Ecosystem impacts of human usage and the effectiveness of zoning for biodiversity conservation: broad-scale fish census

Final analysis and recommendations 2007

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Russ Babcock, Mick Haywood, Mat Vanderklift, Geordie Clapin, Matt Kleczkowski, Darren Dennis, Tim Skewes, Dave Milton, Nicole Murphy, Richard Pillans, Andrew Limbourn

CSIRO Marine and Atmospheric Research

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SUMMARY

Populations of fish targeted by recreational fishers in the Ningaloo Marine Park were surveyed in 2006 and 2007 to assess whether populations in pre-existing sanctuary zones (established in 1987) differed from those in areas that were open to fishing. Herbivorous fish from major families in this functional group were also censused. A further aim of the work was to provide baseline data on populations from newly declared sanctuary zones that could be used to assess future trends in protected populations as well as across the park as a whole. Over 900 sites were surveyed over this time using underwater visual census (UVC), with effort focused on 12 sanctuary zones distributed along the length of the park.

Fish assemblage structure showed clear trends with habitat and from north to south. There was also a significant overall difference in fish assemblages inside and outside sanctuary zones. The zoning related patterns appeared to be complex however, and examination of assemblages on a region by region basis showed zoning-related patterns in assemblages at only three sites, where targeted species were among those most likely to explain observed differences in assemblages. Non-target groups, including large grazers (scarids and kyphosids) were also associated with these differences. Among the species most commonly targeted by anglers there was an overall increase in biomass for the yellow tailed emperor (*L. atkinsoni*) which was between 0.9 and 2.4 times greater in pre-existing sanctuary zones, as well as in the spangled emperor (*L. nebulosus*) with biomass between 0.4 and 2.8 times greater. These trends in fish biomass were largely driven by the size structure of populations in sanctuary zones. The trends in both of these species were strongest in the in fish greater than the minimum legal size, consistent with fishing being the factor driving these differences. Other species that showed significant biomass increases in sanctuary zone areas were *Epinephelus rivulatus* in regions in which pre-existing sanctuaries were present, and *Lutjanus argentimaculatus* at the Exmouth Gulf region at Bundegi, where this species is more widely distributed than on Ningaloo Reef proper.

Other species commonly targeted by recreational fishers were significantly more common outside sanctuary zones than inside them. The reasons for this are unclear but are likely to be complex, relating to the uneven distribution of habitat among pre-existing sanctuary zones and open areas, movements and habitat preferences of these species, as well as the distribution of fishing effort around the reef. Most of these species are strongly associated with reef slope habitats which have been relatively poorly represented in pre-existing zones. Significant trends in relation to fishing pressure were nevertheless present among many of these species, which included large groupers

and sharks, with biomass tending to be significantly lower in areas with higher levels of recreational fishing pressure.

Comparisons among reserves of different sizes showed no clear trends in effectiveness of zones with respect to the size of sanctuary zones. At Osprey sanctuary zone there appeared to be fewer *L. nebulosus* than had been measured in surveys in 1987. The downward trend in abundance was smaller in the Osprey sanctuary zone sites than in the adjacent fished sites.

The sampling methods employed delivered a high level of statistical power and allowed and examination of effects along the entire extent of the marine park as well as within individual regions. They provide the basis for the design of an ongoing monitoring and research program which should take advantage of recent developments in sampling design that will allow for systematic rotation of sampling and offer greater economy and precision and provide the most accurate possible estimates of absolute population density. The design should use the latest information (e.g. from Ningaloo Collaboration Cluster) for stratification of sampling among habitats. Future monitoring related research should include cross-calibration of deep water BRUV and shallow water UVC sampling. Other research needs highlighted by this project include the need to further investigate the potential for indirect effects of fishing due to apparent effects on shark populations in the Park.

BACKGROUND

Fishing is perhaps the most ubiquitous of human influences in the ocean. The impact of fishing on target species is often intense, and frequently targets predatory species (Crowder et al. 2008). In developed nations, a large proportion of the catch is taken by recreational fishers (Arlinghaus & Cooke 2005). Due to the difficulty of managing multiple sectors, each of which may be targeting multiple species, and also in recognition of the need to manage the ecosystems that support target species as well as target species themselves, ecosystem-based management is increasingly used (Crowder et al 2008). One important tool used in this form of management is a spatially-explicit approach. In Western Australia, one key form of spatial management is Marine Parks, which are established for multiple reasons, among which protection from fishing falls within a much broader mandate of conserving biodiversity and ecological processes.

Areas that are closed to fishing may directly protect the fish populations that reside within them, they are also thought to benefit adjacent fisheries by emigration of adult and juvenile fishes (the "spillover" effect; Rowley 1994) and the export of pelagic eggs and larvae (Roberts and Polunin 1991, Roberts 1995). Whether these benefits occur or not is dependent on a range of factors such as the size of the reserve and the mobility of the adult and larval fish. Many species of coral reef fish are strongly site-attached with relatively small home-ranges (Munro and Williams 1985, Zeller 1999) and some studies have suggested coral reef fish larvae may be retained in the vicinity of their natal reefs (Leis and Goldman 1987, Kobayashi 1989, Almanay et al. 2007). These characteristics may mean that for many species the benefits of protection from exploitation are localised to the area within and immediately adjacent to the reserve.

The Ningaloo Marine Park and Muiron Islands Marine Management Area are located approximately 1200 km north of Perth, and encompass approximately 263,343 ha and 28,616 ha respectively. The *Ningaloo Marine Park* was gazetted in 1987 and the Muiron Islands Marine Management Area was gazetted in 2004. A review of the Management Plan began in 2000; the revised Management Plan was approved by the Minister in January 2005. Changes in the current Management Plan include extending the Marine Park southwards to incorporate the full extent of the reef, increasing the number and extent of Sanctuary Zones, and introducing Special Purpose Benthic Protection and shore-based line fishing zones. A key ecological value identified in the Management Plan was the diversity of fish found within the Ningaloo Marine Park, and fishing (particularly recreational) was identified as a major pressure on this value. An objective was therefore established to "ensure the species distribution and abundance of finfish species are not unacceptably impacted by recreational and commercial fishing". The primary vehicle for achieving this objective is the zoning strategy.

The purpose of this project was twofold: to test the effectiveness of previously established Sanctuary Zones and to provide the first data towards a long-term data set in newly declared Sanctuary Zones. These data will become an integral part of ongoing research and monitoring of the Ningaloo Marine Park, to facilitate not only the assessment of the ecosystem effects of fishing, but also the evaluation of the effectiveness of zoning for biodiversity conservation, and for conserving and managing target fish populations both inside and outside sanctuary zones. The surveys provide data for the newly established zones, as well as for zones already established within the park under the previous management plan. Where possible the survey built on existing data sets, though these were limited in scope and spatial extent.

Objectives

The specific objectives of this project were to survey fish taxa targeted by anglers (mainly species within the families Labridae, Lethrinidae, Lutjanidae, Serranidae, and Carangidae), as well as on taxa that may be affected by incidental capture (Haemulidae and sharks) in order to:

1. Measure the distribution, abundance and size-structure of their populations within the Ningaloo Marine Park,
2. Provide data for quantitative comparison of these parameters among Ningaloo Marine Park zones (pre-2005 sanctuary zones, new sanctuary zones, benthic protection zones, recreational zones and general use zones), and
3. Provide data that will form the basis for being able to:
    - Measure the rate and magnitude of any changes in target species population abundance or size structure related to changes in marine park zoning,
    - Determine how patterns in abundance and size structure of target species vary with respect to factors such as size of reserve, type of reserve, distance from boundary and fish life-history, and
    - Parameterize and test spatially-explicit models of target species populations.

Data relating to other questions, such as the potential for direct effects on non-target species (bycatch), or indirect effects of fishing through effects on lobster or on grazing fish species, were also collected during this project as a concurrent set of separate objectives. The bulk of these objectives will be reported elsewhere.

Need

In the case of a fish population released from fishing pressure by spatial closures, several immediate responses may be envisaged, and these might be broadly categorized into two categories: the population may increase in abundance, or it may stay much the same. The processes underlying these responses may be far more varied. A population may increase in abundance if it has been measurably affected by fishing, but not to the extent that would inhibit recovery. Conversely, if there is no change in abundance possible reasons can include the contrasting possibilities that either it was not measurably reduced by fishing, or conversely that it was reduced to such an extent that it is reduced below some threshold and may only be able to recover very slowly. It may also be that the area closed was too small, in relation to the range of movement of individual fish, so that they were still essentially exposed to fishing.

The Ningaloo Marine Park is a Multiple-Use Marine Park with several different types of management zone. The different types of zone are intended to achieve a wide range of goals, but in practical terms their main impact on human usage has been to restrict spatial patterns of commercial and recreational fishing within the park. This zoning has been achieved at substantial financial and emotional cost, consequently it is essential that WA Department of Environment and Conservation (DEC) and other state agencies assess the response of fished populations in order to evaluate the effectiveness of zones for a range of targeted species, and across the various places where they are used.

Not all fish species behave in the same way, some moving much more widely than others, and this may substantially affect the way they respond to changes in fishing pressure. In acknowledgement of this it is important to measure which species increase in abundance or size after implementation of zones and whether this response varies with the size of spatial closure. For example it might be predicted that if highly mobile species respond, this will only be evident in large zones. Depending on fish movement and fishing pressure, the effects of zoning might lead to boundary effects such as either increased densities of fish outside Sanctuary zones, or reduced densities of fish just inside boundaries.

Variations in fish behaviour can interact in other important ways with the zone type, such as Sanctuary Zone (SZ) or Special Purpose Benthic Protection (SPBPZ). It is often assumed that pelagic species are so mobile that they will receive little or no benefit from sanctuary zones, and that they can be protected solely by measures such as minimum legal size and bag limits; this assumption requires testing.

METHODS

Survey design

Survey sites in the Ningaloo Marine Park were selected from among coastal areas stretching from of Gnaraloo in the south to the Muiron Islands in the north. Potential sites were initially identified from a series of digital spatial data sets including geo-referenced aerial photograph mosaics, benthic habitat maps, and marine park zonings for both new and old plans. The marine park zoning data were loaded into a GIS (Arc View 3.3), where the old and new plans were overlaid to generate an entire coverage including pre-existing zone boundaries and the recent extensions to the pre-existing zones.

To facilitate accurate distance measurement, all GIS layers were initially projected to UTM (zone 49) coordinates. A 200m grid from was then overlaid across the study area from Gnaraloo to the Muiron Islands, from which potential sites were selected randomly. Specifically, sites were chosen by generating a single random point within each 200m grid cell using the Sample 3.03 extension for ArcView 3.3. The aerial photographs were overlaid with the combined zoning and habitat data, and the point coverage from the 200m grid. From this, a selection of sites was chosen from the randomly generated points.

Sites from among the randomly generated points were then selected such that the effects of several factors could be tested. These factors included location of management zone, age of management zone, and habitat. Within each management zone, samples were stratified by habitat (outer reef slope, reef flat, and lagoon), and distance from zone boundary.

Sampling around each no-take zone was spatially structured to make it possible to pick up any spatial gradients in fish abundance that might have developed relative to park zoning. Importantly we avoided constructing a “paired BACI” type design using a cluster of sites inside and outside each zoning treatment. Reconnaissance of the reef prior to the project suggested there was a high degree of spatial variation at scales of 100-1000m that could potentially be confounded with treatment effects. Therefore within any pre-existing sanctuary zone, sites would be placed within the centre of the zone as well as near the boundaries (except the seaward boundary). Outside each sanctuary zone an equivalent spatial structure was established, with sites that were adjacent to the boundary (< 0.5km), as well as other sites that were distant from the boundary (>1km). The Maud zone was an exception because there is no similar fringing reef present immediately to the north of the Maud Sanctuary zone. Within each of these strata, sites were also stratified with respect to reef habitats, to include outer reef slope, reef flat and lagoon sites. A further aspect accommodated by the design was the fact that newly expanded zones included pre-existing zones, so the establishment of sites had to be sufficient to be able to assess the effects of pre-existing zones as well as to lay the basis for detection of trends than may develop in new zones over time (Fig. 1). Sites selected based on these criteria were then projected into geographic co-ordinates (WGS 84) and downloaded to a GPS unit.

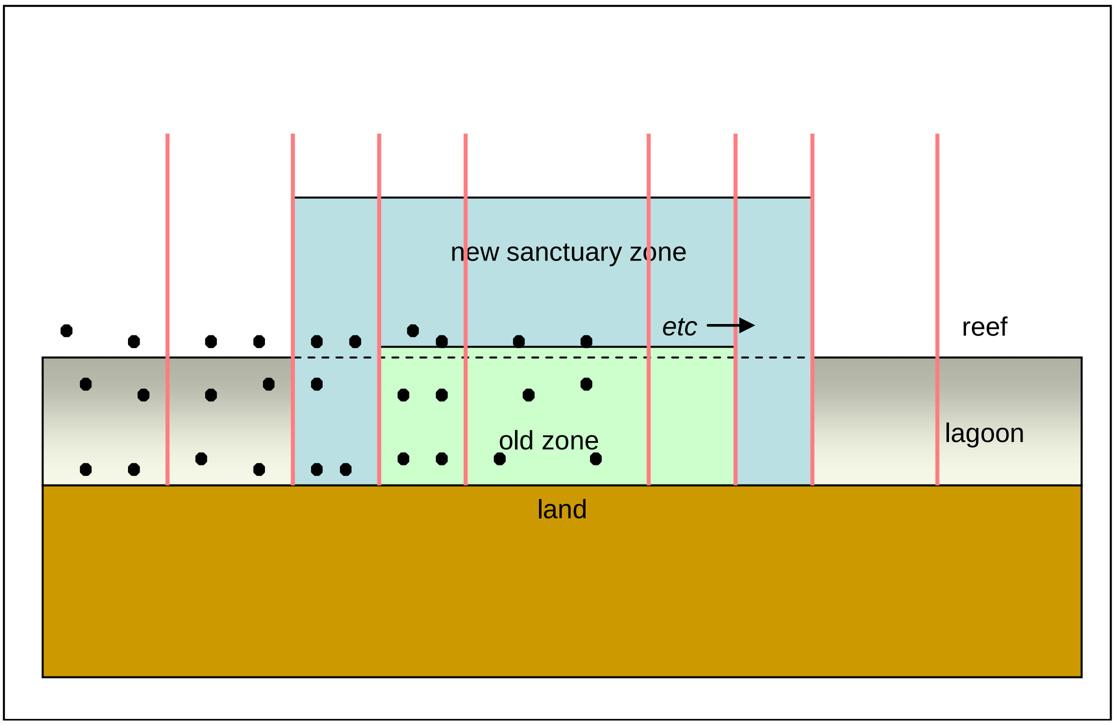


Figure 1. Diagram of sampling design to achieve representation of large scale habitat types, historical variation in zoning and potential gradients in effects on fish populations.

Field Sampling

Fishes within the Ningaloo Marine Park were sampled using underwater visual census (UVC). Survey sites were located in the field using a hand-held GPS unit; at each site a single SCUBA diver swimming along a 100m x 10m belt transect, identifying, counting, and estimating the total length of fishes observed within the transect.

Transect length was measured by the diver using a modified Chainman©. This device measures distance by paying out biodegradable 0.3mm cotton twine and displaying the length of twine on a counter easily viewed by the diver. On reaching the seabed, the diver wraps a coil of twine around a solid structure then begins the 100m transect. Upon reaching the end of the transect, the twine is wrapped around a structure, broken off, then left on the benthos to biodegrade within a few days. This method greatly increases the efficiency of the transect method since a line does not need to be laid or retrieved as would be necessary using the traditional tape measure approach.

Due to the high diversity of fishes in tropical reef systems it was decided that censuses would focus on several discrete guilds of fish rather than the entire fish assemblage. Focusing attention on particular guilds minimized the tendency to overlook species of interest in a highly dynamic and diverse fish assemblage, and thus increased the accuracy and precision of surveys. The guilds under investigation included major predatory fishes that are targeted by recreational fishers, taxa that may be incidentally captured, as well as the main herbivorous families. Predatory fishes surveyed included those from the families Lethrinidae, Lutjanidae, Serranidae, Carangidae, Scombridae, Labridae, Haemulidae, and Carcharhinidae while the herbivorous families surveyed included; Scaridae, Siganidae, Acanthuridae, and Kyphosidae.

Where possible, fishes observed on any transect were identified to species level. In order to minimize inter-observer variation in fish identification, photographic species identification guides were produced and divers trained to identify fishes from the families of interest prior to the commencement of field work. In addition, diver’s length estimates were calibrated underwater using fish silhouettes of known length.

In addition to surveying fishes and spiny lobsters, each diver characterized the benthic habitat by estimating percent cover of sessile life forms (e.g. coral, algae) and substratum classes (e.g. sand, rubble, boulders), and the cover of live versus dead coral (English et al. 1997). Other information recorded by the SCUBA diver included the depth, visibility, and the compass bearing of the direction swum. A snorkel diver would follow the SCUBA diver and record the percentage cover of the various coral growth forms (branching, tabulate, digitate, massive, encrusting, sub-massive), and the species composition of algae and seagrasses. To complement this habitat data, the snorkel diver also took multiple photographs of the benthos along the length of each transect.

Operationally, the sampling involved deploying one SCUBA and one snorkel diver at each sampling location without anchoring the vessel. Each 100m transect took approximately 30 minutes to complete. Since only a single transect was conducted at each site, transects represented a replicate in a given zone–habitat strata. Working in this way using two teams on separate inflatable boats, it was possible to complete up to 40 transects per day. This regime, whilst lacking resolution at the site scale, maximized the resolution of sampling at the larger scale of most interest to the objectives of this study, and allowed collection of density and size data for fishes over a broad area of the Ningaloo Marine Park.

Analysis

Data were broadly stratified by management zone, habitat and region for analyses, with habitats being defined as reef slope, reef flat, and lagoon. Because the new zoning provisions were either not in existence or were relatively recent at the time of the surveys, management zones were classified as either no-take (inside pre-existing sanctuary zones established in 1987) or open (outside pre-existing sanctuary zones) Zoning, Habitat and Region were treated as fixed effects (e.g. Willis et al. 2003).

Fish assemblage data sets were examined using multivariate analyses, mainly Permutational Anova and MANOVA (Permanova) for hypothesis testing and Canonical Analysis of Principal Coordinates (CAP). Where Permanova showed significant differences among *a priori* groupings (Regions, Habitats, Zoning) CAP was used for visualizing groups within the data and assessing species primarily responsible for these groupings (PRIMER and PERMANOVA+, Anderson et al 2008). Biomass data (derived from length estimates and published Length-weight relationships in FISHBASE; Froese and Paulyl. 2008) were used in these analyses because any changes in assemblage structure related to the effects of no-take zones would be most likely to be reflected by differences in biomass (i.e. populations of targeted species are expected to have higher proportions of individuals greater than minimum legal size in pre-existing sanctuary zones).

Univariate analyses were used to further explore the data for species that were shown to be important based on multivariate analyses, or which were expected to show a response to marine park protection based on them being major contributors to the recreational fish catch in the Ningaloo Marine Park (Sumner et al 2002). These analyses used log linear analyses (GENMOD procedure in SAS) using an over-dispersed poisson distribution since the count data generally did not (and are not expected to) conform to normal distributions. For part of the data set, we used multiple-regression of fish counts against a number of key habitat variables in order to try to reduce the inherent variability in the data. Residuals derived from this regression were then subjected to the same log-linear analyses described above. The statistical power (probability of not detecting a significant difference) of these analyses was also calculated for key species *Lethrinus nebulosus* and *Lethrinus atkinsoni* both as post hoc analyses of performed tests, as well as in the form of analyses of power for effect sizes simulated as 50% and 100% differences in means, as well as for the observed differences in means. The simulations used poisson distributed variance structures in the simulation routines (Hintze 2008).

We were able to take advantage of an earlier survey conducted in 1987 (Ayling and Ayling 1987) to provide some indication of temporal change in the iconic angling target species *Lethrinus nebulosus* over a period of 20 years in the Osprey Sanctuary. Based on maps provided in the Ayling study we re-sampled 76 of the same sites, using almost identical techniques (the primary distinction being the length and width of the transects: Aylings' transects were 50 × 10m). These data were also subjected to log linear analyses as means for the other univariate data.

RESULTS

Extent of Sampling

The surveys in 2006 and 2007 comprised a total of 930 transects (together comprising 93 kilometers of transect swam by the divers) in sections of the park from the Muiron Islands in the north to Gnaraloo Sanctuary in the south. The surveys were centered on 12 management zones in the park, 7 of which were sanctuary zones that have been existence since the park was first declared in 1987, 2 were new sanctuary zones (Lighthouse Bay, Farquhar and Gnaraloo) and 2 were Conservation Areas at the Muiron Islands. The surveyed sites were divided between the southern (4), central (4) and northern (4) regions of the park, and were designed to include a balanced representation of large and small sanctuaries, as well as a representative range of reef habitats within each of these regions (Fig. 2). Details of the sampling sites are presented in Figures 3-9 and Annexure 1.

