CHAPTER 1: General Introduction

1.1 MARINE PROTECTED AREAS & CONSERVATION PLANNING

1.1.1 Need for Marine Protected Areas

There is an increasing level of threat to marine ecosystems associated with rising population and advancing technology at global, regional, and local scales (Worm et al. 2006, Halpern et al. 2008, Mora et al. 2009, Stallings 2009). Pressures include higher levels of exploitation using more-sophisticated techniques; response to pressures can include reduction in biodiversity (Robbins et al. 2006, Watson et al. 2007, Roberts 2009). Direct effects of human activity include fishing and habitat loss with impacts to biotic communities and ecological processes (Babcock et al. 1999, Tuya et al. 2004, Robbins et al. 2006, Worm et al. 2006, Myers et al. 2007, Stallings 2009). Indirect effects can include altered oceanographic patterns and ecosystems associated with climate change (Hobday et al. 2006, Hoegh-Guldberg et al. 2007, Poloczanska et al. 2007). These threats and pressures require active management and greater understanding if we are to minimise our impact on marine biodiversity (Roberts & Polunin 1991, Shears & Babcock 2002, Lubchenco et al. 2003, McCook et al. 2009). Spatial protection, through Marine Protected Areas (MPAs) has been recognised and adopted worldwide as an essential component of the overall approach to maintaining biodiversity (Roberts & Hawkins 2000, Palumbi 2002, Lubchenco et al. 2003, Selig & Bruno 2010), either as a primary management mechanism or as a back-up insurance policy (Russ 2002), and many studies have demonstrated their value (Roberts & Hawkins 2000, Roberts et al. 2001, Russ 2002, Halpern 2003, Willis et al. 2003, Russ et al. 2004, Lester et al. 2009). However their effectiveness is not guaranteed and depends on their individual management arrangements (Curley et al. 2002, Stewart et al. 2003, Nardi et al. 2004, Russ & Alcala 2004).

MPAs can be established for various reasons including nature conservation, fisheries ecosystem management, species-specific management including threatened species, environmental management, socio-economic reasons including protection of tourism resources or indigenous places of importance, or any combination of the above. Their over-riding objectives may include conservation of biodiversity and/or habitats, maintenance of ecological processes, conservation of seascapes and wilderness attributes, and/or protection of wildlife. They may be used to protect biomass of targeted or key species, spawning biomass, spawning sites, aggregation sites, nursery areas, and habitat of species important to commercial or recreational fisheries (Hastings & Botsford 2003, Lubchenco et al. 2003, Gladstone 2007). All of these objectives relate to components of biodiversity and are linked as parts of ecosystems. Establishing an MPA for one objective will benefit others. Overall, conservation of biodiversity is implicit in establishing an MPA.

1.1.2 MPA management

Marine Protected Areas include both fully protected marine reserves and multiple-use marine parks allowing a range of activities within different zones. They function primarily by managing direct human activity and use that may influence or impact their primary objective(s). Fully protected marine reserves, marine sanctuaries, and marine national parks prohibit extractive activities inside their declared boundary and may have additional management and regulations or restrictions. Multiple-use marine parks often have multiple and potentially conflicting objectives and attempt to balance these using a combination of zoning plans, management plans, and regulations. Zoning plans have a number of ‘zones’ that spatially subdivide the marine park into different areas where activities are or are not lawful. ‘No-take’ zones generally prohibit or restrict removal of flora, fauna and non-living material. Multiple use marine parks have the benefit of covering a much larger area than might be otherwise supported by society or achievable for a fully-protected reserve. This enables a more holistic management approach, including input into management of adjacent catchments (NSW MPA 2001, Fernandes et al. 2005, The Ecology Centre University of Queensland 2009). However a potential disadvantage is that a zoning scheme within a marine park may be ineffectively designed to achieve its primary objectives. Reasons for this may include limitations in available biophysical knowledge and/or political pressure applied by various interest groups (Banks & Skilleter 2010). Effective planning is crucial for a multiple-use marine park, or a network of marine parks, to succeed in meeting their objectives.

Within Australia, the need for a National System of Representative Marine Protected Areas (NRSMPA) has been identified and this system is gradually being established (ANZECC TFMPA 1998, 1999). The primary goal of the NRSMPA is biodiversity conservation and maintenance of ecological processes (ANZECC TFMPA 1998). The national and regional planning framework for establishing this system was initially the Interim Marine and Coastal Regionalisation for Australia (IMCRA), which divided coastal waters into 60 marine bioregions based on a range of physical and biological information (ANZECC 1998). A complete NRSMPA would require at least one MPA in each bioregion including highly protected areas (IUCN categories I and II). The current regionalisation is the Integrated Marine and Coastal Regionalisation for Australia (IMCRA Version 4, 2006) (DEH 2006), which has maintained these meso-scale units, although 70 bioregional units (30 reef, 40 non-reef) were identified during the rezoning of the Great Barrier Reef Marine Park (GBRMP) which came into force in 2004. In New South Wales (NSW) there are 5 coastal bioregions currently identified under IMCRA which have been examined at the individual bioregional scale (Breen et al. 2004, Breen 2007). However, IMCRA may be further refined and ‘work that builds on existing datasets is the most cost-effective way to add value to the bioregionalisation’ (DEH 2006). Demersal fish and other taxa were used to define benthic provincial bioregions in IMCRA and finer-scale patterns in demersal fish distributions will further inform this process and assist the NSRMPA goals.

Also underpinning the primary goal of the NSRMPA are three principles: Comprehensive, Adequate, and Representative (CAR). Comprehensiveness relates to inclusion of the full range of ecosystems recognised at an appropriate scale across and within bioregions. Adequacy relates to the required level of reservation to ensure ecological viability of populations, communities and species. Representative relates to the marine areas selected for inclusion in the NRSMPA, reasonably reflecting the biotic diversity of the marine ecosystems within them. Once an individual marine park is selected, the zoning plan within it (if multiple use) is a primary mechanism to try and achieve the CAR principles. ‘No take’ zones, equivalent to reserves, should spatially represent the ecosystems and the biotic diversity within that marine park. However, adequacy will not be known for most species within an individual marine park and, due to marine connectivity, generally relates to networks of reserves.

Conservation of marine biodiversity, marine habitats, and ecological processes are the primary objectives and legal obligations of marine parks in NSW, which are zoned for multiple-use. Where consistent with these objectives, they aim to balance conservation and use, providing for enjoyment, understanding, and various human activities including sustainable fishing (NSW Government 1997). The NSW Marine Parks Authority, responsible for managing marine parks in NSW, is establishing a system of marine protected areas that represent the range of marine diversity and habitats in this State. These have been selected using a bioregional approach (Avery 2001, Breen et al. 2004, Breen 2007) concentrating on areas that represent marine habitats and marine communities within those bioregions, and which may also have unique features that make them special. They are legally enforceable protected areas that are declared through legislation passed in the NSW Parliament. There are four types of zone under the NSW Marine Parks Act 1997: Sanctuary Zone; Habitat Protection Zone; General Use Zone; and Special Purpose Zone. Sanctuary zones (SZ) are the highest form of zoning protection in NSW and prohibit extractive activity such as fishing and collecting, being 'no take'. A key role and challenge of marine parks in NSW is to maintain the health of marine systems in the face of increasing State-wide population and pressure. The primary opportunity to achieve this within declared marine parks is through effectively designed zoning plans, including suitable arrangement of SZ.

1.1.3 Planning the arrangement of zones

There are a wide range of mechanisms that can be used to plan the arrangement of zones. These can vary from ad hoc through to systematic methods using a range of physical, biological, and socio-economic information. The extent of information used in planning can also vary considerably. Zones can be arbitrarily placed with no information, be based on 'expert' opinion, or utilise datasets that range from limited to comprehensive with biological, physical and ecological information available at different scales. Most use a combination. They can also be based on biological or physical surrogates.

Zone planning in NSW marine parks has primarily used habitat as a representative surrogate for biodiversity, combined with other biological and social information. This habitat approach has utilised a Habitat Classification System (HCS) to develop a map of intertidal and seafloor habitats (NSW MPA 2008), with a portion of each HCS category represented in SZ. However, the suitability of the HCS as a surrogate requires testing. A habitat approach is unlikely to represent all species effectively and a more systematic approach may be complementary in identifying areas of particular value to species. Systematic approaches using planning tools based on spatial algorithms are guided by three key concepts: complimentarity, irreplaceability, and vulnerability (Sarkar et al. 2006). Complementarity incorporates the principle that to efficiently maximise representation of biodiversity, sites should be selected that are most-different in their biotic component. Irreplaceability indicates the probability of a site being needed to achieve targets; the higher the irreplaceability the more important a site is. Vulnerability relates to persistence, ecological processes, threats, use, and environment. Applying these concepts can improve the effectiveness and the cost-efficiency of protected area selection, by indicating locations with particular value to biodiversity and by minimising the area required to achieve defined targets (Ferrier et al. 2000, Pressey & Cowling 2001, Cowling et al. 2003, Stewart et al. 2003).

Systematic approaches are complementary to expert–based approaches (e.g. local knowledge of managers, expert panels), with a combination of both likely to be more effective in determining solutions (Cowling et al. 2003). They can support decision making by managers, not replace managers from decision making (Sarkar et al. 2006). Their value to planning is through providing rigorous and scientifically defensible options. There are a number of algorithm planning tools available, including Marxan (Ball & Possingham 2000) which has been used in medium and large-scale Marine Protected Area (MPA) planning (Leslie et al. 2003, Fernandes et al. 2005, Cook & Auster 2006). Systematic Planning has been used to examine and select suitable candidate areas for marine parks in NSW within each bioregion (Breen et al. 2003, 2004, Breen 2007). This has included the use of two planning programs that utilise algorithms, C-Plan and Marxan. Early systematic planning was also conducted by the CSIRO (Ward et al. 1999) in Jervis Bay at a scale comparable to that of the subsequently-declared Jervis Bay Marine Park in NSW, and which assisted in the declaration of that marine park. This involved a range of biotic variables (fish, algae, macro-invertebrates) and habitat comprehensively surveyed within a grid system. Unfortunately that information was subsequently lost through changes in computer systems / programs over time and cannot be applied to a current zoning review of JBMP. Therefore, so far systematic planning has not been applied in NSW at the marine park scale to assist in the development of a zoning plan. However, using these powerful planning tools at the marine park scale is essential, if the full range of planning options is to be effectively assessed.

1.1.4 The Solitary Islands Marine Park

The Solitary Islands Marine Park (SIMP) in northern New South Wales (NSW), Australia, was the first multiple-use marine park in NSW and covers 72,000 hectares in area along a north-south oriented coastline of about 80 km. The SIMP is positioned in the Tweed-Moreton bioregion, which stretches from Moreton Bay to just south of Coffs Harbour. It contains unique reef habitats within NSW due to the presence of offshore islands up to 12 km from the coast, and therefore shallow reef a long way offshore (NSW MPA 2008). More generally, there is extensive reef habitat throughout the SIMP as a result of seaward outcropping of the adjacent coastal range, which needs consideration in planning the arrangement of zones.

In total, the SIMP has been managed under three different Acts. It was first declared under the *Fisheries and Oyster Farms Act 1935* as the Solitary Islands Marine Reserve (NSW) in May 1991. It was then managed under the *Fisheries Management Act 1994*, which superseded the earlier Act. It then became the Solitary Islands Marine Park in January 1998 when the *NSW Marine Parks Act 1997* was declared. The adjacent Solitary Islands Marine Reserve (SIMR) in Commonwealth waters was established in 1993. The SIMR (Commonwealth) is also zoned for multiple use with the same zoning categories as the SIMP. Combined, SIMP and SIMR cover 87,000 ha; however the initial Plan of Management, which outlined the zoning scheme, protected less than 0.2% of these areas in 'no take' SZ, which were mainly around islands. The first zoning scheme for the Solitary Islands Marine Park came in force in May 1991 when it was first declared as a reserve (Figure 1a). This remained in place until August 2002, when it was rezoned under the *NSW Marine Parks Act 1997* (Figure 1b) with conservation of biodiversity and ecological processes as the primary objective (NSW Marine Parks Authority, 2002). A Management Plan for the SIMR was established in 2001 under the *Environment Protection and Biodiversity Conservation Act 1999* as per IUCN Category VI: a managed resource protected area (Commonwealth of Australia, 2001). Both plans are currently being reviewed (NSW MPA 2009). Having undergone rezoning and now undergoing review, the SIMP and SIMR combined, provide an example of a complex and adaptive management structure.

The 2002 rezoning of the SIMP was guided by the CAR principles, as part of the NSW Government's commitment towards establishing the NRSMPA, and as per other marine parks in NSW, a representative habitat approach was taken in the absence of suitable biotic data at an appropriate scale. Examples of each habitat type, as a 'surrogate' for biotic diversity, were to be included in SZ. The habitat categories separated rocky shores, beaches, estuaries, and subtidal habitats. Subtidal habitat categories were based on substrate type, depth of reefs, and surrounding bathymetry, developed using the findings of benthic studies (drop-video and depth-sounder transects) in combination with existing hydrographic data. The SIMP was then mapped using these categories (Mau 1997, Mau et al. 1998, NSW MPA 2000). This map was used to help plan the arrangement of zones in 2002 which resulted in representative protection of all broad habitat categories (when considered in conjunction with zoning arrangements in the SIMR) and 12% of the SIMP gazetted in sanctuary zones. The initial habitat categories were not systematic but attempted to link benthic patterns to habitat, and included reef: rising from <20m depth; rising from 20-35m to within 15m of the surface; rising from 20-35m to depths deeper than 15m; low-profile rising from >35m; high-profile rising from >35m; and 'mixed' where there was a combination of categories. The specific rationale for these, especially a mixed category, was not clear. A more-systematic HCS, with categories based on substrata (unconsolidated, reef) and depth (shallow <20m; intermediate; deep >60m), was later adopted as a standard for marine parks in New South Wales in 2005, although 25m was selected as the shallow-intermediate boundary in the SIMP due to a recognised prevalent change in coral to sponge communities at this depth in this marine park. However, given the SIMP is positioned in a tropical-temperate biotone (Zann 2000), an HCS based primarily on depth was unlikely to represent all biotic gradients.

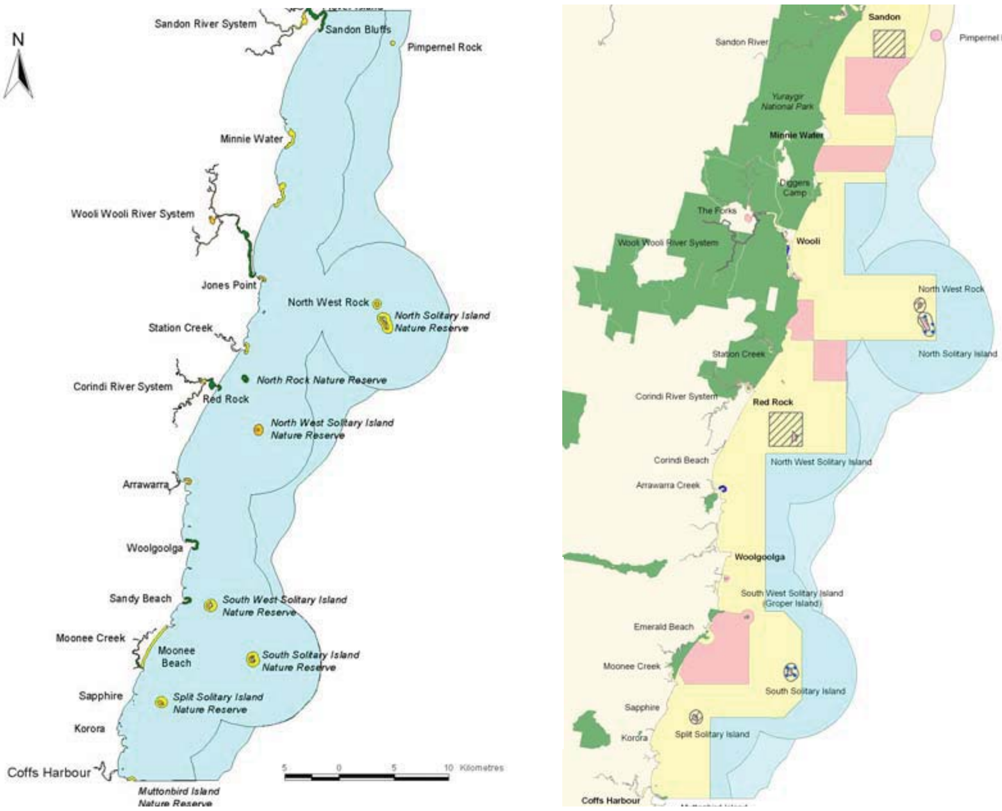

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Figure 1: SIMP / SIMR Zoning Plans. A = original SIMP zoning scheme with orange = sanctuary zone. B = existing SIMP and SIMR zoning schemes with pink = sanctuary zone

1.2 REEF FISH & CONSERVATION MANAGEMENT

1.2.1 Reef fish patterns – application to HCS and planning

Reef fish are often a species-rich, high-biomass, highly-visible component of biodiversity in marine systems. They are an important group to consider in marine park planning, not only to conserve the diversity of reef fishes in their own right (Gladstone 2007), but because of their importance to ecological function (Shears & Babcock 2002), and their social, cultural and economic value (Henry & Lyle 2003). They have also been found, in some cases, to be useful and reliable surrogates for other taxa (Ward et al. 1999, Beger et al. 2003), although not unequivocally (Gladstone & Owen 2007). They have been used to help assign bioregional units

(DEH 2006) and to help develop habitat classifications and biophysical maps used in conservation planning (Williams and Bax 2001.). More confidence can be placed on habitat classifications used as ‘surrogates’ for biotic patterns (Jordan et al. 2005b, Stevens & Connolly 2005) if they are verified by biological surveys (Stevens & Connolly 2004).

1.2.2 Influence of physical, environmental, and ecological factors on reef fish assemblages

There are a large number of factors that can influence spatial patterns in reef-fish assemblages. Physical habitat can vary in terms of structure, complexity and heterogeneity (Garcia-Charton & Perez-Ruzafa 2001), due to complex and synergistic interactions between many factors, including geology, geomorphology, topography, benthic communities, depth, and environmental gradients. Environmental gradients generated through local hydrodynamic, climatic, and physical influences can vary in space and time (Friedlander & Parrish 1998b) and include interactions between wave activity, aspect, exposure, turbidity, light, depth, and disturbance regime (Gust et al. 2001). Ecological processes can influence assemblages at local scales through various mechanisms associated with population dynamics and species life histories. These include dispersal (Leis & Carson-Ewart 1998), recruitment (Doherty & Fowler 1994, Booth et al. 2000) and settlement (Connell & Jones 1991, Lincoln Smith et al. 1991), density dependence (Hixon & Webster 2002, Shima & Osenberg 2003), competition and predation (Beukers & Jones 1997) and trophic-dynamics and partitioning (Choat et al. 2004). All of the above factors may influence reef-fish assemblages in some way and do not operate in isolation. Many individual studies have examined the influence of some of these factors, with few studies examining the synergy between more than three (Shima 2001). The overall complexity and variability in the influence of all factors and their interactions, and paucity of knowledge of the ecology of individual species, precludes a complete assessment, although overall understanding is cumulatively improving (Sale 2002). The influence of different factors also depends on the scale being investigated (Danilowicz et al. 2001). The spatial and temporal scales at which assemblages are considered can strongly affect the variability, stability and persistence of those assemblages (Curley et al. 2002, Griffiths 2003, Gladstone 2007). Although the influence of all these factors, or any of them, may not be understood for a particular region, they are embedded within assemblage patterns (Underwood et al. 2000). Knowledge of different assemblages of fish, based on strong patterning, has considerable utility to MPA planning. Representing examples of assemblages within 'no take' sanctuary zones will encapsulate the factors responsible.

1.2.3 Benefits of 'no take' sanctuary zones and guidance for their design

Various benefits of 'no take' areas have been demonstrated over the past 20 - 30 years. Overall, fish, mollusc, and crustacean densities have been shown to increase in 'no take' areas, whether they are fully protected reserves (Russ & Alcala 1996a, Babcock et al. 1999, Edgar & Barrett 1999, Lester et al. 2009), or sanctuary zones (SZ) within multiple-use marine parks (Ayling & Ayling 1998, Westera et al. 2003). Benefits have been demonstrated for various species targeted by fishing (Buxton & Smale 1989, Polunin & Roberts 1993, Wantiez et al. 1997, Mapstone et al. 2004), including spearfishing (Chapman & Kramer 1999, Jouvenel & Pollard 2001, Lowry & Suthers 2004). Benefits to the broader assemblage and overall biomass have also been demonstrated (Evans & Russ 2004, Watson et al. 2007, Stobart et al. 2009), with fish getting bigger and/or the fish community getting more diverse in terms of number of species (Russ & Alcala 1996b, 1998a, b, c, Stobart et al. 2009). 'No take' areas can affect the size structure of exploited fish species, with larger size classes and greater maximum size detected (Buxton & Smale 1989, Polunin & Roberts 1993). Some strong community and ecological influences, termed trophic cascades, have occurred due to MPAs, where an increase in one species has influenced another, in turn changing the benthic community (Babcock et al. 1999, McClanahan 2000). Fishing down of large predatory fishes has been implicated in top-down trophic cascades and indirect effects on coastal marine communities (Pinnegar et al. 2000, Shears & Babcock 2002, Shears & Babcock 2003). This in turn can promote changes in fish assemblages and trophic guilds with domination of fewer species (Tuya et al. 2004).

