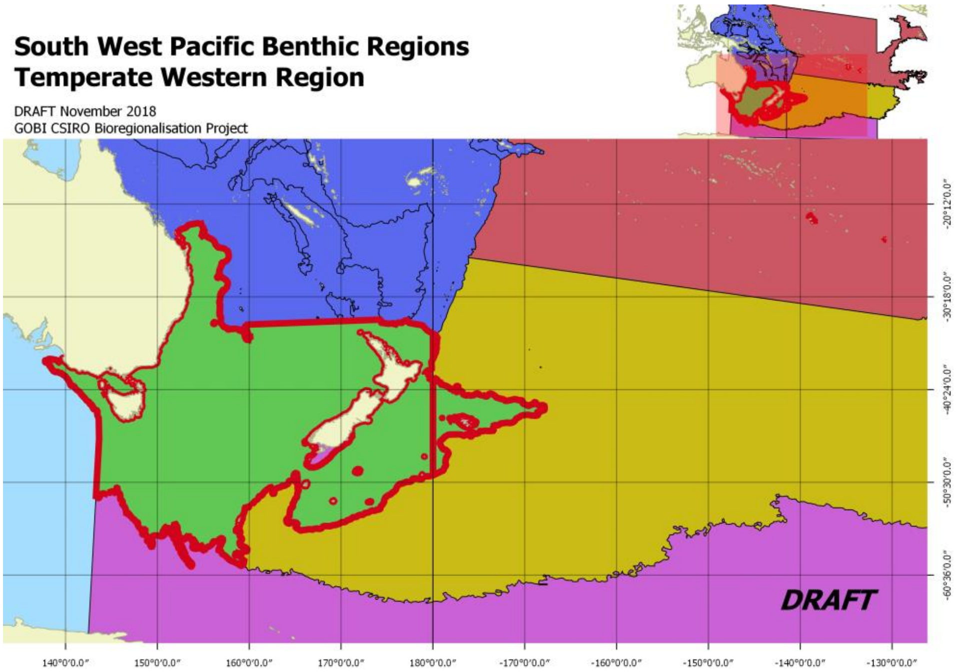
Commented [WS(H2]: Both this and the next map need to have the eastern boundary fixed. We need t make a nice clean latitudinal line along the eastern mot boundary of the overall region and get rid of the dodgy bathyal contour.

3.2.6 Tropic Eastern Bathyal



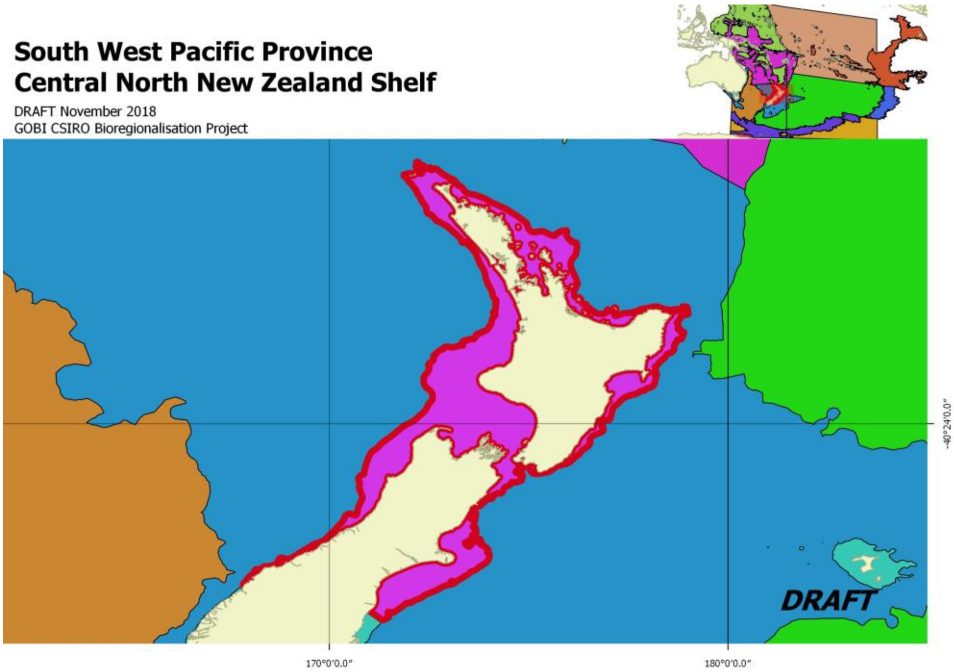
The Tropic Eastern Bathyal province is based on the modelled distribution of ophiuroids and squat lobsters using the Regions of Common Profile Method (Foster *et al.,* 2013), see the Appendix 'Statistical Bioregions' for details. This approach separated out the bathyal province between 200 and 3500 meters depth. This is slightly different form other regionalisation's which made this boundary at 2000 meters (O'Hara *et al.,* 2011). The 2000 to 3500 meter region could be viewed as the lower bathyal and a more depauperate subset of the shallower bathyal region. We however, do not define an upper and lower bathyal region, but recognise that there will be an affinity between these two bathomes (e.g. GOODS classification and Watling et al., 2013).

3.3 Temperate Western Region



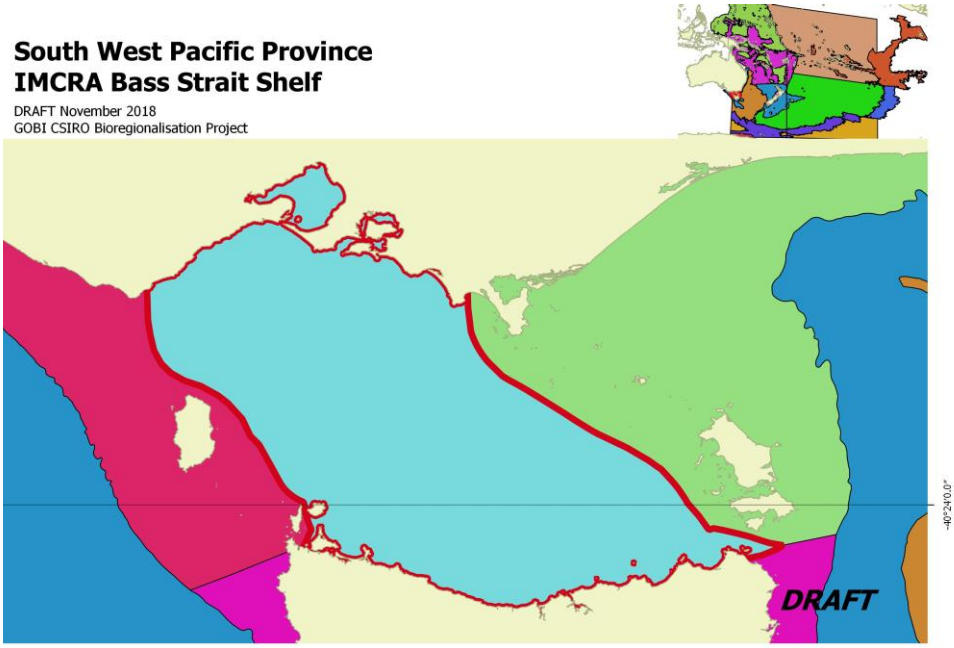
The Temperate Western Pacific Region is a large bioregional province which includes temperate regions of Australia and much of New Zealand's economic exclusive zone (EEZ). The northern latitudinal boundary which sits below Lord Howe, New Caledonia and Kermedecs and cuts slightly north up the eastern coast of Australia to match the distribution of Australia's IMCRA regions. On the Australian coastline the southern boundary reflects the latitudinal break in the middle of the Central Eastern IMCRA transition province (IMCRA 4). The eastern boundary follows New Zealand's EEZ bathyal boundary (~3500 meters) and reflects the partitioning of this region as seen in the GOOD biogeographic classification (GOODS report). This reflects the distribution of benthic fauna across this region, which largely ends at this boundary due to much deeper seafloor areas to the east and a lack of island which can support these species. The southern boundary is driven by the extent of the sub-polar front and the sub-antarctic front. This boundary is slightly shifted to adhere to follow the bathyal depth contour that runs at 3500 meters across this Southern Indian and Pacific Antarctic mid-ocean ridges.