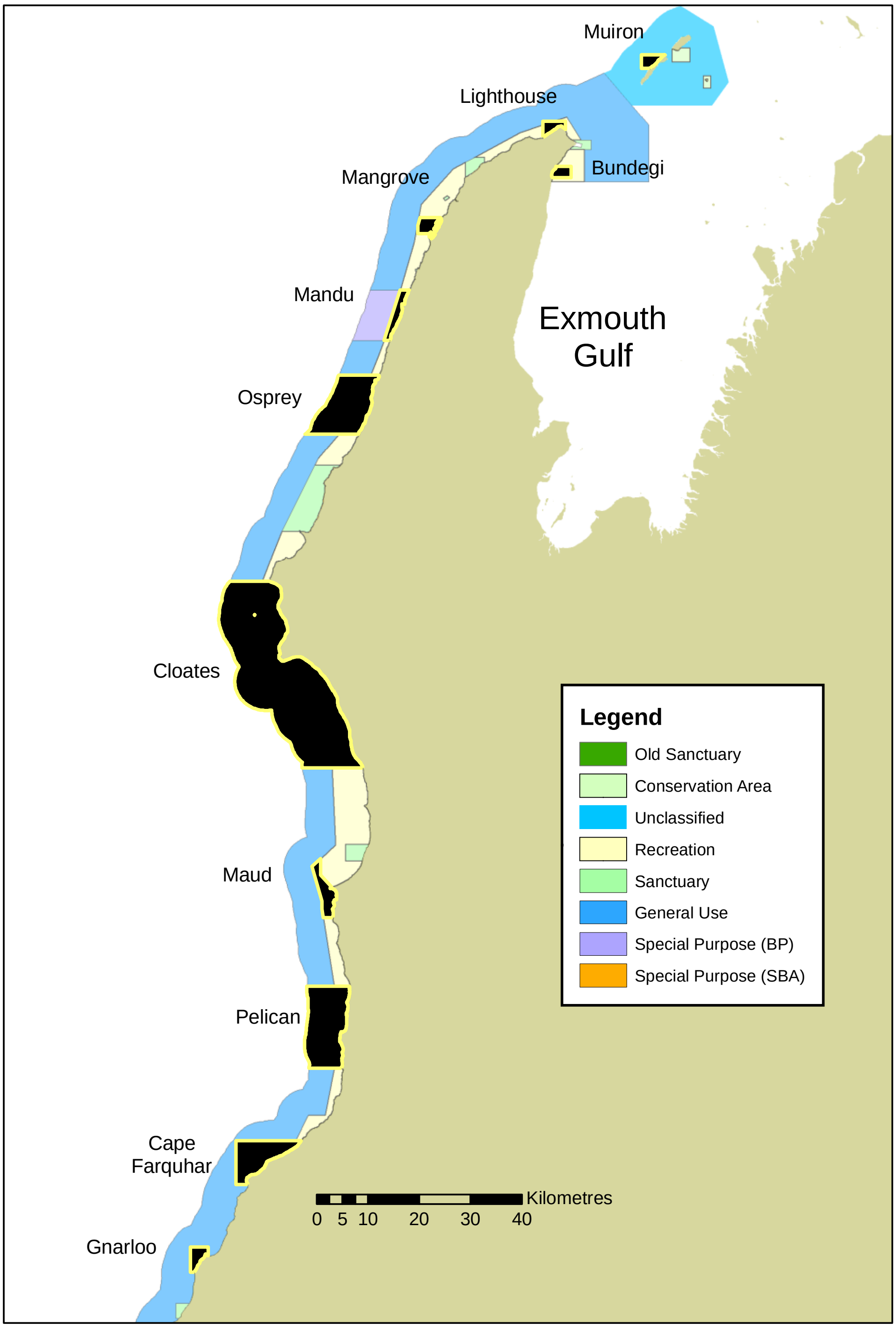


Figure 2. Ningaloo Marine Park. Sanctuaries sampled in this set of surveys are outlined in yellow.

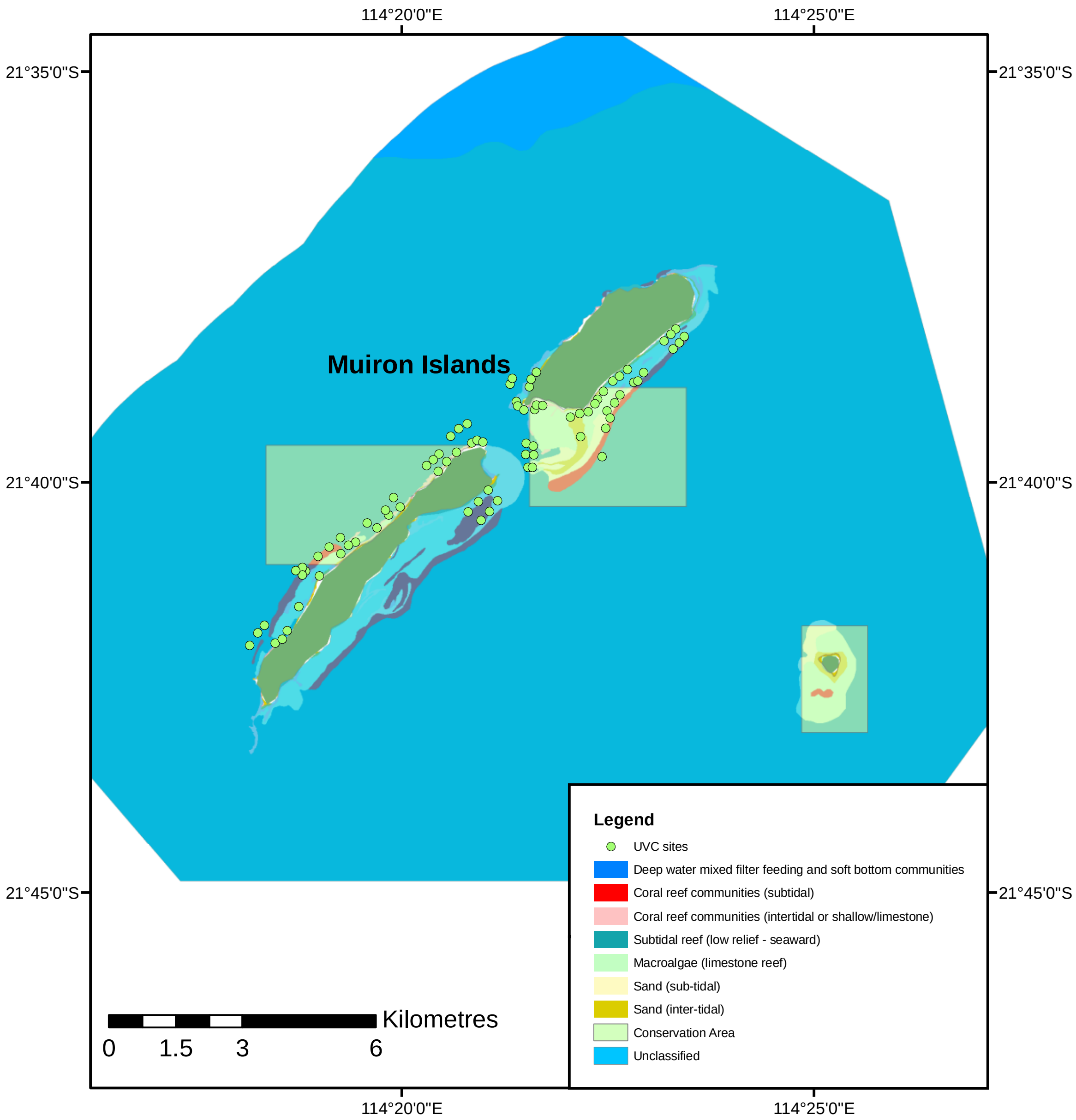


Figure 3. Detail of sampling sites at Muiron Island sanctuary zones (Conservation Area).

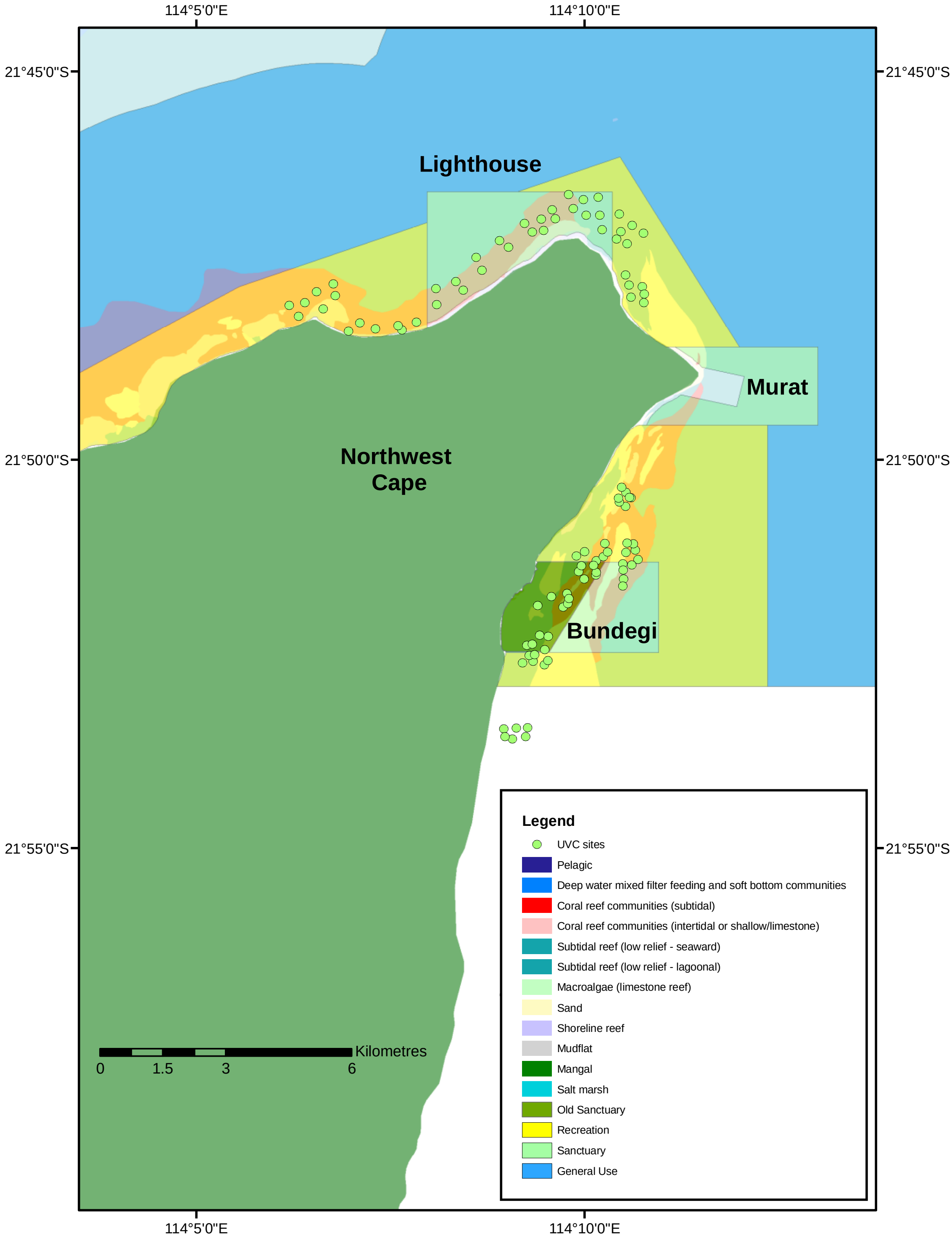


Figure 4. Detail of sampling sites at Lighthouse and Bundegi sanctuary zones.

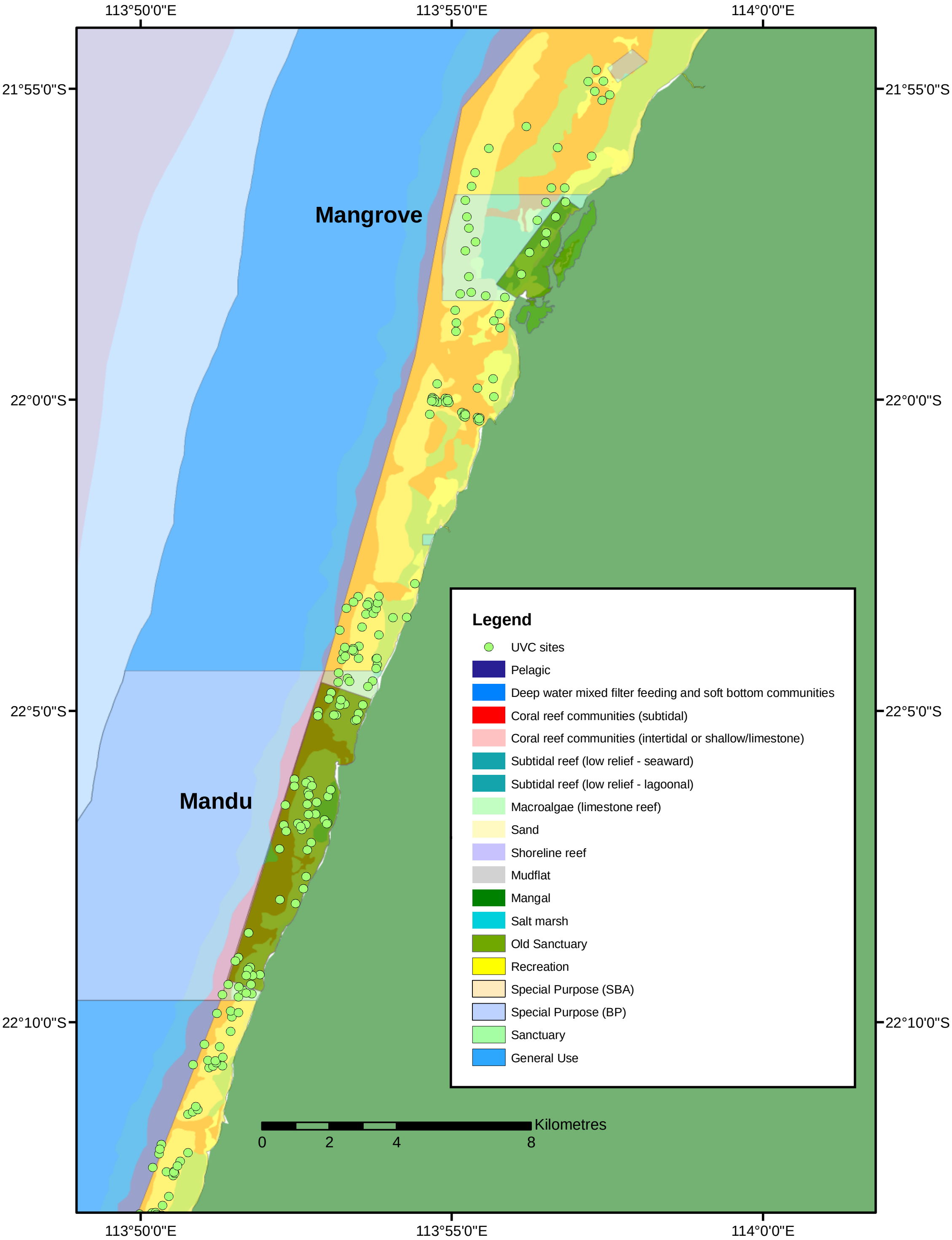


Figure 5. Detail of sampling sites at Mangrove and Mandu sanctuary zones.

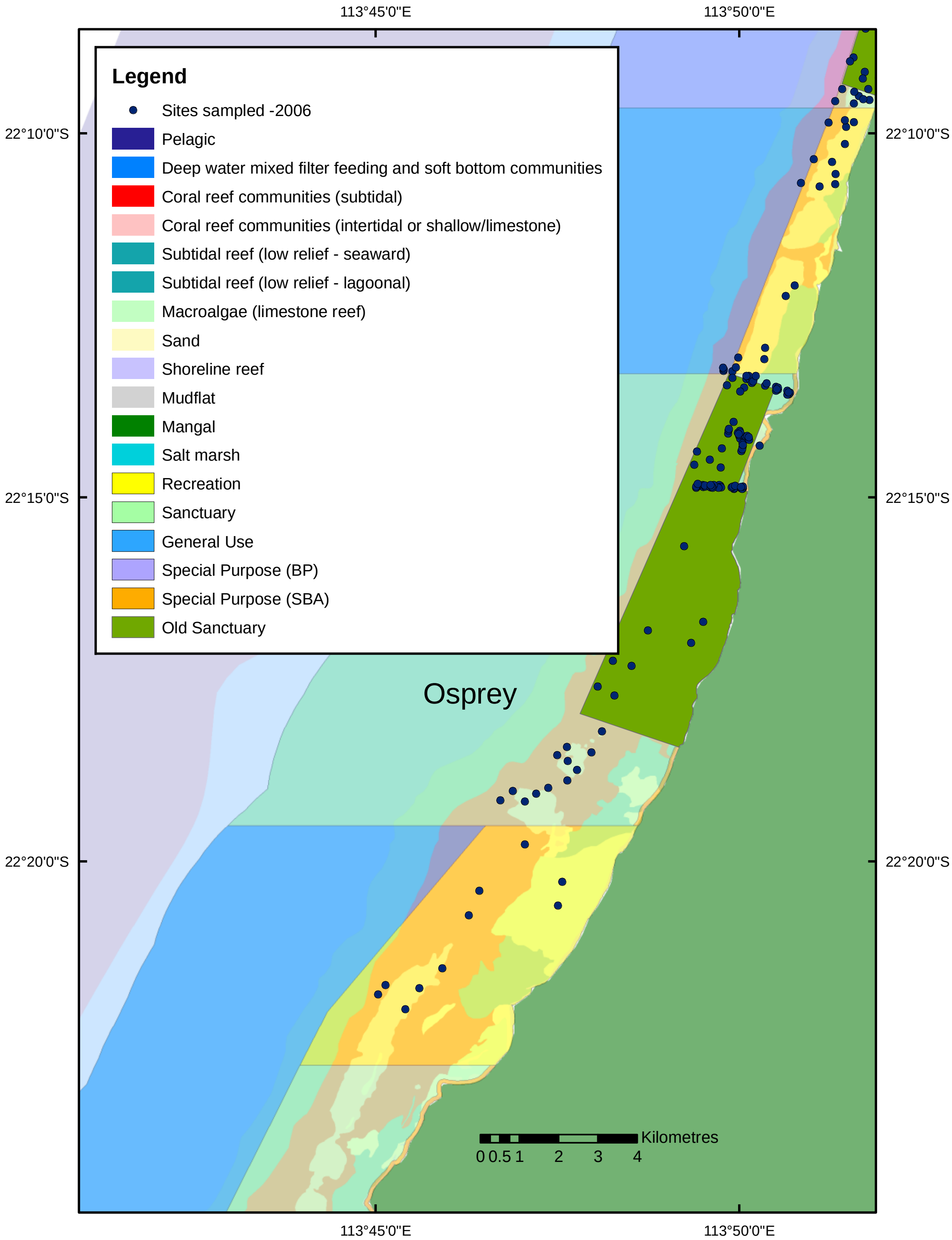


Figure 6. Detail of sampling sites at Osprey sanctuary zone. High density clusters of sites around the northern boundary of the pre-existing sanctuary zone are repeats of sites sampled by Ayling and Ayling (1987).

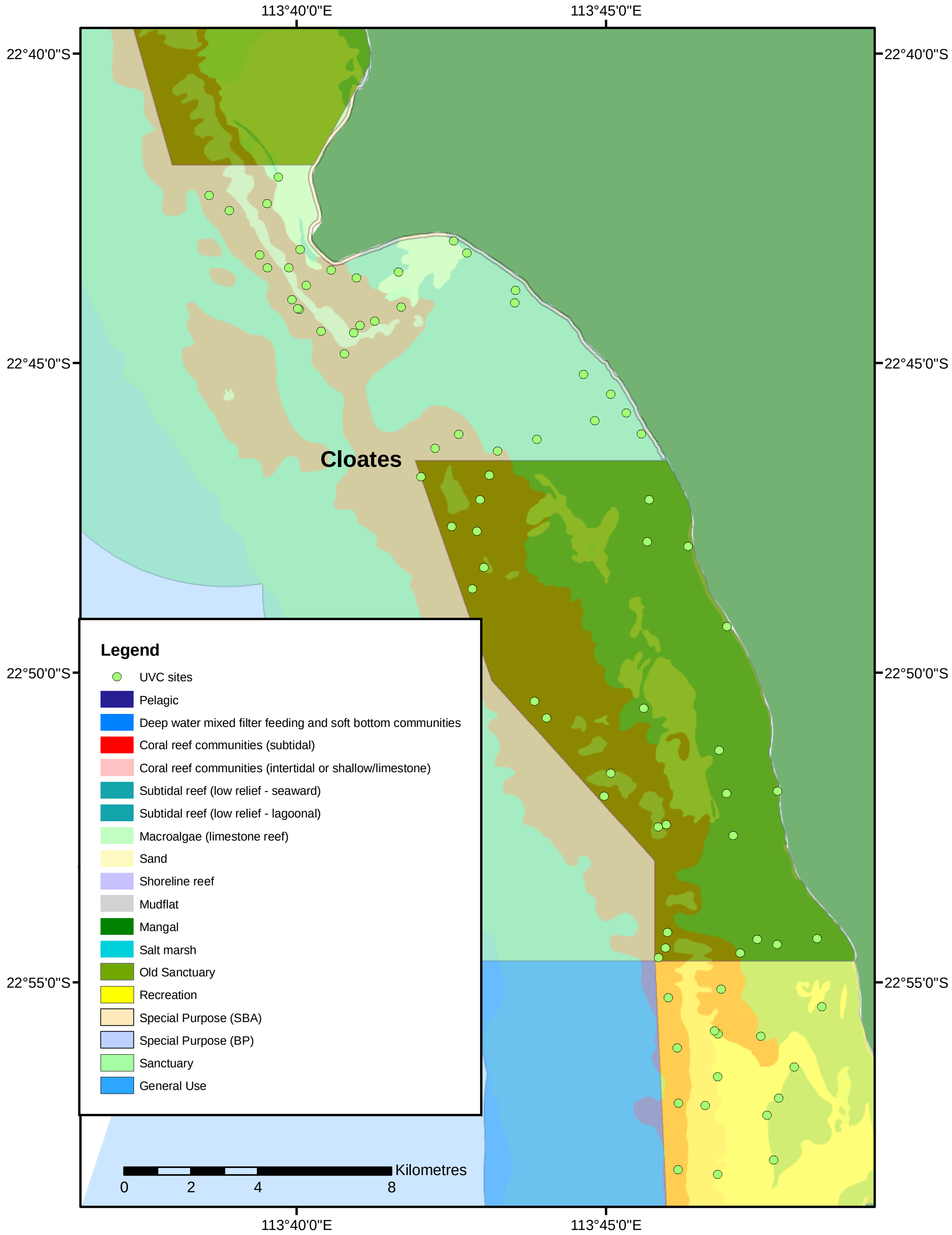


Figure 7. Detail of sampling sites at Cloates (Dugong) sanctuary zone.