The syntheses of these and other studies have provided guidelines to marine park design (Roberts & Hawkins 2000, Airame et al. 2003, Allison et al. 2003, Halpern 2003, Lubchenco et al. 2003, Lester et al. 2009, McCook et al. 2009, The Ecology Centre University of Queensland 2009). Declaring a marine park and establishing a zoning scheme will not automatically result in a difference between densities and communities inside and outside of 'no take' zones, as biological systems take time to respond. A number of studies have indicated a period of at least 10 to 25 years is required for the full benefits of a 'no take' zone to develop for reef fishes (McClanahan 2000, Russ & Alcala 2004, McLanahan & Graham 2005). Additionally, the influence of SZ can vary spatially and by species, with a stronger response closer to population centres where there is greater pressure applied and removed (Mapstone et al. 2004). The size of a 'no take' area has been shown to influence its effectiveness, with smaller having fewer detectable increases compared to larger (Edgar & Barrett 1999). Larger 'no take' areas or SZ are also more likely to include a range of sites more-suitable for different species and/or encompass more species (Griffiths & Wilke

2002). Zone shape can also influence effectiveness, with higher densities in the centre due to edge effects associated with fishing pressure along the edge, migration of fish, natural variability, or any combination of these (Rakitin & Kramer 1996, Willis et al. 2000). Where 'no take' zones encompass an entire reef, greater protection might be provided due to those species unlikely to cross sand (Chapman & Kramer 1999). Densities may also influence the movement patterns of some species in relation to SZ (Zeller et al. 2003). Physical and biological impacts (e.g. destructive storms, disease, oil spills) can reduce benefits of SZs (Allison et al. 2003) although recovery may occur more rapidly if they are more ecologically robust due to protection of marine biodiversity (Worm et al. 2006). Therefore, with the potential for more intense storms more frequently associated with climate change (Poloczanska et al. 2007, Keller et al. 2009), risk should be spread among areas, by replicating SZs (McCook et al. 2009). Marine systems are also highly variable both geographically and through time. Marine parks need to be large to account for this variability and to represent marine communities at different scales (Curley et al. 2002, Gladstone 2007). However, the size, area and shape of zones will also depend to some extent on the geography and geomorphology of the area and the size of the marine park.

1.3 THE EAC & REEF FISH IN THE SIMP

1.3.1 The East Australian Current and biotic patterns in the SIMP

The Tweed Moreton bioregion covers part of a transition zone, where tropical waters associated with the southerly flow of the East Australian Current (EAC) overlap and mix with cooler north-flowing counter-currents and localised intrusion of cooler bottom shelf waters (Cresswell et al. 1983, Marchesiello & Middleton 2000, Roughan & Middleton 2004). There is also a 'mix' of tropical and temperate biota, which has long been recognised as an important and diverse biological feature in NSW (Zann 2000). This recognition was demonstrated by public pressure for the Solitary Islands to be declared a marine reserve as early as the 1960's (Pollard 1981), and a principle reason it was eventually declared as the first marine park in NSW. However, actual knowledge and understanding of this 'mix' at the scale of the SIMP, from both a biotic and oceanographic perspective, is poor. Cross-shelf gradients in biota within the SIMP have been described for corals and tropical molluscs with increased species-richness at offshore islands (Veron et al. 1974, Harriott et al. 1994). This is believed to be strongly influenced by cross-shelf variation in the EAC, but this assumption has not been tested. Spatial and temporal variation in the EAC has not been examined within the SIMP at appropriate scales to determine if this is the case. Without a clearer understanding of how the EAC varies in this region, its influence on biodiversity in the SIMP will remain poorly understood. This influence is likely to be complex and not a simple cross-shelf transition given the vagaries of the current at regional and smaller spatial scales (Boland 1979, Cresswell et al. 1983, Lee et al. 2007). Sea temperature is likely to be a suitable proxy to increase understanding of the EAC given strong sea-temperature differentials associated with the EAC and adjacent temperate waters in NSW and the availability of Sea Surface Temperature satellite imagery.

1.3.2 Knowledge of reef fish in the SIMP at the commencement of this study

Reef fish are an important component of the biodiversity in SIMP and should be effectively represented in SZ. This requires knowledge of their patterns of biodiversity, biogeography and assemblage structure at suitable scales. Although there have previously been reef fish studies in the SIMP, they have mainly been checklist inventories determining the presence of species. These include observational / capture / photographic inventories: Dave Pollard (NSW Fisheries) observational diving surveys in the 1970's; Barry Hutchins (West Australian Museum) observational and rotenone surveys in the 1980's; The Solitary Islands Research Group (SURG) photographic guide to fishes in SIMP, and collections by the Australian Museum (e.g. compiled by Rule et al. 2007). These data-sets have contributed to knowledge of species-richness in the SIMP, but have limitations for conservation planning due to their restricted spatial extent at the scale of the SIMP and/or lack of abundance information. There are also extractive records: recreational fishing competition surveys and other recreational fishing surveys (Henry et al. 1996, Schmeissing 1997, Henry & Lyle 2003, Malcolm et al. 2005), and commercial fishery records (Ferrell & Sumpton 1998) which have indicated the species most-targeted/exploited in the SIMP. Again, these data have utility to management but are also limited by not being spatially-linked to a position or grid at a scale suitable for zone planning. There have been a few ecological surveys looking at seasonality of species (Foxall 1997) and physical influences (Harrison 2003) which have contributed to management knowledge, but these studies were at a small spatial scale around a single island. More recently, studies on selected tropical reef fish recruitment (Booth et al. 2007) and UVC monitoring of nearshore reefs (Smith et al. 2006, Smith et al. 2008) have also been conducted at larger geographic scales that include the SIMP. A comprehensive MSc. study of fish assemblages at Julian Rocks and adjacent waters near Cape Byron, ~120 kms further north, recorded 530 fish species (Parker 1999). However, comprehensive surveys of reef fishes at the marine park scale of the SIMP, examining assemblage patterns, community structure, abundance, biogeography, and relationship to environmental and physical factors, had not been conducted prior to this study. At the time this study commenced, 280 species of reef fish were reported from the SIMP (NSW MPA 2000). This was expected to be an underestimate, given an absence of deeper reef surveys and extensive areas of sub-tidal reef not sampled. With identified cross-shelf gradients in other biota, it was suspected there would also be strong patterns in reef fish biodiversity. Therefore, this study is expected to improve biodiversity conservation planning and outcomes within the SIMP, and therefore within NSW as part of the National Representative System of MPAs.

1.4 STUDY AIMS & OBJECTIVES

The primary aim of this study is to assess the utility of habitats and other surrogate approaches in marine conservation planning. To help achieve this, fish assemblages will be comprehensively surveyed on reefs throughout the SIMP to increase understanding of their spatial and temporal patterns. The current HCS used in the SIMP can then be tested using reef fish as the test group. Located within a tropical-temperate transition zone, this study will also increase understanding of the EAC in relation to the SIMP and contribute to knowledge of biogeography and biodiversity, again for utility in conservation planning. Temporal stability in patterns will be examined to ensure they are not ephemeral at the scale of years; more consistent patterns having greater application to planning the arrangement of zones. Assemblages in marine parks in separate bioregions will also be examined to support/challenge expected differences. Differences will emphasise the need to represent assemblages within a bioregion, given they are unlikely to be present elsewhere. This study also aims to further develop the usefulness of surrogate approaches for marine conservation planning, by identifying families that can effectively represent assemblage patterns. Selected reef fish data (including identified surrogate families) and HCS categories applied to seafloor mapping across the SIMP, will be analysed using Marxan. This systematic approach (Marxan) will be used to identify planning units of particular value to biodiversity conservation, complementary to using a representative habitat approach. Overall, this study will facilitate effective planning for biodiversity representation within the SIMP and inform planning the arrangement of zones in other marine parks in NSW and elsewhere.

The specific objectives by Chapter were:

- Chapter 1: To outline the need and background for this study
- Chapter 2: To examine spatial and temporal variation of sea-temperature and SST patterns in the SIMP at a range of scales and interpret these patterns in relation to the East Australian Current (EAC). Put this information in a useable format to explore how the EAC is likely to influence fish diversity and assemblage patterns in this subtropical area.
- Chapter 3: To identify patterns of reef-fish assemblages present in the SIMP and correlate these to the influence of five broad factors (distance-from-shore, depth range, latitude, dominant benthos, attachment to emergent rock) that encompass a range of habitat, ecological and environmental influences. Use the most influential to refine the HCS if appropriate and define criteria for any identified categories. Also determine if spatial patterns are maintained over the temporal scale of years.
- Chapter 4: To compare fish assemblages detected using BRUVS on reef from 15m down to the deepest depths found in the SIMP (75m). Correlate assemblage patterns with five broad factors (distance from shore, depth, dominant benthos, 'reef type', latitude) encompassing a range of habitat, ecological and environmental influences. Use these patterns to test the depth-based HCS

categories: shallow (<25m), intermediate (25m-60m depth) and deep (below 60m depth); and to refine them if appropriate. To increase knowledge of these deeper reef fish assemblages in the SIMP.

- Chapter 5: To examine across-shelf gradients in shallow community structure and biogeography within the SIMP for shallow (<25m) reef fish. This to include gradients in species richness, latitudinal affiliation (e.g. tropical vs temperate) and biogeographic affinity (e.g. endemic vs cosmopolitan species). Examine these gradients for species most-influential in discriminating patterns and for abundant species.
- Chapter 6: To compare assemblage patterns in the SIMP with other marine parks in NSW in separate bioregions using BRUVs, and to test the persistence in an assemblage pattern in the SIMP over the scale of 5 years using this method.
- Chapter 7: To determine if there are suitable surrogate families that will reflect patterns shown by the broader reef fish community in the Solitary Islands Marine Park and for species richness. If identified, apply these to systematic planning (Chapter 8).
- Chapter 8: To assess and compare 'clean slate', optimised, and existing arrangements of sanctuary zones, based on selected representative reef fish and the refined HCS habitat map for the SIMP, using a systematic algorithm method (Marxan).
- Chapter 9: Conclusions: To synthesise findings and their application to the SIMP

CHAPTER 2: Variation in sea temperature and the East Australian Current in the Solitary Islands region between 2001 - 2008

Chapter 2 examines the influence of the East Australian Current within the SIMP and adjacent waters between Ballina and Smokey Cape over various temporal and spatial scales. Historically, there has been little information in the SIMP on the influence of habitat and environmental factors shown to structure reef fish assemblages elsewhere. Studies of other taxa such as hard corals indicate there are strong environmental differences from inshore to offshore. These are assumed to be associated with differences in the influence of the EAC across the continental shelf, resulting in variability in sea temperature and transport of larvae, in combination with habitat availability. This gradient is likely to have a strong influence on spatial patterns of fish assemblages. Sea temperature and Sea Surface Temperature data was therefore quantified to help interpret these patterns and increase understanding of the EAC and colder water intrusions in the SIMP.

Chapter 2 was submitted as a journal article in a Special Issue on the East Australian Current and has been accepted for publication:

Malcolm, HA, Davies, PL, Jordan, A, Smith, SDA (in press) Variation in sea temperature and the East Australian Current in the Solitary Islands region between 2001-2008. **Deep Sea Research II** Special Issue on the East Australian Current.

Statement of Originality:

I certify that the substance of Chapter2 is original work undertaken as part of this study

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Signature

Statement of Contribution:

I certify that the substance of Chapter 2 was undertaken as per the following contributions:

I established the sea temperature monitoring program in the SIMP and have maintained the logger station deployments and data management over the period 2002 - 2008. I did the descriptive analyses on the sea temperature data. Peter Davies developed the SST images and determined average sea temperature from the grids associated with the logger stations. I selected and compared the SST images with sea temperature anomalies. Peter Davies did the spectral analyses. I wrote the initial draft which was finalised through collaborative writing with Peter Davies, Alan Jordan and Stephen Smith.

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Signature (Hamish Malcolm)

Signature (Associate Professor Stephen Smith)

CHAPTER 3: Using patterns of reef fish assemblages to refine a Habitat Classification System for marine parks in NSW, Australia.

Chapter 2 demonstrated a strong oceanographic gradient from inshore to offshore in the SIMP. Therefore a single category for shallow (<25m) reef in the Habitat Classification System is unlikely to effectively represent biotic pattern. This required testing given the importance of the HCS to conservation planning in the SIMP and in other marine parks in NSW.

In Chapter 3, assemblage patterns of shallow reef fishes at broadly dispersed sites across the SIMP were correlated with factors that encompass a range of habitat, environmental, and ecological influences. These correlations were used to indicate which of these factors, most strongly influence these patterns and criteria describing them were defined. Temporal variability in assemblage patterns was also compared over years to assess stability.

Chapter 3 has been published as a journal article:

Malcolm, HA, Smith, SDA, Jordan A (2010) Using patterns of reef fish assemblages to refine a Habitat Classification System for marine parks in NSW, Australia. **Aquatic Conservation: Marine and Freshwater Ecosystems** 20:83-92

Statement of Originality:

I certify that the substance of Chapter 3 is original work undertaken as part of this study

[redacted]

Statement of Contribution:

I certify that the substance of Chapter 3 was undertaken as per the following contributions:

I designed the study, undertook the field work, data entry, data analyses, and constructed the figures. I wrote the initial draft which was finalised through collaborative writing with Stephen Smith and Alan Jordan.

[redacted]

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Signature (Hamish Malcolm)

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Signature (Associate Professor Stephen Smith)

CHAPTER 4: Testing a depth-based habitat classification system against reef fish assemblage patterns in a subtropical marine park.

As shown in Chapter 3, there were strong cross-shelf patterns in shallow reef fish assemblages; the HCS refined accordingly. However, this did not test the suitability of depth criteria defining the shallow (<25) category, nor the intermediate or deep (>60m) categories. Additionally, it was not known if cross-shelf patterns occurred below 25m. Therefore, in Chapter 4, due to the presence of significant areas of reefs below workable SCUBA depths, Baited Remote Underwater Video (BRUV) was used to compare spatial patterns of reef fish from 15 m down to the deepest reef (75 m) occurring in the SIMP. This was conducted on reef mapped using multi-beam swath acoustics, in order to determine variables of interest against which patterns were correlated.

Chapter 4 has been submitted as a journal article, reviewed and accepted with revision. It has now been revised and resubmitted. Awaiting publication decision at the time this thesis was submitted:

Malcolm, HA, Jordan A, Smith SDA (in review) Testing a depth-based habitat classification system against reef fish assemblage patterns in a subtropical marine park **Aquatic Conservation: Marine and Freshwater Ecosystems**.

Statement of Originality:

I certify that the substance of Chapter 4 is original work undertaken as part of this study

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Statement of Contribution:

I certify that the substance of Chapter 4 was undertaken as per the following contributions:

I designed the study, undertook the field work, video analyses, data analyses, and constructed the figures, except Figure 1 by Edwina Mesley and Figure 4, which I designed, but which was constructed by Deb Wall. I wrote the initial draft which was finalised through collaborative writing with Stephen Smith and Alan Jordan.

[redacted]

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CHAPTER 5: Biogeographical and cross-shelf patterns of reef fish assemblages in a transition zone

A strong cross-shelf oceanographic gradient in the EAC and sea temperature was demonstrated in Chapter 2, which supports the findings of studies that have shown cross-shelf gradients in richness of hermatypic corals and tropical representation of molluscs (Veron et al. 1974, Harriott et al. 1994, Smith and Harrison unpublished data). Improved knowledge of cross-shelf patterns in diversity and species biogeography within the SIMP is therefore crucial to effective biodiversity planning.

In Chapters 3 and 4, the HCS categories were tested and refined according to biotic pattern (based on reef fish but this also reflects that of dominant-benthos). This has considerable utility for planning the arrangement of zones. However, greater understanding as to reasons for these patterns and the species driving them will improve this utility. Patterns in biogeography and species-richness on shallow reef, for the full suite of species, abundant species, and for discriminating species were therefore examined in Chapter 5.

Chapter 5 has been published as a journal article:

Malcolm, HA, Jordan, A, Smith, SDA (*2010*) Biogeographical and cross-shelf patterns of reef fish assemblages in a transition zone. **Marine Biodiversity** 40:181-193

Statement of Originality:

I certify that the substance of Chapter 5 is original work undertaken as part of this study

[redacted]

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Signature

Statement of Contribution:

I certify that the substance of Chapter 5 was undertaken as per the following contributions:

I undertook the field work, data entry, data analyses, and constructed the figures. I wrote the initial draft which was finalised through collaborative writing with Stephen Smith and Alan Jordan.

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CHAPTER 6: Spatial and temporal variation in reef fish assemblages of marine parks in NSW, Australia - baited video observations

Chapters 3 & 4 demonstrated that assemblages vary cross-shelf and with depth, with utility for representative planning within the SIMP. However, it is possible these assemblages may be represented in marine parks in other bioregions in NSW. Although bioregional differences are expected, these require testing. Additionally, existing bioregional boundaries may change as further information is gained (DEH 2006). Confirmation of bioregional differences in various studies will strengthen the validity of bioregions as a regional planning tool.

In Chapter 6, Baited Remote Underwater Video (BRUV's) was used to compare assemblage patterns detected in the SIMP with those in marine parks in other bioregions in NSW, determined by other studies (Steve Lindfield, Honours Study - Port Stephens Great Lakes Marine Park; James Wraith, Honours Study – Jervis Bay Marine Park) using the same sampling design. Additionally, the use of BRUVs as a standard survey method for sampling fish assemblages was a recent development (Cappo et al. 2004) with considerable application but a current need for development and assessment. An examination of the stability in temporal patterns detected using baited video had not been reported in the literature before this study. Confirmation of stability in assemblage patterns over the scale of years also increases their valid use in planning.

Chapter 6 has been published as a journal article:

Malcolm HA, Gladstone W, Lindfield S, Wraith J, Lynch TP (2007) Spatial differences and temporal stability in reef fish assemblages of marine parks in New South Wales, Australia - baited video observations. **Marine Ecology Progress Series** 350:277-290

Statement of Originality:

I certify that the substance of Chapter 6 is original work undertaken as part of this study

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Signature

Statement of Contribution:

I certify that the substance of Chapter 6 was undertaken as per the following contributions:

I undertook the design, field sampling and video analysis of BRUVS in the SIMP 2002 - 2006. The sampling and video analysis of BRUVs in the Port Stephens Great Lakes Marine Park was undertaken by Steven Lindfield and William Gladstone as part of Stevens' Honours study. The sampling and video analysis of BRUVs in the Jervis Bay Marine Park in 2005 was undertaken by James Wraith and Tim Lynch as part of James' Honours study. The PERMANOVA and SIMPER analyses between marine parks were undertaken by William Gladstone. The univariate analyses were undertaken by James Wraith. I did the multivariate temporal analyses within SIMP. All authors contributed equally to the structure and write-up of this journal paper.

[redacted]

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Signature (Hamish Malcolm)

[redacted]

Signature (Associate Professor Stephen Smith)

CHAPTER 7: Objective selection of surrogate families to describe reef fish assemblages in a subtropical marine park

This study will also test the usefulness of some surrogate approaches for marine conservation planning. In addition to testing and refining the HCS as a surrogate for representing biotic pattern in Chapters 3 and 4, there is potential utility for identifying fish surrogates that effectively describe overall fish assemblage patterns. Fish surrogates may have application for examining biodiversity patterns; as diversity indicators to help evaluate spatial and temporal changes due to marine park management; to increase efficiency of diver surveys; and to undertake systematic planning.

In Chapter 7 the suitability of different families as surrogates to represent assemblage patterns and estimate species richness were assessed.

Chapter 7 has been published as a journal article:

Malcolm HA, Smith, SDA (2010). Objective selection of surrogate families to describe reef fish assemblages in a subtropical marine park. **Biodiversity and Conservation**. 19:3611-3618

Statement of Originality:

I certify that the substance of Chapter 7 is original work undertaken as part of this study

[redacted]

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Signature

Statement of Contribution:

I certify that the substance of Chapter 7 was undertaken as per the following contributions:

This study was based on similar work undertaken by Associate Professor Stephen Smith on molluscs as a surrogate. I undertook the field work, data entry, data analyses, and constructed the figures. I wrote the initial draft which was finalised through collaborative writing with Stephen Smith.

[redacted]

....

Signature (Hamish Malcolm)

[redacted]

Signature (Associate Professor Stephen Smith)

CHAPTER 8: Representing reef fish and habitat in a marine park: comparing 'no take' zoning options using Marxan

Although representing habitat is an important mechanism for conservation planning in NSW marine parks, there are constraints in this approach. Systematic planning using broad-scale biodiversity data can increase the efficiency and effectiveness of zoning in meeting representation goals and complement the representative-habitat approach. The refined HCS (Chapters 3, 4) and improved seabed mapping in the SIMP provides an opportunity to systematically examine representation of habitat categories within zones using Marxan. The comprehensive fish surveys provide an opportunity to evaluate whether a habitat-only approach effectively identifies areas with specific aspects of species diversity and conservation value. Planning units that could most efficiently improve representation at different representative target levels were identified. This has not previously been conducted within NSW marine parks and case-studies at this scale (870 km^2) are scant. Thus, Chapter 8 has implications for Marxan use in other marine parks in NSW, and more broadly.

Chapter 8 has been written as a journal article to be submitted to Biodiversity and Conservation, but has not yet been submitted:

Malcolm HA, Mesley E, Jordan A, Davies PL, Ingleton T, Hessey S, Pressey RL, Smith SDA (to be submitted) Representing reef fish and habitat in a marine park: comparing 'no take' zoning options using Marxan. **Biodiversity and Conservation**.

Statement of Originality:

I certify that the substance of Chapter 8 is original work undertaken as part of this study

[redacted] ....

Statement of Contribution:

I certify that the substance of Chapter 8 was undertaken as per the following contributions:

Initial scoping of this study was undertaken by Steve Smith, Bob Pressey and me. I undertook all the fish sampling, fish data entry and species selection. The habitat mapping was undertaken by the Habitat Mapping Group in DECCW, which includes Peter Davies, Tim Ingleton, Edwina Mesley and Alan Jordan. The GIS analyses that determined the relevant tables and layers needed to run the various Marxan analyses were carried out by Edwina Mesley. Edwina also determined the existing proportion of each HCS category in SZ. I ran the various Marxan analyses. I wrote the initial draft except for the section on GIS methods (Edwina Mesley), which was finalised through collaborative writing with Edwina Mesley, Alan Jordan, Tim Ingleton, Steve Smith and Sam Hesse.