3.3.1 Central North New Zealand Shelf



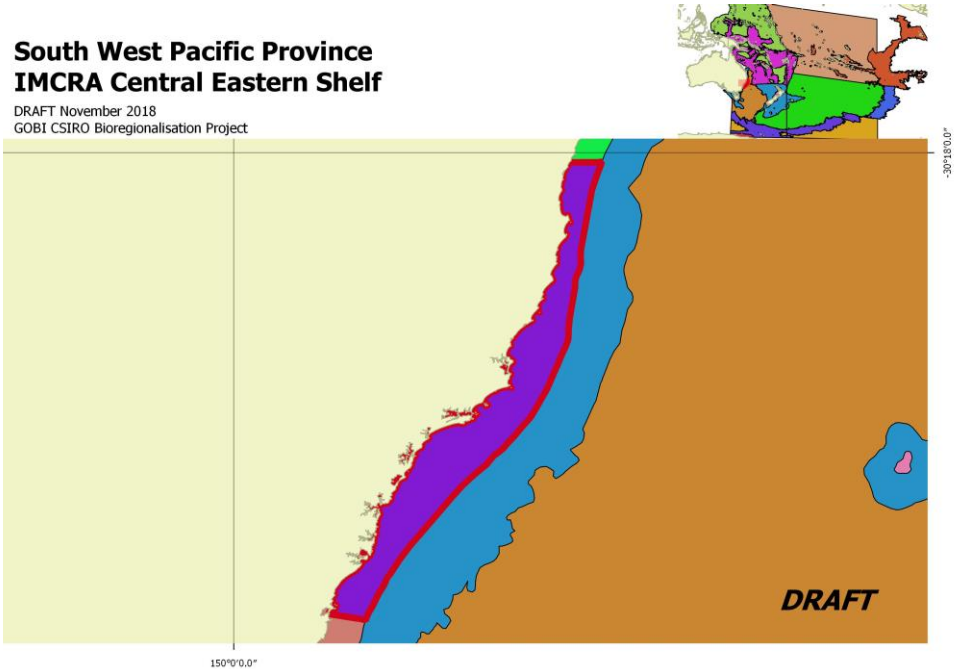
The Central North New Zealand shelf regionalisation is shallower shelf areas that encompass the top of New Zealand's south island and the north island. This classification is based on the work of classification of demersal fishers, the physical environment and ophiuroids (O'Hara *et al.,* 2011; Stephenson *et al.,* 2017). These region came directly from Stephsenson *et al.,* 2017 'ten groups' output, which a more generalised classification for this region. The Central North New Zealand Shelf Province was constrained to shelf habitats.

3.3.2 IMCRA Bass Strait Shelf



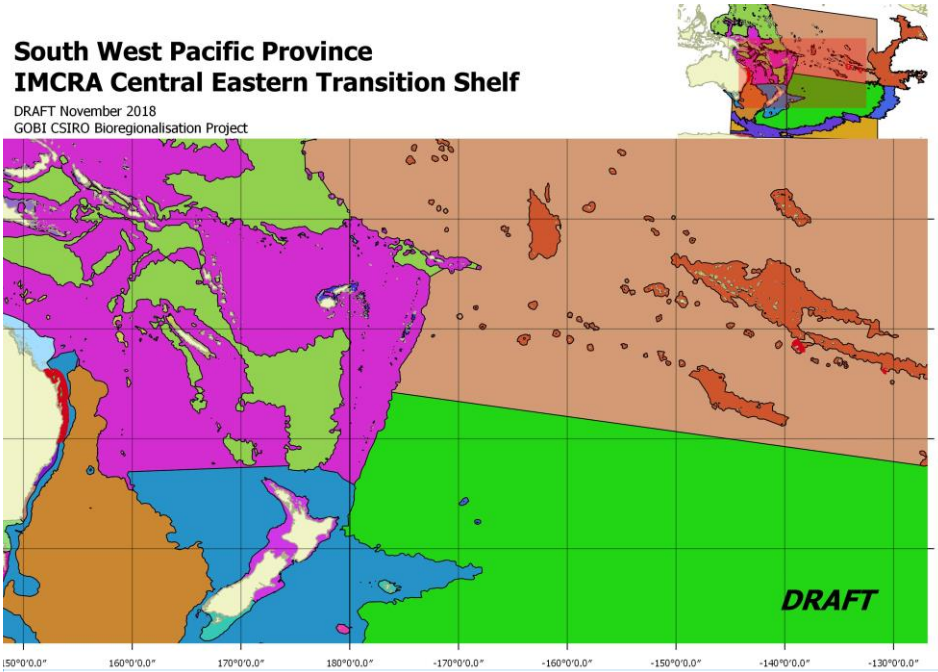
The IMCRA Bass Strait Shelf province is taken directly from Australia's national marine bioregionalisation. This is a shallow strait between Victoria and Tasmania. Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap *et al.,* 2005).

3.3.3 IMCRA Central Eastern Shelf



The IMCRA Central Eastern Shelf province is taken directly from Australia's national marine bioregionalisation. This province is located on the east margin shelf of Australia. Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap *et al.,* 2005). This area is constrained to the shelf and was originally derived based on the depth wise structure of demersal fish.

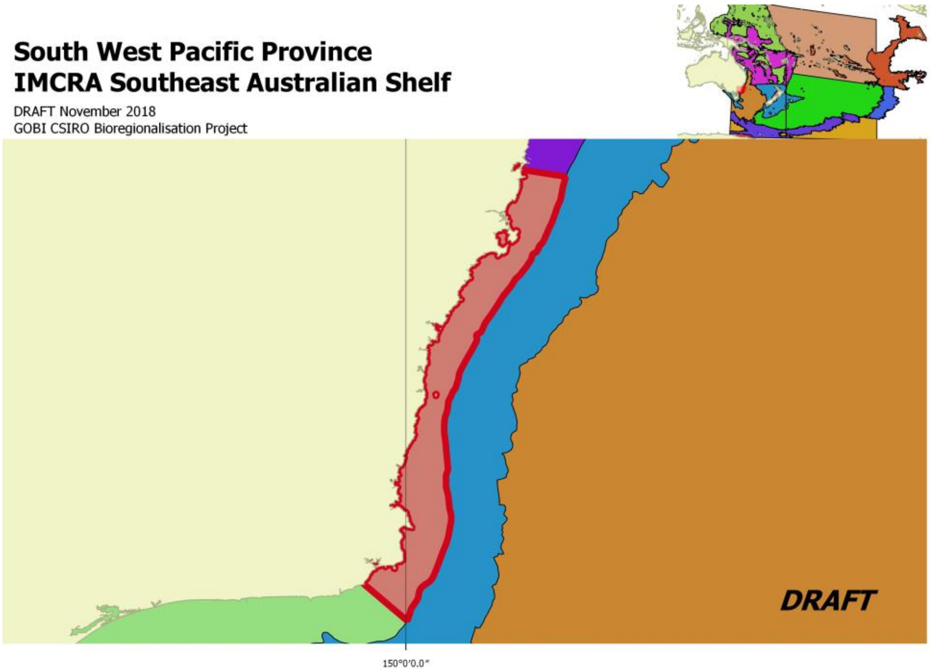
3.3.4 IMCRA Central Eastern Transition Shelf



The IMCRA Central Eastern Transition Shelf province is taken directly from Australia's national marine bioregionalisation. This province is located on the east margin shelf of Australia. Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap et al., 2005). This area is constrained to the shelf and was originally derived based on the depth wise structure of demersal fish. This region also reflects where tropical species are transition into a sub-tropical and temperate fauna.

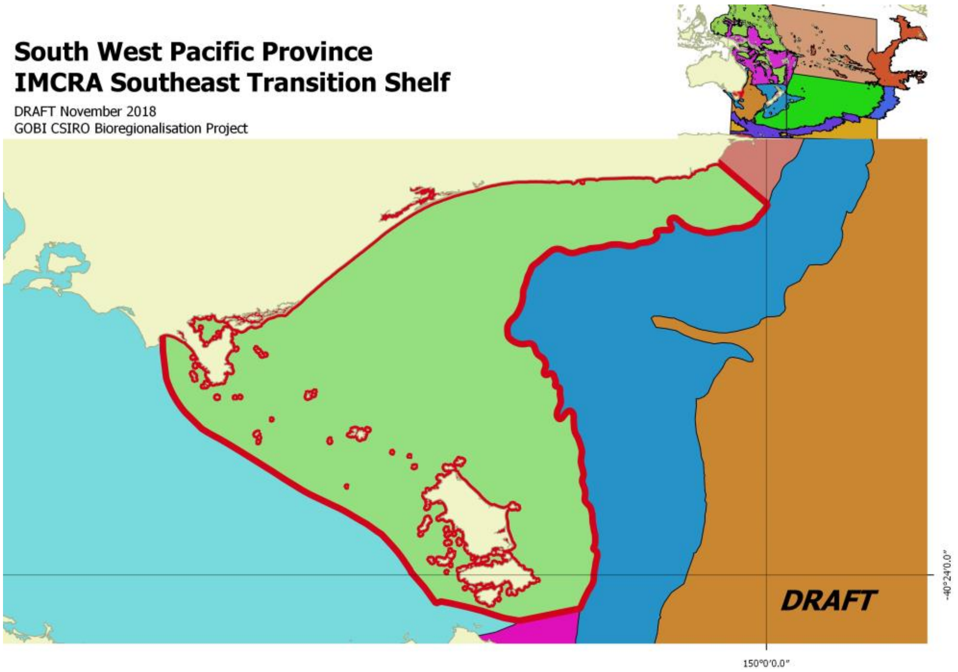
Commented [WS(H3]: This one needs fixing, looks like a island in the eastern tropic pacific has accidently been grouped into this region.