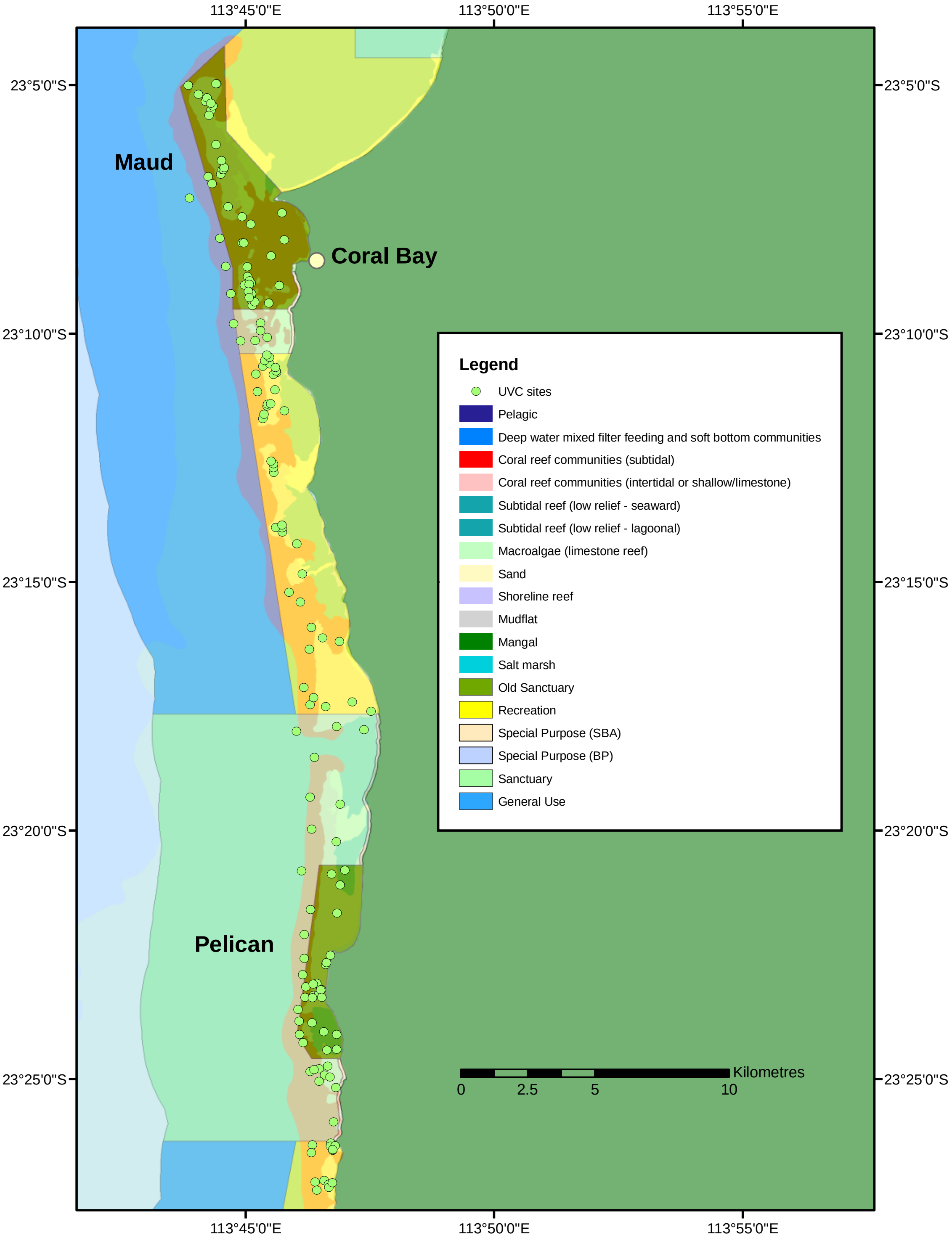


Figure 8. Detail of sampling sites at Maud and Pelican sanctuary zones.

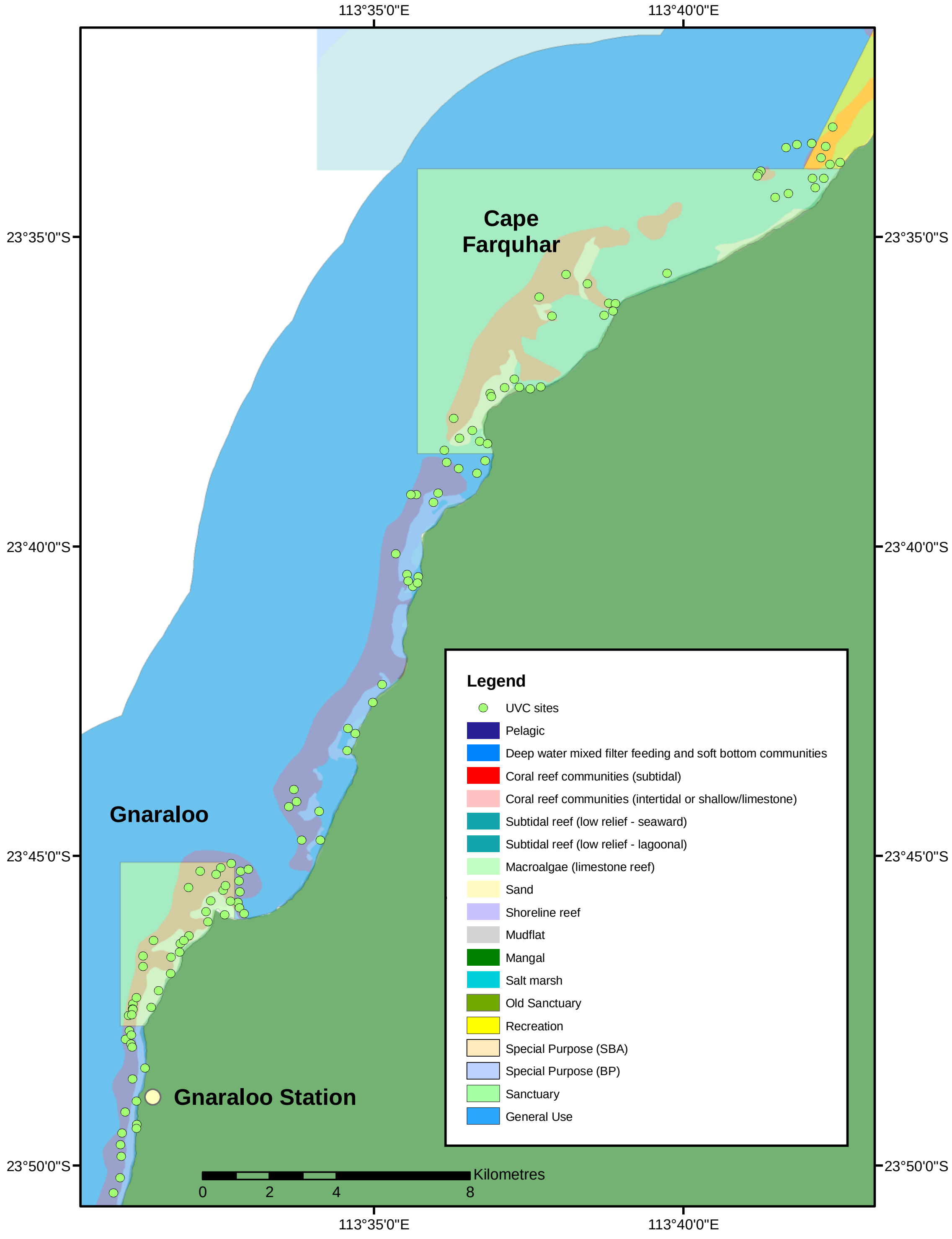


Figure 9. Detail of sampling sites at Farquhar and Gnaraloo sanctuary zones.

General trends in fish assemblages

There were significant trends in the composition of the fish assemblage among regions and among habitats across reefs (Table 1). There was a general latitudinal trend in assemblage structure among Regions, as well as trends across the reef among habitats.

Table 1. Results of permutational analysis of variance (PERMANOVA) based on Bray Curtis similarities calculated from fourth root transformed biomass. P-value generated from 999 permutations of residuals under a reduced model.

Source	**df**	**SS**	**MS**	**Pseudo-F**	**P(perm)**	**Unique perms**
Region	10	19914	1991.4	2.443	**0.001**	997
Habitat	2	7697.5	3848.7	3.7732	**0.001**	998
Region × Habitat	17	17666	1039.2	1.2749	**0.015**	993
Res	18	14673	815.14			
Total	47	61746				

Among habitats, reef slope assemblages were the most distinct (fig. 10), with more species that were found rarely if ever in other habitats. These included species such as the Grey Reef Shark *Carcharinus amblyrhynchos*, the Spanish Mackerel *Scomberomorus commerson* and the Coronation Trout *Variola louti* (Fig. 11). Lagoon and reef flat habitat had more species in common with each other than with the reef slope, although there were still some species, such as the parrotfish *Leptoscarus vaigiensis,* that were found almost exclusively in *Sargassum*-covered pavement common in many lagoon areas. These areas also held relatively large numbers of *Lethrinus nebulosus* and *L. atkinsoni* recruits which were not noted elsewhere (Fig. 12). The species most highly correlated with the presence of reef slope was the parrotfish *Chlorurus sordidus;* however this species was also found in lagoon and reef slope habitats.

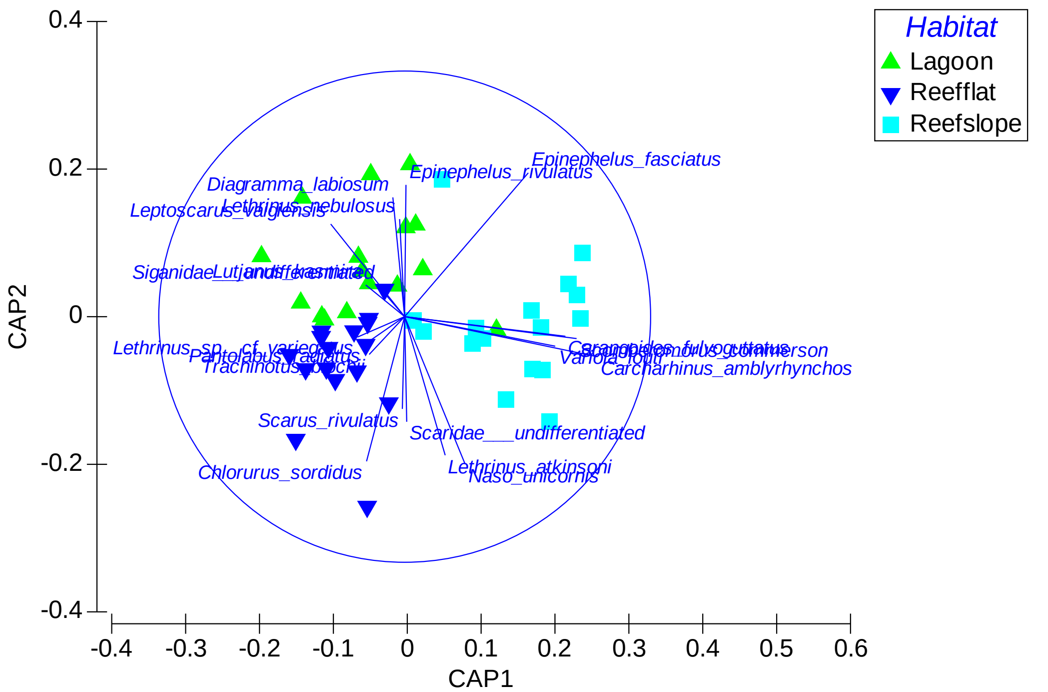


Figure 10. Differentiation of fish assemblages among habitats illustrated by CAP (constrained ordination) plot overlaid with bi-plot of the 20 species most highly correlated with CAP axes. The total correct classification of groups was 38 of 48 or 79%. Data points represent average values for each region, inside and outside sanctuary zones within each habitat type.

Regionally the most distinctive assemblages were found at the geographic extremes of the Ningaloo Marine Park, with Bundegi, the Muiron Islands, Lighthouse Bay and Gnaraloo all hosting assemblages that were distinct from more central regions (Figure 13). A suite of tuskfish species (*Choerodon cyanodus, C. schoenleinii, C. cauteroma*) were characteristic of Bundegi and Lighthouse Bay. Among the large groupers, Coral Trout (*Plectropomus* spp) were mainly recorded at Bundegi and the Muiron Islands, while Coronation Trout *V. louti* predominated in the more wave exposed regions of the western coastal reefs (Fig. 14). Species such as *Plectorhynchus schotaf* were found mainly in southern sites in the Gnarloo region though they also were common on coastal reefs in Batemans Bay (Cloates).

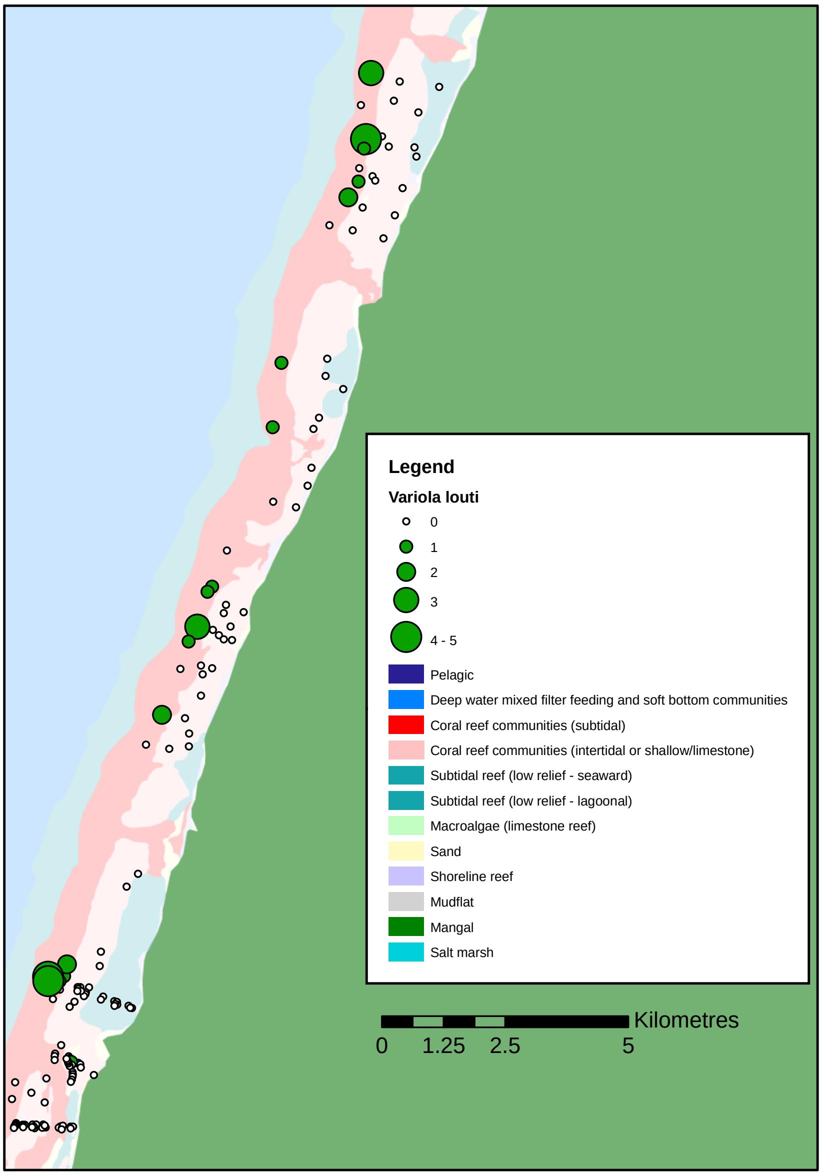


Figure 11. Distribution of Coronation Trout *Variola louti* in the Mandu Sanctuary Zone. This species was only recorded in reef slope habitats.

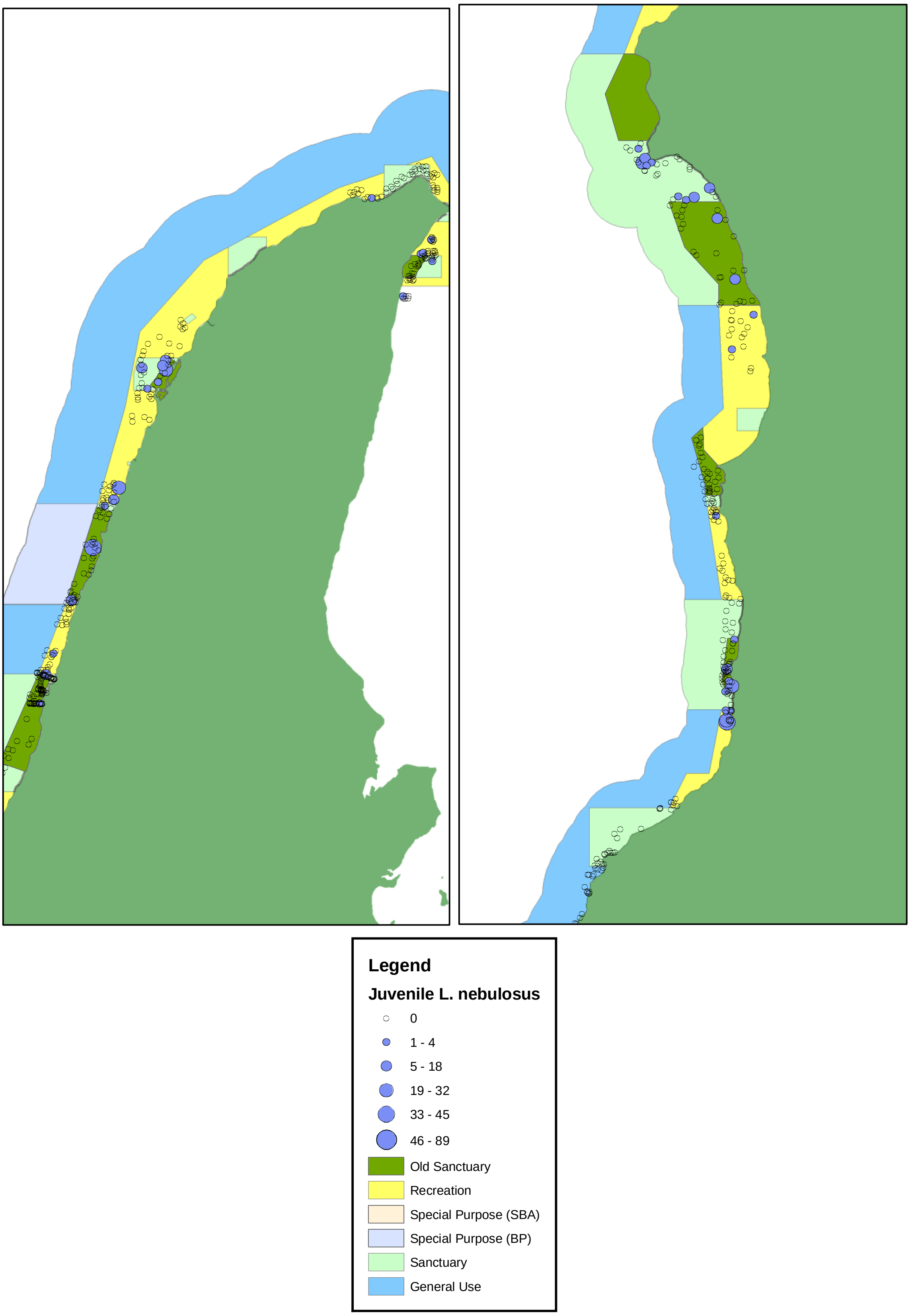


Figure 12. Distribution of juvenile (≤15 cm TL) *Lethrinus nebulosus* throughout the Ningaloo Marine Park.

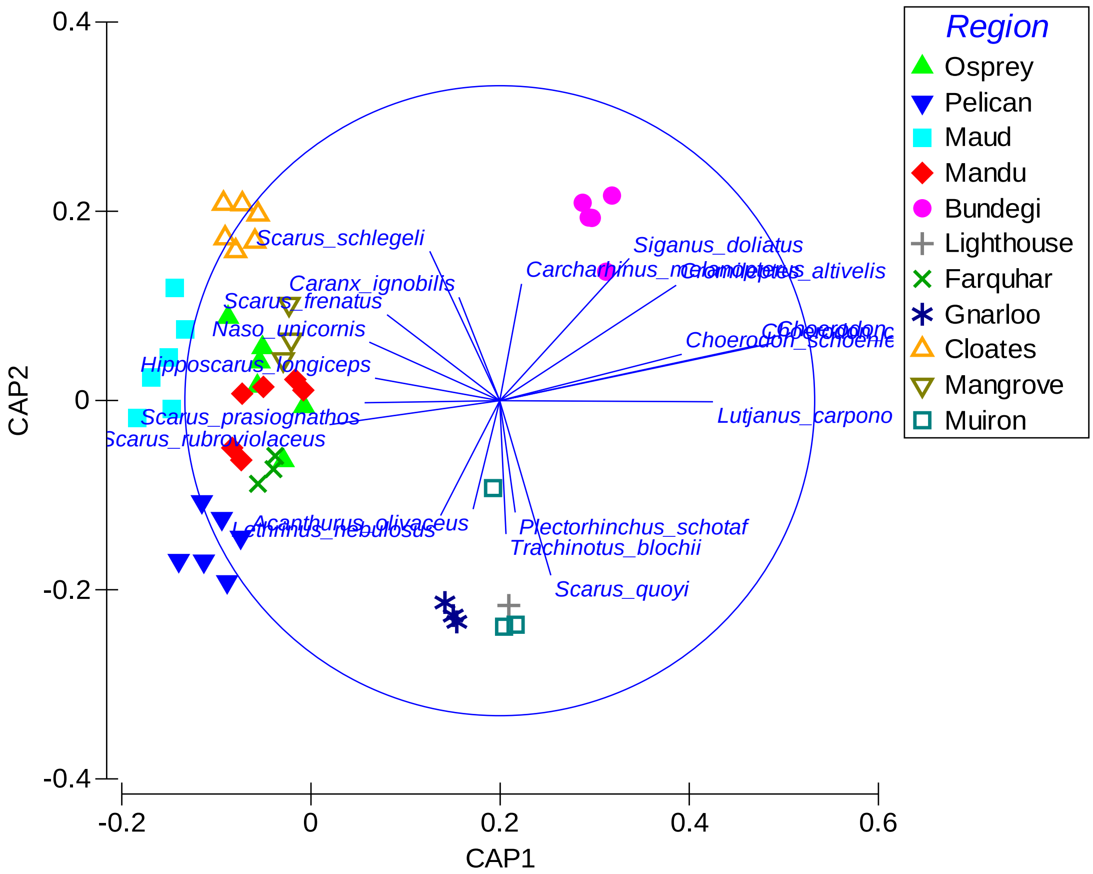


Figure 13. Differentiation of fish assemblages among regions illustrated by a CAP plot overlaid with bi-plot of 20 species most highly correlated with CAP axes. The total correct classification of groups was 24 of 48 or 50%. Data points represent average values for each region, inside and outside sanctuary zones within each habitat type.