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Signature (Hamish Malcolm)

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Signature (Associate Professor Stephen Smith)

CHAPTER 9: Conclusions

The Solitary Islands Marine Park contains a diverse reef fish fauna, enriched by its position within a tropical temperate transition zone with more than 550 reef fish species now recorded from the SIMP in total. Over 330 species (Appendix 3) were recorded during this study, 90% rarely, broadly sampled across the extent of reef. Overall, the influence of the East Australian Current (EAC) was strong with more than 50% of these tropical, although the most-abundant were predominantly temperate or subtropical.

Habitat is often used as a surrogate for biodiversity in marine conservation planning, as is the case in NSW. However, the validity for this requires testing. This study has demonstrated the utility of linking patterns of biota, in this case reef fish, to habitat categories. This has advanced the larger study of marine conservation planning. Reef-fish assemblage patterns were used to refine the Habitat Classification System (HCS) used in the SIMP. There were distinct cross-shelf patterns in shallow assemblages determined using diver timed-counts and these discontinuities were used to refine 3 HCS categories for shallow reef (<25m deep): inshore <1.5 km; mid-shelf; and offshore >6 km from the mainland coast. The inshore category supported more temperate species and the highest proportion of endemics. The offshore category had the strongest tropical Indo-Pacific influence and the highest species-richness, particularly adjacent to islands. Many east-coast subtropical endemics were only recorded on mid-shelf reefs. This corresponds with strong cross-shelf variation in the EAC demonstrated by sea temperature patterns, with the warmer EAC more-frequently influencing the SIMP in offshore waters and colder counter-currents and cold water intrusions more frequently inshore. However, this strong influence on tropical species offshore weakened with depth.

There were also distinct assemblage patterns with depth determined from Baited Remote Underwater Video (BRUV) surveys and previous HCS depth categories were largely supported by the new data. Intermediate-depth assemblages separated from shallow at 25m, with intermediate assemblage patterns strongly influenced by temperate and subtropical species. Intermediate-depth assemblages still showed a cross-shelf pattern, although weaker than for shallow. There was also some gradation in structure between sites in 30-40m and those in 40-50m. Deep reefs are only found offshore (>6 km from the mainland coast), and occur down to the deepest sections of the SIMP in about 75 m. Assemblages from deep reefs separated from those on intermediate reefs, but this occurred at 50 m rather than the previous criteria of 60 m; the HCS was refined accordingly.

From this research, it is apparent that the initial HCS, used in the 2002 rezoning of the SIMP, did not effectively represent biological patterns, at least not for reef fish. There is now a tested relationship between the HCS and biotic pattern (Figure 1).

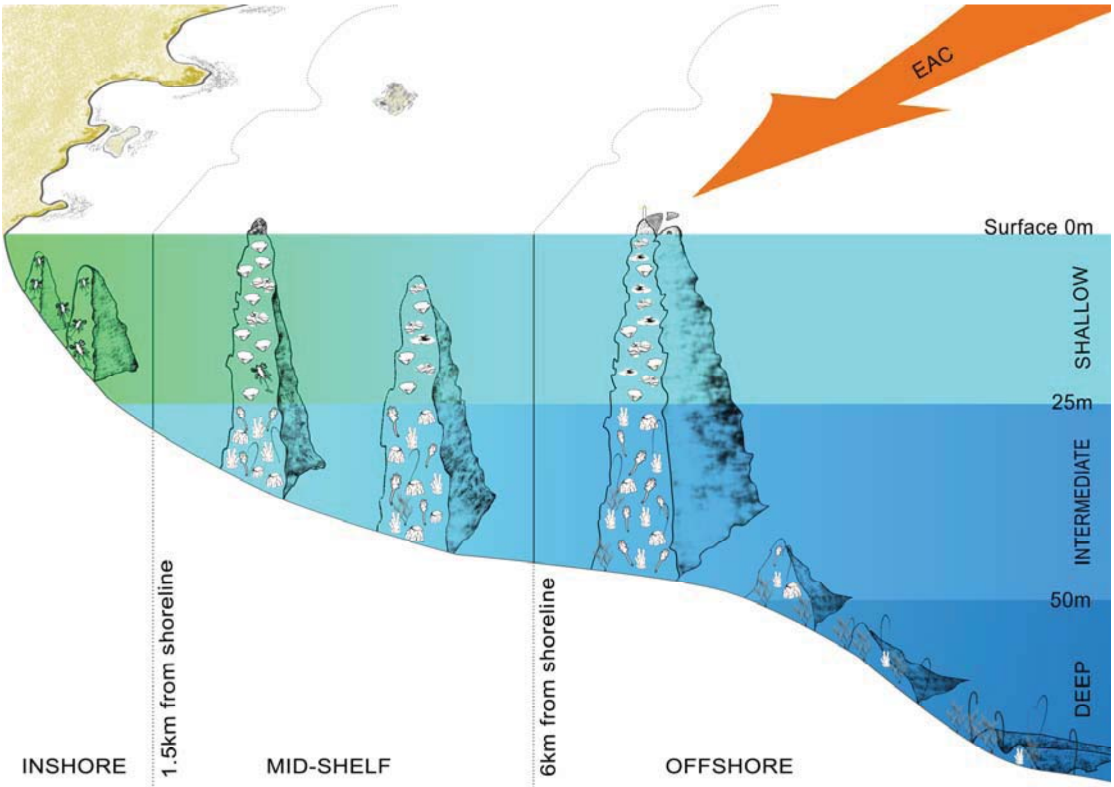

Figure 1: Refined Habitat Classification System for the Solitary Islands Marine Park

All the refined HCS reef categories have some unique biodiversity values in terms of representing assemblages of species, individual species, abundance of species, and biogeographic influences. These values are likely to persist through time as assemblage patterns, from timed counts and BRUV's, were found to be stable at the marine park scale over the scale of years. This refined HCS is therefore an important tool for the zoning review currently in progress as at October 2010 (NSW MPA 2009). Inclusion of all categories in sanctuary zones, preferably replicated, would achieve a more representative zoning system for biodiversity, consistent with CAR (Comprehensive, Adequate, Representative) principles under the National Representative System for Marine Protected Areas (NRSMPA). Ideally sanctuary zones in the intermediate depth category should cover the full range of depths within that category. No deep reef (0%) is currently represented within SZ.

The assemblage recorded in the SIMP was different from marine parks in bioregions further south, supporting this regionalisation defined under the NRSMPA. Some groups of species were more prevalent or only recorded in the SIMP including some of the subtropical endemic species. This supports the need for effective representation of biota and habitats within the SIMP as part of a network of marine protected areas in NSW and Australia, given marine parks in other bioregions are unlikely to fill gaps in representing assemblages and individual species.

Reliable data on the distribution of key taxa is essential for conservation planning. However, surveying the full suite of reef fish species can be challenging and logistically constrained. Using subsets of taxa, or surrogates, that reliably reflect patterns of the broader assemblage, can facilitate this process. From this study, the two most diverse families in the SIMP were the wrasse (Labridae) and the damselfishes (Pomacentridae), which comprise about 25% of overall species richness. These two families combined, closely reflect spatial patterns shown by the full assemblage in shallow (<25m) waters. They are an effective surrogate to represent assemblage patterns of reef fish but were not so effective at predicting relative species richness. They cover a range of trophic groups and include a mix of tropical and temperate species. Their use as surrogates in the Solitary Islands Marine Park and elsewhere in the subtropics has great potential to assist in systematic planning. Identification of suitable biodiversity surrogates is an important tool for marine biodiversity conservation and this study has advanced this field.

Knowledge about deeper reef habitats has increased considerably in the SIMP and SIMR since they were last zoned, with swath-acoustic backscatter and bathymetry mapping using interferometric sidescan sonar. The refined HCS, in combination with improved swath-acoustic mapping, was used to further evaluate representation in sanctuary zones during the current review of the zoning plan. This was done using simple comparisons with previous classifications, as well as more systematically using Marxan. If overall representation is to be increased from the current 12% in the SIMP (10% SIMP + SIMR combined), Marxan analyses have identified some areas outside of current SZ, which should be considered in future planning. In particular, areas of deeper habitat should be included in SZ with a large cross-shelf transect in at least one (or both) of the two positions that the SIMP is the broadest (around the latitude of South Solitary Island and the latitude of North Solitary Island). If the current zoning plan was not in place, a cross-shelf transect through either would be as-efficient to achieve 20% representation of the HCS and reef fish species. With the current arrangement of zones the most-efficient change to achieve 20% representation may be to establish a large southern SZ, although this may be biased by a constraint in the method and does not consider social or economic costs. To achieve 30% representation, both would be required for the most-efficient solution.

Both habitat mapping, across the entire SIMP using the refined HCS, and fish data from the various surveys in this study, was used in the Marxan analyses. This study has demonstrated the relative effectiveness of using habitats and/or species data for conservation planning. The combination of habitat and fish was more effective at capturing known 'hotspots' of species richness than the habitat mapping alone in generating solutions. Fish data alone was too constrained for the purposes of systematic planning at the marine park scale, but was informative about species representation in the current sanctuary zones. From Marxan analyses, about 23% of the (500 m x 500 m) planning units with fish data available would be required to represent 20% of the relative abundance of all species analysed. The existing zoning arrangement represents the relative abundance of most individual reef fish species within sanctuary zone at the current level (10%), although some are not represented. These are mainly deeper reef species.

Under the refined HCS, deep reef (0%) and intermediate offshore reef (1%, most <40m depth) are markedly under or unrepresented in sanctuary zones relative to other categories. However, percentage representation must be considered with caution for other categories, especially where they are limited in extent (e.g. shallow offshore reef 1.15 km^2). In this case a small area (0.4 km^2) can represent a high proportion of that category (SZ = 35%), even though these SZs are small and narrow (≤200 m wide) in extent. Therefore a range of information should be examined in conjunction when considering biodiversity / habitat representation and the arrangement of zones. Additional to identification of under-represented categories, examination of community structure at the site level, combined with preliminary Marxan analysis, has also identified sites with high value and irreplaceability for overall protection of biodiversity. Overall, this study emphasises the importance of effective systematic planning being undertaken early in the development of marine protected areas in order to maximise representation for the amount of area protected in 'no take' zones.

These results are currently (as at October 2010) informing a review of the SIMP Zoning Plan (NSW MPA 2009). Subsequent reviews of the SIMP are to be undertaken every ten years. Advances in scientific techniques, technology and software (including a combination of BRUVS, swath-acoustic mapping, multivariate and Marxan analyses), which have become available since the previous reviews in SIMR (2001) and SIMP (2002), have greatly increased knowledge of habitat and reef fish biodiversity in this area as well as our ability to address specific questions that are relevant to management; such advances are likely to continue into the future. This case study provides an example of 'evolving science further informing management' and highlights the value of updating management strategies, at the sub-decadal to decadal scale, as new data and knowledge are gained.

Some future research needed in the SIMP includes: greater understanding of upwelling processes in relation to the EAC and potential implications of a strengthening EAC on fish assemblages; increased understanding of temporal variation at a range of scales; increased knowledge of ecological processes, in particular recruitment and migration and functional redundancy; and knowledge of the unconsolidated sediment fish fauna. Ongoing fine-scale habitat mapping is also required to improve systematic conservation planning.

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APPENDICES

Appendix 1a: Timed count Sites
Appendix 1b: Timed count surveys
Appendix 2a: BRUV sites used to test depth-based HCS categories
Appendix 2b: BRUV replicates used to test depth-based HCS categories
Appendix 3: Comparison of BRUV assemblages between 3 marine parks
Appendix 4: Checklist of reef fish species in the SIMP recorded during this study and average relative abundance by refined HCS category

Appendix 1a. Timed count sites

Site No.	Location	Site	Latitude	Longitude	min depth (m)	max depth (m)	Depth range (m)	Dist. from coast (km)	dominant benthos	reeftype	position
1	**North Solitary**	**Anemone Bay**	29.92251	153.38883	8	21	13	11.4	coral + anemones	emergent	offshore
2	**North Solitary**	**Elbow Cave**	29.93012	153.39028	5	18	13	11.1	coral + sessile invertebrates	emergent	offshore
3	North Solitary	Bubble Cave	29.927	153.38629	5	19	14	11.3	coral + anemones	emergent	offshore
4	North Solitary	Eastern side	29.92507	153.39033	12	25	13	11.6	coral + sessile invertebrates	emergent	offshore
5	**NW Rock**	**Fish Soup**	29.91297	153.3842	7	15	8	10.81	sessile invertebrates	emergent	offshore
6	**NW Rock**	**West side**	29.91273	153.38335	7	13	6	10.8	coral + sessile invertebrates	emergent	offshore
7	**South Solitary**	**north end**	30.20196	153.26748	8	20	12	7.76	coral + sessile invertebrates	emergent	offshore
8	South Solitary	Manta Arch	30.20262	153.26806	15	25	10	7.91	sessile invertebrates	emergent	offshore
9	South Solitary	E Side	30.20517	153.26784	13	25	12	7.94	sessile invertebrates	emergent	offshore
10	South Solitary	Buchanans Wall	30.20671	153.2661	8	18	10	7.83	coral + sessile invertebrates	emergent	offshore
11	**Split Solitary**	**turtle mooring**	30.24107	153.17793	7	14	7	2.3	coral + sessile invertebrates	emergent	mid
12	Split Solitary	Shark gutter	30.24046	153.18342	7	14	7	2.8	coral + sessile invertebrates	emergent	mid
13	Split Solitary	Pomfrey Point	30.23811	153.1814	8	13	5	2.6	coral + sessile invertebrates	emergent	mid
14	**Groper Is.**	**northern side**	30.15939	153.22572	6	14	8	1.9	coral + sessile invertebrates	emergent	mid
15	Groper Is.	Eastern side	30.15914	153.22804	10	15	5	2.2	coral + sessile invertebrates	emergent	mid
16	Groper Is.	SW corner	30.1624	153.2246	6	12	6	1.9	sessile invertebrates	emergent	mid
17	**NW Solitary**	**Tall Timbers**	30.01771	153.26829	6	14	8	5	coral + sessile invertebrates	emergent	mid
18	NW Solitary	E Gutters	30.01976	153.27137	5	17.5	12.5	5.3	complex sand gutters and rock ridges	emergent	mid
19	**Wrights Reef**	**Wrights Reef**	30.01248	153.29812	18	30	12	7.26	sessile invertebrates	submerged	offshore
20	Pimpernel Rock	Cave to Peak	29.69807	153.39742	10	30	20	6.7	mixed sessile invertebrates	submerged	offshore
21	**Hitlers Bommie**	**north side**	29.91484	153.38693	7	30	23	11.06	coral + sessile invertebrates	submerged	offshore
22	Hitlers Bommie	west end	29.91441	153.3862	10	20	10	10.97	coral + sessile invertebrates	submerged	offshore
23	**Black Rock**	**Black Rock**	30.20062	153.25665	8	18	10	6.74	sessile invertebrates	submerged	offshore
24	**Wash (South Sol)**	**SE side**	30.19989	153.25223	8	30	22	6.37	sessile invertebrates	submerged	offshore
25	40 Acres	40 Acres w side	30.20133	153.21393	9	17	8	3.35	coral + sessile invertebrates	submerged	mid
26	**40 Acres**	**Site 1**	30.20422	153.21272	8	20	12	3.56	coral + sessile invertebrates	submerged	mid
27	40 Acres	SE corner	30.20271	153.21755	10	17	7	3.75	coral + sessile invertebrates	submerged	mid

28	40 Acres	northern side	30.20151	153.21629	8	17	9	3.56	coral + sessile invertebrates	submerged	mid
29	**Surgeons Reef**	**mooring**	30.00762	153.27045	5	14	9	4.5	coral + sessile invertebrates	submerged	mid
30	Trag Reef	Trag Reef	30.28129	153.19794	14	20	6	4.94	sessile invertebrates	submerged	mid
31	**Split Bommie**	**Cell Rock**	30.23968	153.19502	7	17	10	3.97	coral + sessile invertebrates	submerged	mid
32	Split Bommie	Jefferey Shoal	30.2498	153.20104	10	21	11	4.72	sessile invertebrates	submerged	mid
33	Split Bommie	west end	30.24027	153.19282	10	17	7	3.72	sessile invertebrates	submerged	mid
34	Red Rock Reef	Red Rock Reef	30.00382	153.23579	6.5	11	4.5	1.5	sessile invertebrates, macroalgae,coral	submerged	inshore
35	Dougherties Wash	amphitheatre	29.94543	153.27849	5	11	6	1.84	sessile invertebrates	submerged	mid
36	Doherties Wash	Exposed	29.94498	153.28008	5	11	6	1.9	coral + sessile invertebrates	submerged	mid
37	Moonee Bombie I	Moonee Bombie I	30.22037	153.1824	11	16	5	1.93	macroalgae + sessile invertebrates	submerged	mid
38	Marsh Shoal	Marsh Shoal	30.25723	153.17018	11	17	6	2.6	macroalgae + sessile invertebrates	submerged	mid
40	Korora	Lobster Rocks	30.26195	153.14596	5	8	3	0.67	macroalgae + sessile invertebrates	submerged	inshore
41	**Muttonbird Island**	**North Side**	30.30337	153.15103	3	11	8	0.1	macroalgae + sessile invertebrates	emergent	inshore
42	**Flat Top Point**	**eastern side**	30.13087	153.21104	5	10	5	0.1	macroalgae + sessile invertebrates	emergent	inshore
43	Woolgoolga Reef	nw side	30.09504	153.20655	4	8.5	4.5	0.56	macroalgae + sessile invertebrates	emergent	inshore
44	**Woolgoolga Reef**	**eastern side**	30.09622	153.20864	5	10	5	0.79	macroalgae + sessile invertebrates	emergent	inshore
45	Diggers Camp Headland	north side platform	29.81238	153.29322	2	5	3	0.1	macroalgae + sessile invertebrates	emergent	inshore
46	Diggers Camp Headland	one-tree point	29.82894	153.29478	7	12	5	0.4	macroalgae + sessile invertebrates	emergent	inshore
47	Minnie Waters	lagoon	29.77091	153.30222	2	4	2	0.1	macroalgae + *Zostera* seagrass	emergent	inshore
48	Park Beach Bommie	all round	30.29577	153.15292	6	12	6	0.89	macroalgae + sessile invertebrates	submerged	inshore
49	Chopper Rock	Chopper Rock	30.00804	153.25614	7	15	8	3.39	coral + sessile invertebrates	submerged	mid
50	North Rock	SE Corner	29.97776	153.26042	6	14	8	2.06	macroalgae + sessile invertebrates	emergent	mid
51	Barcoongerie Shoal	Shingle Break	29.92066	153.27641	4	8.5	4.5	0.53	macroalgae + sessile invertebrates	emergent	inshore
52	Barcoongerie Shoal	seaward	29.92631	153.28013	4	10	6	1.13	sessile invertebrates	submerged	inshore
53	Barcoongerie Shoal	northern side	29.92631	153.28013	7	10	3	0.53	sessile invertebrates	emergent	inshore
54	Pebbly Beach Reef	North end Pebbly	29.93747	153.2637	4.5	8.5	4	0.2	sessile invertebrates	submerged	inshore
55	McAuleys Reef	McAuleys Reef	30.28177	153.16313	10	15.5	5.5	1.62	macroalgae + sessile invertebrates	submerged	inshore
56	Emerald Beach	Look at Me Know	30.1773	153.19375	4	9	5	0.1	macroalgae + sessile invertebrates	emergent	inshore
57	Bare Bluff	SE of headland	30.15751	153.20852	4	9	5	0.1	macroalgae + sessile invertebrates	emergent	inshore
58	Arrawarra Headland	end of headland	30.05965	153.20749	4	7	3	0.1	macroalgae + sessile invertebrates	emergent	inshore
59	Bar 2	Bar 2	29.90844	153.27464	7	11	4	0.25	macroalgae + sessile invertebrates	submerged	inshore
60	Bar 3	Bar 3	29.90142	153.27636	7	9	2	0.3	macroalgae + sessile invertebrates	submerged	inshore
61	Jones Point	northern side	29.89057	153.2754	3	6	3	0.1	sessile invertebrates	emergent	inshore
62	Mulloway Headland	end of headland	30.07653	153.20793	3.5	7	3.5	0.1	macroalgae + sessile invertebrates	emergent	inshore

63	Woolgoolga Headland	end of headland	30.10994	153.21614	6	9	3	0.1	macroalgae + sessile invertebrates	emergent	inshore
64	Reef 5518	UVC-15	29.92453	153.29635	12	18	6	2.46	coral, sessile invertebrates and kelp	submerged	mid
65	Sandon Shoals	UVC - 11	29.71228	153.34972	7	15	8	3.45	sessile invertebrates	submerged	mid
66	Sandon Shoals	UVC - 12	29.7112	153.34529	7	17	10	3.13	sessile invertebrates	submerged	mid
67	Corindi	pipeclay reef	30.01892	153.21633	6	10	4	0.6	macroalgae + sessile invertebrates	submerged	inshore
68	Diggers Headland	end of headland	30.27105	153.14923	6	12	6	0.1	macroalgae + sessile invertebrates	emergent	inshore
69	Saphire Reef	southern reef	30.24353	153.15463	3	9	6	0.57	macroalgae + sessile invertebrates	submerged	inshore
70	McAuleys Headland	end of headland	30.27844	153.1487	3	8	5	0.1	macroalgae + sessile invertebrates	emergent	inshore
71	Little Muttonbird Is.	eastern side reef	30.29592	153.14588	3	8.5	5.5	0.56	macroalgae + sessile invertebrates	emergent	inshore