3.3.5 IMCRA Southeast Australian Shelf



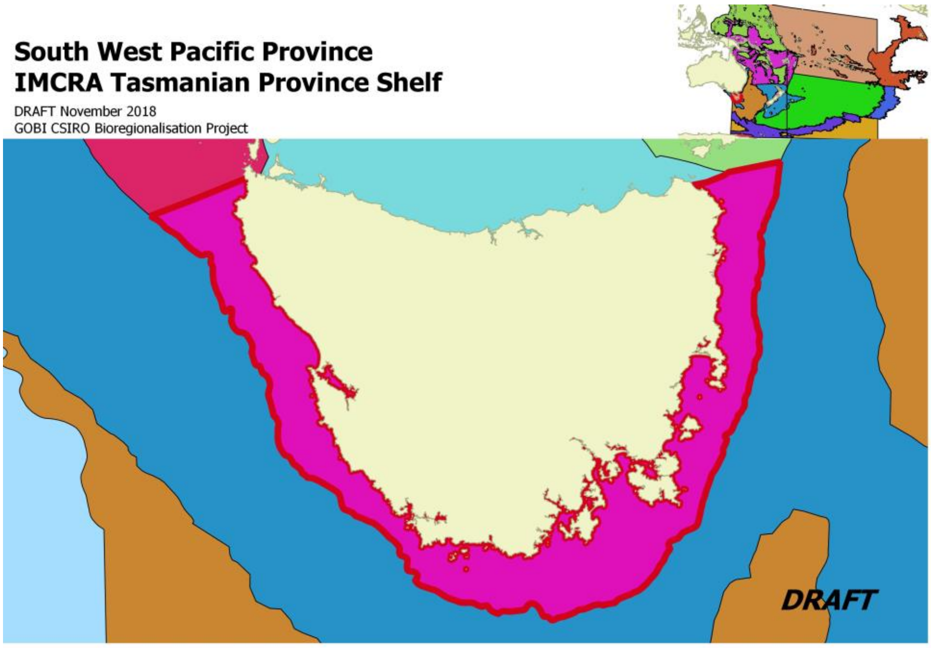
The IMCRA Southeast Australian Shelf province is taken directly from Australia's national marine bioregionalisation. This province is located on the southeast shelf of Australia. Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap et al., 2005). This area is constrained to the shelf and was originally derived based on the depth wise structure of demersal fish. This region also reflects where sub-tropical fauna transitions into a temperate fauna, but also where the east coast shelf starts to wrap into the Bass Strait.

3.3.6 IMCRA Southeast Transition Shelf



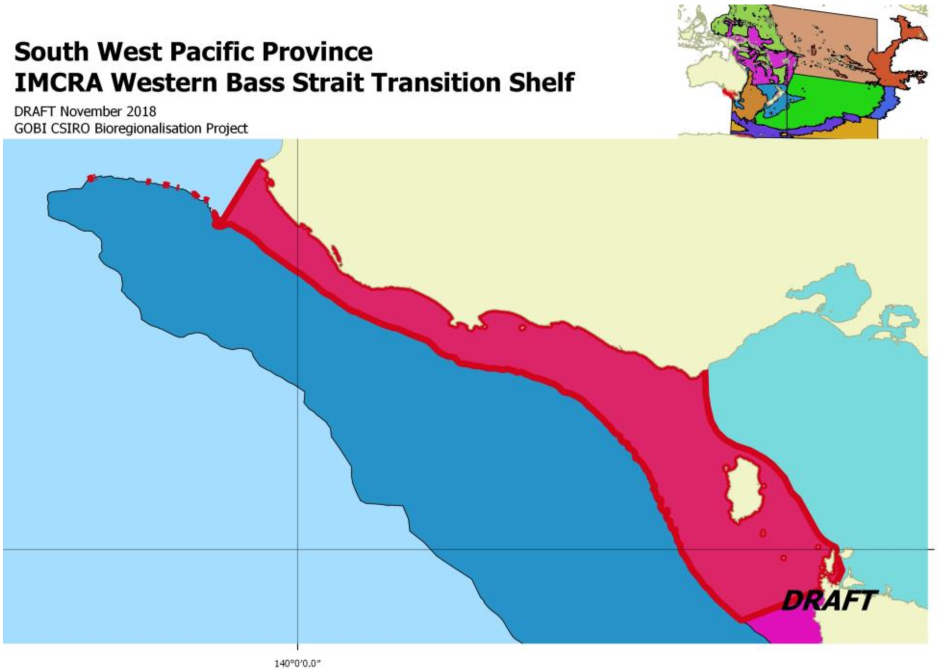
The IMCRA Southeast Transition Shelf province is taken directly from Australia's national marine bioregionalisation. This province is located on the southeast shelf of Australia. Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap et al., 2005). This region where the east coast shelf starts to wrap into the Bass Strait.

3.3.7 IMCRA Tasmanian Province Shelf



The IMCRA Tasmanian Shelf province is taken directly from Australia's national marine bioregionalisation. This province is located around Tasmania shelf (excluding Bass Strait). Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap et al., 2005).

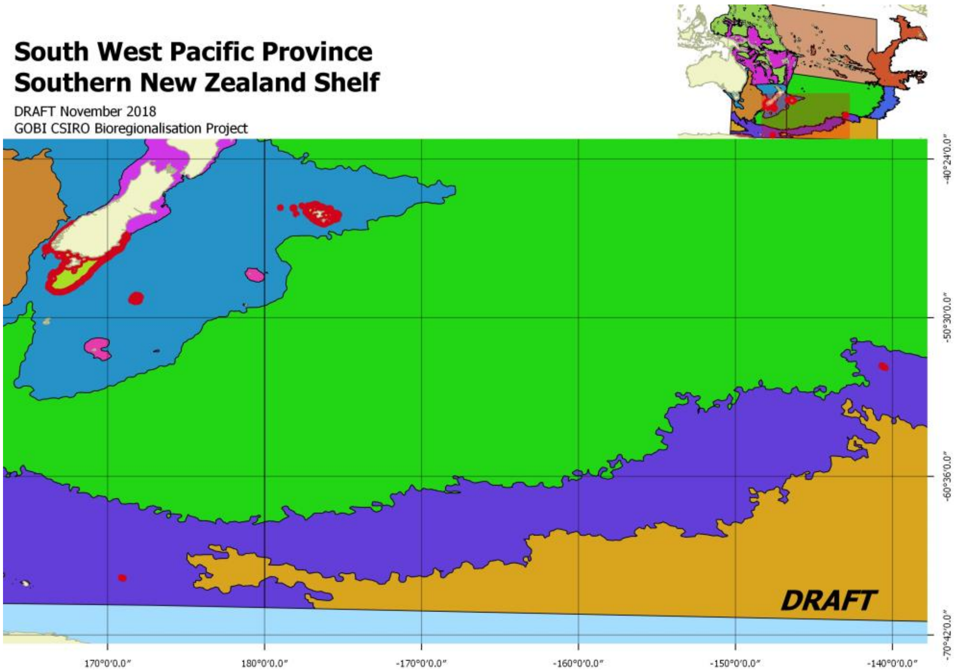
3.3.8 IMCRA Western Bass Strait Transition Shelf



The IMCRA West Bass Strait Transition Shelf province is taken directly from Australia's national marine bioregionalisation. This province is located west of Bass Strait. Within the IMCRA framework it is based on the distribution of demersal fishes and geomorphic features. See the IMCRA report for details (Heap et al., 2005). It also reflect the start of the longitudinal change in fauna from the east coast to the west coast of Australia.

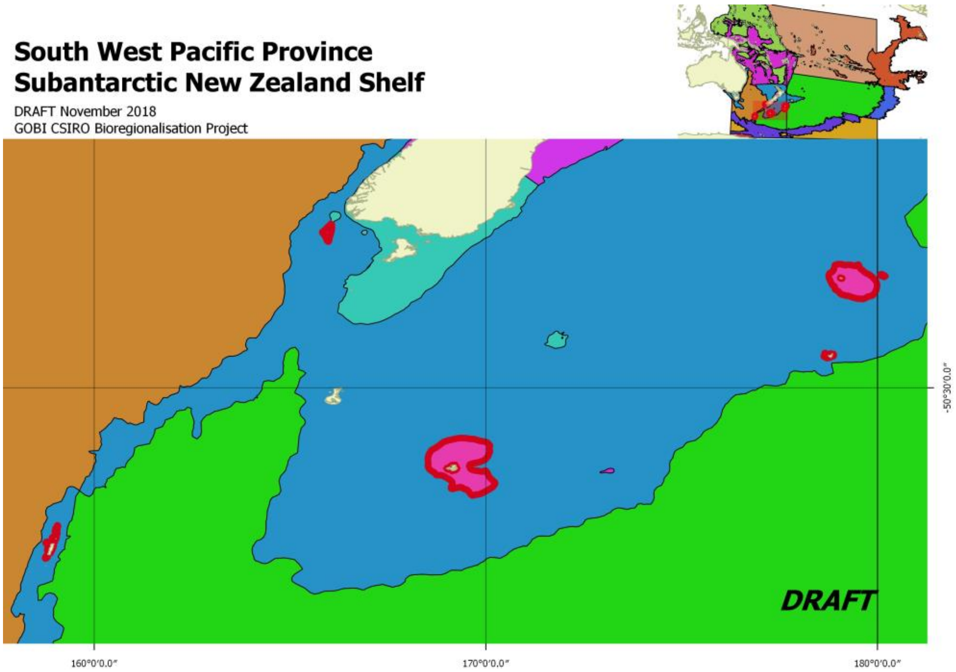
3.3.9 Southern New Zealand Shelf

Commented [HD(H4]: Southern new Zealand shelf needs to be fixed includes some ridge system.