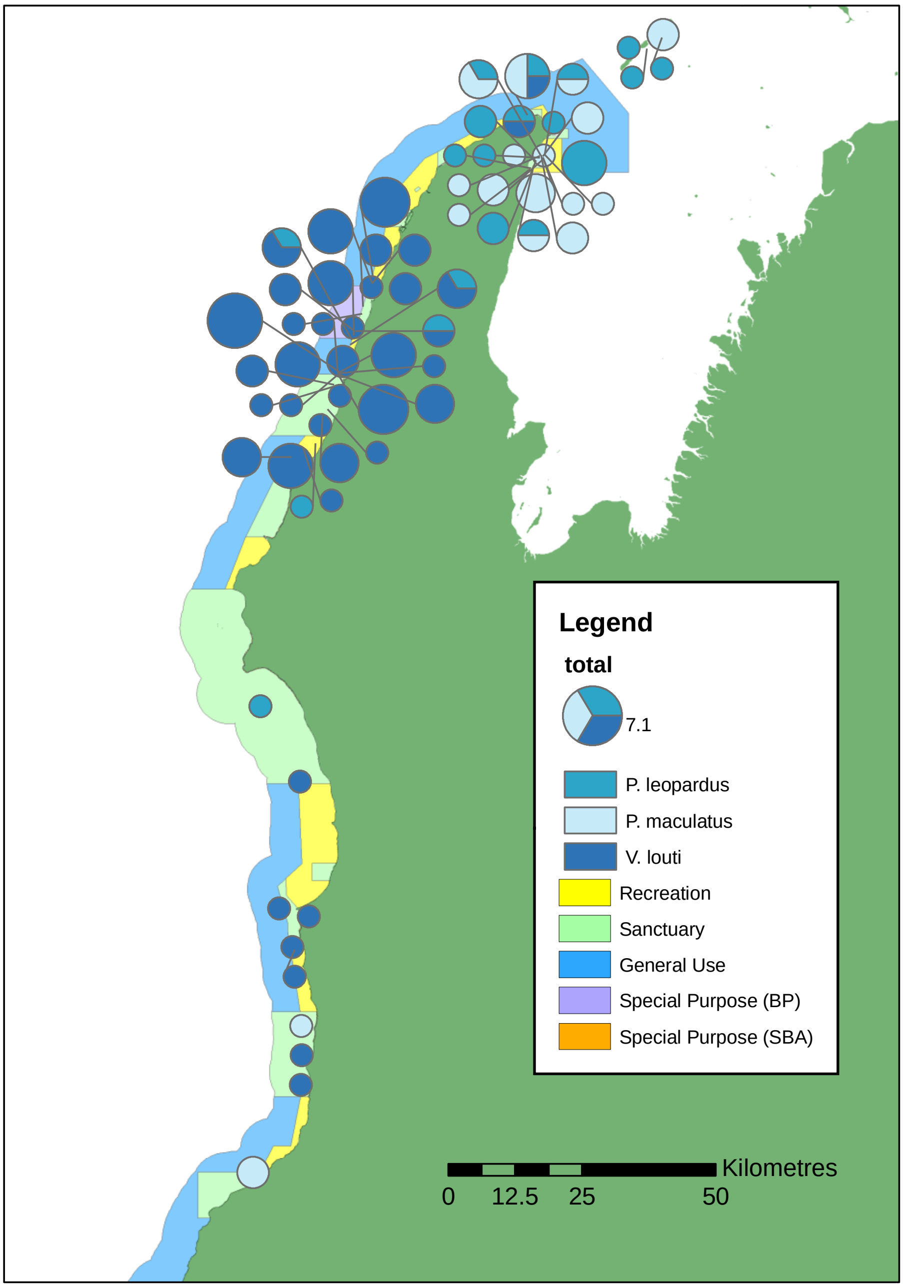


Figure 14. Distribution of large groupers (Serranidae: *Variola louti*, *Plectropomus leopardus* and *P. maculatus*) in shallow water (<15m).

Since there were clear differences among habitats, as well as an interaction between region and habitat, a subset of the data using reef slope assemblages was analysed to illustrate the high level of concordance between latitude and assemblage structure (Fig. 15). This demonstrated a clear trend in assemblage structure with latitude, probably partly related to regional differences in habitat outlined above but also to true latitudinal patterns. Latitudinal changes in species composition are illustrated by tuskfish, with Baldchin Groper (*C. rubescens*) more common in the south of the Ningaloo region, and Black Spot Tuskfish (*C. schoenlienii*) more common in the north (Figure 16). There was a relatively strong separation of the northern sites (Muiron, Bundegi and Lighthouse) from those in the south as indicated by their separation at above 50% similarity level (Fig. 15).

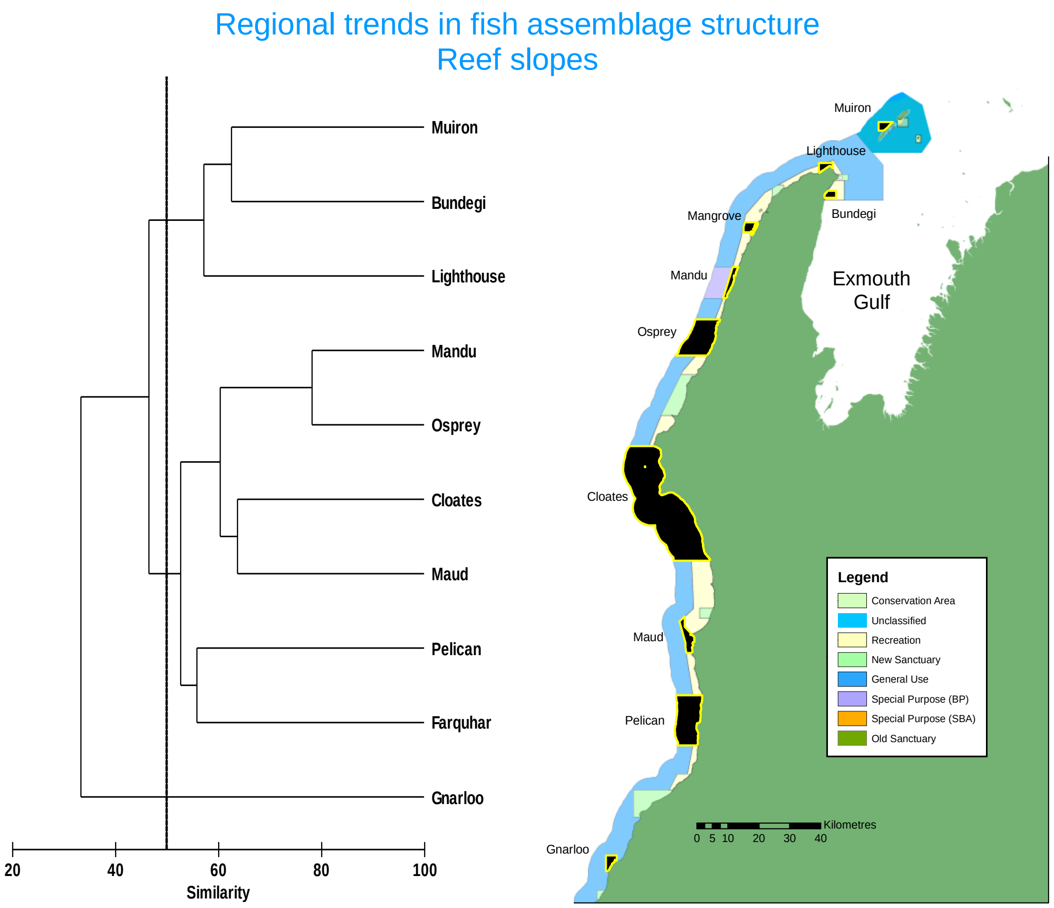


Figure 15. Latitudinal gradient in reef slope fish assemblage structure along the Ningaloo Marine Park. Data were from reef slope sites only, averaged by Region, fourth root transformed and using Bray-Curtis similarity.

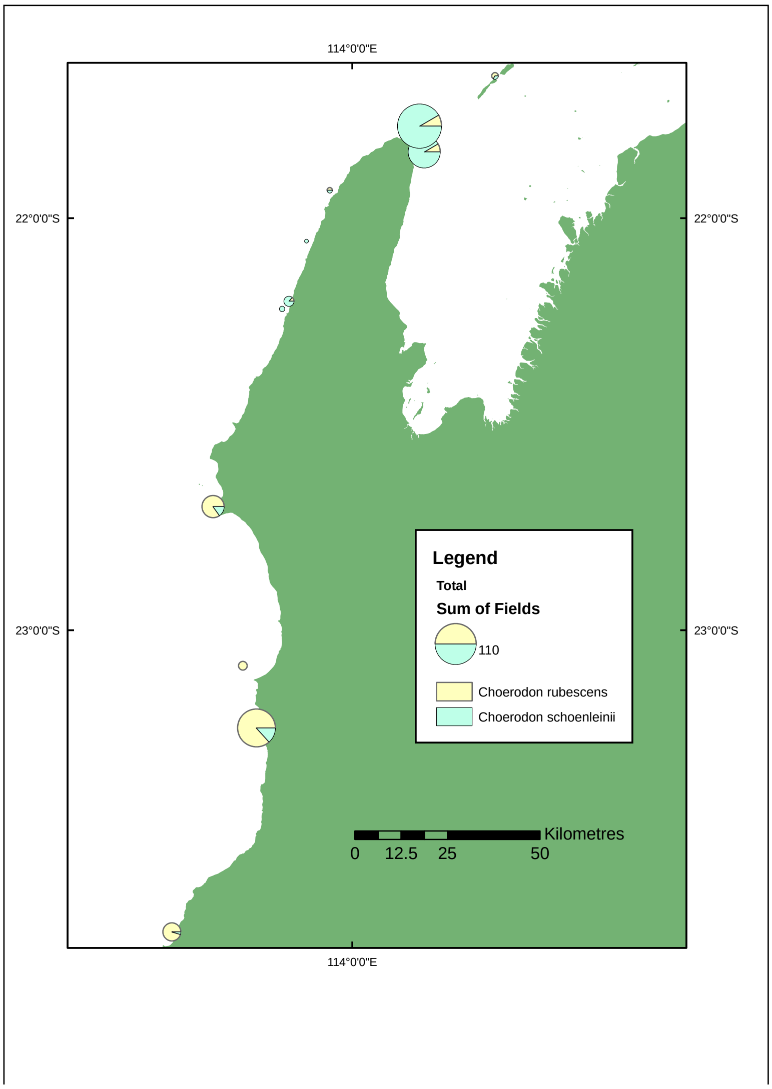


Figure 16. Latitudinal trends in the abundance of Tuskfish (*Choerodon rubescens* and *C. schoenleinii*).

The effect of management zoning regime on fish assemblage structure was tested in an orthogonal analysis that included habitat and regional effects as well as zone (Table 2). In addition to the influence of Habitat and Region effects which remained important, the influence of management zone (P(perm)=0.048) and Zoning × Region interaction (P(perm) = 0.001) was also highly significant. Analysis of the data constrained by Zoning x Habitat groups using CAP produced a classification success of only 39% (Fig. 17) reflecting the lack of a significant Zoning x Habitat interaction in the permutational analysis of variance. Nevertheless within each habitat type there is an indication of separation between zoning types (Fig. 17), suggesting that regional variations my be partly responsible for the lack of clear differentiation and warranting further exploration of zoning effects at a Region by Region basis.

Table 2. Results of permutational analysis of variance (PERMANOVA) testing for the effect of Region, Habitat and management zoning, based on Bray Curtis similarities calculated from fourth root transformed biomass. P-value generated from 999 permutations of residuals under a reduced model

Source	**df**	**SS**	**MS**	**Pseudo-F**	**P(perm)**	**Unique perms**
Zoning	1	4395.3	4395.3	1.4692	**0.048**	997
Habitat	2	38649	19324	6.4593	**0.001**	997
Region	10	1.7001E5	17001	5.6820	**0.001**	994
Zoning x Habitat	2	5975.8	2987.9	0.9987	0.472	999
Zoning x Region	6	23323	3887.2	1.2990	**0.010**	999
Habitat x Region	17	1.1104E5	6531.5	2.1832	**0.001**	996
Zoning x Habitat x Region	9	29632	3292.5	1.1005	0.147	994
Res	591	1.7681E6	2991.7			
Total	638	2.2968E6				

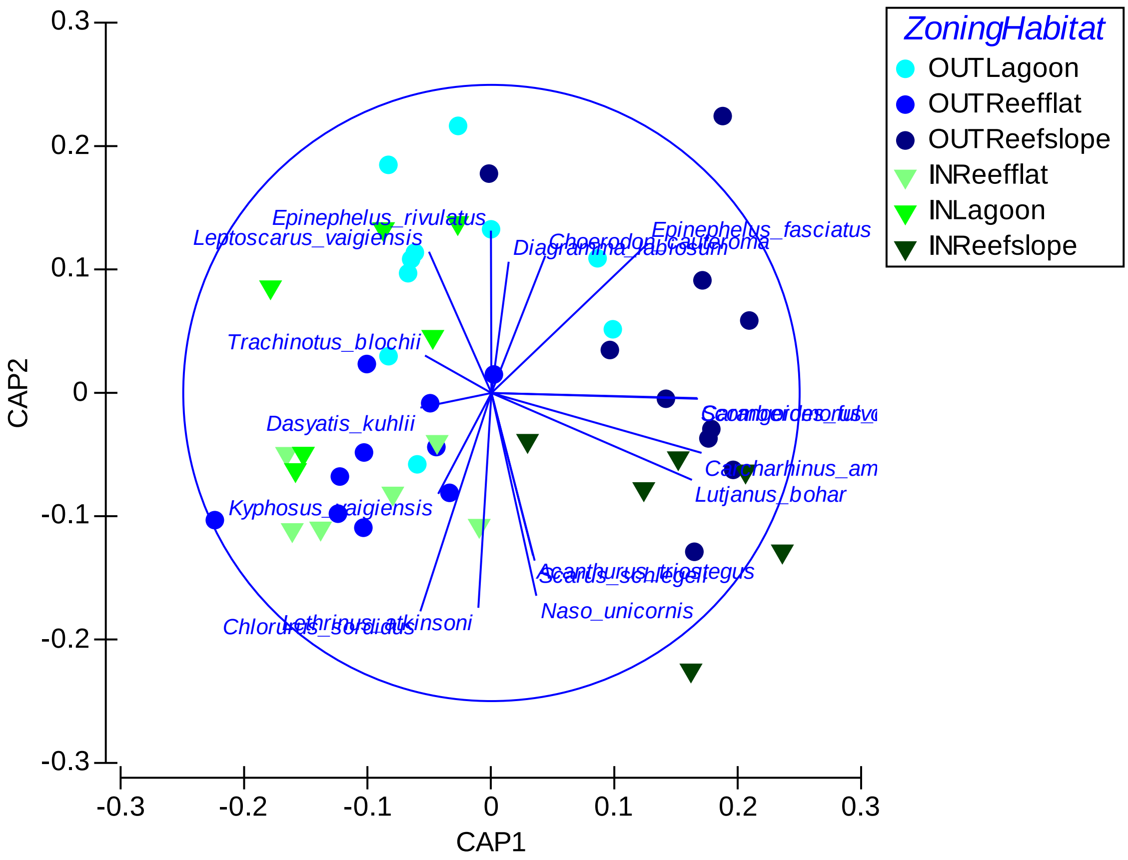


Figure 17. Differentiation of fish assemblages between zones and habitats across 12 Regions in the Ningaloo Marine Park, illustrated by a CAP plot overlaid with bi-plot of 20 species most highly correlated with CAP axes. Data points represent average values for each region, inside and outside sanctuary zones within each habitat type.

Regional trends in fish assemblages

Among regions the influence of habitat on species assemblages was a consistent source of variation. However the influence of sanctuary zones, while evident for pre-existing sanctuary zones in some Regions (notably Mangrove and Mandu), was quite variable (Table 3). There were no interactions between Habitat and Zoning which would indicate that fish assemblages in different habitats respond differently to the management zones.

Table 3. Results of permutational analysis of variance (PERMANOVA) testing for the effect of management zones in different regions, based on Bray Curtis similarities calculated from fourth root transformed biomass. P-value generated from 999 permutations of residuals under a reduced model. Only regions with "old" sanctuary zones (established 1987) are included.

	P(perm)		
Region	**Zoning**	**Habitat**	**Status × Habitat**
Bundegi	**0.027**	0.127	0.31
Mangrove	**0.001**	**0.021**	**-**
Mandu	**0.001**	**0.001**	0.8
Osprey	0.36	**0.001**	0.11
Cloates	0.25	**0.001**	0.1
Maud	0.96	**0.001**	0.247
Pelican	0.24	**0.001**	0.27

At Bundegi, Mangrove and Mandu where strong zoning effects were apparent, the data were further explored to identify which species were most highly correlated with the differences. At Bundegi the geomorphology of the reef is quite different from that of the main Ningaloo reef tract. In the reef slope habitat at Bundegi the sanctuary zone was characterized by *Epinephelus bilobatus* and *Carangoides fulvoguttatus* (Fig. 18). Both of these are target or potentially by-catch species. Other species characteristic of the reef slope within the sanctuary zone were mainly parrotfish such as *Chlorurus sordidus, C. bleekeri*, *Scarus prasiognathus* and *S. rivulatus. Plectorhinchus flavomaculatus* was characteristic of unprotected reef slope. There was a high level of overlap among reef flat sites from inside and outside the sanctuary zone. The reef flat sites were characterized by a higher proportion of potential angling target or bycatch species such as *Lethrinus nebulosus, Epinephelus rivulatus, E. quoyanus, Choerodon cyanodus* and *Lutjanus carponotatus.*

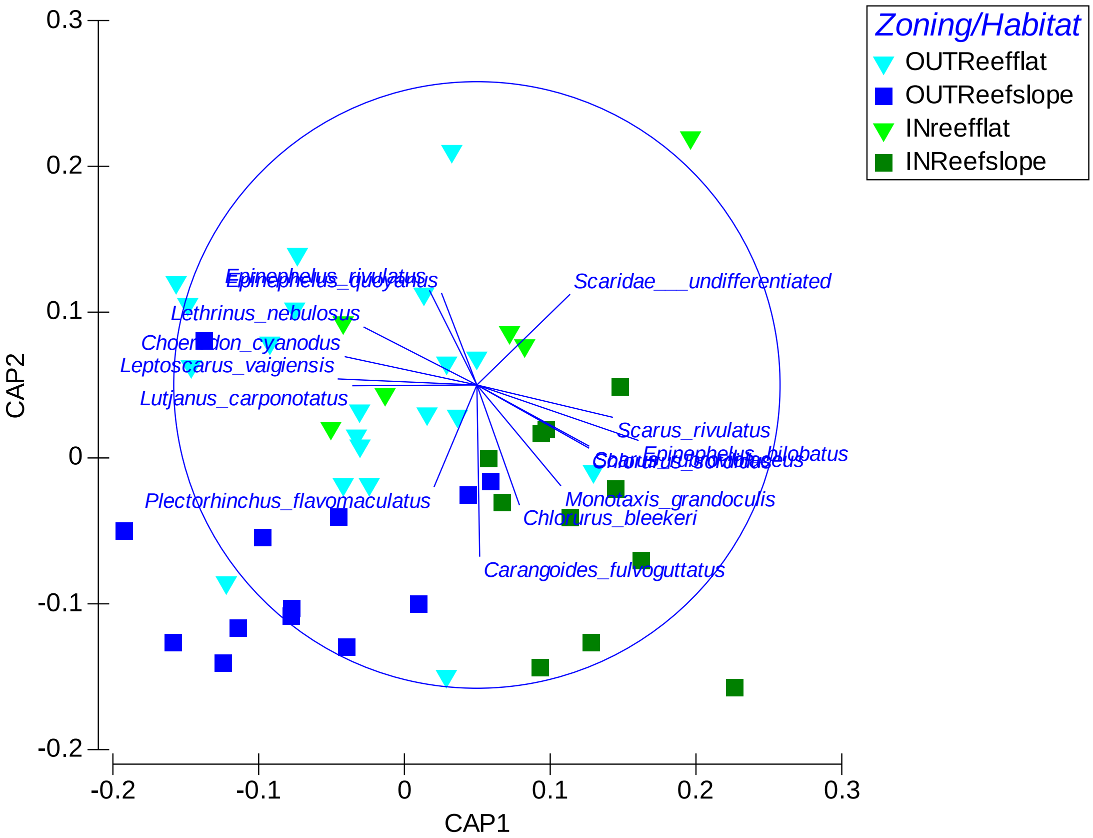


Figure 18. Bundegi Sanctuary Zone. Differentiation of fish assemblages between zones and habitats illustrated by a CAP plot overlaid with bi-plot of 20 species most highly correlated with CAP axes. Points displayed are data for sites average across all sampling seasons 2006-07)

At Mangrove Sanctuary zone, the initial sanctuary zone included only the lagoon habitat, consequently the analysis was restricted to comparison of sites within this habitat with sites in the lagoon and reef flat outside the sanctuary (Fig. 19). Higher abundances of *Epinephelus rivulatus*, (a species very commonly caught by anglers), were characteristic of the sanctuary zone (Fig. 19). Species characteristic of unprotected reef flat habitat were mainly herbivorous species, but included some angling target species such as *Lutjanus carponotatus*, *Choerodon schoenleinii*, and *Lethrinus nebulosus.*

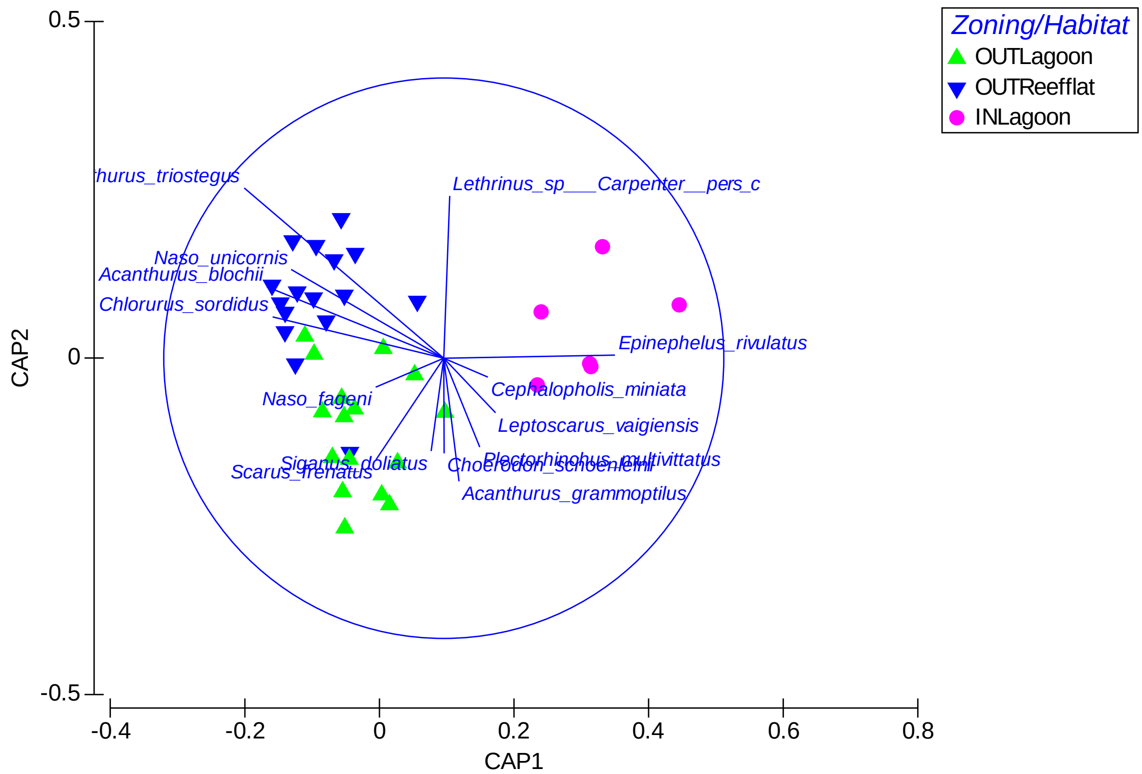


Figure 19. Mangrove Sanctuary Zone. Differentiation of fish assemblages between zones and habitats, illustrated by a CAP plot overlaid with bi-plot of 20 species most highly correlated with CAP axes. Points displayed are data for sites average across all sampling seasons 2006-07)

At the Mandu Sanctuary zone, all habitats were present within the pre-existing sanctuary zone, although the area of reef slope contained within it was small, and so all habitats were included in the analysis. Species having a higher biomass within the sanctuary zone (and positive values of CAP2) included the target species *Lethrinus nebulosus*, and *L. atkinsoni* (Fig., 20). The herbivorous species *Kyphosus vaigiensis*, *Scarus schlegeli* and *Chlorurus sordidus* were also characteristic of sites within the sanctuary zone. *Plectorhinchus multivittatus* was characteristic of unprotected sites (mainly reef flat and lagoon). Although not shown in Figure 20 because of its relatively weak association with the CAP axes, *Variola louti* was the only target species that was characteristic of reef slope sites, and though it did tend to be associated with the sanctuary zone, this was a relatively weak trend.