Appendix 1b. Timed count surveys

Site No	Location	Site	Date	Start time	# Spp.	Conditions (wind, sea/swell)	Vis (m)	Depth range (m)	Current
1	North Solitary	Anemone Bay	20/06/2001	11:00	80	10 knot NW	17	12 to 23	nil
1	North Solitary	Anemone Bay	14/07/2001	9:40	72	10 knot NW	20	13 to 19	mod E
1	North Solitary	Anemone Bay	12/12/2001		73	1.5m swell, raining	12	12 to 20	north
1	North Solitary	Anemone Bay	6/04/2002		76	20 knot S	15	9 to 20	nil
1	North Solitary	Anemone Bay	5/03/2003	9:45	67	2m swell	17	9 to 23	light
1	North Solitary	Anemone Bay	13/02/2004	12:30	77	15 knot NE,1m NE	12	8 to 22	light SW
1	North Solitary	Anemone Bay	4/02/2005	11:30	85	10 knot NE, 1.5m	30	8 to 21	mod SW
2	North Solitary	Elbow Cave	24/04/2001	12:00	66	10 knots NW	15	5 to 13	low
2	North Solitary	Elbow Cave	21/09/2001		66	10 – 12 knot SE, 1.5m	10	8 to 20	v. light
2	North Solitary	Elbow Cave	15/03/2003	10:30	64	15kn SE, 1m	15	6 to 14	nil
2	North Solitary	Elbow Cave	6/02/2004	14:30	71	calm	30	6 to 15	nil
2	North Solitary	Elbow Cave	21/01/2005	9:50	76	12 - 15 knot,	20	5 to 18	S
3	North Solitary	Bubble Cave	24/04/2001	10:10	76	calm	15	5 to 19	low
4	North Solitary	Eastern side	11/05/2005	10:40	70	calm	30	12 to 25	light S
5	NW Rock	Fish Soup	20/06/2001	12:30	72	light surge	15	6 to 14	light
5	NW Rock	Fish Soup	14/07/2001	11:40	75	10 knot NW, 0.5m	14	9 to 15	light
5	NW Rock	Fish Soup	9/04/2003	12:50	63	15 kn SE, 1.5m	15	8 to 16	light
5	NW Rock	Fish Soup	6/02/2004	12:15	67	calm	30	7 to 15	light S
5	NW Rock	Fish Soup	12/02/2005	10:25	53	calm	15	6 to 16	nil
6	NW Rock	W side	20/06/2001	13:05	57	12 knot NW, choppy	15	6 to 10	nil
6	NW Rock	W side	9/04/2003	13:20	61	15kn SE, light surg	12	8 to 12	nil
6	NW Rock	W side	6/02/2004	12:50	71	calm	30	7 to 13	nil
6	NW Rock	W side	12/02/2005	11:00	68	calm	15	5 to 14	nil
7	South Solitary	N end	17/04/2001	14:20	54	calm, 1m	15	10 to 19	nil
7	South Solitary	N end	11/09/2001	10:10	59	10 – 15 knot NE	12	8 to 18	mod SW
7	South Solitary	N end	14/02/2002		57	light wind, 1m	20	16 to 8	light NW
7	South Solitary	N end	24/09/2002	14:25	60	15 knot NE	15	8 to 18	mod SW
7	South Solitary	N end	29/01/2003	11:30	71	10knot NE, calm	15	6 to 18	light S
7	South Solitary	N end	27/01/2004	11:50	65	calm	12	6 to 17	mod SE
7	South Solitary	N end	22/01/2005	10:50	71	15-20 knot S, 1.5m	25	8 to 20	mod S
8	South Solitary	Manta Arch	17/04/2001	12:10	47	calm, 1m	13	15 to 25	low
9	South Solitary	E Side	18/04/2001	15:25	57	calm, 0.5m	6	14 to 20	low
9	South Solitary	E Side	13/04/2005	9:45	60	15 to 20 knot SE, 1m	20	13 to 25	light S
10	South Solitary	Buchanans	30/01/2001	12:50	40	light northerly, 1m	11	9 to 15	low
10	South Solitary	Buchanans	1/05/2003	10:30	53	light	12	8 to 15	light S
10	South Solitary	Buchanans	3/03/2005	13:30	55	1m	13	8 to 18	light
11	Split Solitary	turtle	22/06/2001	9:15	48	10 knot SE 0.5m	8	8 to 15	nil
11	Split Solitary	turtle	13/02/2003	14:35	45	15 kn NE, 1.5m	10	6 to 15	nil
11	Split Solitary	turtle	14/01/2004	10:45	51	<10 knots, 1m	12	7 to 15	light
11	Split Solitary	turtle	20/01/2005	13:05	36	15 to 20 knots, 1.5m	10	7 to 14	light S
12	Split Solitary	E side	7/12/2001	10:50	38	calm, 1.5m	8	8 to 12	
12	Split Solitary	E side	27/04/2005	9:30	36	<10 knots, 1.5	15	7 to 14	light S
13	Split Solitary	Pomfrey Pt	12/05/2001	14:00	38	15 knots, 1.5m	7	8 to 15	low
13	Split Solitary	Pomfrey Pt	12/04/2005	10:40	34	1.5m swell E	10	8 to 13	mod SW
14	Groper Is.	N side	12/05/2001	9:50	51	10 knots, 1m	7	7 to 15	low
14	Groper Is.	N side	25/01/2003	9:25	52	calm	6	6 to 13	nil
14	Groper Is.	N side	27/01/2004	10:00	41	calm	6	6 to 14	light SE
14	Groper Is.	N side	20/01/2005	11:20	50	15 knots NW, 1.5m	14	6 to 14	nil
15	Groper Is.	E side	12/05/2001	12:30	30	1.5m	7	10 to 15	low
15	Groper Is.	E side	3/03/2005	12:00	51	light winds, 1.5m	12	10 to 15	mod S
16	Groper Is.	SW corner	27/04/2005	11:15	47	SE <10 knots, 1m	15	6 to 12	nil
17	NW Solitary	Tall Timbers	17/05/2001	15:00	51	V calm	15	6 to 13	low
17	NW Solitary	Tall Timbers	13/02/2003	12:55	54	15 to 20 kn SE, 1.5m	12	6 to 15	nil
17	NW Solitary	Tall Timbers	10/02/2004	12:30	59	10 knots NE, 1m	12	6 to 16	mod S

						NE			
17	NW Solitary	Tall Timbers	2/03/2005	12:00	58	15 kn NE, 1 m	14	6 to 14	nil
18	NW Solitary	E Gutters	11/05/2003	10:30	48	calm	10	5 to 18	nil
19	Wrights Reef		13/02/2003	9:50	37	calm	20	18 to 30	nil
19	Wrights Reef		13/02/2004	10:00	45	1m sea from NE	12	18 to 30	mod S
19	Wrights Reef		2/03/2005	10:20	40	1m swell, 15 kn NW	10	18 to 30	light S
20	Pimpernel Rk	Cave to Peak	27/04/2001	13:00	49	calm	20	10 to 35	low
20	Pimpernel Rk	Cave to Peak	23/07/2003	9:30	44	NE 15kn, 1m	18	10 to 35	strong-S
20	Pimpernel Rk	Cave to Peak	9/06/2004	13:10	50	calm	8	10 to 33	nil
21	Hitlers Bom	N side	9/04/2003	10:00	56	10 kn SE,1 - 1.5m	20	10 to 22	light
21	Hitlers Bom	N side	6/02/2004	10:25	49	calm	30	7 to 21	light S
21	Hitlers Bom	N side	11/05/2005	12:30	46	10 kn 1.0 m	20	10 t0 22	strong S
22	Hitlers Bom	W end	9/04/2003	11:50	59	10 kn SE, 1.5m	20	10 to 20	light
23	Black Rock		25/01/2003	11:00	43	calm	12	8 to 17	nil
23	Black Rock		23/01/2004	11:00	39		15	18 to 8	mod S
23	Black Rock		22/01/2005	13:00	47	15 knot SE, 1.5m	14	8 to 18	mod S
24	Wash	S side	11/05/2003	8:45	37	calm	14	5 to 29	mod S
24	Wash	S side	23/01/2004	9:40	40	<10kn NE, 1.0m sea	12	6 to 28	mod S
24	Wash	S side	1/03/2005	10:00	42	< 10 knots, 1.5m SE	15	8 to 30	mod N
25	40 Acres	W side	7/06/2001	11:30	51	10 knot NE, 1m	15	9 to 17	low
26	40 Acres	SW corner	29/01/2003	9:00	42	calm	8	8 to 20	light
26	40 Acres	SW corner	3/02/2004	10:00	41	10 knots SE, 0.5m	15	10 to 18	light SE
26	40 Acres	SW corner	20/01/2005	9:40	33	10 knots, 1.5m	14	8 to 20	light S
27	40 Acres	SE corner	3/03/2005	9:20	42	calm, 1.5m NE	10	10 to 17	nil
28	40 Acres	northern side	15/04/2005	9:40	36	<10 knots, 1.5m SE	12	8 to 17	light S
29	Surgeons Rf	mooring	13/02/2003	11:45	42	big swell	15	6 to 17	nil
29	Surgeons Rf	mooring	10/02/2004	10:25	47	1m NE	12	6 to 15	mod S
29	Surgeons Rf	mooring	21/01/2005	12:10	45	1m, 15kn NE	10	5 to 14	nil
30	Trag Reef	Trag Reef	15/08/2001	12:00	41	10 knot NE, 1m	15	14 to 20	mod
31	Split Bommie	Cell Rock	7/06/2001	13:00	38	15 kn NE, squalls,1m	10	15 to 9	low
31	Split Bommie	Cell Rock	31/10/2001		28	Calm, 0.5m	5	14 to 8	mod S
31	Split Bommie	Cell Rock	11/04/2003	9:55	42	15kn SE, 1.5m	10	16 to 7	mod N
31	Split Bommie	Cell Rock	14/01/2004	9:30	34	<10 knot NE, 1m	12	17 to 9	mod S
31	Split Bommie	Cell Rock	1/03/2005	11:45	42	10 kn 1.5m	12	7 to 17	nil
32	Split Bommie	Jefferey Shoal	11/09/2001	12:50	33	15 knot NE	11	8 to 18	light S
32	Split Bommie	Jefferey Shoal	15/04/2005	11:30	40	10 kn SE 1.5m SE	12	21 to 10	light S
33	Split Bommie	W end	12/04/2005	12:30	35	1m E	10	10 to 17	light S
34	Red Rock Rf		21/02/2002	9:40	39	10 – 12 knot NE – NW	12	6 to 11	minimal
35	Doherties	amphitheatre	21/02/2002	13:15	50	10 – 12 knot N, 0.5m	12	5 to 11	light
35	Dougherties	amphitheatre	11/05/2003	14:00	41	light swell	7	5 to 10	light
36	Doherties	exposed	21/02/2002	11:15	45	10 – 15 knot NE, 0.5m	12	5 to 11	light S
37	Moonee Bom	Bombie I	11/04/2002	9:45	31	< 5 knot, calm	13	11 to 16	light S
38	Marsh Shoal		11/04/2002	11:15	37	< 5 knot SE, calm	14	11 to 17	
40	Korora	Lobster Rks	11/04/2003		29	10kn SE, 1m swell	4	5 to 8	nil
41	Muttonbird	N Side	20/02/2002		32	0.5m swell, light NE	10	5 to 13	light
41	Muttonbird	N Side	21/08/2002		26	calm	8	3 to 12	nil
41	Muttonbird	N Side	16/01/2003		37	10 kn SE	8	3 to 12	nil
41	Muttonbird	N side	3/02/2004	11:25	31	15 kn SE	12	5 to 12	light SE
41	Muttonbird	N Side	10/02/2005	13:20	35	calm 0.5m nE	10	3 to 11	nil
42	Flat Top Point	E side	18/07/2001		32	12 knot S, 1m	10	6 to 10	nil
42	Flat Top Point	E side	20/08/2002	14:00	32	light	8	6 to 10	light S
42	Flat Top Point	E side	20/02/2003	14:00	35	1m	10	6 to 10	nil
42	Flat Top Point	E side	29/01/2004	11:00	36	20 kn w offshore, calm	10	6 to 11	nil
42	Flat Top Point	E side	23/02/2004	11:45	30	calm, 1m	5	5 to 10	nil
43	Woolgoolga Rf	NW side	31/01/2001	1030	34	drizzle, 1 m	10	4 to 8.5	low
44	Woolgoolga Rf	E side	20/02/2003	12:30	36	1.5m	11	5 to 10	light N
44	Woolgoolga Rf	E side	29/01/2004	13:45	34	12 kn NE, calm	10	4 to 10	nil
44	Woolgoolga Rf	E side	2/03/2005	13:30	38	15 kn NE, 1m	8	5 to 10	nil
45	Diggers Camp	N of platform	2/04/2003	10:50	30	0.5m	7	2 to 5.5	nil
46	Diggers Camp	One-tree Point	3/06/2005	13:30	34	12 kn SE	12	7 to 12	nil
47	Minnie Waters	lagoon	2/04/2003	13:10	21	0.5m	5	2 to 4	nil

48	Park Bch Bom	bommie	15/04/2005	13:15	27	<12kn SE 1.5m	8	6 to 12	nil
49	Chopper Rock	E side	29/04/2005	12:30	39	12 knot NE, 1m	12	7 to 15	mod S
50	North Rock	SE corner	10/05/2005	10:00	32	10 kn NW 1m	12	6 to 14	light
51	Barcoongerie	shingle bank	10/05/2005	11:45	20	10 kn NE 1m	10	4 to 8.5	nil
52	Barcoongerie	seaward	24/05/2005	12:30	34	NW 10 knots, 1m	12	4 to 10	light S
53	Barcoongeriel	N side	25/05/2005	12:00	32	12kn NW, 1m	12	7 to 10	nil
54	Pebbly Bch Rf	north end	10/05/2005	13:00	39	12 kn NE	10	4 to 8.5	nil
55	McAuley Reef		10/05/2005	14:45	23	15 kn NE 1m	10	10 to 15	nil
56	Look at me Now		11/05/2005	14:00	32	15 kn NE	8	4 to 9	nil
57	Bare Bluff		24/05/2005	10:00	34	10 kn W, 1 m	15	4 to 9	nil
58	Arrawarra		24/05/2005	11:00	32	12 kn NW, light sea	14	4 to 7	nil
59	Bar 2		24/05/2005	14:25	35	12 kn NW, 1m	10	7 to 11	nil
60	Bar 3		24/05/2005	13:30	26	12 kn NW, 1m	10	7 to 9	nil
61	Jones Point		25/05/2005	11:15	34	10 kn NW, 1m	8	2 to 6	nil
62	Mulloway		25/05/2005	13:30	24	10 kn NW, 1m	10	3 to 7	nil
63	Woolgoolga		25/05/2005	14:25	29	10 kn NW, 1m	10	6 to 9	nil
64	Reef 5518		3/06/2005	8:50	40	<10kn SE, 1.5m	14	12 to 18	nil
65	Sandon Shoal		3/06/2005	10:30	43	12 kn SE, 1.5m	15	7 to 15	nil
66	Sandon Shoal		3/06/2005	11:50	49	15kn SE, 1.5m	18	7 to 17	nil
67	Corindi		3/06/2005	15:00	28	12 kn SE, 1.5m	10	6 to 10	nil
68	Diggers Hdlnd		9/06/2005	15:00	41	<10kn SE, 1m	10	6 to 12	nil
69	Saphire Reef		22/06/2005	9:30	29	15 kn WSW, calm	10	2.5 to 9	nil
70	McAuleys		22/06/2005	10:50	34	16 kn WSW, calm	10	3 to 8	nil
71	Littl Muttonbird		22/06/2005	11:50	25	17 kn WSW, calm	10	3 to 8.5	nil

Appendix 2a. BRUV sites used to test and refine depth-based HCS categories

Site latitude and longitude were taken from the most central replicate. Depth range = range of depths from the 3 BRUV replicates per site. Av. Depth = depth averaged from the 3 replicates per site. Reef type: cont = continuous; pat = patchy (<200m in length); Is. = attached to an island with emergent vegetation. Ben code = benthic code, where the 1st number = dominant benthos category and the 2nd number = % cover category. Dominant benthos category: 1 = bare rock; 2 = kelp; 3 = mixed hard and flexible invertebrates; 4 = coral; 5 = mixed flexible invertebrates dominated by sponge; 6 = mixed flexible invertebrates dominated by gorgonians. % cover category: 1 = 0 – 10%; 2 = 11 – 30%; 3 = 31 – 50%; 4 = 51 – 70%; 5 = 71 – 100%.

Site	Latitude	Longitude	Survey date	Depth range (m)	Av. depth per site	reef type	benth. code	Av site dist. from coast	refined HCS category
BR1_1	-30.24083	153.20032	12/9/2007	17 to 17	17.0	cont	42	4.3	shallow midshelf
BR1_2	-30.24131	153.19521	13/9/2007	16 to 17	16.7	cont	42	3.6	shallow midshelf
BR1_3	-30.24885	153.20074	15/9/2007	19 to 21	20.0	cont	31	4.5	shallow midshelf
BR2_1	-30.15895	153.22608	13/9/2007	15.8 to 18.1	17.0	Is.	43	2.5	shallow midshelf
BR2_2	-30.16162	153.23050	12/9/2007	17.5 to 19.3	18.6	Is.	42	1.8	shallow midshelf
BR2_3	-30.16468	153.22672	13/9/2007	15 to 16.7	15.6	Is.	43	2.1	shallow midshelf
BR3_1	-30.20185	153.21870	13/9/2007	16.5 to 20	17.8	cont	42	3.5	shallow midshelf
BR3_2	-30.20170	153.21190	15/9/2007	17.8 to 19	18.3	cont	31	3.3	shallow midshelf
BR3_3	-30.20466	153.21693	12/9/2007	17 to 20	18.8	cont	42	3.8	shallow midshelf
DC1	-29.72806	153.35500	1/9/2007	30 to 32	31	cont	55	4.8	Intermediate mid-shelf
DC10	-30.19387	153.30837	20/6/2008	52 to 56	54	cont	65	10.5	deep
DC11	-29.73703	153.36665	26/9/2008	32 to 34	33	cont	54	6.3	Intermediate offshore
DC13	-29.95428	153.29872	20/8/2008	30 to 31.5	31	cont	53	3.8	Intermediate mid-shelf
DC14	-30.19871	153.29412	9/8/2008	51 to 53	52	cont	53	9.5	deep
DC15	-30.17955	153.30328	20/6/2008	55 to 56.7	56	cont	55	9.3	deep
DC2	-29.73917	153.37500	9/8/2007	30 to 31	30	cont	54	7.0	Intermediate offshore
DC3	-29.70583	153.39250	30/8/2007	42 to 43	42	cont	55	6.5	Intermediate offshore
DC4	-29.77667	153.36167	9/8/2007	31 to 33	32	cont	55	5.6	Intermediate mid-shelf
DC5	-29.72167	153.38083	15/8/2007	31 to 36	33	cont	55	6.6	Intermediate offshore
DC6	-29.69833	153.39642	30/8/2007	41 to 43	42	cont	55	6.7	Intermediate offshore
DC7	-30.21222	153.28833	8/8/2007	39 to 47	42	cont	65	9.7	Intermediate offshore
DC8	-30.20756	153.27686	8/8/2007	42 to 47	44	cont	54	8.8	Intermediate offshore
DC9	-30.20647	153.29390	20/6/2008	50 to 51	50	cont	53	10.1	deep
DD1	-30.19137	153.31069	12/7/2008	60.5 to 63.5	62	cont	65	10.8	deep
DD10	-29.94388	153.44018	2/9/2008	66.5 to 68.5	67	pat	64	16.4	deep
DD3	-30.24290	153.28285	9/7/2008	62 to 63.8	63	cont	64	11.3	deep
DD4	-30.24406	153.29416	9/7/2008	62 to 63.8	63	cont	63	12.3	deep
DD5	-30.18034	153.30864	12/7/2008	61 to 64	63	cont	63	10.2	deep
DD6	-30.21036	153.32364	9/7/2008	65 to 66	65	cont	63	12.7	deep
DD7	-30.20800	153.30008	9/7/2008	60.5 to 65	62	cont	63	10.7	deep
DD8	-29.97196	153.42593	2/9/2008	67.8 to 69.7	69	pat	63	16.1	deep
DD9	-29.96274	153.43579	2/9/2008	68 to 68.7	68	pat	62	16.5	deep
DE1	-30.20911	153.26833	8/8/2007	31 to 32	31	Is.	54	8.2	Intermediate offshore
DE2	-30.20228	153.27256	8/8/2007	31 to 39	34	Is.	53	8.0	Intermediate offshore
DE3	-29.93583	153.39194	18/8/2007	38 to 46	41	Is.	55	11.8	Intermediate offshore
DE4	-29.92083	153.38950	18/8/2007	30 to 31	30	Is.	11	11.2	Intermediate offshore

DM1	-29.96906	153.37659	30/8/2008	45 to 48	47	pat	53	11.7	Intermediate offshore
DM2	-29.96348	153.39156	30/8/2008	40 to 46	43	pat	54	12.7	Intermediate offshore
DP1	-29.71789	153.35489	15/8/2007	30 to 33	31	pat	55	4.3	Intermediate mid-shelf
DP10	-29.75001	153.36043	26/9/2008	34.5 to 36.5	36	pat	55	6.2	Intermediate offshore
DP11	-29.75921	153.37324	26/9/2008	42.5 to 43.5	43	pat	55	7.1	Intermediate offshore
DP12	-29.72091	153.38512	27/9/2008	40.7 42.5	41	pat	54	6.6	Intermediate offshore
DP13	-29.94314	153.30757	20/8/2008	31.5 to 32	32	pat	53	4.3	Intermediate mid-shelf
DP2	-29.75917	153.35750	9/8/2007	40 to 42	41	pat	55	5.7	Intermediate mid-shelf
DP3	-29.72686	153.36494	15/8/2007	32 to 34	33	pat	55	5.6	Intermediate mid-shelf
DP4	-29.79917	153.35333	9/8/2007	41 to 43	42	pat	55	5.4	Intermediate mid-shelf
DP5	-30.19178	153.29256	19/6/2008	52 to 54	53	pat	53	9.1	deep
DP6	-30.20127	153.29787	19/6/2008	51 to 53	52	pat	55	10.5	deep
DP8	-30.19885	153.26137	9/8/2008	28 to 33	31	pat	52	7.0	Intermediate offshore
DP9	-30.19531	153.26994	19/6/2008	37 to 39	38	pat	54	7.5	Intermediate offshore
SO1	-30.19935	153.25678	29/8/2008	18 to 21	19	cont	31	6.7	shallow offshore
SO2	-30.20394	153.26464	9/8/2008	14 to 20	16	cont	31	7.5	shallow offshore
SO3	-30.20464	153.26816	8/8/2008	16 to 20	18	cont	33	7.9	shallow offshore
SO4	-29.92871	153.38960	29/8/2008	16 to 17.5	17	cont	43	11.3	shallow offshore
SO5	-29.91500	153.38737	29/8/2008	14 to 21	18	cont	42	11.2	shallow offshore
SO6	-29.90598	153.38327	29/8/2008	17.5 to 22	20	cont	11	10.6	shallow offshore

Appendix 2b. BRUV replicates used to test and refine HCS depth categories

Rep = replicate BRUV per Site. Reef type: cont = continuous reef > 500m in length; pat = patchy (reef <200m in continuous length); Is. = attached to an island with emergent vegetation.