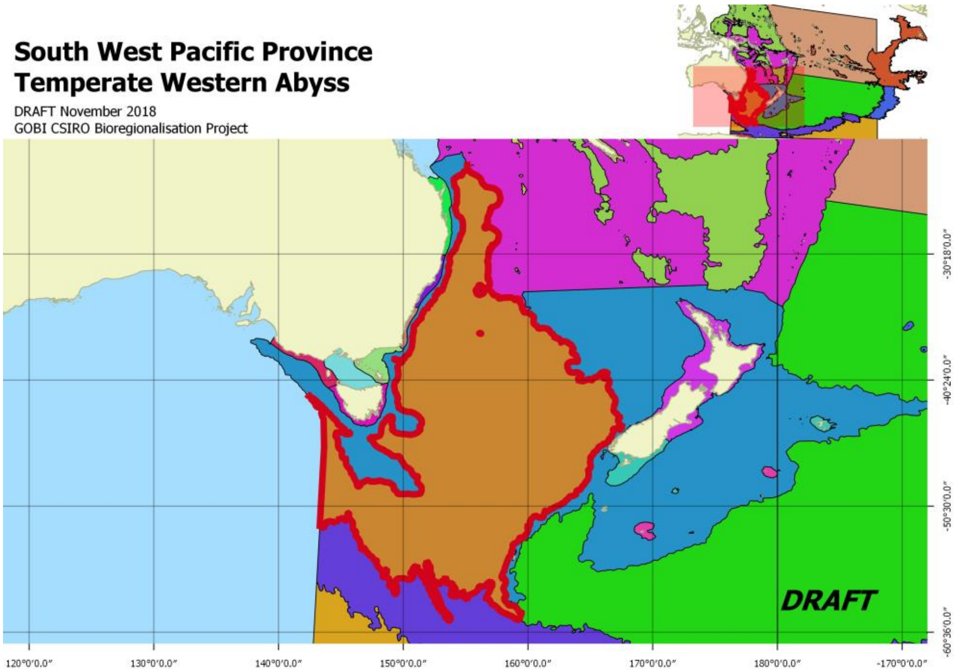
The Southern New Zealand shelf regionalisation is shallower shelf areas that encompass the southern shelf areas of New Zealand's EEZ. This classification is based on the work of classification of demersal fishers, the physical environment and ophiuroids (O'Hara *et al.,* 2011; Stephenson *et al.,* 2017). These region came directly from Stephsenson *et al.,* 2017 'ten groups' output, which a more generalised classification for this region. The Southern New Zealand Shelf Province was constrained to shelf habitats.

3.3.10 Subantarctic New Zealand Shelf



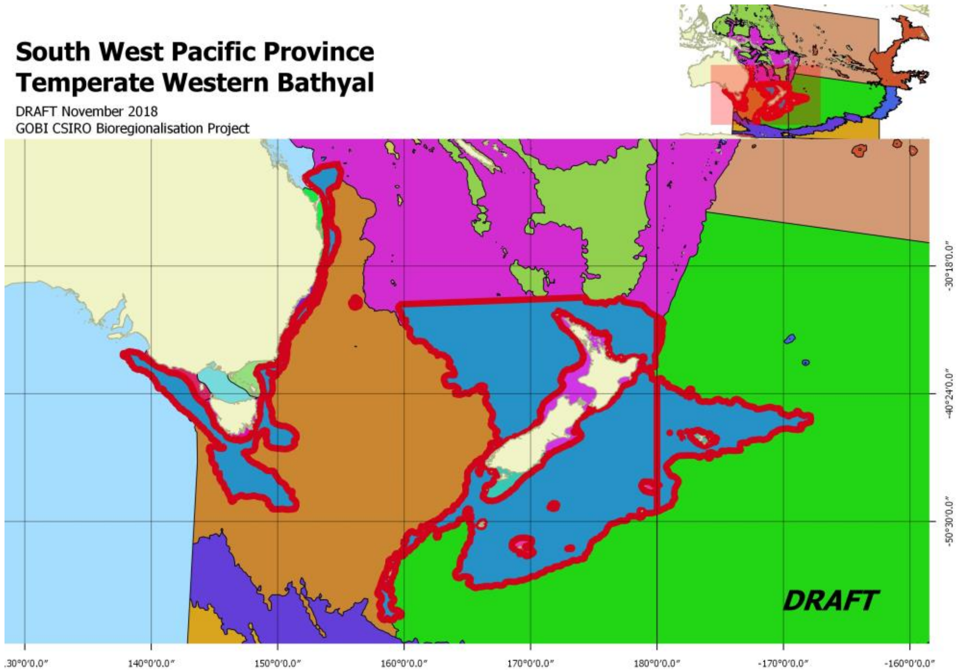
The Subantarctic New Zealand shelf Province contains the shallower shelf areas that represent the subpolar islands in the south of New Zealand's EEZ. This classification is based on the work of classification of demersal fish, the physical environment and ophiuroids (O'Hara *et al.,* 2011; Stephenson *et al.,* 2017). These region came directly from Stephsenson *et al.,* 2017 'ten groups' output, which a more generalised classification for this region.

3.3.11 Temperate Western Abyss



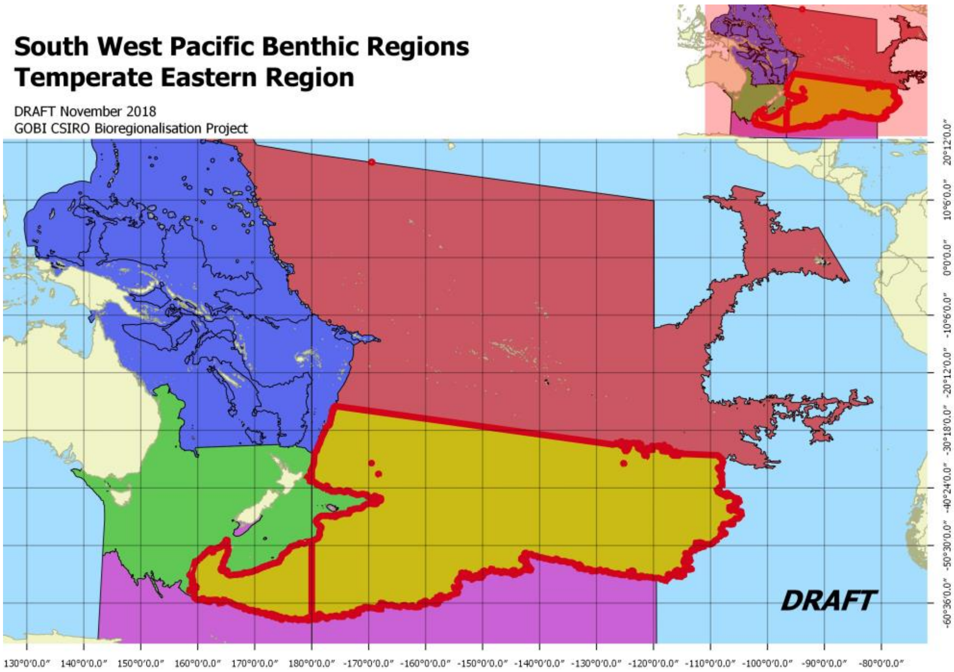
The Temperate Western Abyssal Province is based on the modelled distribution of ophiuroids and squat lobsters using the Regions of Common Profile Method (Foster *et al.,* 2013), see the Appendix 'Statistical Bioregionalisations' for details. This approach separated out the abyssal province at about 3500 meters deep and beyond. This is slightly different form other regionalisation's which made this boundary at 2000 meters (O'Hara *et al.,* 2011). But it does conform to other benthic classifications which draw his boundary at 3500 meters (e.g. GOODS classification and Watling et al., 2013).