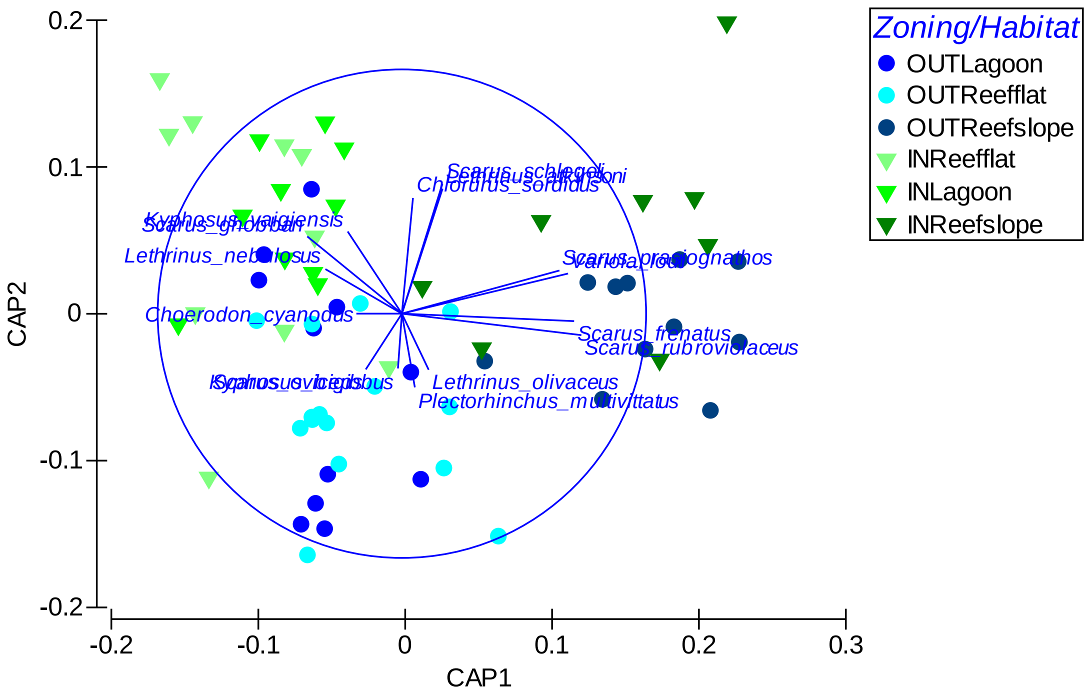


Figure 20. Mandu Sanctuary Zone. Differentiation of fish assemblages between zones and habitats, illustrated by a CAP plot overlaid with bi-plot of 20 species most highly correlated with CAP axes. Points displayed are data for sites average across all sampling seasons 2006-07).

Zoning related trends in targeted species

Total data set

Boat ramp surveys conducted in 1998-1999 by WA Fisheries provided a description of the main recreational target species captured in the Ningaloo Marine Park (Table 4, Sumner et al 2002). From this list a subset of ten taxa were selected that were considered likely to have the potential to be affected by recreational fishing in the study area, and consequently to show responses to marine park sanctuary zoning. Carcharhinid sharks were added to this list because of the potential for them to be an important bycatch group, as well as because of their potential ecological importance (Table 5). Species excluded from this analysis included those that are mainly targeted in deep water (e.g. *Lethrinus miniatus*), in areas such as the Exmouth Gulf (e.g. whiting), or taxa that we did not directly survey (e.g. squids) or bait species (e.g. hardyheads). In the case of some taxa composed of numerous species but with low abundance of individual species, species were aggregated (e.g. Serranidae, Tuskfish). Serranidae excluded *Epinephelus fasciatus* and *E. rivulatus* which were sufficiently abundant for independent analysis. Data were based on count data transformed to biomass, and were likely to conform to a non-normal Poisson distribution.

Table 4. Top target species recorded in WA Fisheries Recreational fishing survey 1998/1999 (Sumner et al. 2002). Species listed in rank order of number kept.

Common name	Scientific name	No. kept	SE kept	No. released	Eaten by sharks
Emperor, spangled	*Lethrinus nebulosus*	22,575	2,064	25,056	2,482
Cod, chinaman	*Epinephelus rivulatus*	19,708	2,053	31,963	189
Emperor, sweetlip	*Lethrinus miniatus*	10,377	1,732	9,823	145
Emperor, blue-lined	*Lethrinus laticaudis*	8,474	1,470	6,877	78
Squids, general	Family *Cephalopodidiae*	8,191	1,580	124	0
Trevally, golden	*Gnathanodon speciosus*	4,805	1,143	1,947	62
Emperor, yellow-tailed	*Lethrinus atkinsoni*	4,672	1,165	5,944	0
Hardyheads/silversides	Family *Atherinidae*	2,658	1,577	0	0
Salmon, threadfin general	Family *Polynemidae*	2,472	851	313	0
Mackerel, narrow-barred Spanish	*Scomberomorus commerson*	2,361	1,081	623	185
Whiting, general	Family *Sillaginidae*	2,078	573	212	0
Sweetlips, general	Family *Haemulidae*	1,816	2,133	1,425	145
Trevally, gold-spotted	*Carangoides fulvoguttatus*	1,767	1,088	510	11
Seapearch, stripey	*Lutjanus carponotatus*	1,427	1,152	672	129
Flathead, general	Family *Platycephalidae*	1,241	1,308	172	0
Trevallies, general	Family *Carangidae*	999	1,078	148	51
Dart, general	Family *Carangidae*	967	1,067	379	0
Cod, Estuary	*Epinephelus coioides*	852	1,069	99	0
Emperor, blue-spotted	*Lethrinus punctulatus*	820	1,114	725	0
Cod, Black-tipped	*Epinephelus fasciatus*	779	1,069	858	0
Trevally, Skipjack	*Pseudocaranx dentex*	770	1,066	652	498
Garfish, general	Family *Hemiramphidae*	758	1,087	29	0
Emperor, variegated	*Lethrinus variegatus*	750	413	782	0
Emperor, Red	*Lutjanus sebae*	680	1,081	29	0
Tuskfish, blackspot	*Choerodon schoenleinii*	648	1,072	831	0
Mackerel, QueenslandSchool	*Scomberomorus queenslandicus*	554	148	149	0
Trout, Coral	*Plectropomus species*	538	1,072	208	47
Rock lobster, tropical	*Panulirus spp.*	536	307	0	0
Groper, baldchin	*Choerodon rubescens*	495	1,476	169	0
Mackerel, shark	*Grammatorcynus bicarinatus*	492	1,062	298	0
Emperor, Spotcheek	*Lethrinus rubrioperculatus*	363	1,062	48	0
Bream, western yellowfin	*Acanthopagrus latus*	146	61	126	0

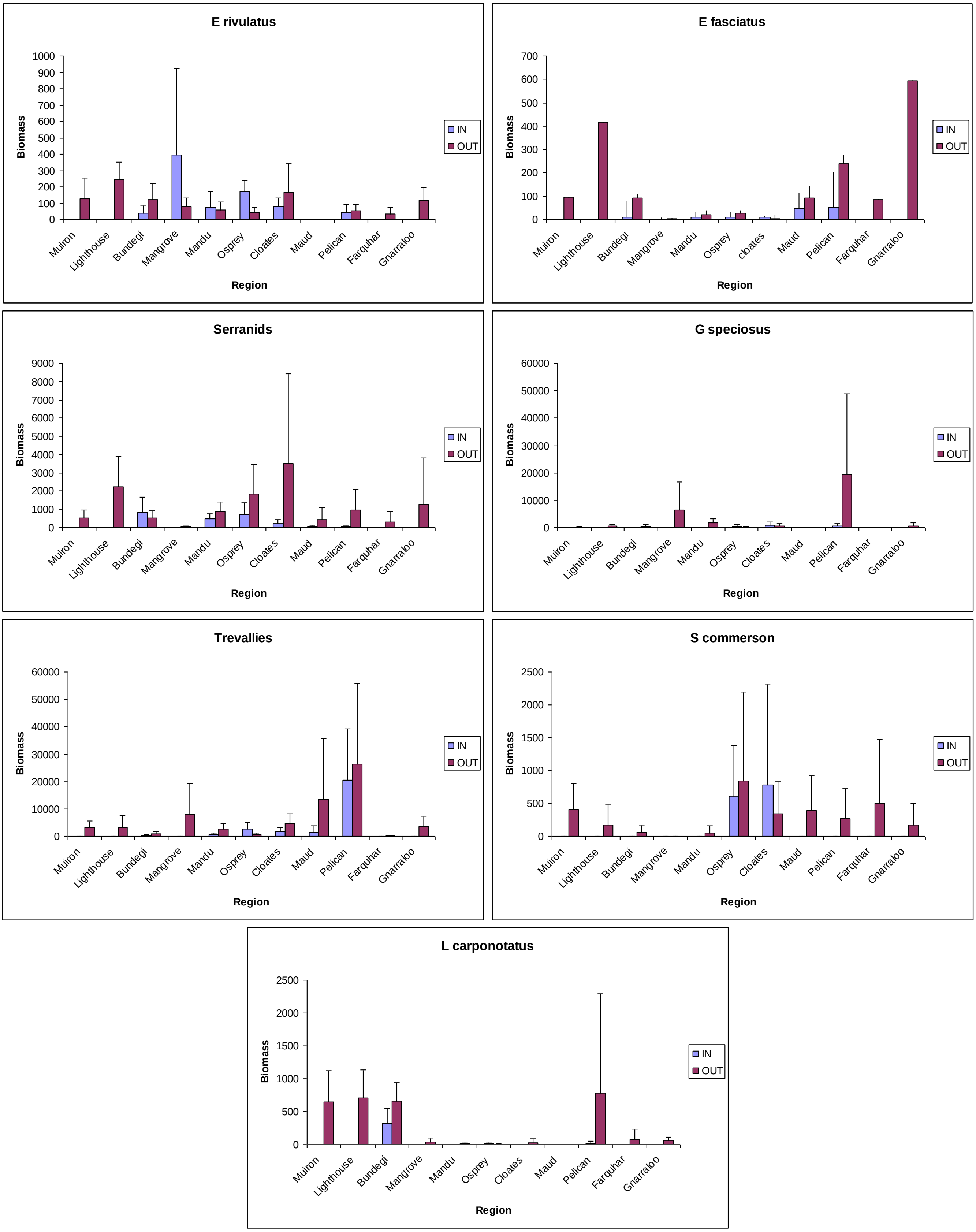


Figure 21. Among-region variation in biomass of top target taxa in the Ningaloo Marine Park. Data are means per transect (g + 95% CI).

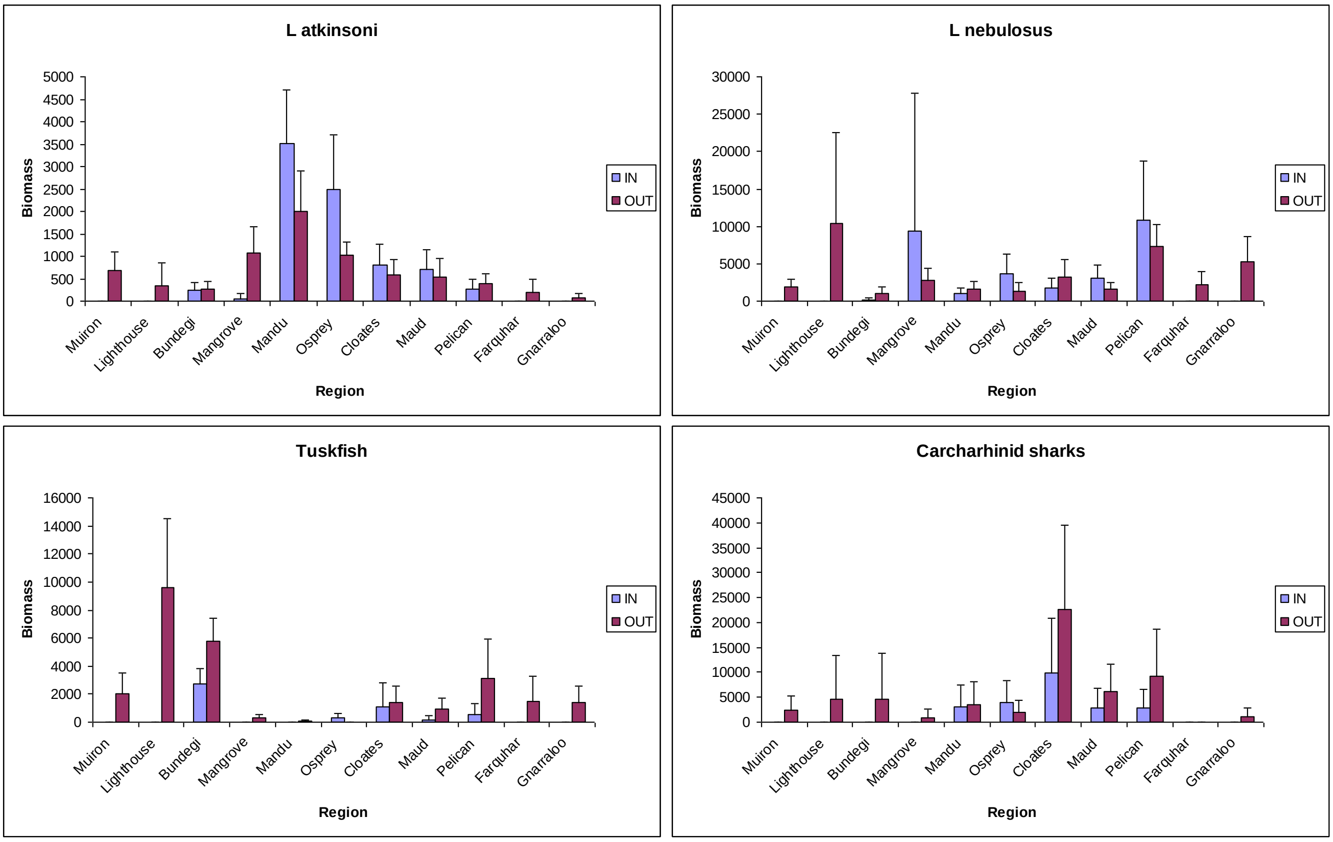


Figure 21 (cont.). Among-region variation in biomass of top target taxa in the Ningaloo Marine Park. Data are means per transect (+95% CI).

Clear regional variation was present for most of the important target taxa. There was a roughly inverse relationship in the regional abundance of the small serranid species *E. rivulatus* and *E. fasciatus* (Fig. 21). *Epinephelus fasciatus* was more common in regions where lagoon habitats are less common, such as the southern areas of the park, Bundegi, and the Muiron Islands. Although not a significant trend, *Epinephelus rivulatus* tended to be most abundant in regions adjacent to the Cape Ranges and Coral Bay where there are well developed lagoon habitats preferred by this species. *Lethrinus atkinsoni* was also most abundant in these regions since they also had extensive reef flat areas which are their preferred habitat (Fig. 21). For other species (e.g. Serranids, Trevallies, *Gnathanodon speciosus*, *Scomberomorus commerson*) regional variation, while significant, did not appear to follow any discernable large scale trend (Fig. 21). *Lutjanus carponotatus* and Tuskfish were more abundant in the northern parts of the park.

Old sanctuary zones

Because the analyses above include all of the regions surveyed, many of which do not include pre-existing sanctuary zones, there is the potential for the interpretation of zoning related trends to be complicated by regional trends in abundance and the clear Zoning x Region interactions support this possibility (Table 5). We therefore conducted a second set of analyses using only the subset of regions that had pre-existing sanctuary zones. The overall results were broadly similar to the analysis of the full data set, with the important exception that in addition to *Lethrinus atkinsoni*, two more of the most commonly targeted species, *L. nebulosus* and *Epinephelus rivulatus* were found to have significantly higher biomass overall in the pre-existing sanctuary zones (Table 5a, Fig. 23). Habitat related trends in abundance appeared to be driving significant trends, with Zoning related differences being greatest in the reef flat habitat for *L. atkinsoni*, while differences in the lagoon were most pronounced for *L. nebulosus* and *E. rivulatus.* Apart from *Scomberomorus commerson*, biomass of the remaining taxa was greatest outside sanctuary zones and also showed a strong tendency to be most abundant in reef slope habitats (Table 5a, Fig. 23).

Table 5. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Ningaloo Marine Park. Bold text; $p < 0.05$. (+) higher biomass inside sanctuary zones, (-) higher biomass outside sanctuary zones. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning Habitat and Region as fixed effects.

	p						
Species	**Zoning**	**Habitat**	**Region**	**Zoning x Habitat**	**Zoning x Region**	**Habitat x Region**	**Zoning x Habitat x Region**
Epinephelus fasciatus	**(-)0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0011**	**<0.0001**	0.3060
Epinephelus rivulatus	0.9015	**<0.0001**	**<0.0001**	**<0.0003**	**0.0254**	**<0.0001**	0.6949
Serranids	**(-)0.0001**	**<0.0001**	**<0.0001**	0.2969	**0.0001**	**0.0124**	0.2313
Gnathanodon speciosus	**(-)0.0001**	**<0.0001**	**<0.0001**	**0.068**	**0.0049**	**0.018**	0.949
Trevallies	**(-)0.0006**	**<0.0001**	**<0.0001**	**<0.0002**	**<0.0001**	**<0.0001**	0.8588
Scomberomorus commerson	0.6901	**<0.0001**	**<0.0001**	**<0.0037**	**0.0278**	**<0.0001**	1.0000
Lutjanus carponotatus	**(-)0.0001**	**<0.0001**	**<0.0001**	**0.0004**	0.1268	**<0.0001**	1.0000
Lethrinus nebulosus	0.3429	**<0.0167**	**<0.0001**	**<0.0395**	0.1072	**0.0001**	0.2778
Lethrinus atkinsoni	**(+)0.0001**	**<0.0001**	**<0.0001**	0.828	**0.0096**	**0.0129**	**0.0016**
Tuskfish	**(-)0.0001**	**<0.0001**	**<0.0001**	0.0601	**0.0055**	**<0.0001**	0.9113
Carcharhinids	**(-)0.0091**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.8291

Table 5a. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in regions with pre-existing sanctuary zones in the Ningaloo Marine Park. Bold text; p < 0.05. (+) higher biomass inside sanctuary zones, (-) higher biomass outside sanctuary zones. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning Habitat and Region as fixed effects.