Dominant benthos codes:

	Category	Code	Description	Cat.
Primary benthic category: dominant benthic assemblage	Bare rock	Br	mostly bare rock	1
	Kelp	Ek	Macro-algal dominated assemblage	2
	Coral	Co	Coral dominated assemblage	3
	Mixed Invertebrate	In	Mixed hard and soft invertebrates (e.g. coral, hydroids, sponge, soft coral, ascidean, etc.). Generally <25m depth	4
	Mixed Flexible Invertebrate	Mi (Sp)	Mixed flexible invertebrates (Sponge gardens with hydrozoans, stalked ascideans, gorgonians, sea-whips, black coral etc.). Generally >25m depth	5
	Mixed Flexible Invertebrate	Mi (Go)	Mixed flexible invertebrates (Gorgonian-dominated + seawhips, black coral, sponges etc.). Generally >25m depth	6
Secondary benthic category: most abundant taxa and/or structuring taxa	Urchins	Ur	Urchins	
	Barnacles	Bl	Barnacles	
	Sargassum	Sr	Sargassum	
	Kelp	Ek	Kelp (*Ecklonia radiata*) dominated	
	Ascidians	As	Ascidians	
	Stalked ascidean	SA	stalked ascidean	
	Coral	Co	Hard corals	
	Soft coral	SC	Soft corals	
	Coralimorphs	Cm	Coralimorphs	
	Sponge	Sp	Sponges	
	SeaWhips	SW	Sea whips	
	Sea pens	Sn	Sea pens	
	Gorgonian	Go	Gorgonians	
	Bryozoan	Bz	Bryozoans	
	Hydrozoan	Hz	Hydroids	
	Crinoid	Cr	Crinoids	
	Other	Ot	Other modifier or microcommunity, include details	
% benthic cover estimate	low	L	0 to 10 %	1
	low_mod	LM	11 to 30 %	2
	moderate	M	31 to 50 %	3
	mod_high	MH	51 to 70 %	4
	high	H	71 to 100 %	5
		%S	estimated percentage of view that is unconsolidated substratus	

Site	Rep	Latitude	Longitude	Date	Time in	Depth (m)	reef type	Dist. from coast (km)	Dominant benthos code
BR1_1	1	-30.24125	153.20163	12/09/2007	12:54	17.0	con	4.4	Br
BR1_1	2	-30.24083	153.20032	12/09/2007	12:58	17.0	con	4.3	Co - LM
BR1_1	3	-30.23929	153.19817	12/09/2007	13:04	17.0	con	4.1	Co - LM
BR1_2	1	-30.24071	153.19235	13/09/2007	13:31	16.0	con	3.6	Co - LM

BR1_2	2	-30.24131	153.19521	13/09/2007	13:36	17.0	con	3.7	Ek - LM
BR1_2	3	-30.24027	153.19029	13/09/2007	13:42	17.0	con	3.5	Ek - L
BR1_3	1	-30.24913	153.19930	15/09/2007	10:48	19.0	con	4.5	Co - LM
BR1_3	2	-30.24885	153.20074	15/09/2007	10:52	20.0	con	4.5	Br (Ek) - LM
BR1_3	3	-30.24996	153.20158	15/09/2007	10:57	21.0	con	4.5	In (As) - LM
BR2_1	1	-30.15759	153.22863	13/09/2007	10:09	18.1	Is.	2.4	Co - M
BR2_1	2	-30.15895	153.22608	13/09/2007	10:14	17.0	Is.	2.5	Co - LM; 20%S
BR2_1	3	-30.15918	153.22486	13/09/2007	10:18	15.8	Is.	2.6	Co - M
BR2_2	1	-30.16248	153.23146	12/09/2007	11:03	17.5	Is.	1.9	Co - LM
BR2_2	2	-30.16162	153.23050	12/09/2007	10:26	19.0	Is.	1.8	Co - L
BR2_2	3	-30.16253	153.23256	12/09/2007	10:31	19.3	Is.	1.7	In (As) - MH
BR2_3	1	-30.16401	153.22506	13/09/2007	11:45	15.0	Is.	2	Co - M
BR2_3	2	-30.16468	153.22672	13/09/2007	11:07	15.0	Is.	2.1	Co - M
BR2_3	3	-30.16598	153.22671	13/09/2007	11:12	16.7	Is.	2.1	In (Sc) - LM
BR3_1	1	-30.20086	153.21733	13/09/2007	12:30	20.0	con	3.5	Co - LM; 30%S
BR3_1	2	-30.20185	153.21870	13/09/2007	12:35	16.5	con	3.6	In (Co/As) - LM
BR3_1	3	-30.20092	153.21605	13/09/2007	12:40	17.0	con	3.4	Co - LM
BR3_2	1	-30.20363	153.21083	15/09/2007	9:44	19.0	con	3.3	In (Co/As) - L
BR3_2	2	-30.20170	153.21190	15/09/2007	9:48	18.0	con	3.3	In (Co/As) - L
BR3_2	3	-30.20219	153.21362	15/09/2007	9:53	17.8	con	3.3	Co - LM; 30%S
BR3_3	1	-30.20319	153.21765	12/09/2007	11:47	19.3	con	3.8	Co - M; 40%S
BR3_3	2	-30.20466	153.21693	12/09/2007	11:51	20.0	con	3.8	In (Co/As) - LM
BR3_3	3	-30.20487	153.21491	12/09/2007	11:55	17.0	con	3.7	Co - LM
DC1	1	-29.73028	153.35375	1/09/2007	11:28	31	con	4.9	Mi (Sp) - H
DC1	2	-29.72806	153.35500	1/09/2007	11:36	32	con	4.9	Mi (Sp/Bz) - H
DC1	3	-29.72610	153.35469	1/09/2007	11:43	30	con	4.7	Mi (Sp) - H
DC10	1	-30.19426	153.30729	20/06/2008	14:28	52	con	10.5	Mi (Go) - H
DC10	2	-30.19387	153.30837	20/06/2008	14:38	55	con	10.6	Mi (Go) - H
DC10	3	-30.19276	153.30662	20/06/2008	14:45	56	con	10.4	Mi (Go/Sw) - H
DC11	1	-29.73869	153.36579	26/09/2008	11:06	34	con	6.3	Mi (Sp/SA) - MH
DC11	2	-29.73703	153.36665	26/09/2008	11:14	32	con	6.3	Mi (Sp) - M: 50%S
DC11	3	-29.73510	153.36655	26/09/2008	11:20	32	con	6.3	Mi (Sp) - H; 40%S
DC13	1	-29.95597	153.29799	20/08/2008	10:30	31.5	con	3.8	Mi (Sp) - M
DC13	2	-29.95428	153.29872	20/08/2008	10:35	30	con	3.8	Mi (Sp/Ek) - M
DC13	3	-29.95241	153.29935	20/08/2008	10:42	30	con	3.9	Mi (Sp) - M
DC14	1	-30.20039	153.29179	9/08/2008	12:05	51	con	9.5	Mi (Sp) - M; 50%S
DC14	2	-30.19871	153.29412	9/08/2008	12:10	51	con	9.6	Mi (Sp) - M; 60%S
DC14	3	-30.19660	153.29262	9/08/2008	12:15	53	con	9.4	Mi (Sp/Go) - M
DC15	1	-30.18066	153.29848	20/06/2008	12:08	55	con	9.2	Mi (Sp) - F
DC15	30	-30.17955	153.30328	20/06/2008	13:32	56.7	con	9.6	Mi (Sp) - H
DC15	3	-30.17877	153.29866	20/06/2008	12:30	56	con	9.2	Mi (Sp) - F
DC2	1	-29.74125	153.37167	9/08/2007	12:05	30	con	6.9	Mi (Sp) - MH
DC2	3	-29.73917	153.37500	9/08/2007	12:15	31	con	7.2	Mi (Sp) - MH
DC2	5	-29.73750	153.37333	9/08/2007	12:20	30	con	7	Mi (Sp) - M
DC3	1	-29.70750	153.39167	30/08/2007	12:35	43	con	6.5	Mi (Mi) - H
DC3	3	-29.70583	153.39250	30/08/2007	12:44	42	con	6.5	Mi (Sp) - H
DC3	5	-29.70472	153.39383	30/08/2007	12:48	42	con	6.5	Mi (Sp) - H
DC4	1	-29.77750	153.35972	9/08/2007	10:54	33	con	5.5	Mi (Sp) - H
DC4	2	-29.77667	153.36167	9/08/2007	10:59	32	con	5.7	Mi (Sp) - H
DC4	3	-29.77542	153.35958	9/08/2007	11:05	31	con	5.5	Mi (Sp) - H
DC5	1	-29.72417	153.37833	15/08/2007	13:40	31	con	6.6	Mi (Sp) - H
DC5	3	-29.72167	153.38083	15/08/2007	13:50	36	con	6.6	Mi (Sp) - H
DC5	5	-29.71889	153.37872	15/08/2007	13:55	31	con	6.5	Mi (Go) - H
DC6	1	-29.69842	153.39883	30/08/2007	11:24	43	con	6.8	Mi (Sp) - H; 50%S
DC6	2	-29.69833	153.39642	30/08/2007	11:29	42	con	6.5	Mi (Sp) - H
DC6	5	-29.69667	153.39917	30/08/2007	11:39	41	con	6.8	Mi (Mi) - H
DC7	1	-30.21400	153.28378	8/08/2007	13:02	40	con	9.6	Mi (Go) - H
DC7	3	-30.21222	153.28833	8/08/2007	13:14	47	con	9.9	Mi (Sp) - H
DC7	5	-30.21139	153.28519	8/08/2007	13:19	39	con	9.6	Mi (Go) - H
DC8	1	-30.20919	153.27739	8/08/2007	11:50	47	con	8.9	Mi (Mi) - MH; 30%S
DC8	2	-30.20756	153.27686	8/08/2007	11:56	42	con	8.8	Mi (Sp) - MH
DC8	5	-30.20431	153.27611	8/08/2007	12:08	42	con	8.6	Mi (Sp) - MH
DC9	1	-30.20726	153.29466	20/06/2008	10:32	51	con	10.2	Mi (Sp) - H; 10%S
DC9	10	-30.20647	153.29390	20/06/2008	11:20	50	con	10	Mi (Sp) - M

DC9	2	-30.20510	153.29534	20/06/2008	10:07	50.3	con	10.1	Mi (Sp) - M; 50%S
DD1	1	-30.19265	153.31185	12/07/2008	10:15	62	con	10.8	Mi (Go) - MH; 30%S
DD1	2	-30.19137	153.31069	12/07/2008	10:20	60.5	con	10.7	Mi (Go) - H; 50%S
DD1	3	-30.18987	153.31156	12/07/2008	10:35	63.5	con	10.8	Mi (Go) - H; 50%S
DD10	1	-29.94559	153.43920	2/09/2008	12:52	68.5	pat	16.3	Mi (Go) - M; 10%S
DD10	2	-29.94388	153.44018	2/09/2008	12:59	66.5	pat	16.4	Mi (Go/Sp) - MH; 10%S
DD10	3	-29.94249	153.44118	2/09/2008	13:07	66.8	pat	16.5	Mi (Go) - MH; 10%S
DD3	1	-30.24414	153.28120	9/07/2008	9:45	63.8	con	11.3	Mi (Go/Sw) - LM; 80%S
DD3	2	-30.24290	153.28285	9/07/2008	9:53	63	con	11.4	Mi (Go/Sw) - MH; 30%S
DD3	3	-30.24109	153.28263	9/07/2008	10:00	62	con	11.3	Mi (Go/Sp) - MH; 40% S
DD4	1	-30.24545	153.29279	9/07/2008	10:56	62.7	con	12.3	Mi (Go/Sp) - LM; 10%S
DD4	2	-30.24406	153.29416	9/07/2008	11:03	62	con	12.3	Mi (Go) - M; 10%S
DD4	3	-30.23936	153.29965	9/07/2008	11:16	63	con	12.4	Mi (Go/Sp) - M; 10%S
DD5	1	-30.18080	153.30625	12/07/2008	11:28	61	con	10	Mi (Go/Sp) - M; 40%S
DD5	2	-30.18034	153.30864	12/07/2008	11:37	64	con	10.2	Mi (Go/Sp) - MH; 10%S
DD5	10	-30.17848	153.31133	12/07/2008	13:02	64	con	10.4	Mi (Go/Sw) - M; 60%S
DD6	1	-30.21208	153.32299	9/07/2008	12:13	66	con	12.8	Mi (Go) - M; 10%S
DD6	2	-30.21036	153.32364	9/07/2008	12:19	65	con	12.7	Mi (Go) - M; 50%S
DD6	3	-30.20868	153.32441	9/07/2008	12:28	65	con	12.7	Mi (Go/Sw) - MH; 20%S
DD7	1	-30.20975	153.29989	9/07/2008	13:27	60.5	con	10.7	Mi (Go) - MH; 10%S
DD7	2	-30.20800	153.30008	9/07/2008	13:33	61	con	10.7	Mi (Go) - M; 80%
DD7	3	-30.20712	153.30183	9/07/2008	13:40	65	con	10.8	Mi (Go/Bc) - LM; 80%
DD8	1	-29.97378	153.42499	2/09/2008	10:17	69.7	pat	16.2	Mi (Go/Sw) - MH; 10%S
DD8	2	-29.97196	153.42593	2/09/2008	14:14	68.3	pat	16	Mi (SW) - LM; 50%S
DD8	3	-29.97001	153.42730	2/09/2008	14:04	67.8	pat	16.1	Mi (Go/Sw) - M; 10%S
DD9	1	-29.96403	153.43500	2/09/2008	11:28	68.5	pat	16.5	Mi (Sw/Go) - M; 50%S
DD9	2	-29.96274	153.43579	2/09/2008	11:36	68	pat	16.5	Mi ((Go/Bc) - LM; 10%S
DD9	3	-29.96124	153.43675	2/09/2008	11:47	68.7	pat	16.6	Mi (Go) - LM; 20%S
DE1	1	-30.21139	153.26839	8/08/2007	10:32	32	Is.	8.2	Mi (Sp) - H
DE1	2	-30.20911	153.26833	8/08/2007	10:39	31	Is.	8.1	Mi (Sp) - M
DE1	5	-30.20694	153.27083	8/08/2007	11:01	31	Is.	8.2	Mi (Sp) - MH
DE2	1	-30.20289	153.27014	8/08/2007	14:20	32	Is.	7.9	Mi (Sp) - H
DE2	2	-30.20228	153.27256	8/08/2007	14:25	39	Is.	8.1	Mi (Sp) - LM; 10%S
DE2	5	-30.20006	153.27128	8/08/2007	14:35	31	Is.	8.1	Mi (Sp/Hy) - M
DE3	1	-29.93750	153.39333	18/08/2008	12:46	46	Is.	11.9	Mi (Mi) - H
DE3	3	-29.93583	153.39194	18/08/2007	13:02	38	Is.	11.7	Mi (Sp) - MH
DE3	2	-29.93417	153.39283	18/08/2007	14:28	40	Is.	11.7	Mi (Sp/Sw) - H
DE4	1	-29.92250	153.39000	18/08/2007	11:34	30	Is.	11.3	Br
DE4	2	-29.92083	153.38950	18/08/2007	11:37	31	Is.	11.3	Br
DE4	3	-29.91993	153.38803	18/08/2007	11:43	30	Is.	11.1	Br
DM1	1	-29.96956	153.38094	30/08/2008	11:32	48	pat	12	Mi (Sp) - M
DM1	2	-29.96906	153.37659	30/08/2008	11:38	45.5	pat	11.6	Mi (Sp) - LM
DM1	3	-29.96747	153.37736	30/08/2008	11:46	47	pat	11.6	Mi (Sp) - M
DM2	1	-29.96403	153.38971	30/08/2008	12:40	40	pat	12.6	Mi (As/Sp) - MH
DM2	2	-29.96348	153.39156	30/08/2008	12:47	46	pat	12.9	Mi (Sp/SA/Go) - MH
DM2	3	-29.96206	153.38815	30/08/2008	12:53	42.8	pat	12.5	Mi (SA/Sp) - MH
DP1	2	-29.71794	153.35706	15/08/2007	11:08	33	pat	4.3	Sp (Sp) - M; 60%S
DP1	3	-29.71789	153.35489	15/08/2007	11:13	30	pat	4.4	Mi (Sp) - LM; 10%S
DP1	5	-29.71583	153.35417	15/08/2007	11:17	30	pat	4.1	Mi (Sp) - H
DP10	1	-29.75160	153.36156	26/09/2008	12:20	34.5	pat	6.2	Mi (Sp) - H; 20%S
DP10	2	-29.75001	153.36043	26/09/2008	12:28	36.3	pat	6.2	Mi (Sp) - H; 30%S
DP10	3	-29.74821	153.36049	27/09/2008	12:15	36	pat	6.3	Mi (Sp) - H
DP11	1	-29.76063	153.37466	26/09/2008	13:36	43.5	pat	7.2	Mi (Sp/Go) - H
DP11	2	-29.75921	153.37324	26/09/2008	13:43	42.5	pat	7.1	Mi (Sp) - H; 10%S
DP11	3	-29.75749	153.37186	26/09/2008	13:50	43	pat	7	Mi (Sp/Go) - M
DP12	1	-29.72275	153.38493	27/09/2008	11:13	41	pat	6.7	Mi (Sp) - MH
DP12	2	-29.72091	153.38512	27/09/2008	11:19	42.5	pat	6.6	Mi (Sp/Go) - MH; 10%S
DP12	3	-29.71906	153.38535	27/09/2008	11:24	40.7	pat	6.5	Mi (Sp/Go) - H
DP13	1	-29.94406	153.30544	20/08/2008	11:31	31.5	pat	4.2	Mi (Sp) - M; 70%S
DP13	2	-29.94314	153.30757	20/08/2008	11:37	32	pat	4.4	Mi (Sp) - M
DP13	3	-29.94172	153.30542	20/08/2008	11:45	32	pat	4.2	Mi (Sp) - M
DP2	2	-29.75939	153.35953	9/08/2007	13:20	42	pat	5.8	Mi (Sp) - H; 10%S
DP2	3	-29.75917	153.35750	9/08/2007	13:25	40	pat	5.7	Mi (Sp) - H
DP2	5	-29.75819	153.35601	9/08/2007	13:30	42	pat	5.6	Mi (Mi) - H; 10%S

DP3	1	-29.72803	153.36639	15/08/2007	12:19	34	pat	5.8	Mi (Sp) - MH; 20%S
DP3	2	-29.72686	153.36494	15/08/2007	12:23	33	pat	5.6	Mi (Sp) - H
DP3	3	-29.72450	153.36417	15/08/2007	12:30	32	pat	5.5	Mi (Sp) - H
DP4	1	-29.80000	153.35556	9/08/2007	14:25	43	pat	5.4	Mi (Sp) - H; 50%S
DP4	2	-29.79917	153.35333	9/08/2007	14:30	43	pat	5.6	Mi (Sp) - H; 10%S
DP4	5	-29.79708	153.35222	9/08/2007	14:38	41	pat	5.2	Mi (Sp) - H
DP5	1	-30.19336	153.29129	19/06/2008	11:18	52	pat	9.1	Mi (Sp/Go) - M; 30%S
DP5	2	-30.19178	153.29256	19/06/2008	11:25	53	pat	9.1	Mi (Sp) - M
DP5	3	-30.18961	153.29327	19/06/2008	11:31	53.8	pat	9.1	Mi (Sp/Go) - MH; 40%S
DP6	1	-30.20315	153.29846	19/06/2008	13:44	52.8	pat	10.6	Mi (Sp/Go) - H
DP6	2	-30.20127	153.29787	19/06/2008	13:52	51.6	pat	10.5	Mi (Sp/Go) - MH
DP6	3	-30.19847	153.29852	19/06/2008	14:00	52.7	pat	10.5	Mi (Sp/Go/Sw) - H
DP8	1	-30.20067	153.26110	9/08/2008	10:57	28	pat	7.1	Br
DP8	2	-30.19885	153.26137	9/08/2008	11:03	31	pat	7	Mi (Sp) - LM; 10%S
DP8	3	-30.19749	153.26064	9/08/2008	11:11	33	pat	6.9	Mi (Hy/Sp) - M
DP9	1	-30.19631	153.27244	19/06/2008	10:10	38	pat	7.7	Mi (Sp) - MH
DP9	2	-30.19531	153.26994	19/06/2008	10:15	37	pat	7.4	Mi (Sp/As) - MH
DP9	3	-30.19377	153.27174	19/06/2008	10:22	39	pat	7.5	Mi (Sp) - LM; 40%S
SO1	1	-30.20089	153.25730	29/08/2008	14:00	21	con	6.8	In (Bl/C) - L
SO1	2	-30.19935	153.25678	29/08/2008	14:05	19	con	6.7	In (Bl/Sp) - L
SO1	3	-30.19891	153.25781	29/08/2008	14:10	18	con	6.7	In (Ur/Bl)
SO2	1	-30.20631	153.26526	9/08/2008	9:32	18	con	7.6	Co - LM
SO2	2	-30.20394	153.26464	9/08/2008	9:56	14	con	7.5	In (Co) - L
SO2	3	-30.20240	153.26539	9/08/2008	10:01	17	con	7.5	In (Co) - L
SO3	1	-30.20705	153.26982	8/08/2008	14:15	18	con	8.1	In (As/Sc) - M
SO3	2	-30.20464	153.26816	8/08/2008	14:20	20	con	7.8	In (Co) - L
SO3	3	-30.20212	153.26856	8/08/2008	14:25	16	con	7.8	In (Zo/As) - M
SO4	1	-29.92704	153.38797	29/08/2008	9:52	17.5	con	11.1	Co - LM
SO4	2	-29.92871	153.38960	29/08/2008	9:58	16	con	11.4	Co - M
SO4	3	-29.93038	153.38967	29/08/2008	10:05	16	con	11.3	Co - M
SO5	1	-29.91642	153.38819	29/08/2008	10:54	18	con	11.1	Co - LM; 20%S
SO5	2	-29.91500	153.38737	29/08/2008	11:04	14	con	11.1	Co - LM
SO5	3	-29.91479	153.38958	29/08/2008	11:12	21	con	11.3	Co - LM
SO6	1	-29.90814	153.38459	29/08/2008	12:05	22	con	10.7	Br
SO6	2	-29.90598	153.38327	29/08/2008	12:10	17.5	con	10.5	Br (Ur)
SO6	3	-29.90450	153.38416	29/08/2008	12:15	20	con	10.6	In (Sp) - LM

Appendix 3. Comparison of BRUV assemblages between 3 marine parks

Species recorded by BRUVS at the Solitary Islands Marine Park in 2006 (SIMP-06), Port Stephens-Great Lakes Marine Park (PSGLMP), and Jervis Bay Marine Park (JBMP). X = species recorded by site and by year within SIMP. Numeric values are Mean MaxN for each marine park (- = not recorded). Distribution: E = Endemic, R = Regional, C = Cosmopolitan, Cir = Circumglobal; with (description) indicating area. Trophic grouping: H = herbivore; Pl = planktivore; Ben = predator non-mobile invertebrates & infauna; Pred = predator of mobile invertebrates/fishes; Pis = dedicated piscivore; Om = omnivore (Ben/Pred/H), Scav = dedicated scavenger (versus opportunistic). Distributions and trophic groupings taken from taxonomic references (Last & Stevens 1994, Randall et al. 1997, Kuiter 2000).