3.3.12 Temperate Western Bathyal



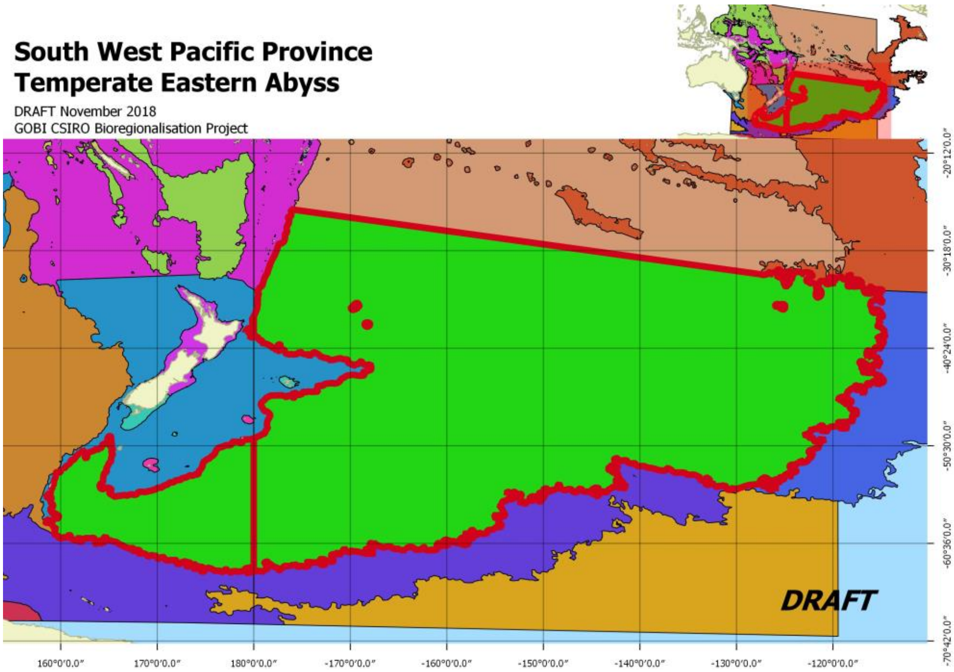
The Temperate Western Bathyal Province is based on the modelled distribution of ophiuroids and squat lobsters using the Region of Common Profile Method (Foster *et al.,* 2013), see the Appendix 'Statistical Bioregionalisations' for details.. This approach separated out the bathyal province between 200 and 3500 meters depth. This is slightly different form other regionalisation's which made this boundary at 2000 meters (O'Hara *et al.,* 2011). The 2000 to 3500 meter region could be viewed as the lower bathyal and a more depauperate subset of the shallower bathyal region. We however, do not define an upper and lower bathyal region, but recognise that there will be an affinity between these two bathomes (e.g. GOODS classification and Watling et al., 2013).

3.4 SW Pacific Temperate Eastern Region



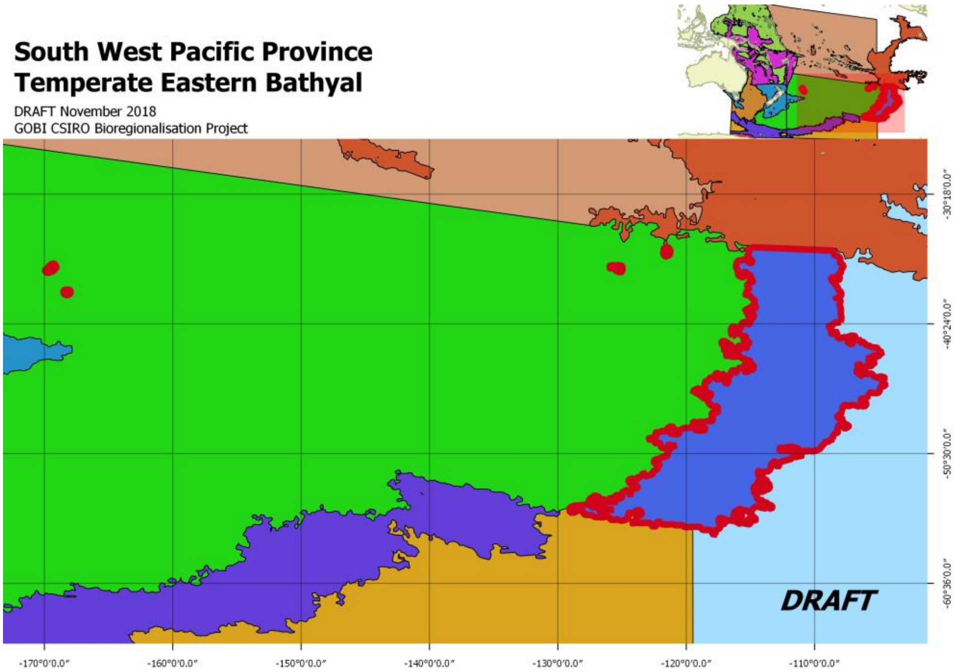
The Temperate Eastern Pacific Regions is bounded to the west by New Zealand's EEZ bathyal boundary (~3500 meters) and reflects the partitioning of this region as seen in the GOOD biogeographic classification (GOODS report). The northern boundary reflects southernmost extent of tropical coral, fishes and other tropical species. The southern boundary is driven by the extent of the subantarctic front. This boundary is slightly shifted to adhere to follow the bathyal depth contour that runs at 3500 meters across this Southern Indian and Pacific Antarctic mid-ocean ridges.

3.4.1 Temperate Eastern Abyss



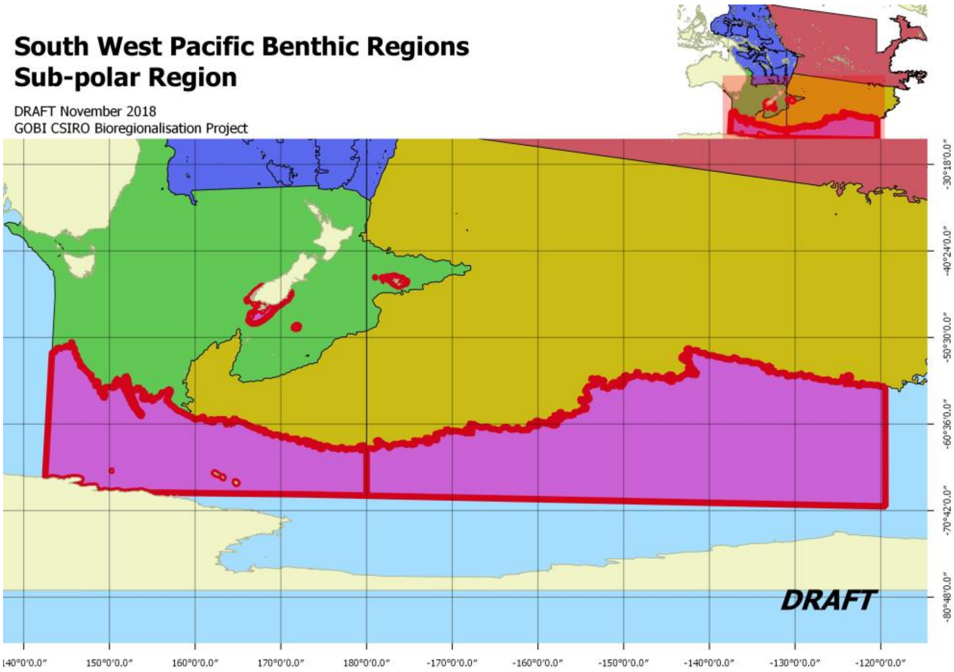
The Temperate Eastern Abyss makes up large parts of the Temperate Eastern Region and is defined based on model output from the ophiuroid analyses and based on the regionalisation in GOODS, which defines the Abyssal region as depths greater than 3500 meter. Due to the lack of biological information from this region, these boundaries are based on predicting observed model based relationships into new areas (as per the ophiuroid models) or are based on a combination of expert derived and environmental data (as per the GOODS classification).

3.4.2 Temperate Eastern Bathyal



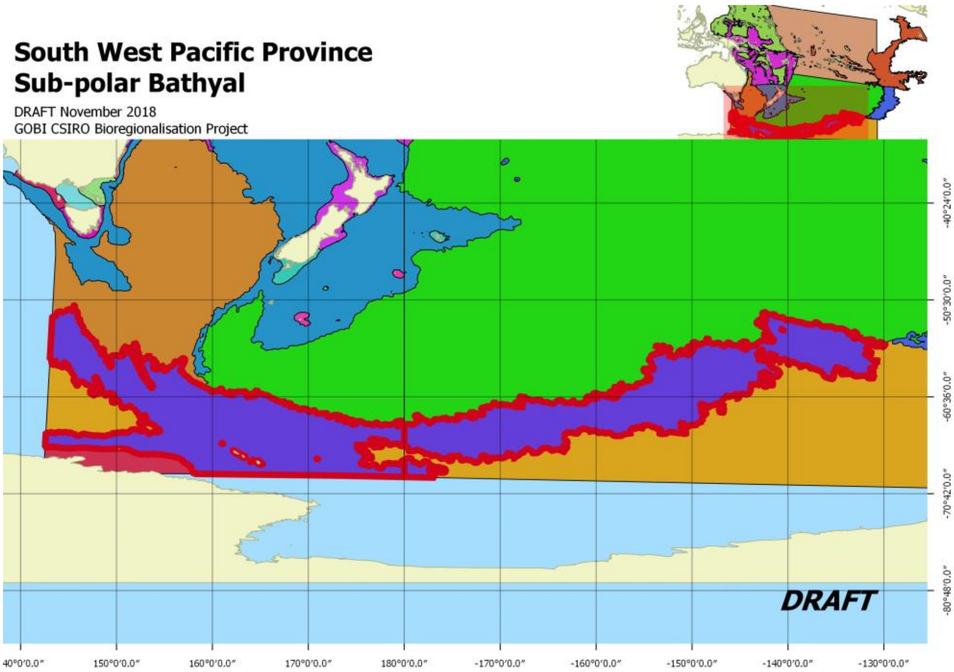
The Temperate Eastern Bathyal are the depth regions of the benthos between 200 and 3500 meters depth within the Temperate Eastern Region. These boundaries are defined based on model output from the ophuiroid analyses and based on the regionalisation in GOODS. Due to the lack of biological information from this region, these boundaries are based on predicting observed model based relationships into new areas (as per the ophiuroid models) or are based on a combination of expert derived and environmental data (as per the GOODS classification).