Species	**p**						
	Zoning	**Habitat**	**Region**	**Zoning x Habitat**	**Zoning x Region**	**Habitat x Region**	**Zoning x Habitat x Region**
Epinephelus fasciatus	**(-)0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**0.0003**	**<0.0001**	0.1232
Epinephelus rivulatus	**(+)0.0002**	**<0.0001**	**<0.0001**	0.1694	**0.0088**	**0.0002**	0.0561
Serranids	**(-)0.0001**	**<0.0001**	**<0.0001**	**<0.0313**	**0.0489**	**0.0001**	**0.0074**
Gnathanodon speciosus	**(-)0.0001**	**<0.0001**	**<0.0001**	0.2070	**0.0790**	**0.0156**	0.9914
Trevallies	**(-)0.0001**	**<0.0001**	**<0.0001**	**<0.0064**	**<0.0022**	**<0.0048**	0.9563
Scomberomorus commerson	0.0937	**<0.0001**	**<0.0001**	**<0.0831**	**0.0060**	**<0.0004**	1.0000
Lutjanus carponotatus	**(-)0.0001**	**<0.0001**	**<0.0001**	**0.0004**	0.1268	**<0.0001**	1.0000
Lethrinus nebulosus	**(+)0.0140**	**<0.0012**	**<0.0001**	**<0.0003**	0.1050	**0.0001**	0.1230
Lethrinus atkinsoni	**(+)<0.0001**	**<0.0001**	**<0.0001**	**0.0339**	**0.0190**	**0.0948**	**0.0019**
Tuskfish	**(-)0.0001**	**<0.0001**	**<0.0001**	**0.0007**	**0.0429**	**<0.0001**	1.0000
Carcharhinids	**(-)0.0246**	**<0.0001**	**<0.0030**	**<0.0001**	**<0.0001**	**<0.0001**	0.5294

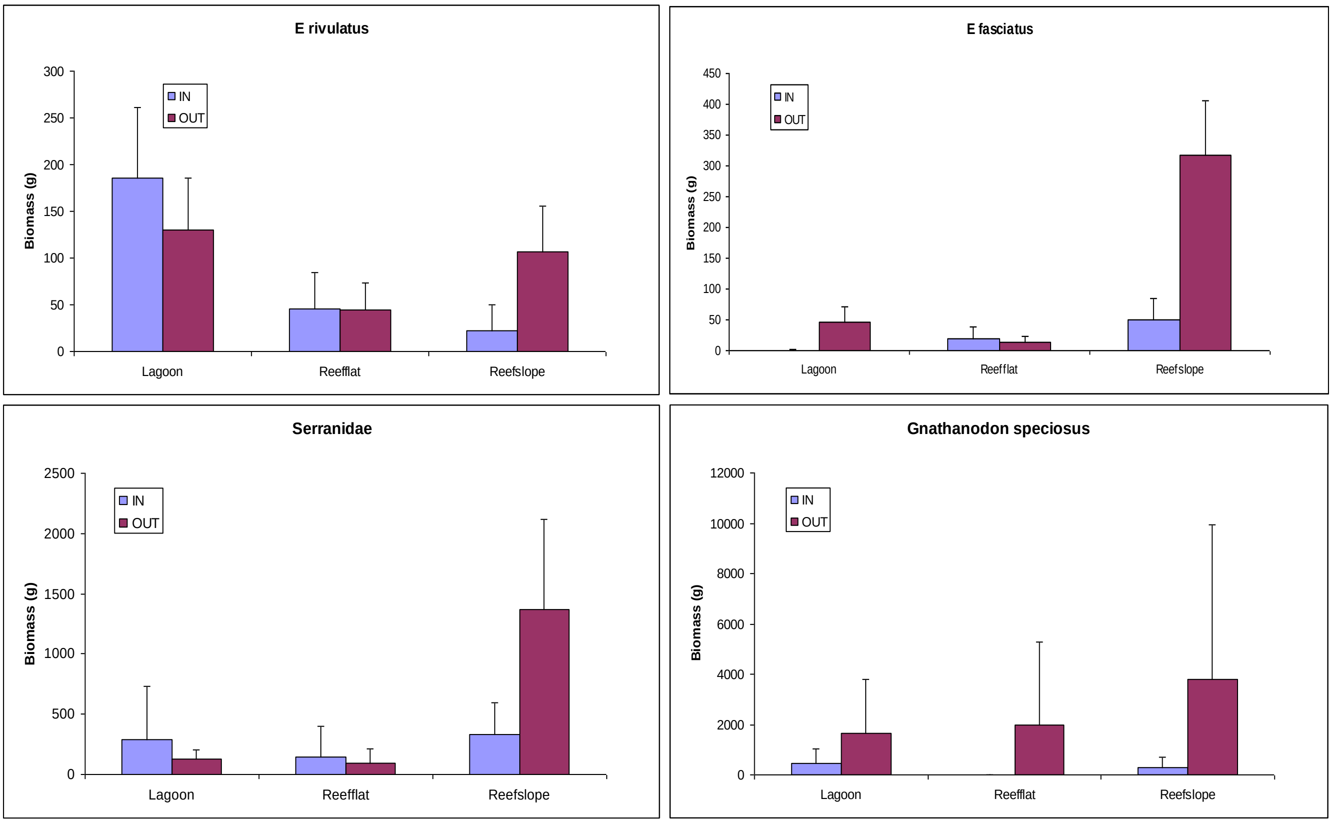
The GENMOD analysis indicated that most taxa showed a significant influence of both Zoning and Habitat (Table 5, Fig. 22). *Lethrinus atkinsoni* biomass was higher inside pre-existing sanctuary zones than outside, for all habitats, although the influence of sanctuary zones was most pronounced in the reef flat habitat, which was where this species was most abundant. In contrast *Lethrinus nebulosus* biomass was higher in the lagoon habitat, and, while there was no significant overall influence of sanctuary zones, there was a significant interaction between zoning and habitat. In the lagoon habitat *L. nebulosus* biomass was higher inside sanctuary zones while on the reef slopes this species' biomass was higher outside (Fig. 22). Multiple regression of *L. nebulosus* biomass against environmental and habitat variables (benthic cover, substratum type, depth) explained little of the overall variation (R-squared =0.103) although the relationship was significant due to the large number of transects and thus the high power of the test (Table 6). Residuals analysis of data for *L. nebulous* (having accounted for small scale habitat factors) gave the same pattern of results even after accounting for transect level variation in habitat that might affect abundance or biomass.

Table 6. Results of Multiple regression *Lethrinus nebulosus* and benthic habitat characteristics of sites in the Ningaloo Marine Park.

Source	**DF**	**SS**	**MS**	**F**	**p**
Regression	12	1532.217	127.6847	8.77	**<.0001**
Residual	916	13332	14.55441		

Variable	**Estimate**	**Error**	**Type II SS**	**F Value**	**Pr > F**
Intercept	-27.251	4.256	596.672	41	**<.0001**
Visibility	0.149	0.033	300.016	20.61	**<.0001**
Depth	-0.012	0.036	1.599	0.11	0.740
% Sand	0.011	0.006	52.405	3.6	0.058
% Rubble	0.001	0.007	0.541	0.04	0.847
% Boulders	0.111	0.048	78.249	5.38	**0.021**
% Bommies	-0.028	0.023	21.995	1.51	0.219
% Pavement	0.004	0.006	7.991	0.55	0.459
% Live Hard Coral	-0.024	0.008	134.222	9.22	**0.003**
% Dead Hard Coral	0.007	0.011	6.223	0.43	0.513
% Algae	-0.017	0.006	111.731	7.68	**0.006**
% Seagrass	0.031	0.039	9.0819	0.62	0.429
Latitude	-1.312	0.189	694.964	47.75	**<.0001**

Contrary to expectations, *Lutjanus carponotatus*, trevallies and tuskfish were significantly more abundant outside sanctuary zones than inside them. They were also more abundant on reef slope habitats though there was no interaction between zoning and habitat (Table 5). A similar overall pattern was evident for *Gnathanodon specious, Epinephelus fasciatus* and serranids and carcharhinids (Table 5, Fig. 22). Other species that did not show a significant overall zoning trend were *Scomberomorus commerson and Epinephelus rivulatus. Epinephelus rivulatus* was most common in the lagoon while *S. commerson* were most common on the reef slope (Fig. 22).



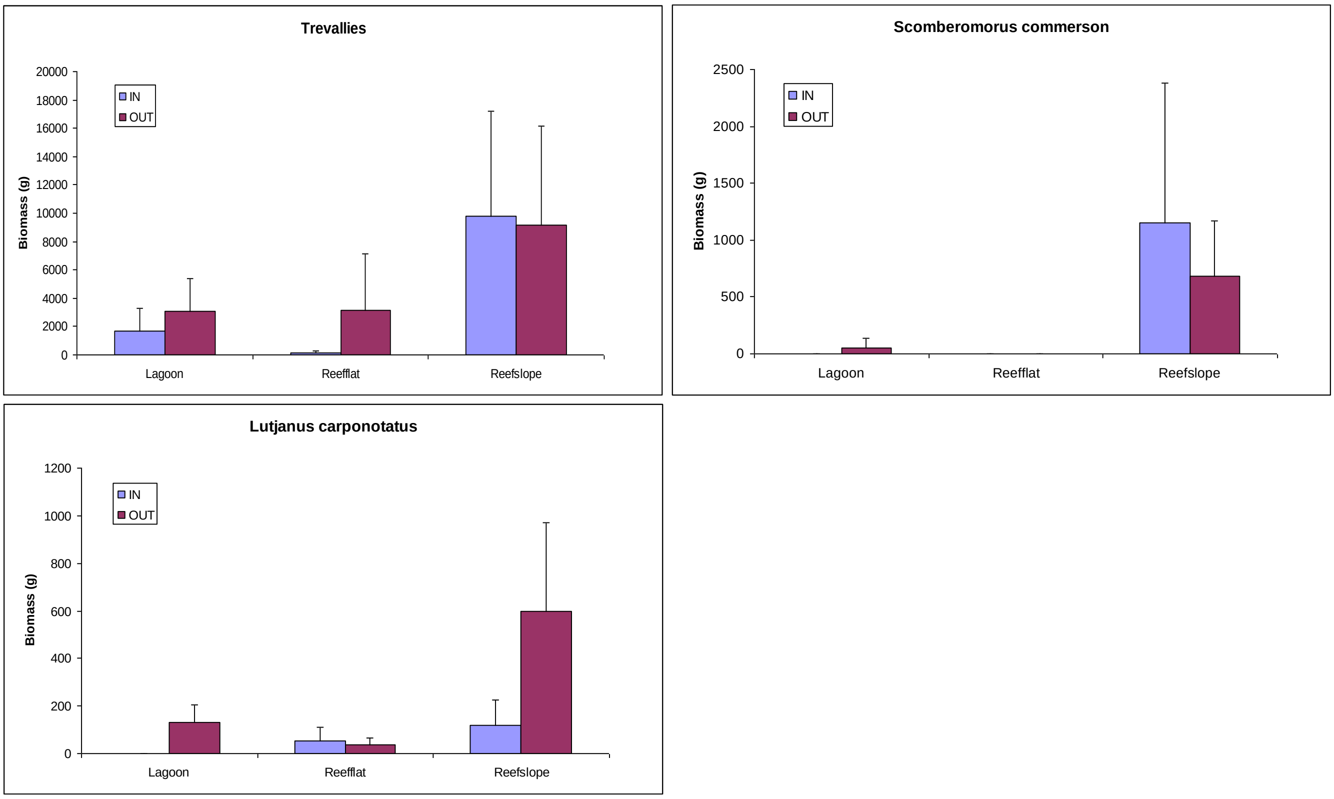


Fig. 22. Habitat and zoning-related trends in biomass of top target taxa in the Ningaloo Marine Park. Data are means per transect (g + 95% CI).

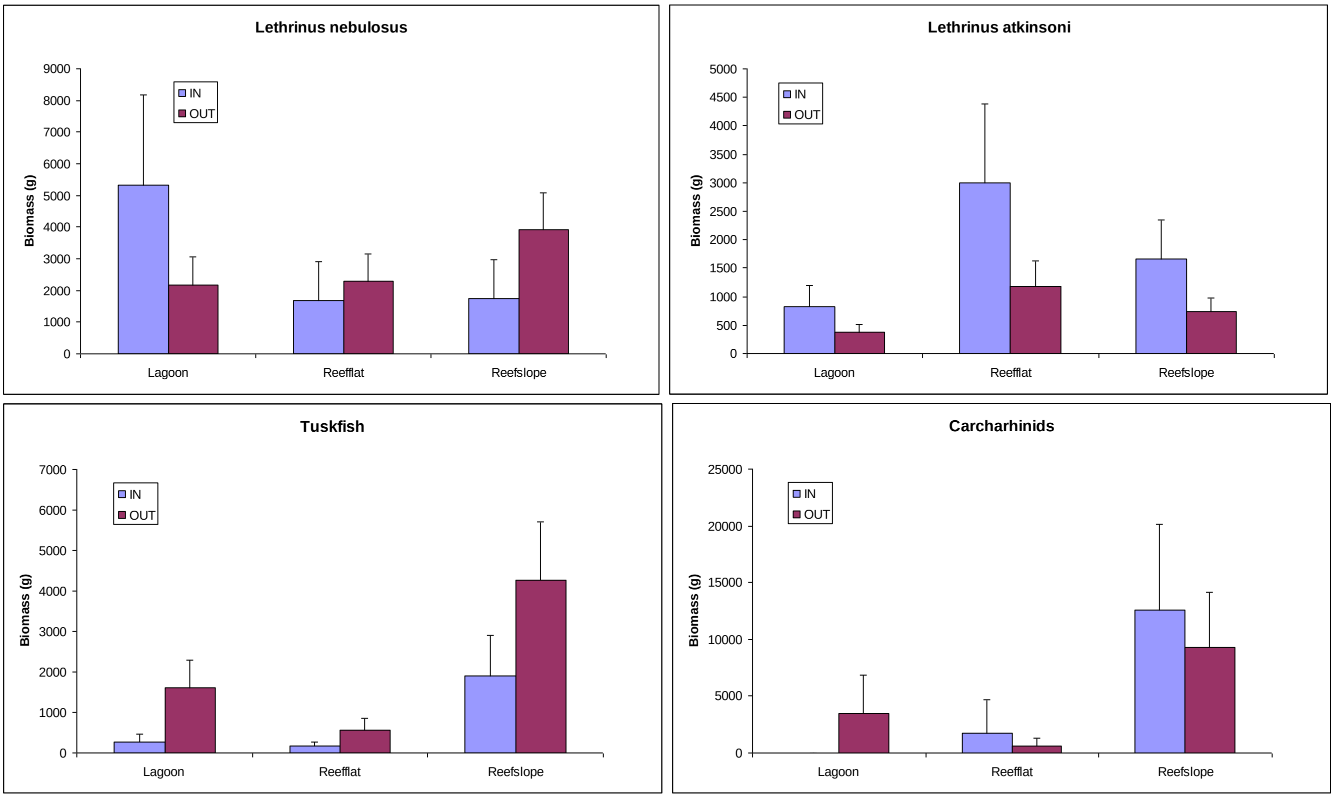


Figure 22 (cont.). Habitat and zoning-related trends in biomass of top target taxa in the Ningaloo Marine Park. Data are means per transect (g + 95% CI).

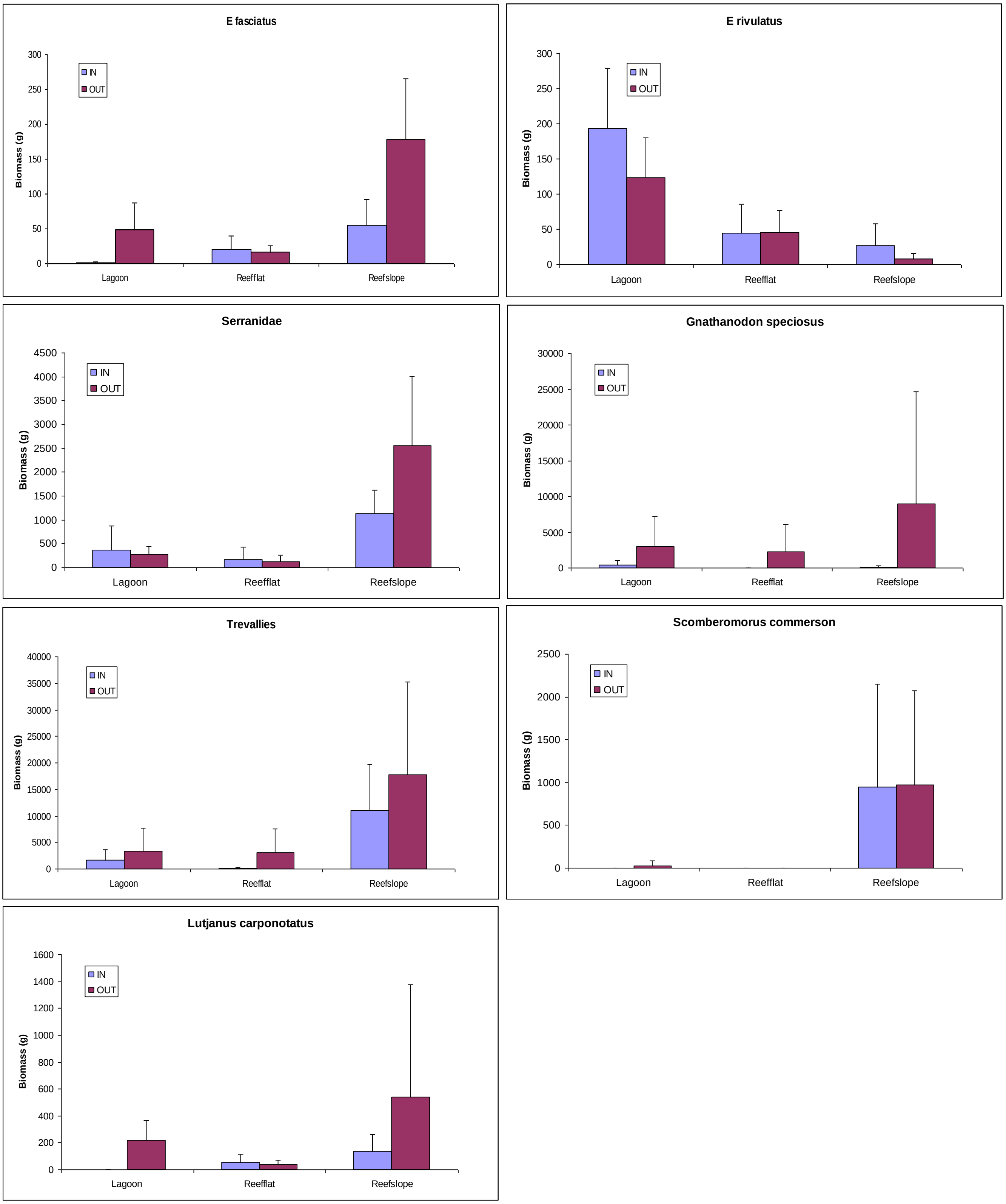


Figure 23. pre-existing Sanctuary Zone Regions habitat and zoning-related trends in biomass of top target taxa in the Ningaloo Marine Park. Data are means per transect (g + 95% CI).

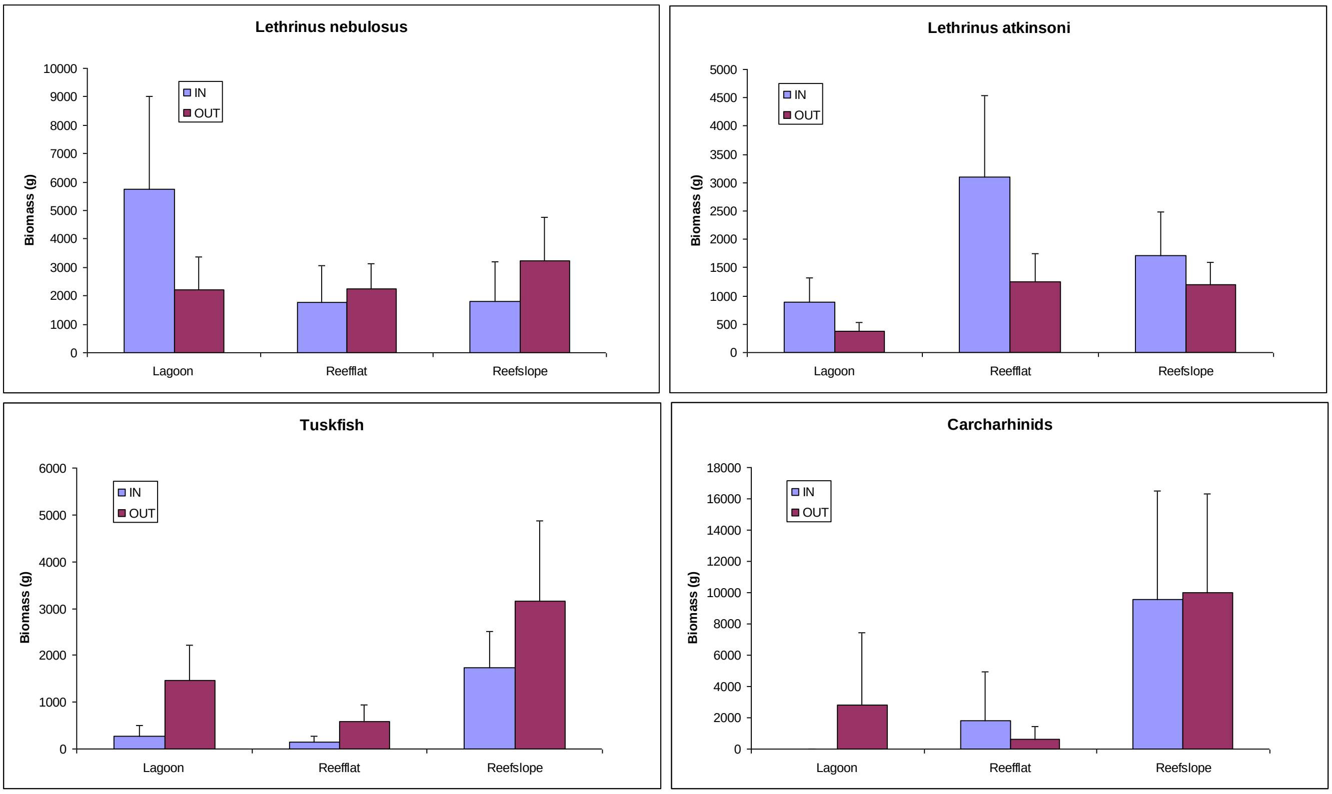


Figure 23 (cont.). Habitat and zoning-related trends in biomass of top target taxa in pre-existing Sanctuary Zone Regions the Ningaloo Marine Park. Data are means per transect (g + 95% CI).

Size-specific trends in target species abundance

In order to better understand patterns in the abundance of common target fish, two of the most commonly targeted species, *Lethrinus nebulosus* and *Lethrinus atkinsoni* (Table 4), were selected for additional analyses, focusing on patterns in density of different size classes within pre-existing sanctuary zones. Significant differences in biomass were detected between zones for both these species (Table 5a). For *L. nebulosu*s overall abundance did not vary significantly between zones, though there was significant variation in abundance at the regional level and among habitats (Table 7). The abundance of fish of different sizes however varied in relation to zoning. For *L. nebulosus* above the minimum legal size (41 cm), as well as for juvenile fish (<10 cm) there was a significantly higher abundance inside pre-existing sanctuary zones. For sublegal sized fish, abundance was significantly higher outside sanctuary zones (Table 7, Fig 24). The Zoning x Habitat and Zoning x Region interactions were also significant. Interactions between zoning and habitat also differed among fish of different size classes, with both juvenile and legal sized fish most abundant in the lagoon while sublegal sized individuals were more common on reef slopes

(Fig. 24) resulting in overall numbers being similar in pre-existing sanctuary zones and elsewhere.