Year		2002	2003	2004	2005	2006	SIMP-06	PSGLMP	JBMP	Distribution	Trophic Grouping
Site		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4					
						Chondrichthyes					
HETERODONTIDAE	*Heterodontus galeatus*						-	0.063	-	E (NSW)	Pred
	H. portusjacksoni						-	1.281	0.719	R (Aus-NZ)	Pred
BRACHAELURIDAE	*Brachaelurus waddi*	x x x x	x x x	x x x	x x x	x x x x	0.563	0.313	-	E (subtrop E Aus)	Pred
ORECTOLOBIDAE	*Orectolobus maculatus*	x x x	x x	x x x	x x	x	0.031	-	0.031	E (temp E Aus)	Pred
	O. ornatus	x x x	x x x x	x x x x	x x x	x x x x	0.375	0.094	-	R (Aus-PNG)	Pred
ODONTASPIDAE	*Carcharias taurus*	x				x	0.031	0.031	-	Cir (temp)	Pis
SCYLIORHINIDAE	*Asymbolus analis*						-	0.031	-	E (NSW)	Pred
TRIAKIDAE	*Mustelus antarcticus*						-	0.031	-	E (temp Aus)	Pred
RHINOBATIDAE	*Aptychotrema rostrata*						-	0.063	0.031	E (NSW)	Pred / Ben
	Trygonorrhina sp.A					-	0.031	0.063		E (temp E Aus)	Scav
DASYATIDAE	*Dasyatis brevicaudata*			x x	x	x	0.031	0.063	0.094	C (southern Indo Pac)	Ben
MYLIOBATIDAE	*Myliobatis australis*	x	x	x			-	0.156	0.094	E (temp Aus)	Ben
						Osteichthyes					
MURAENIDAE	*Gymnothorax prasinus*	x x x x	x x x x	x x x x	x x x x	x x x x	1.031	1.531	1.125	R (Aus , NZ)	Pred
	Gymnothorax prionodon						-	0.031	-	R (NSW, NZ, Japan)	Pred
AULOPIDAE	*Aulopus purpurissatus*	x x x x	x x x x	x x x x	x x x	x x x	0.375	1.000	0.188	E (temp Aus)	Pred
MORIDAE	*Lotella rhacina*						-	0.063	0.219	R (southern Aus, NZ)	Ben
BERYCIDAE	*Centroberyx lineatus*						-	-	0.063	E (southern Aus)	Pl (zoo)
AULOSTOMIDAE	*Aulostomus chinensis*				x		0.031	-	-	C (trop/subtrop Indo Pac)	Pis
TETRAROGIDAE	*Centropogon australis*					x	-	-	0.094	E (SE Aus)	Pred
SCORPAENIDAE	*Scorpaena cardinalis*	x x x x	x x x x	x x x x	x x x x	x x x x	1.938	1.531	0.250	R (Southern Aus, NZ)	Pred
TRIGLIDAE	*Lepidotrigla papilio*						-	-	0.031	E (southern Aus)	Pred
PLATYCEPHALIDAE	*Platycephalus caeruleopunctatus*						-	0.031	-	E (temp E Aus)	Pred
SERRANIDAE	*Acanthistius ocellatus*	x x x x	x x x x	x x x x	x x x x	x x x x	0.438	0.438	0.156	E (SE Aus)	Pred
	Caesioperca lepidoptera						-	-	0.125	R (southern Aus, NZ)	Pl

	Epinephelus fasciatus	x x	x		x	x	0.031	-	-	C (trop/subtrop Indo Pac)	Pred
	Hypoplectrodes annulatus						-	-	0.250	E (temp E Aus)	Pred
	Hypoplectrodes maccullochi	x x x x	x x x x	x x x x	xx x x	x x x x	1.000	0.875	0.563	E (subtrop/temp E Aus)	Pred
	Hypoplectrodes nigroruber						-	0.031	0.031	E (southern Aus)	Pred
PLESIOPIDAE	*Trachinops taeniatus*		x	x x x	x x x	x x	3.750	0.344	-	E (SE Aus)	Pl
DINOLESTIDAE	*Dinolestes lewini*					x x	0.094	0.125	1.469	E (southern Aus)	Pred
CARANGIDAE	*Pseudocaranx dentex*		x x	x	x x x x	x x x	1.094	0.438	0.438	Cir (temp)	Ben / Pred
	Seriola dumerili				x	x	0.031	-	-	Cir (trop/subtrop)	Pred
	Seriola lalandi	x x		x x x		x	0.063	-	0.531	Cir (temp)	Pred
	Seriola rivoliana	x		x	x	x x	0.125	-	-	Cir (trop/subtrop)	Pred
	Trachurus novaezelandiae	x x	x	x	x x	x x	2.188	13.000	9.781	R (southern Aus, NZ)	Pl (zoo)
LUTJANIDAE	*Lutjanus russelli*	x			x x	x x	0.156	-	-	C (trop/subtrop W Pac)	Pred
	Paracaesio xanthura		x	x	x x	x	0.500	-	-	C (trop IndoW Pac)	Pl
SPARIDAE	*Acanthopagrus australis*	x x	x x	x x	x x x	x x	0.125	0.031	-	E (SE Aus)	Pred
	Pagrus auratus	x x x x	x x x x	x x x x	x x x x	x x x x	1.531	2.188	0.406	R (southern Aus, NZ)	Pred
	Rhabdosargus sarba	x x x	x x x	x	x x x	x x	0.469	0.250	-	C (trop/subtrop Indo W Pac)	Pred
MULLIDAE	*Parupeneus spilurus*	x x x	x x x x	x x x x	x x x	x x x	0.188	1.250	0.031	R (Aus,PNG,NZ)	Pred
	Upeneichthys lineatus						-	0.219	0.063	E (temp/subtrop E Aus)	Pred
	Upeneichthys vlamingii						-	-	0.063	E (southern Aus)	Pred
MONODACTYLIDAE	*Schuettea scalaripinnis*	x				x	4.063	-	-	E (subtrop E Aus)	Pl
PEMPHERIDAE	*Pempheris affinis*	x		x		x	0.031	-	-	E (subtrop E Aus)	Pl (zoo)
	Pempheris multiradiata						-	-	0.063	E (southern Aus)	Pl (zoo)
SCORPIDIDAE	*Atypichthys strigatus*	x x x	x x	x x x	x x x x	x x x x	13.000	10.813	12.031	E (temp/subtrop E Aus)	Pl (zoo) / Pred
	Scorpis aequipinnis						-	-	0.031	E (southern Aus)	Pl
	Scorpis lineolata	x x x x	x x x x	x x x x	x x x x	x x x x	12.531	8.844	9.094	R (SE Aus, NZ)	Pl
KYPHOSIDAE	*Girella elevata*	x					-	0.031	-	E (temp/subtrop E Aus)	Om
	Girella tricuspidata						-	0.156	0.313	R (SE Aus, NZ)	H
CHAETODONTIDAE	*Chelmonops truncatus*	x	x x x				-	0.219	0.063	E (NSW)	Ben / Pred
	Heniochus acuminatus		x		x	x	0.094	-	-	C (trop Indo W Pac)	Ben / Pl (zoo)
ENOPLSIDAE	*Enoplosus armatus*	x x x	x x	x	x x x x	x	0.031	0.344	0.188	E (southern Aus)	Ben/ Pl (zoo)
PENTACEROTIDAE	*Pentaceropsis recurvirostris*						-	0.031	-	E (southern Aus)	Ben / Pred
POMACENTRIDAE	*Abudefduf bengalensis*					x	0.031	-	-	C (trop Indo W Pac)	Pl ?
	Chromis hypsilepis	x	x	x x	x x	x	0.156	2.500	2.156	R (E Aus, NZ)	Pl (zoo)
	Mecaenichthys immaculatus	x					-	0.125	0.063	E (NSW)	Om
	Parma microlepis						-	0.781	0.625	E (temp/subtrop E Aus)	Om
	P. unifasciata	x x x x	x x x x	x x x x	x x x x	x x x x	1.688	0.063	-	E (subtrop/temp E Aus)	Om
APLODACTYLIDAE	*Aplodactylus lophodon*		x			x	0.031	0.156	0.031	E (subtrop/temp E Aus)	H
CHEILODACTYLIDAE	*Cheilodactylus fuscus*		x x	x	x		-	0.125	0.219	R (subtrop/temp E Aus, NZ)	Om
	Cheilodactylus vestitus	x					-	0.031	-	R (subtrop/temp W Pac)	Ben / Pred
	Nemadactylus douglasi	x x x	x x x x	x x x x	x x x	x x x	0.188	1.031	0.625	R (subtrop/temp E Aus, NZ)	Pred
LATRIDAE	*Latridopsis forsteri*						-	-	0.031	R (temp SE Aus, NZ)	Pred
LABRIDAE	*Achoerodus viridis*	x x	x	x x x x	x x x	x x	0.188	0.406	0.469	E (subtrop/temp SE Aus)	Pred
	Austrolabrus maculatus	x	x x x x	x x x x	x x x	x x x	0.219	-	-	E (southern Aus)	Ben / Pred
	Bodianus perditio		x x	x x		x x	0.031	-	-	C (subtrop Indo W Pac)	Pred
	Bodianus unimaculatus						-	-	0.063	R (E Aus, NZ)	Pred
	Choerodon venustus	x x	x x	x x	x	x	0.031	-	-	E (subtrop E Aus)	Pred

	Cirrhilabrus punctatus					x	0.031	-	-	R (trop/subtrop W Pac)	Pl (zoo)
	Coris dorsomacula	x		x		x	0.031	-	-	C (trop/subtrop W Pac)	Pred ?
	Coris picta	x x x x	x x x x	x x x x	x x x	x x x	0.656	0.688	0.063	R (subtrop/temp E Aus, NZ)	Pred
	Coris sandageri						-	-	0.031	R (temp SE Aus, NZ)	Pred
	Eupetrichthys angustipes					x	0.031	-	0.031	E (southern Aus)	Ben
	Notolabrus fucicola						-	-	0.031	R (southern Aus, NZ)	Pred
	Notolabrus gymnogenis	x x x x	x x x x	x x x x	x x x x	x x x x	1.531	1.625	0.313	E (subtrop/temp E Aus)	Pred
	Notolabrus tetricus						-	-	0.031	E (temp SE Aus)	Pred
	Ophthalmolepis lineolatus	x x x x	x x x x	x x x x	x x x x	x x x x	1.719	5.531	2.188	E (subtrop/temp Aus)	Pred
	Pseudolabrus guentheri	x x x x	x x x x	x x x	x x x	x x x x	0.313	-	-	E (subtrop E Aus)	Pred
	Suezichthys gracilis						-	-	0.031	C (trop/subtrop W Pac)	Pred
	Stethojulis interrupta					x	0.063	-	-	C (trop W Pac)	Ben
	Thalassoma lunare	x x x	x x	x x	x x	x x x x	0.531	-	-	C (trop W Pac	Pred
	Thalassoma lutescens	x x x x	x x x x	x x x x	x	x x x x	0.531	-	-	C (trop/subtrop Indo W Pac)	Pred
ODACIDAE	*Odax cyanomelas*						-	0.156	0.031	E (subtrop/temp Aus)	H
PINGUIPEDIDAE	*Parapercis stricticeps*		x	x	x	x x x	0.156	-	-	E (subtrop E Aus)	Pred
ACANTHURIDAE	*Prionurus microlepidotus*	x x x x	x x	x x x	x x x x	x x x	1.906	-	-	E (subtrop E Aus)	H / Pl
SIGANIDAE	*Siganus nebulosus*	x	x x		x x	x	0.094	-	-	E (subtrop E, W Aus)	Om
MONOCANTHIDAE	*Acanthaluteres vittiger*						-	-	0.031	E (southern Aus)	Om
	Aluterus monoceros						-	0.063	-	Cir (trop)	Om
	Eubalichthys bucephalus						-	0.344	0.250	E (southern Aus)	Om
	Eubalichthys mosaicus			x	x	x	0.063	0.063	-	E (southern Aus)	Om
	Meuschenia flavolineata						-	0.031	0.500	E (southern Aus)	Om
	Meuschenia freycineti			x			-	1.156	0.375	E (southern Aus)	Om
	Meuschenia scaber						-	0.406	0.063	R (southern Aus, NZ)	Om
	Meuschenia trachylepis		x x x		x	x	0.031	0.281	-	E (subtrop/temp E Aus)	Om
	Meuschenia venusta						-	-	0.031	E (southern Aus)	Om
	Nelusetta ayraudi		x	x	x	x x	0.094	0.125	0.125	R (southern Aus, NZ)	Om
OSTRACIIDAE	*Anoplocapros inermis*						-	0.031	0.031	E (subtrop/temp E Aus)	Pred / Ben
TETRADONTIDAE	*Canthigaster callisterna*	x	x x	x		x x x	0.094	0.031	0.156	R (NSW, NZ)	Ben / Pred
DIODONTIDAE	*Dicotylichthys punctulatus*						-	0.031	-	E (subtrop/temp E Aus)	Pred

Appendix 4. Checklist of reef fish species in the SIMP recorded during this study and relative abundance by refined HCS category

Species are listed in alphabetical order of Class; Order; Family; Genus; Species

Method: TC = timed count; BRUV = Baited Remote Underwater Video.
Numbers in the 5 BRUV columns x HCS categories = average maxN for that category from all replicates, bolded = highest av MaxN, discriminating spp.
S-in = shallow inshore; S-mid = shallow mid-shelf; S-off = shallow offshore; I-mid = intermediate mid-shelf; I-off = intermediate offshore; Deep = deep
Lat = Latitudinal affiliation: temp = temperate; sub = subtropical; trop = tropical;
D = Distribution: c = cosmopolitan, cir = circumglobal, r = regional, e = endemic.
Region: E Aus = eastern Australia, Indo-Pac = Indo-Pacific; IWP = Indo-West Pacific; NSW = NewSouth Wales; NZ = New Zealand
Trophic Group: h = herbivore, pisc = piscivore, pred = predator (generally of mobile inverts etc.), ben = benthic predator of infauna or sessile benthos
(?) = species identification unsure. Species in red identified to genus only.

Relative abundance categories:

Timed count log 5 scores	range	<25% of counts	>25% counts
0	0 fish		
1 to 3	1 to 25 fish	r	r
4	26 to 125 fish	r	c
5	126 to 625 fish	c	a
6 to 7	> 625 fish	a	a

Order	Family	*Species*	**Common name**	method **TC**	**BRUV**	TC **S-in**	TC **S-mid**	TC **S-off**	BRUV **S-mid**	BRUV **S-off**	BRUV **I-mid**	BRUV **I-off**	BRUV **Deep**	**Lat**	**D**	**Region**
Chondrichthys																
Carchariniformes	Carcharhinidae	*Carcharinus sp.*	inidentified whaler		x						0.4					
Carchariniformes	Scyliorhinidae	*Asymbolus sp.*	unidentified catshark		x								0.2			
Carchariniformes	Triakidae	*Mustelus antarcticus*	gummy shark		x								0.11	temp	e	southern Aus
Heterodontiformes	Heterodontidae	*Heterodontus galeatus*	crested port jackson shark	x	x	r	r	r	0.4			0.4	0.13	sub	e	NSW
Lamniformes	Odontaspididae	*Carcharias taurus*	grey nurse shark	x	x		r	r	0.4					temp	g	anti-trop
Mylobatiformes	Dasyatididae	*Dasyatis kuhlii*	blue-spotted stingray	x		r	r	r						trop	c	IWP
Mylobatiformes	Dasyatididae	*Dasyatis thetidis*	black stingray	x		r	r	r						trop/temp	c	SE-Africa - S Aus
Mylobatiformes	Dasyatididae	*Dasyatus brevicaudata*	smooth stingray		x						0.13	0.2		temp	c	SE-Africa - S Aus
Mylobatiformes	Mobulidae	*Manta birostris*	manta ray	x			r							trop/sub	g	circum-trop
Mylobatiformes	Myliobatidae	*Aetobatus narinari*	white-spotted eagle ray	x			r	r						trop	g	circum-trop
Mylobatiformes	Myliobatidae	*Myliobatus australis*	eagle ray	x	x	r	r	r	0.19	0.28	0.4			temp	e	southern Aus
Mylobatiformes	Rhinopteridae	*Rhinoptera neglecta*	australian cownose ray	x		r								trop/sub	e	E Aus
Mylobatiformes	Urolophidae	*Trygonoptera testacea*	common stingaree	*x*		r	r	r						sub/temp	e	E Aus
Mylobatiformes	Urolophidae	unidentified stingaree	Unident. stingaree spp.		x						0.4					
Orectolobiformes	Brachaeluridae	*Brachaelurus waddi*	blindshark	x	x	r	r		**0.37**		0.29	0.07		sub	e	E Aus
Orectolobiformes	Orectolobidae	*Orectolobus halei*	gulf wobbegong		x							0.4		temp	e	SE Aus
Orectolobiformes	Orectolobidae	*Orectolobus maculatus*	spotted wobbegong	x	x	r	r	r	0.15	0.6		0.2		temp	e	SE Aus
Orectolobiformes	Orectolobidae	*Orectolobus ornatus*	dwarf ornate wobbegong	x	x	r	r	r	**0.56**	0.28	0.33	0.06		trop /temp	r	E-Aus
Orectolobiformes	Stegastomatidae	*Stegostoma fasciatum*	leopard shark	x				r						trop	c	IWP
Rhinobatiformes	Rhinobatidae	*Aptychotrema bougainvillii*	short-snout shovelnose ray		x					0.6			0.2	sub	e	E Aus
Rhinobatiformes	Rhinobatidae	*Aptychotrema rostrata*	eastern shovelnose ray	x	x			r			0.4			sub	e	E Aus
Rhinobatiformes	Rhinobatidae	*Trygonorrhina fasciata*	eastern fiddler ray	x	x	r				0.6		0.2	0.7	sub/temp	e	E Aus
Rhinobatiformes	Rhynchobatidae	*Rhynchobatus australiae*	white spotted guitarfish	x		r		r						trop	c	IWP
Torpediniformes	Hypnidae	*Hypnos monopterygium*	coffin ray	x				r						trop/temp	e	Aus
Osteichthys																
Anguilliformes	Congridae	*Conger wilsoni*	eastern conger eel		x				0.4					sub	c	southern hemisphere
Anguilliformes	Muraenidae	*Gymnothorax eurostus*	white-speckled moray	x		r		r						sub	c	Indo-Pac