3.5 SW Pacific Subpolar Region



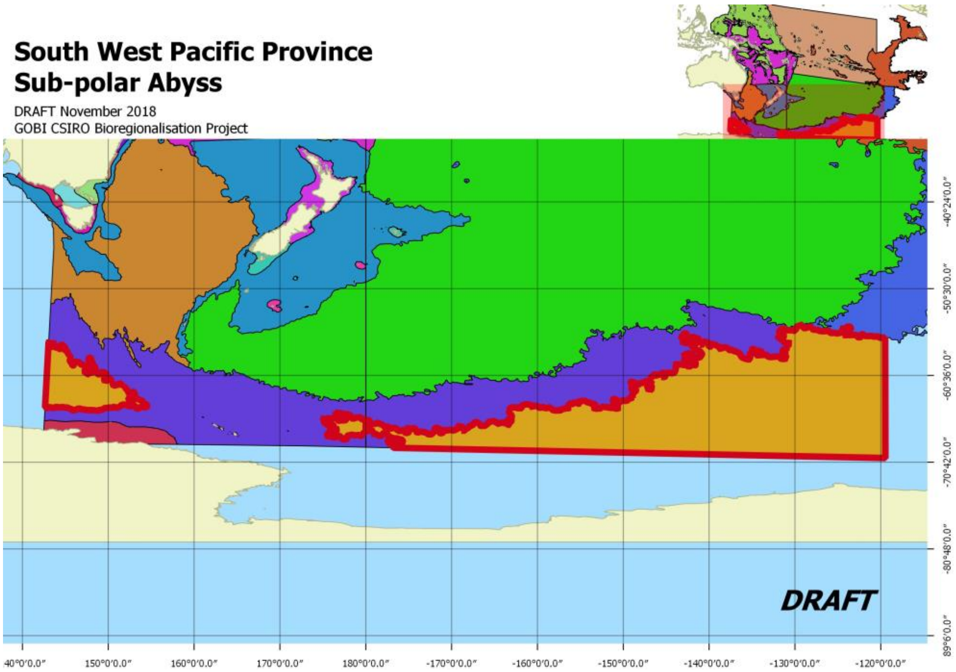
The northern boundary is driven by the extent of the subantarctic front and the bathyal depth contour that runs at 3500 meters across this Southern Indian and Pacific Antarctic mid-ocean ridges. The southern boundary follows the CCAMLR boundary. This area is comprised of temperate and subpolar species which are restricted to subpolar archipelagos and other subpolar islands and seamounts.

3.5.1 Sub-polar Bathyal



The subpolar bathyal province is defined by the bathymetry differentiation that emerged from our model-based bioregionalisation models for ophiuroids, squat lobsters and corals. They also are complemented by other existing schemes such as the GOODS benthic classification. However, the GOODS classification is restricted to ~800m depth, where our analysis shows that the major biogeographic break is along the shelf edge (at approximately 200m). We used the Harris *et al.,* 2008 geomorphic classification as our boundary for defining the start of the bathymetry province. The deepest boundary of the bathymetric province was set at 3500m, which agreed with both the model-based bioregionalisations and the GOODS classification. The Subpolar Bathyal Province follows the Southern Indian and Pacific Antarctic mid-ocean ridges.

3.5.2 Sub-polar Abyss



The Subpolar Abyssal Province sits within the Subpolar Bioregion and is defined by the abyssal regions that emerged from the model-based classification for ophiuroids and the agreed with the GOODS classification. Subpolar Abyssal Province is the deep seafloor (>3500 meters) that is on the southern side of the Southern Indian and Pacific Antarctic mid-ocean ridges.

4 Appendix 1. Statistical Bioregionalisations

We developed and implemented a series of models which extended on a Regions of Common Profile (RCP) models (Foster *et al.,* 2013) to generate biologically data driven bioregions for the Southwest Pacific and the Southwestern Pacific Ocean regions. The RCP approach is a 'Mixture-of-Experts' finite mixture model. This model characterizes a bioregion as a spatial region, where the probability of observing a species, at a randomly chosen location falling within that bioregion, should be approximately constant. Additionally, the chances of observing that species at random sites in different bioregions should be unequal. This model based notion was formally introduced by Foster et al., (2013).

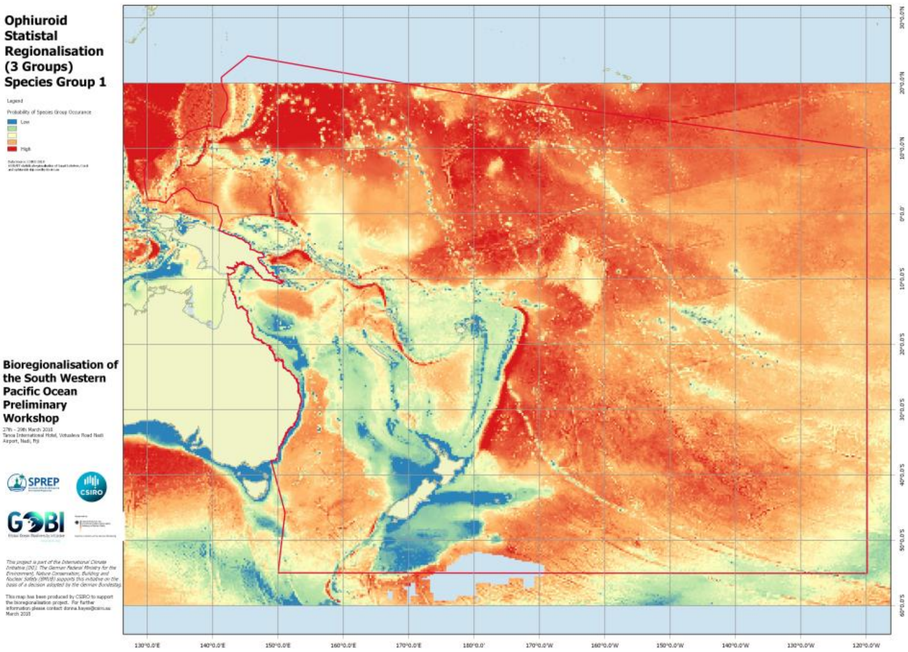
However, at regional scales the availability of broad scale biological datasets tends to decrease, instead, ad-hoc datasets which are an amalgamation of smaller scientific surveys and ad-hoc collections. These records are often kept in natural history collections and in online repositories. These *ad-hoc* data often come with the unfortunate problem of missing information on where species were not observed (absences). As a consequence we can never truly estimate the probability of occupancy form these data as we are missing key information (absences). This also means that the models (built for presence-absence and abundance data) are ill equipped to deal with these data, without some modifications.

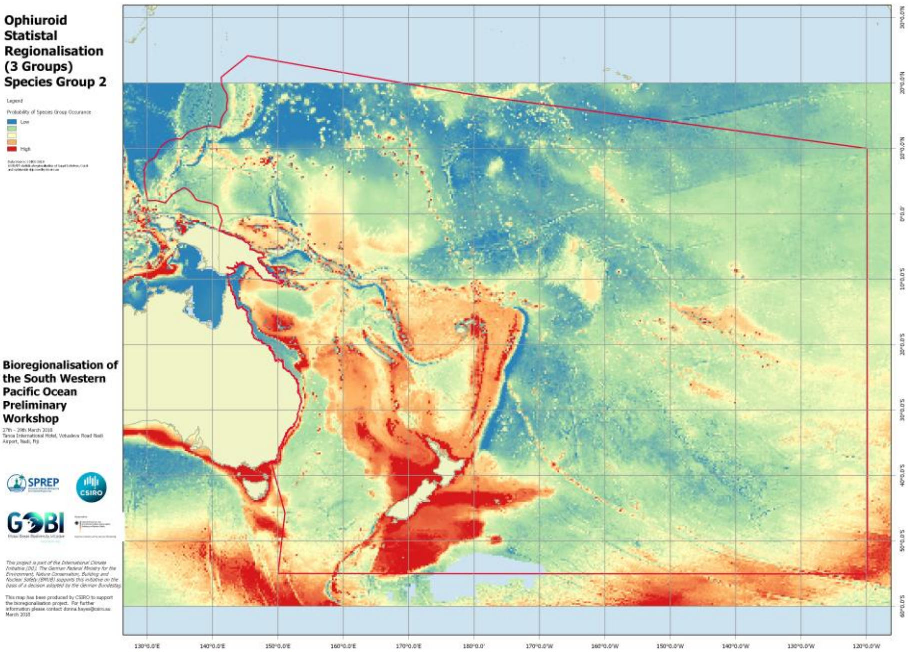
We do this by extending the RCP model to be a spatial point process (Cressie 1993). Based on the current implementation of the RCP models, we can do this simply by generating a spatial Poisson model, which is often done for single species models (Fithian & Hastie, 2014). The inhomogeneous Poisson point process RCP (IPPM-RCP) was fitted as a Poisson model. This was achieved by fitting the model to a grid of environmental predictors, where individual species occurrences are summed to reflect a count (Poisson), the exception being that cells will no species records in them are not excluded from model fitting, but rather are given a value of zero (akin to a background point). This model then produces a bioregions similar to the definition above, but rather than a probability of occurrence of a species within a bioregion, we generate a probability of sighting a species within a bioregion (a density based on the presence points).