Table 7. *Lethrinus nebulosus* relative abundance in pre-existing sanctuaries. Data for three size classes presented as well as for total numbers. Bold text; $p < 0.05$. (+) higher biomass inside sanctuary zones, (-) higher biomass outside sanctuary zones.

	p						
Species	**Zoning**	**Habitat**	**Region**	**Zoning x Habitat**	**Zoning x Region**	**Habitat x Region**	**Zoning x Habitat x Region**
Juveniles <10cm	**(+)0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**	0.2293	1.0000
Sublegal <41cm	**(-)0.0133**	**0.0391**	**<0.0001**	**0.0005**	**0.0487**	**<0.0001**	**0.0056**
Legal >42cm	**(+)0.0113**	**<0.0391**	**<0.0001**	**<0.0005**	**<0.0487**	**<0.0001**	**0.0056**
All	0.1606	**<0.0284**	**<0.0001**	**0.0002**	**0.0454**	**<0.0001**	**0.0179**

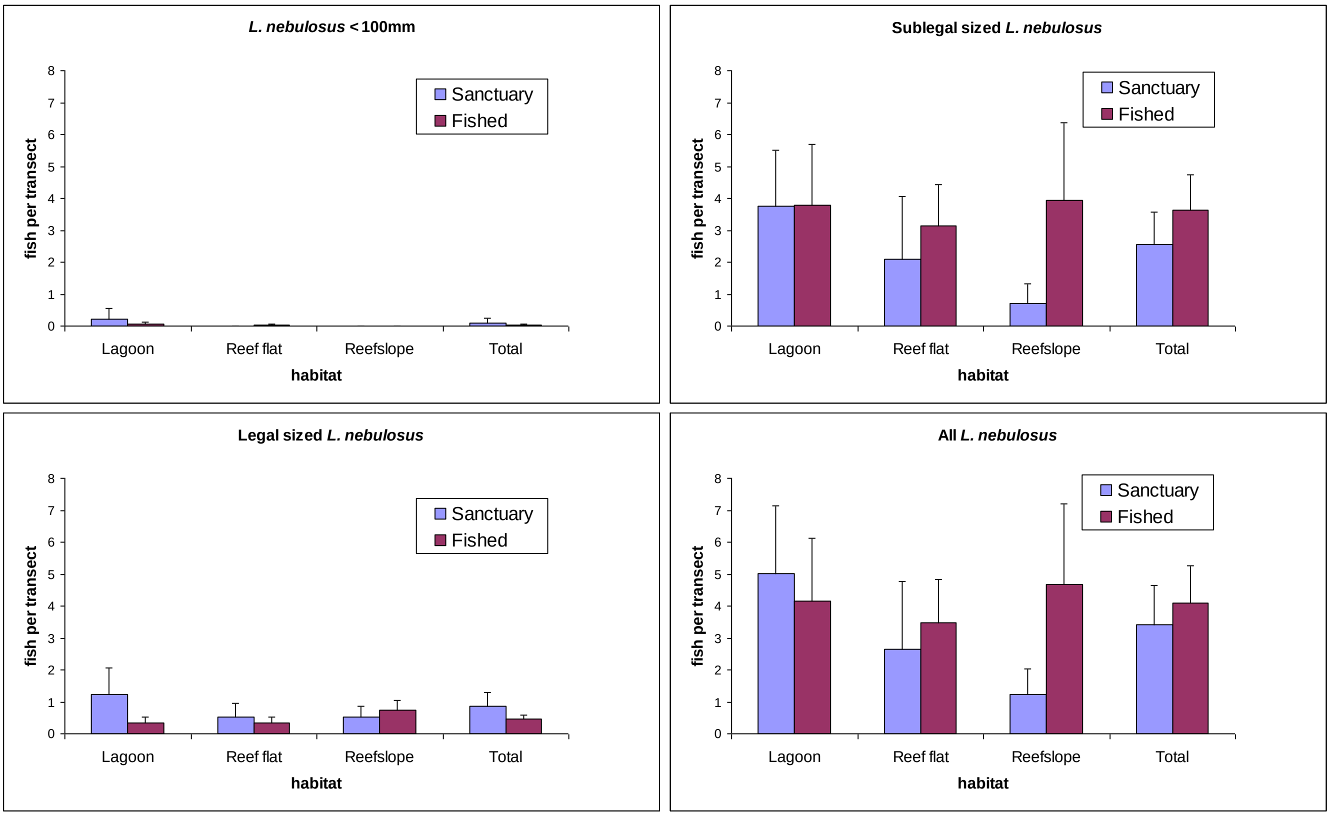


Figure 24. Density of *Lethrinus nebulosus* in relation to reef habitat and Marine Park zoning. pre-existing Sanctuaries only. Data are presented for size classes, recruits or juveniles <100mm Fl, subadults and juveniles below legal size of 410 mm (including recruits <100mm FL, adults greater or equal to 420mm FL, as well as total numbers of individuals. Data are means per transect (g + 95% CI).

For *Lethrinus atkinsoni* the density of fish of all sizes was greater inside sanctuary zones (Table 8, Fig. 25), as well as varying among regions and habitats. These trends in abundance were fairly uniform across habitats, however for *L. atkinsoni* above the minimum legal size, the differences in density were greatest in the reef slope habitat (Fig. 25). For all size classes of fish there were significant Zoning x Region interactions indicating that zoning effects were not uniform among regions (Table 8).

Table 8. *Lethrinus atkinsoni* relative abundance in pre-existing sanctuaries. Data for three size classes presented as well as for total numbers. Bold text; $p < 0.05$. (+) higher biomass inside sanctuary zones, (-) higher biomass outside sanctuary zones.

	p						
Species	**Zoning**	**Habitat**	**Region**	**Zoning x Habitat**	**Zoning x Region**	**Habitat x Region**	**Zoning x Habitat x Region**
Sublegal ≤28cm	**(+)0.0037**	**<0.0001**	**<0.0001**	0.5955	**0.0002**	0.1404	0.1965
Legal >28cm	**(+)0.0004**	**<0.0001**	**<0.0001**	**0.0020**	**0.0023**	**<0.0001**	0.0669
All	**(+)0.0001**	**<0.0001**	**<0.0001**	0.6547	**0.0006**	0.3198	**0.0169**

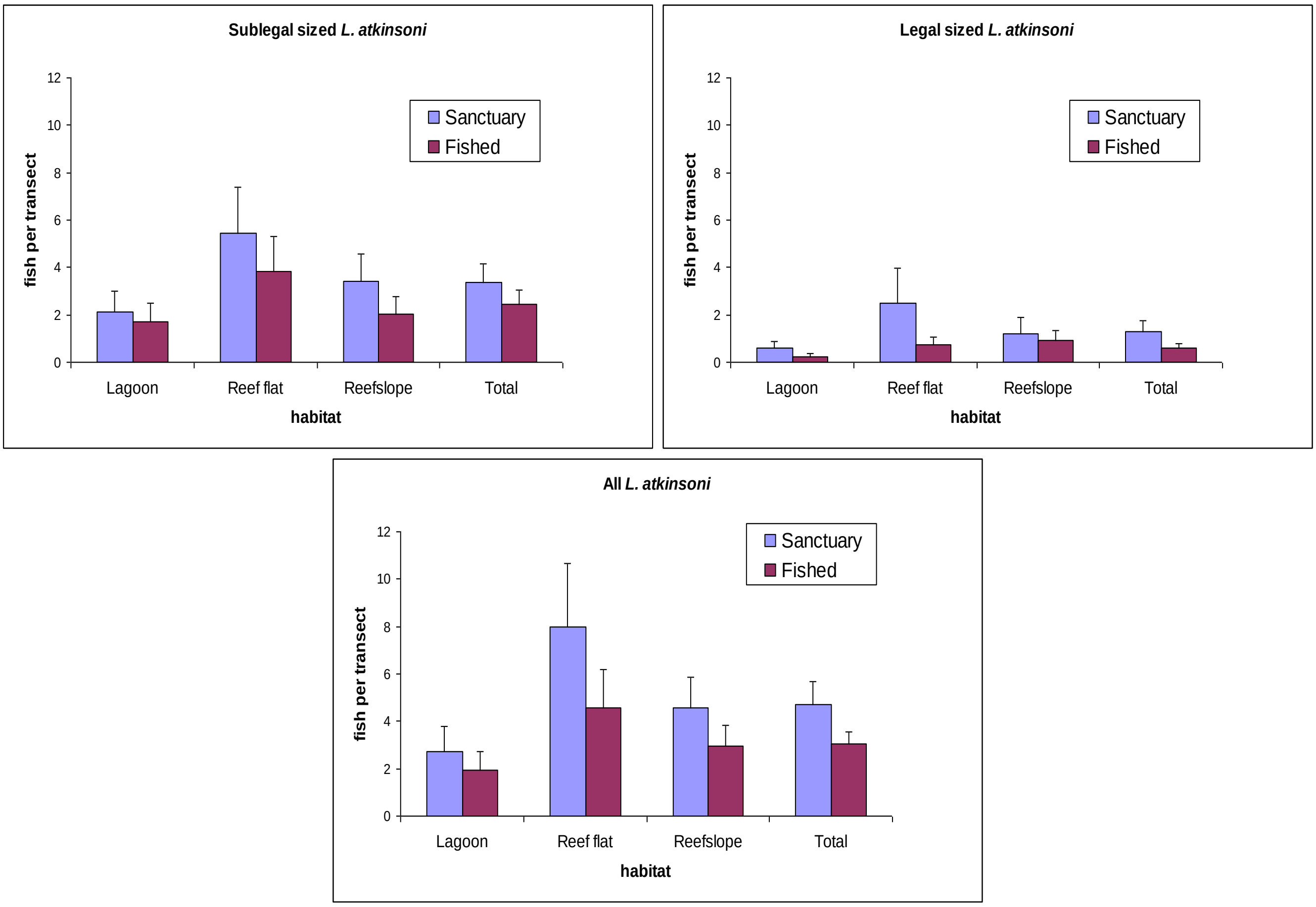


Figure 25. Density of *Lethrinus atkinsoni* in relation to reef habitat and Marine Park zoning. pre-existing Sanctuary Zones only. Data are presented for two size classes, sublegal sized individuals below legal size of 280 mm, adults greater or equal to 280mm FL, as well as for total numbers of individuals. Data are means per transect (+ 95% CI).

Statistical power of sampling

Analysis of statistical power and sample size for counts of *Lethrinus nebulosus* and *L. atkinsoni* indicate that for the observed level of differences between sample populations, power was well above the conventional 80% level (i.e. only a 20% chance of not detecting a real difference in means). For both species, and for legal sized and total fish, power was in fact equal or close to 1 (Fig. 26) for analyses of the entire data set (pre-existing sanctuary zones only) where sample sizes per treatment were always greater than n=330. In all cases the observed differences in means were between 50% and 100% greater inside sanctuary zones. The rapid increase in power at sample sizes of less than n=50 per treatment also means that within regions, (where sample sizes were between 25 to 40 per treatment), the sample size required to detect a doubling of the mean density for the overall population (100% difference) was always less than 25. This suggests that the fact that significant differences in populations of these species within regions was not due to lack of statistical power. For legal sized individuals, the power to detect differences was lower with sample sizes of between 25 and 50 required to achieve 80% power. Larger samples would be required to detect smaller differences i.e. 125 to 160 samples per treatment to detect a 50% increase in density.

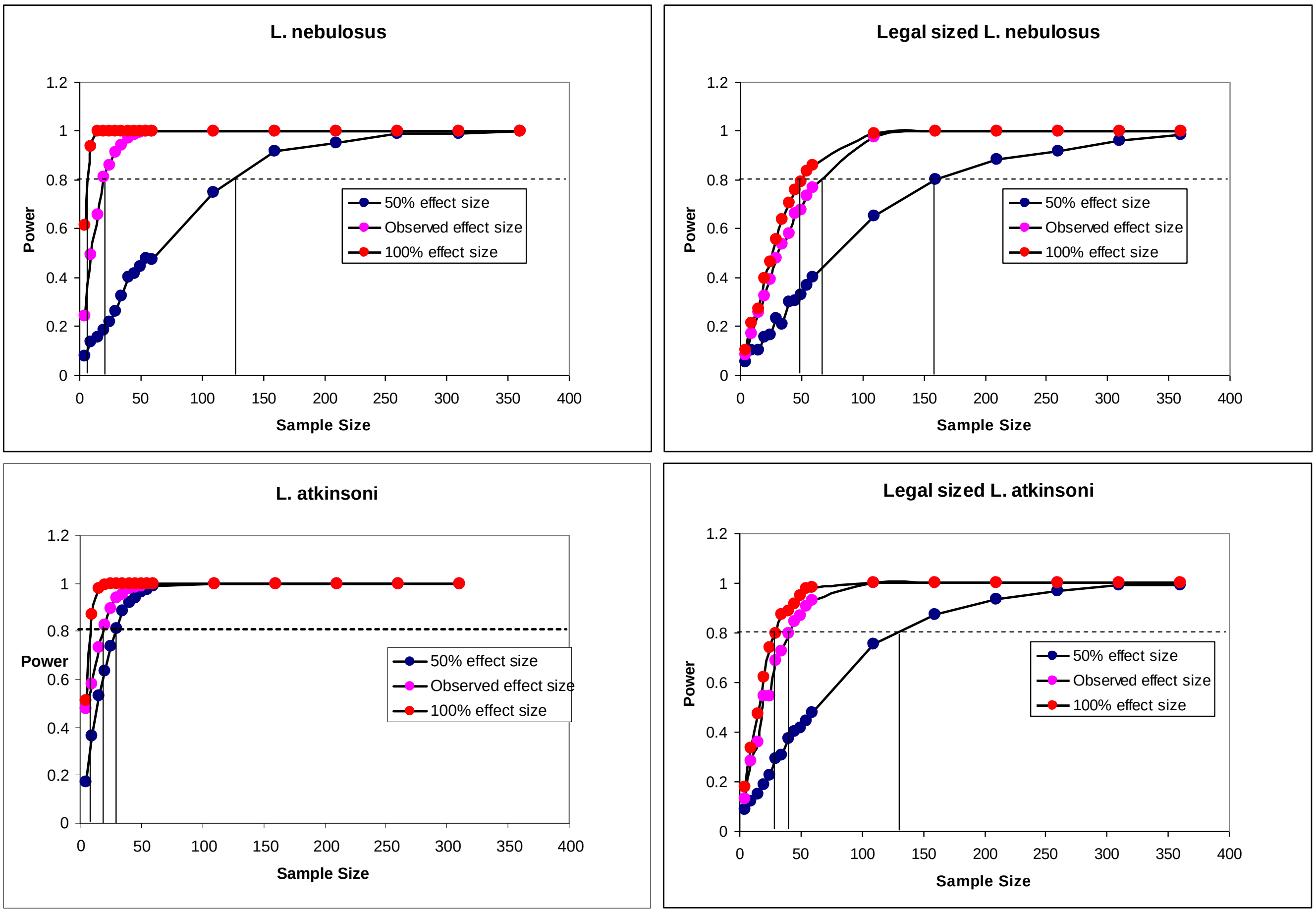


Figure 26. Statistical power and sample size for *Lethrinus* spp. sampled in the Ningaloo Marine Park. Effect sizes indicate the difference between densities observed outside sanctuary zones and sanctuary zone densities 50% and 100% greater, as well as for the observed differences in densities.

Target species biomass in relation to gradients in fishing pressure

Trends in the biomass of major target species were examined in relation to variations in fishing pressure reported from previous surveys of recreational fishing effort (Sumner et al 2002) after preliminary exploration of UVC data suggested there may be inverse trends between these two sets of data (Fig. 27). Analysis of patterns in fish biomass relative to spatial patterns in fishing pressure indicated significant trends existed for the majority of key target groups (Fig 28). This trend was most evident in larger longer lived taxa including serranids, trevallies, and *Carcharhinus amblyrhynchos*, which all showed steadily decreasing trends in biomass with increasing fishing pressure. Similar trends also existed for taxa including all carcharhinid sharks, *Gnathanodon speciosus* and *Lethrinus nebulosus* however in these species the biomass levels at intermediate levels of fishing pressure were similar to those at either high or low fishing pressures (Fig 28). Significant variation was also found for the remaining species (apart from tuskfish) but this was not clearly related to spatial patterns fishing pressure. For *Epinephelus rivulatus*, *E. fasciatus*, *L. atkinsoni*, *Lutjanus carponotatus*, *Scomberomorus commerson* biomass was either higher or lower at intermediate levels of fishing pressure, potentially and did not vary in a consistent way in relation to fishing effort.

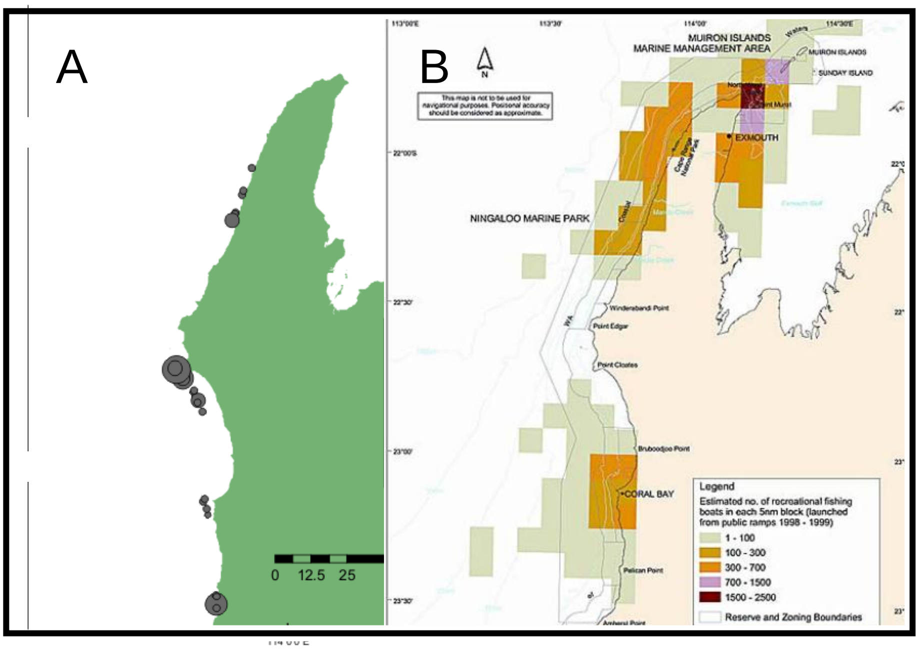


Figure 27. (A) Abundance (per UVC transect) of the gray reef Shark (*Carcharhinus amblyrhynchos*) and (B) distribution of fishing effort around in the Ningaloo Marine Park and western Exmouth Gulf (boats per year in each 6 nm reporting block based on boat ramp surveys in 1999; from Sumner 2002).

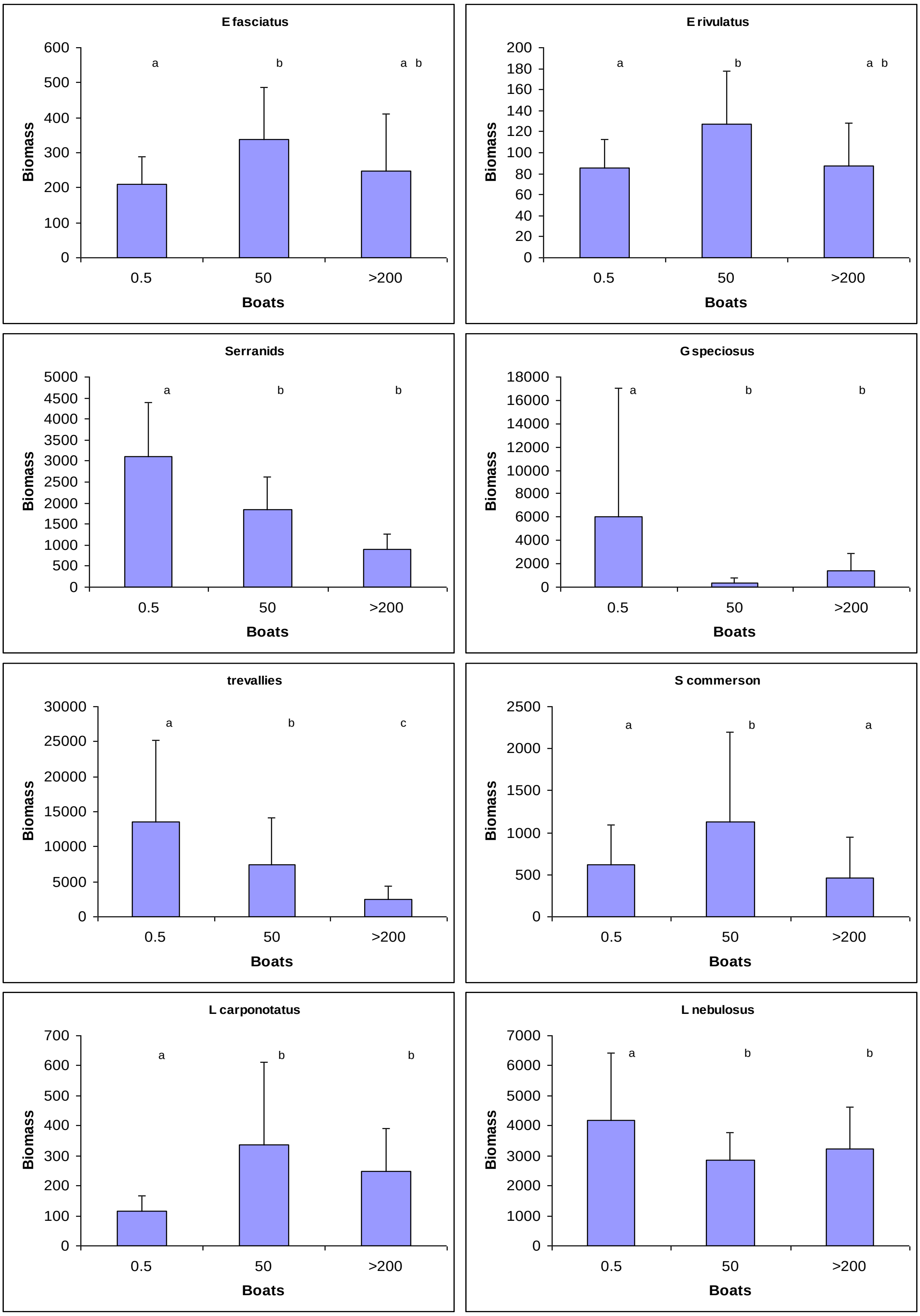


Figure 28. Biomass of top target taxa in the Ningaloo Marine Park relative to fishing pressure. Biomass data are means per transect (g + 95% CI), Fishing effort is boats per year from all 6nm statistical reporting blocks (Sumner et al 2002) in which data were collected. Significant overall variation in biomass was present in relation to fishing pressure for all groups except tuskfish. Letters indicate levels of fishing pressure shown to differ in the basis of pairwise comparisons.