Anguilliformes	Muraenidae	*Gymnothorax prasinus*	green moray	x	x	r	r	r	0.44	**1.06**	0.46	0.78	0.09	sub/temp	r	Aus-NZ
Anguilliformes	Muraenidae	*Gymnothorax prionodon*	sawtooth moray		x						0.08	0.3	**0.93**	temp	r	NSW, NZ, Japan
Anguilliformes	Muraenidae	*Gymnothorax spp.*	unidentified moray	x	x			r	0.4							
Anguilliformes	Muraenidae	*Sideria thyrsoidea*	white eye moray	x	x	r		r		0.11				trop	c	W-Pac
Aulopiformes	Aulopidae	*Aulopos purpurissatus*	sergeant baker	x	x	r	r	r	0.44	0.11	0.46	0.5	0.33	temp	e	Aus
Aulopiformes	Synodontidae	*Synodus dermatogenys*	two spot lizardfish	x				r						trop	c	Indo-Pac
Aulopiformes	Synodontidae	*Synodus jaculum*	tail-blotch lizardfish	x				r						trop	c	Indo-Pac
Aulopiformes	Synodontidae	*Synodus sp.*	unidentified lizardfish	x				r								
Aulopiformes	Synodontidae	*Synodus variegatus*	variegated lizardfish	x			r							trop	c	Indo-Pac
Batrachoidiformes	Batrachoididae	*Batrachomoeus dubius*	frogfish	x		r	r							sub	e	E Aus
Beryciformes	Berycidae	*Centroberyx affinis*	nannygai	x	x	r						0.4	0.9	temp	r	SE Aus - NZ
Beryciformes	Holocentridae	*Myripristis murdjan*	crimson squirrelfish	x		r	r	c						trop	c	Indo-Pac
Beryciformes	Holocentridae	*Sargocentron diadema*	crown squirrelfish	x			r	r						trop	c	Indo-Pac
Perciformes	Acanthuridae	*Acanthurus dussumeri*	eyestripe surgeonfish	x	x	r	r	r		0.6				trop	c	Indo-Pac
Perciformes	Acanthuridae	*Acanthurus mata*	elongate surgeonfish	x				r						trop	c	Indo-Pac
Perciformes	Acanthuridae	*Acanthurus nigrofuscus*	dusky or brown surgeonfish	x		r	r	r						trop	c	Indo-Pac
Perciformes	Acanthuridae	*Acanthurus olivaceus*	orange-blotch surgeonfish	x			r	r						trop	c	Indo-Pac
Perciformes	Acanthuridae	*Acanthurus pyroferus*	mimic surgeonfish	x				r						trop/sub	c	W Pac
Perciformes	Acanthuridae	*Naso unicornis*	unicorn fish	x			r	r						trop	c	Indo-Pac
Perciformes	Acanthuridae	*Paracanthurus hepatus*	blue tang	x				r						trop	c	Indo-Pac
Perciformes	Acanthuridae	*Prionurus maculatas*	spotted sawtail	x		r	r	r						sub	e	E Aus-LHI
Perciformes	Acanthuridae	*Prionurus microlepidotus*	sawtail	x	x	r	a	a	**4.76**	1.22	1.21	0.76	0.07	sub	e	E Aus
Perciformes	Acanthuridae	*Zebrasoma veliferum*	sailfin tang	x			r							trop	c	Indo-Pac
Perciformes	Aplodactylidae	*Crinodus lophodon*	rock cale	x		c	r	r						sub/temp	e	E Aus
Perciformes	Apogonidae	*Apogon aureus*	ring-tail cardinalfish	x			r	r						trop	c	Indo-Pac
Perciformes	Apogonidae	*Apogon capricornis*	capricorn cardinalfish	x				r						trop	c	Indo-Pac
Perciformes	Apogonidae	*Apogon limenus*	sydney cardinalfish	x		r	r	r						sub/temp	e	E Aus
Perciformes	Apogonidae	*Apogon properuptus*	orange-lined cardinal	x				r						trop	r	E Aus- New Cal
Perciformes	Apogonidae	*Cheilodipterus macrodon*	tiger cardinalfish	x			r	r						trop	r	W Pac
Perciformes	Apogonidae	*Rhabdamia gracilis*	slender cardinalfish	x			a									
Perciformes	Blennidae	*Aspidontus dussumieri*	lance blenny	x			r	r						trop	c	Indo-Pac
Perciformes	Blennidae	*Aspidontus taeniatus*	false cleanerfish	x				r						trop	c	Indo-Pac
Perciformes	Blennidae	*Exallias brevis*	short bodied blenny	x				r						trop	c	Indo-Pac
Perciformes	Blennidae	*Plagiotremis rhinorhyncos*	tube-worm fang-blenny	x			r	r						trop/sub	c	Indo-Pac

Perciformes	Blennidae	*Plagiotremus tapeinosoma*	hit & run fang-blenny	x	x	r	r	r	0.4	0.6				trop/sub	c	Indo-Pac
Perciformes	Caesionidae	*Caesio caerulaurea*	gold banded fusilier	x			r	c						trop	c	Indo-Pac
Perciformes	Caesionidae	*Pterocaesio digramma*	blacktip fusilier	x			r	c						trop/sub	c	Indo-Pac
Perciformes	Caesionidae	*Pterocaesio tile*	neon fusilier	x	x			r		0.6				trop	c	Indo-Pac
Perciformes	Carangidae	*Carangoides ferdau*	banded trevally	x			r	r						trop	c	Indo-Pac
Perciformes	Carangidae	*Carangoides orthogrammus*	thicklip or blue trevally	x			r	r						trop	c	Indo-Pac
Perciformes	Carangidae	*Caranx ignobilis*	giant trevally	x			r							trop	c	Indo-Pac
Perciformes	Carangidae	*Caranx melampygus*	blue-fin trevally	x				r						trop	c	Indo-Pac
Perciformes	Carangidae	*Caranx sexfaciatus*	big-eye trevally	x				r						trop	c	Indo-Pac
Perciformes	Carangidae	*Decapterus muroadsi*	southern mackeral scad	x		r								trop/sub	c	W Pac
Perciformes	Carangidae	*Elagatis bipinnulata*	rainbow runner	x				r						trop	g	circum-trop
Perciformes	Carangidae	*Gnathanodon speciosus*	golden trevally	x			r							trop	c	Indo-Pac
Perciformes	Carangidae	*Pseudocaranx dentex*	white trevally	x	x	r	r	r	1.07	1.5	**3.58**	0.13	0.07	sub/temp	g	anti-trop
Perciformes	Carangidae	*Scomberoides lysan*	double-spotted queenfish	x				r						trop	c	Indo-Pac
Perciformes	Carangidae	*Seriola dumerili*	amberjack	x				r						trop	g	circum-trop
Perciformes	Carangidae	*Seriola hippos*	samsonfish	x	x			r	0.37	0.67	0.4	0.31	0.13	temp	r	southern Aus
Perciformes	Carangidae	*Seriola lalandi*	yellowtail kingfish	x	x	r	r	c	0.4	0.11		0.13	0.49	sub/temp	g	sub/temp
Perciformes	Carangidae	*Seriola rivoliana*	highfin amberjack, almaco jack	x			r	r						trop	g	circum-trop
Perciformes	Carangidae	*Trachinotus botla*	common dart	x		r	r							trop	c	IWP
Perciformes	Carangidae	*Trachurus declivis*	horse mackerel, jack mackerel	x												
Perciformes	Carangidae	*Trachurus novaezelandiae*	yellowtail scad	x	x	a	a	r			11.4		4.44	temp	r	southern Aus - NZ
Perciformes	Chaetodontidae	*Chaetodon auriga*	threadfin butterflyfish	x			r							trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Chaetodon citrinellus*	citron butterflyfish	x			r	r						trop	c	IWP
Perciformes	Chaetodontidae	*Chaetodon flavirostris*	dusky butterflyfish	x	x		r	r	0.4			0.2		trop/sub	r	SW Pac
Perciformes	Chaetodontidae	*Chaetodon guentheri*	gunthers butterflyfish	x	x	r	r	c	0.41	2.44	0.21	**2.04**	0.2	trop/sub	c	W Pac
Perciformes	Chaetodontidae	*Chaetodon kleinii*	brown butterflyfish	x			r	r						trop/sub	c	Indo-Pac
Perciformes	Chaetodontidae	*Chaetodon ornatissimus*	ornate butterflyfish	x				r						trop	c	IWP
Perciformes	Chaetodontidae	*Chaetodon pelewensis*	dot & dash butterflyfish	x			r	r						trop	c	W Pac
Perciformes	Chaetodontidae	*Chaetodon plebius*	bluespot butterflyfish	x				r						trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Chaetodon speculum*	ovalspot butterflyfish	x				r						trop	c	IWP
Perciformes	Chaetodontidae	*Chaetodon trifascialis*	chevroned butterflyfish	x		r	r	r						trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Chaetodon unimaculatus*	teardrop butterflyfish	x				r						trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Chaetodon vagabundus*	vagabond butterflyfish	x			r	r						trop	c	Indo-Pac

Perciformes	Chaetodontidae	*Chelmonops truncatus*	truncate coralfish	x	x	r	r	r	0.4		0.4	0.24	0.13	sub	e	E Aus
Perciformes	Chaetodontidae	*Coradion altivelus*	highfin coralfish	x		r	r							trop/sub	r	W Pac
Perciformes	Chaetodontidae	*Forcipiger flavissimus*	long-nose butterflyfish	x				r						trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Heniochus acuminatus*	reef bannerfish	x			r	r						trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Heniochus chrysostomus*	pennant bannerfish	x				r						trop	c	Indo-Pac
Perciformes	Chaetodontidae	*Heniochus diphreutes*	schooling bannerfish		x					**0.26**						
Perciformes	Chaetodontidae	*Heniochus monoceros*	masked bannerfish	x			r	r						trop	c	Indo-Pac
Perciformes	Cheilodactylidae	*Cheilodactylus fuscus*	red morwong	x	x	r	c	c	0.15	0.11	0.21	0.35	0.11	sub/temp	r	SE Aus - NZ
Perciformes	Cheilodactylidae	*Cheilodactylus vestitus*	crested morwong	x	x	r	r	r		0.11		0.6		trop/sub	r	W Pac
Perciformes	Cheilodactylidae	*Nemadactylus douglasi*	blue or grey morwong	x	x		r	r	0.52	0.28	0.75	1.19	**1.53**	sub/temp	r	E Aus - NZ
Perciformes	Chironemidae	*Chironemus marmoratus*	kelpfish / hiwihiwi	x		c	r	r						temp	r	E Aus - NZ
Perciformes	Cirrhitidae	*Cirrhitichthys aprinus*	threadfin hawkfish	x	x		r	r	0.4					trop/sub	c	W Pac
Perciformes	Cirrhitidae	*Cirrhitichthys falco*	coral hawkfish	x			r	r						trop	c	W Pac
Perciformes	Cirrhitidae	*Cirrhitus splendens*	splendid hawkfish	x				r						sub	e	LHI - northern NSW
Perciformes	Cirrhitidae	*Cyprinocirrhites polyactis*	lyre-tail hawkfish	x			r	r						trop/sub	c	IWP
Perciformes	Cirrhitidae	*Paracirrhites forsteri*	blackside hawkfish	x			r	r						trop	c	Indo-Pac
Perciformes	Dinolestidae	*Dinolestes lewini*	longfin pike	x		r								temp	e	southern Aus
Perciformes	Echeneididae	*Echeneis naucrates*	slender suckerfish	x	x			r	0.7					trop	c	cir except E Pac
Perciformes	Enoplosidae	*Enoplosus armatus*	old wife	x	x	r	r	r	0.52	0.39	1.54	0.3	0.44	sub/temp	e	southern Aus
Perciformes	Gerreidae	*Gerres subfasciatus*	common silverbelly	x		r								trop/sub	e	Aus
Perciformes	Girellidae	*Girella elevata*	rock blackfish	x		r	r							temp	e	E Aus
Perciformes	Girellidae	*Girella tricuspidata*	luderick	x			r							temp	r	SE Aus - Nz
Perciformes	Glaucosomidae	*Glaucosoma scapulare*	pearl perch	x	x		r	r	0.22		0.58	0.17	0.71	sub	e	E Aus
Perciformes	Gobiidae	*Valenciennia strigata*	goldheaded sleeper goby	x			r							trop	c	Indo-Pac
Perciformes	Haemulidae	*Plectorhinchus flavomaculatus*	netted sweetlips	x	x	r	r	r	0.4	0.6		0.2		trop/sub	c	Indo-Pac
Perciformes	Haemulidae	*Plectorhinchus gibbosus*	brown sweetlips	x			r	r						trop	c	Indo-Pac
Perciformes	Haemulidae	*Plectorhinchus picus*	dotted sweetlips	x			r	r						trop	c	Indo-Pac
Perciformes	Haemulidae	*Plectorhinchus unicolor*	somber seetlips	x												
Perciformes	Kyphosidae	*Kyphosus sydneyanus*	southern silver drummer	x		r	r	r						temp	r	S Aus - SW Pac
Perciformes	Labridae	*Achoerodus viridus*	eastern blue groper	x	x	r	r	r	0.15	**0.44**	0.21	0.35	0.02	sub/temp	e	E Aus

Perciformes	Labridae	*Anampses caeruleopunctatus*	diamond wrasse	x	x	r	r	r	0.7	0.6				trop	c	Indo-Pac
Perciformes	Labridae	*Anampses femininus*	blue-tail wrasse	x	x			r				0.2		sub/temp	r	S Pac
Perciformes	Labridae	*Anampses meleagrides*	spotted wrasse	x				r						trop	c	Indo-Pac
Perciformes	Labridae	*Anampses neoguinaicus*	new guinea wrasse	x				r						trop/sub	c	W Pac
Perciformes	Labridae	*Austrolabrus maculatus*	black spotted wrasse	x	x	r	c	r	**0.33**		0.25	0.04		temp	e	E Aus / SW Aus
Perciformes	Labridae	*Bodianus axillaris*	coral hogfish	x			r	r						trop/sub	c	Indo-Pac
Perciformes	Labridae	*Bodianus diana*	dianas hogfish	x				r						trop	c	Indo-Pac
Perciformes	Labridae	*Bodianus frenchii*	foxfish	x	x		r	r			**0.69**	0.56	0.13	temp	e	W, S Aus
Perciformes	Labridae	*Bodianus izuensis*	striped hogfish		x							0.2	0.7	sub	c	ante-equatorial
Perciformes	Labridae	*Bodianus mesothorax*	splitlevel hogfish	x				r						trop	c	W pac
Perciformes	Labridae	*Bodianus perditio*	goldspot hogfish	x	x		r	r			0.4	0.7		sub	c	Indo-Pac
Perciformes	Labridae	*Bodianus unimaculatus*	pigfish		x							0.2	**0.93**	temp/sub	r	ante-equatorial SE Aus, NZ
Perciformes	Labridae	*Chelio inermis*	cigar wrasse	x		r	r	r						trop	c	Indo-Pac
Perciformes	Labridae	*Choerodon venustus*	venus tusk fish	x	x		r	r	0.15		**0.5**	0.52	0.07	trop/sub	r	northern Aus
Perciformes	Labridae	*Cirrhilabrus punctatus*	small spotted wrasse	x			r	r						trop	r	W Pac
Perciformes	Labridae	*Coris aygula*	clown coris	x			r	r						trop	c	IWP
Perciformes	Labridae	*Coris batuensis*	variegated rainbowfish	x				r						trop	c	Indo-Pac
Perciformes	Labridae	*Coris bulbifrons*	double header	x			r							sub	e	LHI-E Aus
Perciformes	Labridae	*Coris dorsomacula*	pink-lined coris	x	x	r	r	r	0.11	**0.28**				trop/sub	c	W Pac
Perciformes	Labridae	*Coris gaimard*	gaimards wrasse	x				r						trop	c	IWP
Perciformes	Labridae	*Coris picta*	comb coris	x	x	r	r	r	**1.78**	1.22	0.88	1.41	0.18	sub	r	E Aus - NZ
Perciformes	Labridae	*Coris sandageri*	sandaggers wrasse	x				r						temp	r	NZ - SE Aus
Perciformes	Labridae	*Eupetrichthys angustipes*	snakeskin wrasse	x		r	r							temp	e	southern Aus
Perciformes	Labridae	*Gomphosus varius*	birdnose wrasse	x				r						trop	c	W Pac
Perciformes	Labridae	*Halichoeres chrysus (?)*	golden wrasse	x				r						trop/sub	c	W Pac
Perciformes	Labridae	*Halichoeres hortulanus*	checkerboard wrasse	x			r	r						trop	c	Indo-Pac
Perciformes	Labridae	*Halichoeres margaritaceus*	pearly wrasse	x			r	r						trop	c	Indo-Pac
Perciformes	Labridae	*Halichoeres marginatus*	dusky wrasse	x			r	r						trop	c	Indo-Pac
Perciformes	Labridae	*Halichoeres nebulosus*	clouded wrasse	x	x	r	r	r		0.6				trop	c	Indo-Pac
Perciformes	Labridae	*Halichoeres prosopeion*	two-tone wrasse	x			r							trop	c	W Pac

Perciformes	Labridae	*Hemigymnus fasciatus*	barred thicklip	x				r						trop	c	Indo-Pac
Perciformes	Labridae	*Hologymnosus annulatus*	ring wrasse	x				r						trop	c	Indo-Pac
Perciformes	Labridae	*Hologymnosus doliatus*	eastern ring wrasse	x			r							trop	c	Indo-Pac
Perciformes	Labridae	*Labrichthys unilineata*	tubelip wrasse	x			r							trop	c	Indo-Pac
Perciformes	Labridae	*Labriodes bicolor*	bicolour cleaner wrasse	x				r						trop	c	Indo-Pac
Perciformes	Labridae	*Labroides dimidiatus*	cleaner wrasse	x	x	r	r	r	0.4	0.11	0.13	0.4		trop	c	Indo-Pac
Perciformes	Labridae	*Labropsis australis*	southern tubelip	x				r						trop	r	W Pac
Perciformes	Labridae	*Macropharyngodon choati*	choats wrasse	x			r	r						trop/sub	r	E Aus - New Cal
Perciformes	Labridae	*Macropharyngodon kuiteri*	kuiters wrasse	x				r						sub	r	E Aus - New Cal
Perciformes	Labridae	*Macropharyngodon meleagris*	leopard wrasse	x			r	r						trop	c	W Pac
Perciformes	Labridae	*Notolabrus gymnogenis*	crimson-banded wrasse	x	x	a	c	r	**1.63**	0.89	1.13	1	0.04	sub/temp	e	E Aus
Perciformes	Labridae	*Opthalmolepis lineolata*	maori wrasse	x	x	r	r		**2.93**	0.17	1.71	1.37	0.22	sub/temp	e	southern Aus
Perciformes	Labridae	*Pictilabrus laticlavius*	senator wrasse	x		r	r							temp	e	southern Aus
Perciformes	Labridae	*Pseudojuloides cerasinus*	candy wrasse	x			r							trop	c	IWP
Perciformes	Labridae	*Pseudolabrus guentheri*	gunthers wrasse	x	x	r	r	r	0.26	**0.5**	0.04	0.02		sub	e	E Aus
Perciformes	Labridae	*Pseudolabrus luculentus*	luculentus wrasse	x	x		r	r				0.4		sub	r	E Aus - NZ
Perciformes	Labridae	*Pterogogus enneacanthus*	cockeral wrasse	x				r						trop	c	W Pac
Perciformes	Labridae	*Stethojulis bandanensis*	red-spot wrasse	x		r	r	r						trop	c	W Pac
Perciformes	Labridae	*Stethojulis interrupta*	cut-ribbon wrasse	x	x	r	r	r		0.11				trop/sub	c	W Pac
Perciformes	Labridae	*Stethojulis strigiventer (?)*	silver streaked wrasse	x			r							trop	c	W Pac
Perciformes	Labridae	*Suezichthys arquatus*	painted rainbow wrasse	x			r	r						sub	r	SW Pac
Perciformes	Labridae	*Thalassoma amblycephalum*	two-tone wrasse	x			r	c						trop/sub	c	W Pac
Perciformes	Labridae	*Thalassoma hardwicke*	sixbar wrasse	x			r	r						trop	c	W Pac
Perciformes	Labridae	*Thalassoma janseni*	jansens wrasse	x		r	r	r						trop/sub	c	IWP
Perciformes	Labridae	*Thalassoma lunare*	moon wrasse	x	x	r	c	a	0.85	**3.06**		0.56		trop/sub	c	IWP
Perciformes	Labridae	*Thalassoma lutescens*	yellow moon wrasse	x	x	r	r	c	0.85	**2**		0.04		trop/sub	c	W Pac
Perciformes	Labridae	*Thalassoma purpureum (?)*	surge wrasse	x				r						trop	c	IWP
Perciformes	Lethrinidae	*Gnathodentex aureolineatus*	gold-spot emperor	x				r						trop	c	Indo-Pac
Perciformes	Lethrinidae	*Lethrinus genivittatus*	lancer		x					0.6		0.2		trop/sub	c	W Pacific
Perciformes	Lethrinidae	*Lethrinus miniatus*	sweet-lip emperor	x			r	r						trop	c	W Pac
Perciformes	Lethrinidae	*Lethrinus nebulosus*	spangled emperor	x			r	r						trop	c	Indo-Pac