We used the IPPM-RCP method to generate bioregions from benthic regions of the southwest Pacific Ocean we developed three seafloor taxonomic groups, brittle stars (Ophiuroidea), squat lobsters (Galatheoidea and Chirostyloidea) and cold water corals (Octocorallia). Three biological datasets were used that included 363 brittle star, 160 squat lobster and 14 coral species with greater than 10 observations across the southwest Pacific Ocean region. These biological data were fitted to a set of environmental and spatial data, including latitude, longitude, depth, nitrate, oxygen, silicate and temperature as linear and quadratic terms. The environmental covariates were derived from the World Ocean Atlas datasets, and were trilinearly interpolated to the seafloor using the GEBCO bathymetry layer. The log area of each cell is also included as an offset to account for any latitudinal bias in cell size.

Based on model fitting, taking a parsimonious approach, we found three broad regions for the ophiuroid and coral species, and four for the squat lobster dataset. The number of groups was derived based on Bayesian Information Criteria. Spatial predictions where made across the Southwest Pacific Ocean seafloor for each taxa, which contained mean (point) and standard errors in the prediction of each archetype (group).

These model predictions where then taken to the first Southwest Pacific Ocean expert elicitation workshop for generating bioregions across the Southwest Pacific Ocean. After consultation among experts with reference to these models and local knowledge of the region three broad scale bioregional provinces were agreed upon which represented broad scale biological and physical classifications which strongly reflected predicted distribution form the IPPM-RCP models. The large regions where then used at the top of hierarchical scheme which then classified finer scale region within each of the broad provinces.




Ophiuroid Statistal Regionalisation (3 Groups) Species Group 2
Legend
Probability of Species Group Occurrence
Low
High
Bioregionalisation of the South Western Pacific Ocean Preliminary Workshop
27th - 29th March 2018
Tanoa International Hotel, Votualevu Road Nadi Airport, Nadi, Fiji
SPREP
CSIRO
GOBI
This project is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) supports this initiative on the basis of a decision adopted by the German Bundestag.
This map has been produced by CSIRO to support the bioregionalisation project. For further information please contact donna.hayes@csiro.au
March 2018
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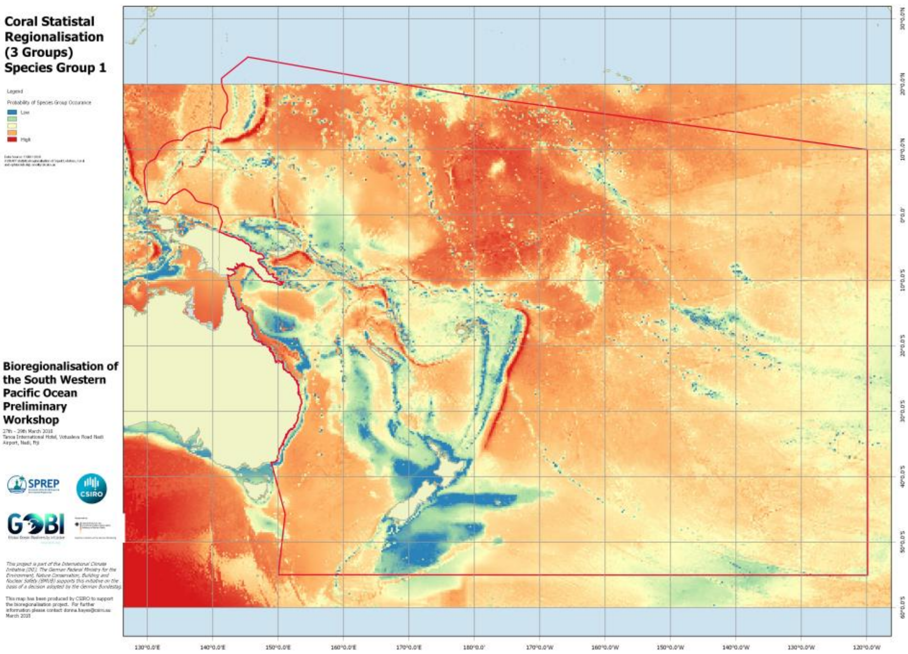
Coral Statistal Regionalisation (3 Groups) Species Group 1
Legend
Probability of Species Group Occurrence
Low
High
Bioregionalisation of the South Western Pacific Ocean Preliminary Workshop
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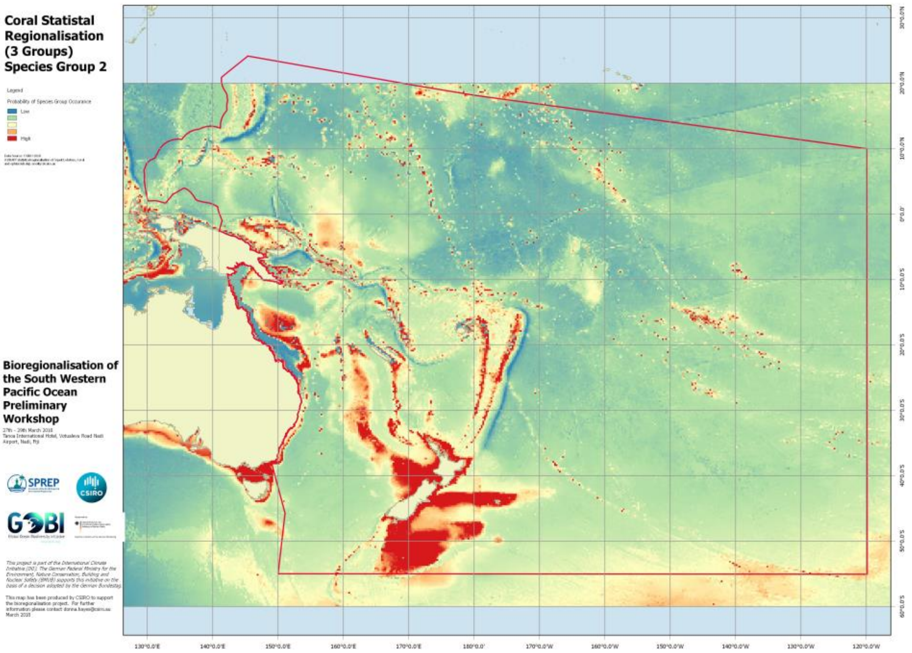
Coral Statistal
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(3 Groups)
Species Group 2
Bioregionalisation of
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Pacific Ocean
Preliminary
Workshop
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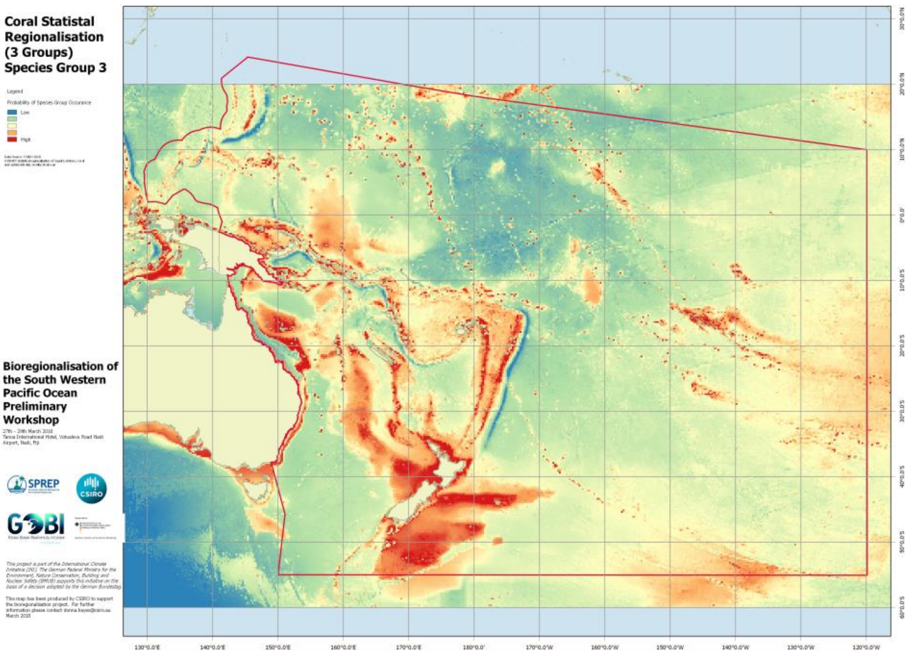
CSIRO