Perciformes	Lethrinidae	*Monotaxis granoculis*	big-eye bream	x				r						trop	c	Indo-Pac
Perciformes	Lutjanidae	*Aprion virescens*	green jobfish	x				r						trop	c	Indo-Pac
Perciformes	Lutjanidae	*Lutjanus adetti*	hussar		x							0.11	0.2	trop/sub	c	E Aus - Coral Sea
Perciformes	Lutjanidae	*Lutjanus argentimaculatus*	mangrove jack	x		r	r	r						trop	c	Indo-Pac
Perciformes	Lutjanidae	*Lutjanus bohar*	red bass	x			r	r						trop	c	Indo-Pac
Perciformes	Lutjanidae	*Lutjanus fulviflammus*	black-spot snapper	x		r	r									
Perciformes	Lutjanidae	*Lutjanus kasmira*	bluestripe seaperch	x				r						trop	c	Indo-Pac
Perciformes	Lutjanidae	*Lutjanus russelli*	moses perch	x	x	r	r	r	0.7		0.8	0.6		trop	c	W Pac
Perciformes	Lutjanidae	*Lutjanus sebae*	red emperor	x										trop	c	Indo-Pac
Perciformes	Lutjanidae	*Paracaesio xanthura*	southern fusilier	x	x	r	r	a	0.7	0.89		2.85		trop	c	Indo-Pac
Perciformes	Malacanthidae	*Malacanthus brevirostris*	flagtail blanquilo	x	x			r		0.6				trop	c	Indo-Pac
Perciformes	Microcanthidae	*Atypichthys strigatus*	mado	x		a	a	a						sub/temp	e	SE Aus
Perciformes	Microcanthidae	*Microcanthus strigatus*	stripey	x		r	r	r						sub	c	IWP
Perciformes	Microdesmidae	*Ptereleotris evides*	arrow goby	x				r						trop	c	Indo-Pac
Perciformes	Monodactylidae	*Monodactylus argenteus*	silver batfish	x		a	r							trop	c	Indo-Pac
Perciformes	Monodactylidae	*Shuettea scalaripinnis*	eastern pomfret	x	x	c	a	a			0.4	0.7		sub	e	E Aus
Perciformes	Mullidae	*Mulloidichthys flavolineatus*	square-spot goatfish	x				r						trop	c	Indo-Pac
Perciformes	Mullidae	*Mulloidichthys vanicolensis*	yellow-stripe goatfish	x	x	r	r	c					0.2	trop	c	Indo-Pac
Perciformes	Mullidae	*Parupeneus multifasciatus*	banded goatfish	x				r						trop	c	Indo-Pac
Perciformes	Mullidae	*Parupeneus pleurostygma*	round spot goatfish	x	x			r		0.6				trop	c	Indo-Pac
Perciformes	Mullidae	*Parupeneus spilurus*	blackspot goatfish	x	x	r	r	c	0.52	2.6	0.5	1.65	0.42	trop/sub	c	W Pac
Perciformes	Mullidae	*Upeneichthys lineatus*	blue-lined goatfish	x	x	r					0.33	0.22	**0.56**	sub	e	E Aus
Perciformes	Mullidae	*Upeneus spp.*	unidentified goatfish	x		r	r									
Perciformes	Mullidae	*Upeneus traygula*	bartail goatfish	x		r								trop	c	Indo-Pac
Perciformes	Nemipteridae	*Scolopsis bilineata*	bridled monocle bream	x			r	r						trop	c	W Pac
Perciformes	Odacidae	*Odax cyanomelas*	herring cale	x		r								temp	e	southern Aus
Perciformes	Pempherididae	*Pempheris affinis*	black-tipped bullseye	x	x	a	a	a	0.11	0.6		0.9		sub	e	E Aus
Perciformes	Pempherididae	*Pempheris compressa*	small-scale bullseye	x	x	r	a	r				0.4		sub	e	E Aus
Perciformes	Pempherididae	*Pempheris otaitensis*	copper sweeper	x		r	r	c						trop	c	IWP
Perciformes	Pempherididae	*Pempheris schwenki (?)*	silver sweeper	x				r						trop	c	Indo-Pac
Perciformes	Pinguipedidae	*Parapercis ramsayi*	spotted grubfish		x							0.2	0.4			
Perciformes	Pinguipedidae	*Parapercis stricticeps*	white-streaked grubfish	x	x		r	r	0.19	0.11		0.2	0.2	sub	e	E Aus
Perciformes	Plesiopidae	*Assessor flavissimus*	yellow devilfish	x				r						trop	e	QLD
Perciformes	Plesiopidae	*Paraplesiops bleekeri*	eastern blue devil	x	x		r		0.4		0.4			sub	e	E Aus
Perciformes	Plesiopidae	*Trachinops taeniatus*	eastern hulafish	x	x	a	a	a	**5.96**	0.28	1.17	0.46		temp	e	SE Aus

Perciformes	Pomacanthidae	*Centropyge bispinosus*	two-spined angelfish	x			r	r						trop	c	Indo-Pac
Perciformes	Pomacanthidae	*Centropyge flavissimus*	lemonpeel angelfish	x				r						trop	c	Indo-Pac
Perciformes	Pomacanthidae	*Centropyge tibicen*	keyhole angelfish	x	x	r	r	r		0.6				trop	c	Indo-Pac
Perciformes	Pomacanthidae	*Chaetodontoplus meredethi*	queensland yellowtail angelfish	x	x			r			0.13			trop	e	E Aus
Perciformes	Pomacanthidae	*Pomacanthus imperator*	emperor angelfish	x				r						trop	c	Indo-Pac
Perciformes	Pomacanthidae	*Pomacanthus semicirculatus*	half-circle angelfish	x			r	r						trop	c	Indo-Pac
Perciformes	Pomacentridae	*Abudefduf bengalensis*	bengel sergeant	x		r	r							trop	c	IWP
Perciformes	Pomacentridae	*Abudefduf septemfasciatus*	banded sergeant	x			r							trop	c	Indo-Pac
Perciformes	Pomacentridae	*Abudefduf sexfasciatus*	scissor-tail sergeant	x				r						trop	c	Indo-Pac
Perciformes	Pomacentridae	*Abudefduf vaigiensis*	sergeant major	x			r	r						trop	c	Indo-Pac
Perciformes	Pomacentridae	*Abudefduf whitleyi*	whitleys sergeant	x			r	r						trop/sub	r	E Aus - New Cal
Perciformes	Pomacentridae	*Amphiprion akindynos*	brown anemonefish	x			r	a						trop/sub	r	E Aus - New Cal
Perciformes	Pomacentridae	*Amphiprion latezonatus*	broadband anemonefish	x	x		r	r		0.33				sub	e	E Aus - Norfolk Is.
Perciformes	Pomacentridae	*Amphiprion melanopus*	black anemonefish	x				r						trop	c	W Pac - E Indonesia
Perciformes	Pomacentridae	*Chromis abyssicola*	deep water chromis		x						0.4		0.2	?	r	?
Perciformes	Pomacentridae	*Chromis atripectoralis*	black axil chromis	x				r						trop	c	Indo-Pac
Perciformes	Pomacentridae	*Chromis flavomaculata*	yellow-tail puller	x	x		r	r		0.72			0.7	sub	c	W Pac -ante-equatorial
Perciformes	Pomacentridae	*Chromis fumea*	smokey puller	x			r							sub	c	W Pac -ante-equatorial
Perciformes	Pomacentridae	*Chromis hypsilepis*	one-spot puller	x	x		r	a	0.85	**2.94**		1.3		temp	r	E Aus - NZ
Perciformes	Pomacentridae	*Chromis margaritifer*	half and half puller	x			r	r						trop	c	W Aus to W Pac
Perciformes	Pomacentridae	*Chromis nitida*	barrier reef chromis	x			r							trop/sub	e	E Aus
Perciformes	Pomacentridae	*Chromis weberi*	webers chromis	x			r	r						trop	c	Indo Pac
Perciformes	Pomacentridae	*Chrysiptera flavipinnis*	yellow-finned damsel	x		r	r	r						trop	r	E Aus
Perciformes	Pomacentridae	*Chrysiptera notialis*	southern damsel	x			r	r						sub	r	E Aus - New Cal
Perciformes	Pomacentridae	*Dascyllus reticulatus*	reticulated damsel	x		r	r	a						trop	c	Indo Pac
Perciformes	Pomacentridae	*Dascyllus trimaculatus*	threespot damsel	x	x		r	a		2.78				trop	c	Indo Pac
Perciformes	Pomacentridae	*Mecaenichthys immaculatus*	immaculate damsel	x	x	r	r	r	0.04		**0.29**	0.22	0.27	sub/temp	e	E Aus
Perciformes	Pomacentridae	*Neopomacentrus azysron*	yellow tail damsel	x			r	r						trop	c	Indo Pac

Perciformes	Pomacentridae	*Parma microlepis*	white ear	x	x	r	r				0.33	**0.35**	0.2	temp	e	E Aus
Perciformes	Pomacentridae	*Parma oligolepis*	big scale parma	x		r	r	r						trop/sub	e	E Aus
Perciformes	Pomacentridae	*Parma polylepis*	banded scalyfin	x		r		r						trop/sub	r	E Aus - oceania
Perciformes	Pomacentridae	*Parma unifasciata*	girdled parma	x	x	a	a	a	2.26	**2.39**	0.83	0.61		sub/temp	e	E Aus
Perciformes	Pomacentridae	*Plectrogliphidodon dickii*	dicks damsel	x			r	r						trop	c	Indo Pac
Perciformes	Pomacentridae	*Plectrogliphidodon johnstonianus*	johnston damsel	x			r	r						trop	c	Indo Pac
Perciformes	Pomacentridae	*Plectrogliphidodon lacrymatus*	jewel damsel	x				r						trop	c	Indo Pac
Perciformes	Pomacentridae	*Pomacentrus australis*	australian damsel	x			r							sub	e	E Aus
Perciformes	Pomacentridae	*Pomacentrus bankanensis*	fire damsel	x		r								trop	c	W Pac
Perciformes	Pomacentridae	*Pomacentrus coelestis*	blue damsel	x	x	r	c	a	0.7	0.28				trop/sub	c	W Pac
Perciformes	Pomacentridae	*Pomacentrus imitator (?)*	imitator damsel	x			r							trop	c	W Pac
Perciformes	Pomacentridae	*Pomacentrus nagasakiensis*	sandy damsel	x			r	r						trop	c	W Pac
Perciformes	Pomacentridae	*Pomacentrus pavo*	azure damsel	x				r						trop	c	W Pac
Perciformes	Pomacentridae	*Stegastes apicalis*	yellow tipped gregory	x		r	r							trop/sub	c	E Aus
Perciformes	Pomacentridae	*Stegastes gasgoynei*	gold belly gregory	x	x	r	r	r		0.22				sub	r	E Aus - NZ
Perciformes	Pomatomidae	*Pomatomus saltatrix*	Tailor	x			r	r						trop/sub	g	Atlantic, Indian, E Aus
Perciformes	Priacanthidae	*Priacanthus blochii*	glass eye	x				r						trop	c	Indo-Pac
Perciformes	Priacanthidae	*Priacanthus macracanthus*	spotted bigeye	x			r	r						trop/sub	c	W Pac
Perciformes	Rachycentridae	*Rachycentron canadum*	Cobia		x								0.2	trop	g	cir exept E Pac
Perciformes	Scaridae	*Scarus altipinnus*	minifin parrotfish	x			r							trop	c	W Pac
Perciformes	Scaridae	*Scarus chameleon*	chameleon parrotfish	x				r						trop	c	W Pac
Perciformes	Scaridae	*Scarus frenatus*	bridled parrotfish	x				r						trop	c	Indo-Pac
Perciformes	Scaridae	*Scarus ghobban*	blue-barred parrotfish	x			r	r						trop	c	Indo Pac
Perciformes	Scianidae	*Argyrosomus hololepidotus*	jewfish, mulloway	x	x			r			0.42			temp	g	southern hemisphere
Perciformes	Scianidae	*Atractoscion aequidens*	teraglin, trag		x						0.63	0.11	0.31			
Perciformes	Scombridae	*Sarda australis*	australian bonito	x	x		r	r				0.2		temp	e	southern Aus
Perciformes	Scombridae	*Scomber australasicus*	slimy mackeral	x			r	r						sub	c	S Pac, N Pac
Perciformes	Scorpididae	*Atypichthys strigatus*	mado		x				3.48	**30.8**	28.42	25.26	20.07	temp/sub	e	E Aus
Perciformes	Scorpididae	*Microcanthus strigatus*	stripey		x						0.8			sub	c	Indo W Pacific
Perciformes	Scorpididae	*Scorpis lineolata*	silver sweep	x	x	r	a	a	**22**	2.39	7.08	9.8	1.64	sub/temp	r	E Aus - NZ

Perciformes	Serranidae	*Acanthistius ocellatus*	wirrah	x	x	r	r	r	0.26		0.8	0.7		temp	e	SE Aus
Perciformes	Serranidae	*Caesioperca lepidoptera*	butterfly perch		x						0.04	0.48	**0.64**	temp	r	southern Aus, NZ
Perciformes	Serranidae	*Cephalopholis miniata*	coral cod	x		r	r	r						trop	c	Indo-Pac
Perciformes	Serranidae	*Cephalopholis spiloparaea (?)*	strawberry rockcod	x			r							trop	c	Indo-Pac
Perciformes	Serranidae	*Cephalopholis urodeta*	flagtail rockcod	x			r	r						trop	c	W-C Pac
Perciformes	Serranidae	*Diploprion bifasciatum*	barred soapfish	x			r							trop	c	IWP
Perciformes	Serranidae	*Epinephelus coioides*	estuary cod	x				r						trop	c	Indo-Pac
Perciformes	Serranidae	*Epinephelus daemelii*	black cod	x	x	r	r	r	0.4					sub	r	E Aus - NZ
Perciformes	Serranidae	*Epinephelus fasciatus*	red-barred cod	x	x	r	r	r	0.04	**0.22**				trop/sub	c	Indo-Pac
Perciformes	Serranidae	*Epinephelus lanceolatus*	queensland groper	x				r						trop	c	Indo-Pac
Perciformes	Serranidae	*Epinephelus quoyanus*	long-finned cod	x		r		r						trop	c	IWP
Perciformes	Serranidae	*Epinephelus undulatostriatus*	maori cod	x	x	r	r				0.4	0.2		sub	e	E Aus
Perciformes	Serranidae	*Hypoplectrodes annulatus*	black-banded seaperch		x						0.13	0.7	0.2	temp	e	E Aus
Perciformes	Serranidae	*Hypoplectrodes macullochi*	half-banded sea-perch	x	x	r	r	r	1.44	0.61	1.21	1.3	0.78	sub/temp	e	E Aus
Perciformes	Serranidae	*Hypoplectrodes nigroruber*	banded sea-perch	x			r	r						sub/temp	e	southern Aus
Perciformes	Serranidae	*Pseudanthias fasciatus*	red-stripe seaperch	x				r						trop/sub	c	W Pac
Perciformes	Serranidae	*Pseudanthias pictilis*	purple-yellow seaperch	x				r						sub	r	E Aus - New Cal
Perciformes	Serranidae	*Pseudanthias squamipinnis*	orange seaperch	x		r	r	r						trop	c	Indo-Pac
Perciformes	Serranidae	*Trachypoma macracanthus*	strawberry cod	x			r	r						sub	r	NSW - NZ
Perciformes	Serranidae	*Variola louti*	coronation trout	x				r						trop	c	Indo-Pac
Perciformes	Siganidae	*Siganus nebulosus*	happy moment	x	x	r	r	c		0.33	0.8	0.17		sub	e	E + W Aus
Perciformes	Sparidae	*Acanthopagrus australis*	bream	x	x	c	r	r	0.7					sub	e	E Aus
Perciformes	Sparidae	*Pagrus auratus*	snapper	x	x	r	r	r	1.63	0.72	0.83	**1.89**	3	sub/temp	r	southern Aus - NZ
Perciformes	Sparidae	*Rhabdosargus sarba*	tarwhine	x	x	r	r	r	0.26	0.28		0.8	0.9	trop/sub	c	Indo-Pac
Perciformes	Sphyraenidae	*Sphyraena flavicauda*	yellowtail barracuda	x		r								trop	c	Indo-Pac
Perciformes	Tripterygiidae	*Enneapterygius rufopileus*	black cheek threefin	x		r	r	r						sub	e	E Aus - LHI
Perciformes	Tripterygiidae	*Enneapterygius spp.*	unidentified triplefin	x		r	r	r								
Perciformes	Zanclidae	*Zanclus cornutus*	moorish idle	x			r	r						trop	c	Indo-Pac
Scorpaeniformes	Platycephalidae	*Thysanophrys cirronasus*	rock flathead	x		r								sub/temp	e	southern Aus
Scorpaeniformes	Scorpaenidae	*Pterois volitans*	lionfish	x		r	r	r						trop	c	IWP
Scorpaeniformes	Scorpaenidae	*Scorpaena cardinalis*	red rockcod	x	x	r	r	r	1.81	**2.17**	0.83	1.07	0.13	sub/temp	r	E Aus - NZ

Scorpaeniformes	Scorpaenidae	*Scorpaena cookii*	cooks rockcod	x	x							0.2		temp	R	NSW - NZ
Scorpaeniformes	Scorpaenidae	*Scorpaenodes littoralis*	shore scorpionfish	x										trop/sub	c	Indo-Pac
Siluriformes	Plotosidae	*Cnidoglanis macrocephala*	estuary catfish	x		r								temp	e	southern Aus
Syngnathiformes	Aulostomidae	*Aulostomus chinensis*	trumpetfish	x	x	r	r	r	0.4	0.6				trop/sub	c	Indo-Pac
Syngnathiformes	Aulostomidae	*Fistularia spp.*	flutemouth	x	x		r	r		0.11						
Syngnathiformes	Syngnathidae	*Solegnathus spinosissimus*	spiny pipehorse		x							0.2	0.4	temp	r	E Aus - NZ
Tetradontiformes	Aracinidae	*Anoplocapros inermis*	eastern smooth boxfish	x	x	r					0.4			temp	e	E Aus
Tetradontiformes	Balistidae	*Abalistes stellatus*	starry triggerfish		x							0.2		trop	c	Indo W Pacific
Tetradontiformes	Balistidae	*Balistoides conspicullum*	clown triggerfish	x			r	r						trop	c	Indo-Pac
Tetradontiformes	Balistidae	*Pseudobalistes flavomarginatus*	yellow margin triggerfish	x				r						trop	c	Pac
Tetradontiformes	Balistidae	*Sufflamen bursa*	scimitar triggerfish	x			r							trop	c	Indo-Pac
Tetradontiformes	Balistidae	*Sufflamen chrysopterus*	half-moon triggerfish	x	x	r	r	r		0.6				trop	c	Indo-Pac
Tetradontiformes	Balistidae	*Sufflamen fraenatus*	bridled triggerfish	x			r	r						trop/sub	c	Indo-Pac
Tetradontiformes	Balistidae	unidentified Ballistid spp	unidentified triggerfish	x	x			r		0.6						
Tetradontiformes	Diodontidae	*Dicotylichthys punctulatus*	three bar porcupinefish	x	x	r	r	r	0.4		0.4		0.4	sub	e	E Aus
Tetradontiformes	Diodontidae	*Diodon holocanthus*	fine-spotted porcupine fish	x				r						trop	cir	circum-trop
Tetradontiformes	Diodontidae	*Diodon hystrix (?)*	porcupinefish	x			r	r						trop	cir	circum-trop
Tetradontiformes	Diodontidae	*Diotontid spp.*	unidentified porcupinefish	x			r									
Tetradontiformes	Monocanthidae	*Brachaluteres jacksonianus*	pygmy leatherjacket	x	x			r			0.4			temp	e	southern Aus
Tetradontiformes	Monocanthidae	*Cantherinus pardalis*	honeycomb leatherjacket	x				r						trop/sub	c	Indo-Pac
Tetradontiformes	Monocanthidae	*Eubalichthys bucacephalus*	black reef leatherjacket		x							0.4		temp	e	southern Aus
Tetradontiformes	Monocanthidae	*Eubalichthys mosaicus*	mosaic leatherjacket	x	x	r	r		0.4			0.11		sub/temp	e	southern Aus
Tetradontiformes	Monocanthidae	*Meuschenia freycineti*	six spine leatherjacket	x	x				0.4		0.17	0.6	0.7	temp	e	southern Aus
Tetradontiformes	Monocanthidae	*Meuschenia scaber*	velvet leatherjacket		x								0.9	temp	r	southern Aus, NZ
Tetradontiformes	Monocanthidae	*Meuschenia spp.*	unidentified leatherjacket	x	x		r	r	0.4	0.6	0.13	0.9	0.16			
Tetradontiformes	Monocanthidae	*Meuschenia trachylepis*	yellow-finned leatherjacket	x	x	r	r	r	0.04		0.12	0.06	0.07	sub/temp	e	E Aus
Tetradontiformes	Monocanthidae	*Nelusetta ayraudi*	chinaman leatherjacket		x						0.4	0.9	0.51			
Tetradontiformes	Monocanthidae	*Paraluteres prionurus*	mimic filefish	x				r						trop	c	Indo-Pac
Tetradontiformes	Monocanthidae	*Pervagor alternans*	yellow-eyed leatherjacket	x				r						trop/sub	c	Indo-Pac

Tetradontiformes	Monocanthidae	*Scabinichthys granulatis (?)*	rough leatherjacket	x		r								temp	e	southern Aus
Tetradontiformes	Ostraciidae	*Ostracion cubicus*	yellow boxfish	x				r						trop	c	Indo-Pac
Tetradontiformes	Ostraciidae	*Ostracion meleagris*	black boxfish	x				r						trop	c	Indo-Pac
Tetradontiformes	Tetradontidae	*Arothron firmamentum (?)*	mainstay puffer	x		r								temp	c	SW Pac - Japan
Tetradontiformes	Tetradontidae	*Arothron hispidus*	stars & stripes pufferfish	x		r	r	r						trop	c	Indo-Pac
Tetradontiformes	Tetradontidae	*Arothron nigropunctatus*	black spotted pufferfish	x				r						trop	c	Indo-Pac
Tetradontiformes	Tetradontidae	*Arothron stellatus*	starry toadfish	x		r								trop	c	Indo-Pac
Tetradontiformes	Tetradontidae	*Canthigaster callisterna*	clown toby	x	x			r	0.7	0.6	0.4	0.6	0.2	sub	r	NSW - NZ
Tetradontiformes	Tetradontidae	*Canthigaster valentini*	saddled puffer	x				r						trop	c	Indo-Pac
Tetradontiformes	Tetradontidae	*Torquigener pleurogramma*	weeping toado	x		r								temp	e	southern Aus