Coral Statistal
Regionalisation
(3 Groups)
Species Group 3
Bioregionalisation of
the South Western
Pacific Ocean
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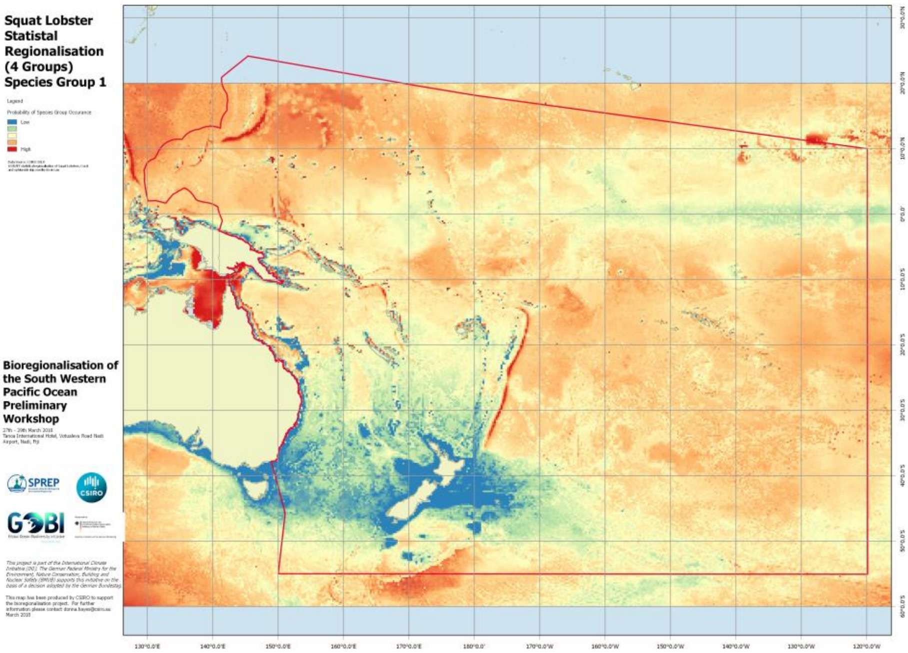
Squat Lobster Statistal Regionalisation (4 Groups) Species Group 1
Legend
Probability of Species Group Occurance
Low
High
Bioregionalisation of the South Western Pacific Ocean Preliminary Workshop
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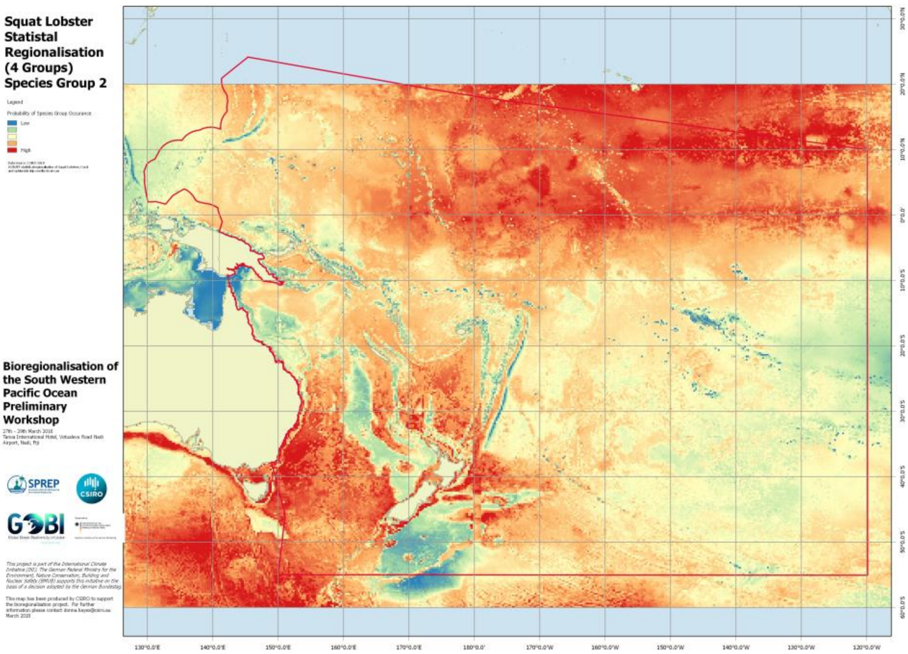
Squat Lobster Statistal Regionalisation (4 Groups) Species Group 2
Legend
Probability of Species Group Occurance
Low
High
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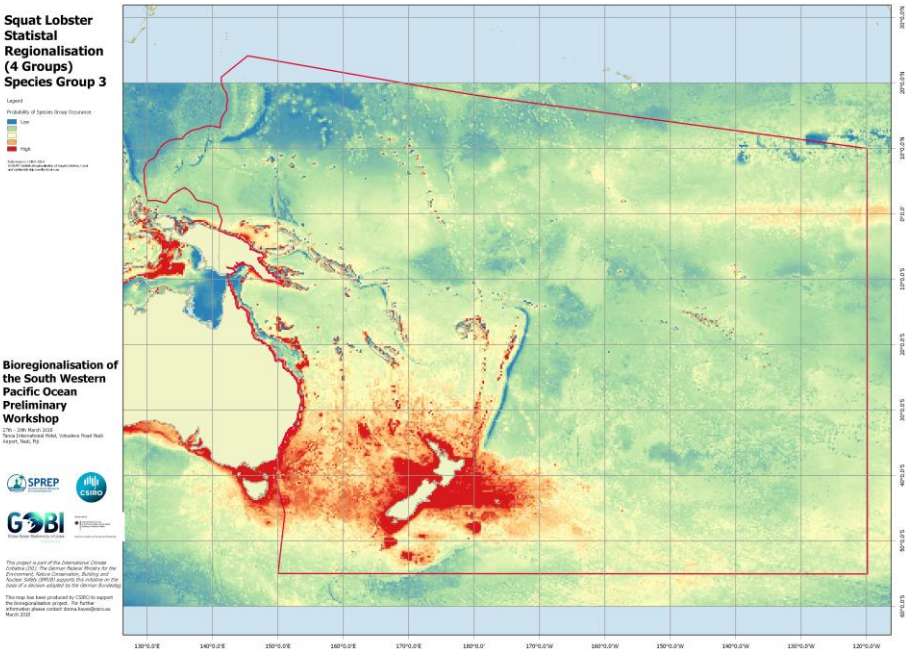
Squat Lobster
Statistal
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Species Group 3
Bioregionalisation of
the South Western
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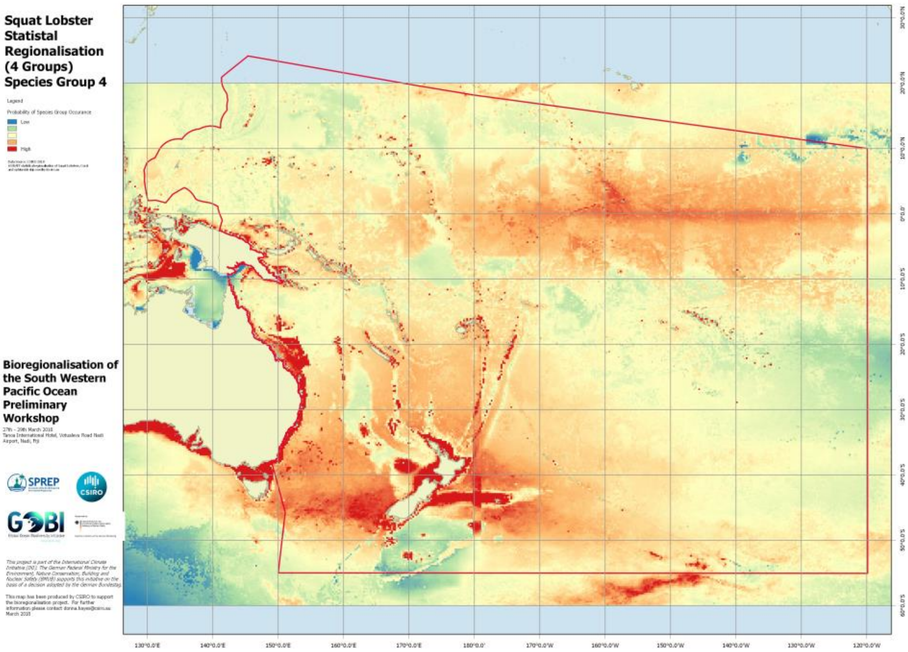
Squat Lobster
Statistal
Regionalisation
(4 Groups)
Species Group 4
Bioregionalisation of
the South Western
Pacific Ocean
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