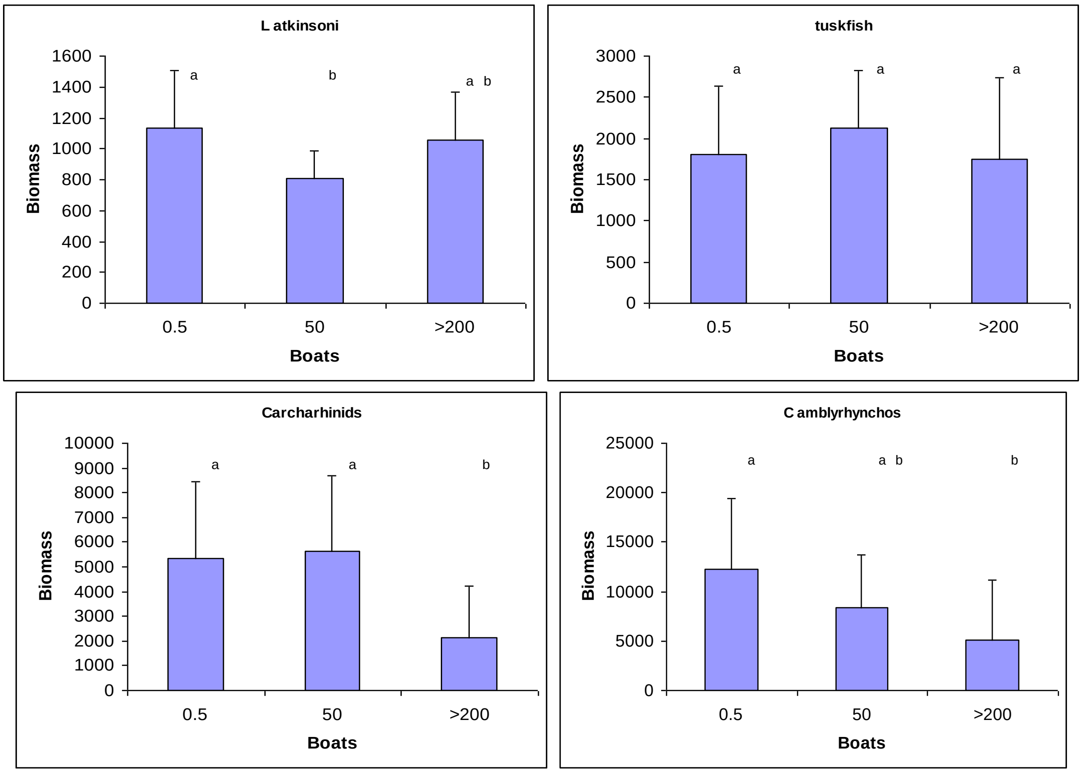


Figure 28 (cont.). Biomass of top target taxa in the Ningaloo Marine Park relative to fishing pressure. Biomass data are means per transect (g + 95% CI), Fishing effort is boats per year from all 6nm statistical reporting blocks (Sumner et al 2002) in which data were collected. Significant overall variation in biomass was present in relation to fishing pressure for all groups except tuskfish. Letters indicate levels of fishing pressure shown to differ in the basis of pairwise comparisons.

Within-region responses of target species

Because analysis of the full data set showed significant variation among regions, and because graphical analysis showed the potentially significant interactions between region, habitat, and zoning, the effects of zoning and habitat on fish biomass were analysed separately for each region. Since the main purpose for conducting this further analysis was to better understand the potential effects of established sanctuary zones, only regions in which such zones were established in 1987 were subjected to this more detailed analysis. Analyses are for all fish.

Bundegi

Significantly greater biomass of serranids was found inside the sanctuary zone at Bundegi than outside it (Table 9). A similar, though narrowly non-significant, trend was found for *Epinephelus rivulatus*. *Lutjanus argentimaculatus* was the only other species with significantly higher biomass within the sanctuary. Biomass of tuskfish and trevallies including *Gnathanodon speciosus* was higher outside the sanctuary. In the case of the trevallies the trends were largely the result of groups of large individuals being found outside the sanctuary. For most species habitat was an important influence on biomass (Table 9).

Table 9. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Bundegi Sanctuary Zone. Offshore Lagoon/patch-reef habitat was not included in the comparison since no areas equivalent to this habitat were present in the pre-existing sanctuary zone. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects. -; no test due to unbalanced data set.

Species	**Zoning effect-size**	**p**		
		Zoning	**Habitat**	**Status x Habitat**
Epinephelus fasciatus	-	-	-	-
Epinephelus rivulatus	3.4	0.07	**0.0001**	0.22
Serranids	**8.2**	**0.001**	**0.004**	0.34
Gnathanodon speciosus	**0**	**0.0003**	**0.0001**	-
Trevallies	**0.3**	**0.048**	**0.014**	0.105
Scomberomorus commerson	**0**	**0.0003**	**0.0001**	-
Lutjanus carponotatus	0.9	0.81	0.11	0.39
Lethrinus nebulosus	0.4	0.08	0.91	0.10
Lethrinus atkinsoni	0.9	0.62	0.95	0.58
Tuskfish	**0.6**	**0.004**	**0.006**	0.338
Carcharhinids	-	0.06	**0.0006**	-
Lutjanus argentimaculatus	**37.8**	**0.0001**	**0.0001**	**0.014**

Mangrove

Only the serranid *E. rivulatus* showed significantly higher biomass inside the pre-existing sanctuary zone than outside it (Table 10). Biomass of *Lethrinus nebulosus* was greater inside the sanctuary zone but this pattern was narrowly non-significant (p=0.07). For all other species that showed significant differences between zones, biomass was greater outside the sanctuary. To a large extent this is likely to have been the result of the relatively low overall biomass of these species in the lagoon habitat and the fact that the pre-existing Mangrove sanctuary zone was relatively small.

Table 10. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Mangrove Sanctuary Zone. Comparisons made only within Lagoon habitats since the entire original sanctuary area was within this habitat. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects. -; no test due to unbalance data set.

Species	**Zoning effect-size**	**p**		
		Zoning	**Habitat**	**Status x Habitat**
Epinephelus fasciatus	-	-	-	-
Epinephelus rivulatus i	**3.4**	**0.03**	-	-
Serranids o	**0.09**	**0.02**	-	-
Gnathanodon speciosus	**0**	**0.047**	-	-
Trevallies	**0**	**0.025**	-	-
Scomberomorus commerson	-	-	-	-
Lutjanus carponotatus	**0**	**0.038**	-	-
Lethrinus nebulosus	3.6	0.07	-	-
Lethrinus atkinsoni	**0.08**	**0.013**	-	-
Tuskfish	**0**	**0.005**	-	-
Carcharhinids	-	-	-	-

Mandu

Only *Lethrinus atkinsoni* had higher biomass inside the pre-existing sanctuary zone at Mandu than outside it (Table 11). For all other species that showed significant differences between zones, biomass was greater outside the sanctuary. For most species habitat was an important influence on biomass (Table 11).

Table 11. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Mandu Sanctuary Zone. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects.

Species	**Zoning effect-size**	**p**		
		Zoning	**Habitat**	**Status x Habitat**
Epinephelus fasciatus	0.5	0.13	**0.0001**	0.94
Epinephelus rivulatus	1.3	0.47	**0.0001**	**0.008**
Serranids	**0.6**	**0.04**	**0.0001**	0.23
Gnathanodon speciosus	**0.03**	**0.0001**	**0.0001**	0.777
Trevallies	**0.21**	**0.001**	**0.001**	0.689
Scomberomorus commerson	**0**	**0.0001**	**0.0001**	1.000
Lutjanus carponotatus	**0**	**0.0001**	**0.0009**	1.000
Lethrinus nebulosus	0.7	0.238	0.109	**0.064**
Lethrinus atkinsoni	**1.8**	**0.014**	**0.0149**	0.194
Tuskfish	**0.2**	**0.002**	**0.001**	**0.002**
Carcharhinids	1.14	0.7	**0.0001**	1.0

Osprey

The majority of key targeted species showed significantly higher biomass inside the pre-existing sanctuary zone at Osprey than outside it (Table 12). In particular, tuskfish were thirty times more abundant inside the sanctuary zones than outside. Shark biomass was also more abundant inside the zone, although this pattern was very narrowly non-significant (p=0.051). Biomass of serranids, trevallies, carcharhinids and *L. carponotatus* was significantly lower inside the pre-existing sanctuary zone. For most species habitat was an important influence on biomass (Table 12).

Table 12. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Osprey Sanctuary Zone. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects.

		p		
Species	**Zoning effect-size**	**Zoning**	**Habitat**	**Status x Habitat**
Epinephelus fasciatus	**0.4**	**0.009**	0.94	**0.0001**
Epinephelus rivulatus	**4.05**	**0.0001**	**0.0001**	0.7
Serranids	**0.4**	**0.0007**	**0.001**	**0.001**
Gnathanodon speciosus	**4.9**	**0.001**	**0.0001**	**0.0003**
Trevallies	**3.64**	**0.0004**	**0.0001**	0.94
Scomberomorus commerson	0.7	0.29	**0.0001**	1.0
Lutjanus carponotatus	**6.5**	**0.0002**	**0.0001**	1.0
Lethrinus nebulosus	**2.8**	**0.001**	**0.0001**	0.095
Lethrinus atkinsoni	**2.4**	**0.0001**	**0.0001**	**0.0067**
Tuskfish	**30.1**	**0.001**	**0.001**	0.9
Carcharhinids	1.95	0.051	**0.0001**	1.0

Cloates

Only *S. commerson* showed significantly higher biomass inside the pre-existing Dugong sanctuary zone at Cloates than outside it (Table 13). Biomass of *E. fasciatus* was also more abundant inside the zone, although this pattern was narrowly non-significant (p=0.054). Biomass of trevallies, serranids, Lutjanus carponotatus and carcharhinids were significantly lower inside the pre-existing sanctuary zone. For most species habitat was an important factor determining biomass (Table 13).

Table 13. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Cloates Sanctuary Zone. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects.

Species	**Zoning effect-size**	**p**		
		Zoning	**Habitat**	**Status x Habitat**
Epinephelus fasciatus	2.1	0.054	0.0001	1.0
Epinephelus rivulatus	0.5	0.14	0.014	0.95
Serranids	**0.04**	**0.0012**	**0.0001**	0.99
Gnathanodon speciosus	1.3	0.61	0.177	0.26
Trevallies	**0.4**	**0.03**	**0.0011**	0.71
Scomberomorus commerson	**2.3**	**0.038**	**0.0001**	1.0
Lutjanus carponotatus	**0.02**	**0.0001**	**0.0001**	0.49
Lethrinus nebulosus	0.53	0.17	0.56	0.38
Lethrinus atkinsoni	1.35	0.37	**0.0036**	0.624
Tuskfish	0.8	0.5	0.4	**0.04**
Carcharhinids	**0.4**	**0.026**	**0.0001**	0.62

Maud

Only *L. nebulosus* showed significantly higher biomass inside the pre-existing sanctuary zone at Maud than outside it (Table 14). Biomass of serranids, trevallies, tuskfish and carcharhinids and *S. commerson* was significantly lower inside the pre-existing sanctuary zone. Numbers of *E. rivulatus*, *G. speciosus*, and *L. carponotatus* were insufficient for testing. For most species habitat was an important factor determining biomass (Table 14).

Table 14. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Maud Sanctuary Zone. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects.

Species	**Zoning effect-size**	**p**		
		Zoning	**Habitat**	**Zoning x Habitat**
Epinephelus fasciatus	0.5	0.07	**0.0001**	0.238
Epinephelus rivulatus	-	-	-	-
Serranids	**0.1**	**0.0009**	**0.0001**	0.64
Gnathanodon speciosus	-	-	-	-
Trevallies	**0.1**	**0.004**	**0.001**	0.889
Scomberomorus commerson	**0**	**0.0001**	**0.0001**	1.0
Lutjanus carponotatus	-	-	-	-
Lethrinus nebulosus	**2.0**	**0.0025**	**0.0001**	**0.003**
Lethrinus atkinsoni	1.3	0.4	0.24	0.0001
Tuskfish	**0.2**	**0.0004**	0.057	**0.0005**
Carcharhinids	**0.5**	**0.04**	**0.0001**	**0.001**

Pelican

There were no species with significantly higher biomass inside the pre-existing sanctuary zone at Pelican (Table 15). Biomass of *Lethrinus nebulosus* was slightly greater inside the sanctuary but this was not close to being a significant trend. Serranids, *Epinephelus fasciatus*, *Gnathanodon speciosus*, *Lutjanus carponotatus*, tuskfish and carcharhinid biomass was significantly lower inside the pre-existing sanctuary zone. For most species habitat was an important factor determining biomass (Table 15).

Table 15. Top target taxa selected for statistical analysis of potential responses to sanctuary zoning in the Pelican Sanctuary Zone. Bold text; $p < 0.05$. Zoning effect-size is the ratio of biomass inside pre-existing sanctuary zones relative to that outside. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Habitat as fixed effects.

Species	**Zoning effect-size**	**p**		
		Zoning	**Habitat**	**Status x Habitat**
Epinephelus fasciatus	**0.2**	**0.001**	**0.0001**	0.90
Epinephelus rivulatus	0.9	0.76	0.15	**0.003**
Serranids	**0.05**	**0.0005**	**0.0001**	1.0
Gnathanodon speciosus	**0.03**	**0.007**	**0.03**	0.96
Trevallies	0.8	0.60	**0.0001**	0.32
Scomberomorus commerson	**0**	**0.002**	**0.0001**	1.0
Lutjanus carponotatus	**0.02**	**0.0057**	**0.0001**	1.0
Lethrinus nebulosus	1.5	0.24	0.12	0.48
Lethrinus atkinsoni	0.7	0.41	**0.039**	0.755
Tuskfish	**0.2**	**0.003**	**0.001**	0.96
Carcharhinids	**0.3**	**0.03**	**0.0001**	1.0

Effect size vs reserve size

For the three taxa in which zoning effects were apparent across all regions with pre-existing sanctuary zones (*Lethrinus atkinsoni*, *L. nebulosus*, and tuskfish), we compared estimates of effect size (Tables 9-15) with a range of sanctuary zone characteristics; area, perimeter, sea perimeter (i.e. perimeter excluding the terrestrial or shoreline boundary), area/perimeter, area/sea perimeter). Effect size was defined as the ratio of the biomass of the target species inside to the biomass outside. The correlations between effect size and sanctuary area were generally poor (Fig. 29), explaining little of the variation among sanctuaries, and were non-significant. Similarly regression analysis of effect size against perimeter, sea perimeter, area/perimeter, and area/sea perimeter, did not reveal any significant relationships. Visually the results for *L. atkinsoni* show a trend most consistent with expectations, with a positive trend in the data (higher effect size in larger sanctuaries). While a better fit was achieved for logged values of effect size (Fig. 29) neither the regression for a linear fit (p=0.54) or for log Effect size (p=0.50) were significant. For this species, which was the only one to show a overall higher biomass sanctuary zones the parameter best correlated with effect size was ln(area/perimeter) with an R^2 of 0.36 (p=0.15). Slightly negative trends were found in the other two species in which zoning effects were less clear (restricted to single habitat in *L. nebulosus*) or even negative (tuskfish).

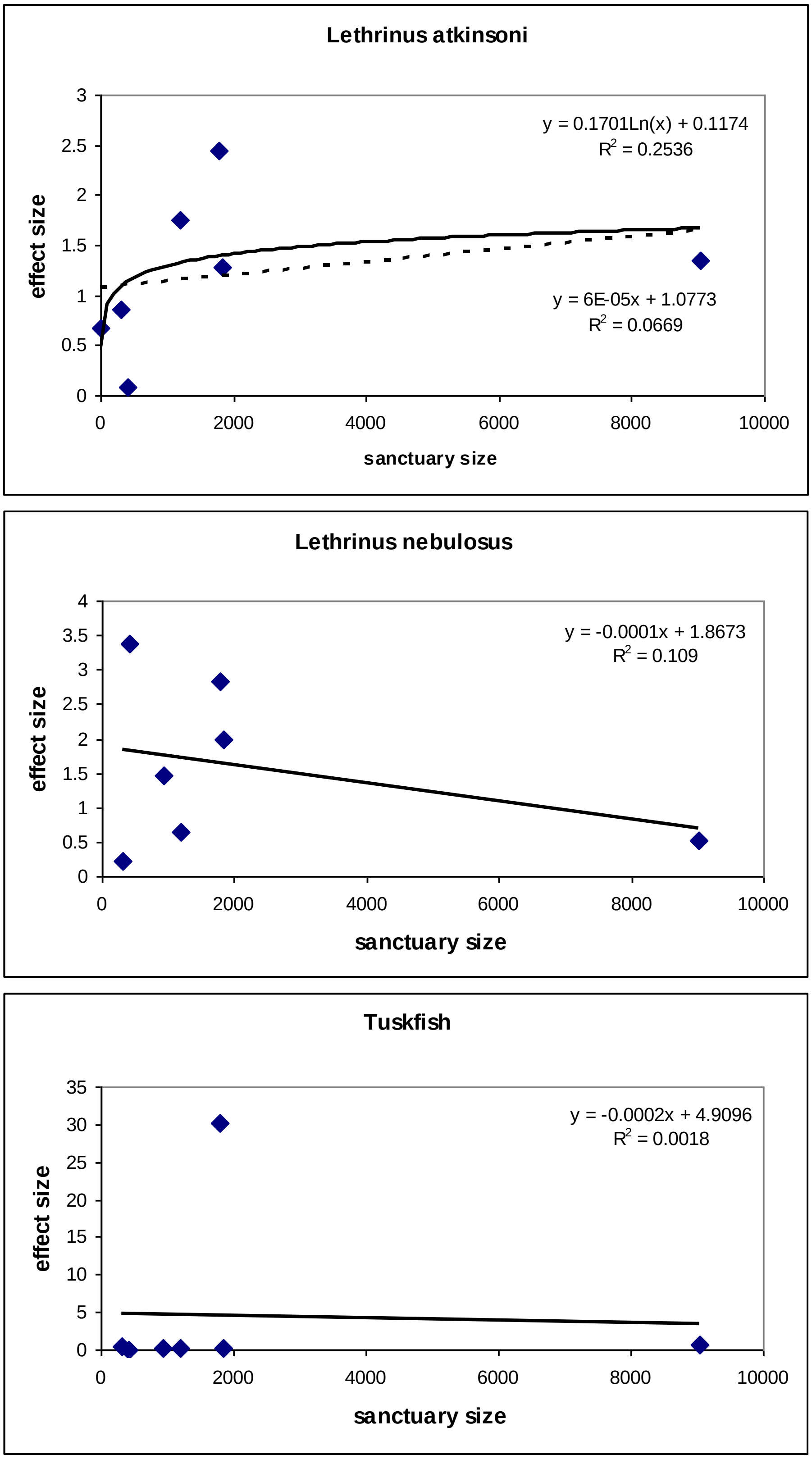


Figure 29. Regressions between effect-size and sanctuary size for key target species showing significant trends across all pre-existing sanctuary areas.

Temporal comparisons

Temporal patterns in abundance of the most targeted species, *Lethrinus nebulosus*, were compared, taking advantage of detailed surveys undertaken in 1987 in the Sandy Bay area at the northern border of the Osprey Sanctuary zone (Ayling and Ayling 1987). Fifty-six of the sites surveyed by Ayling and Ayling (1987) were re-surveyed in 2006. Overall there were significant temporal and spatial effects but no interaction between the year of sampling and the zoning status (Table 16). At the time of the first survey there were already nearly twice as many *L. nebulosus* in the areas that were to ultimately become part of the Osprey sanctuary zone (Fig. 30). In both fished and unfished areas numbers dropped between 1987 and 2006, though the drop was greater in the fished areas (by a factor of 12.5) than it was in the unfished areas (a factor of 1.9).

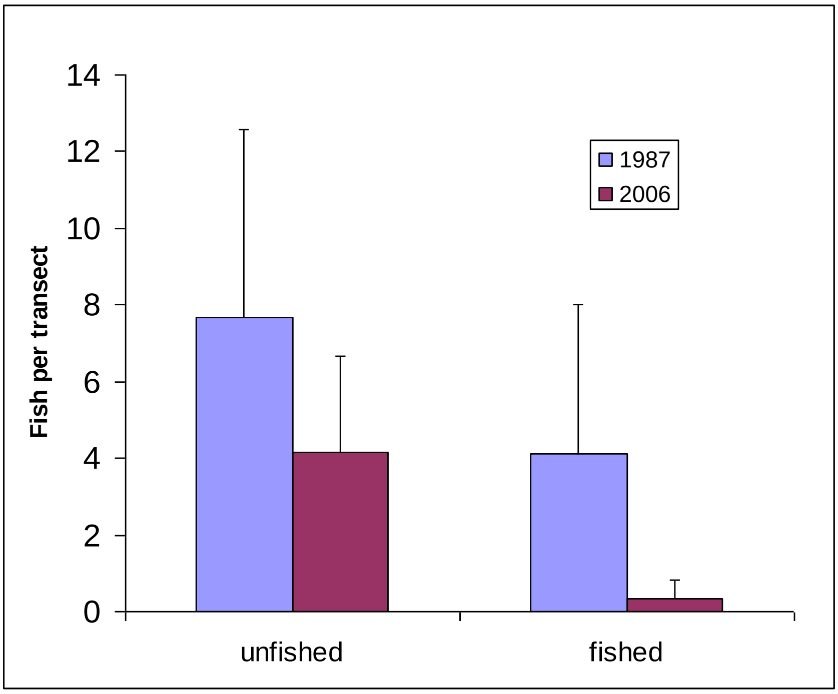


Figure 30. Comparison of *Lethrinus nebulosus* density 1987 to 2006. Sites were divided among areas that fell either side of a sanctuary zone boundary at the northern end of the Osprey sanctuary zone. Transects in 1987 and 2006 both had the same coverage $1000m^2$. Data are means per transect + 95%CI.

Table 16. Temporal and spatial comparison of the abundance of *Lethrinus nebulosus* populations. Results presented are significance levels for log linear analysis (SAS GENMOD) with Zoning and Survey as fixed effects.

Source	Deviance	Num DF	Den DF	F Value	p
Intercept	2164.469				
Survey	2061.824	1	142	7.62	0.0065
Zoning	1954.058	1	142	8	0.0054
Year x Zoning	1913.065	1	142	3.04	0.0833

DISCUSSION

General trends in fish assemblages

Regional, habitat and latitudinal variation

Regionally distinct fish assemblages were apparent and broad differences existed between assemblages found in northern areas influenced by Exmouth Gulf waters (Muiron Islands, Bundegi and Lighthouse regions), central areas characterized by well developed “offshore” fringing reef environments (Mangrove, Mandu, Osprey, Cloates, Maud, Pelican and Farquhar), and southern areas with narrow fringing reefs and coastal nearshore fringing reefs (Gnaraloo). These patterns may well be related to geomorphological differences in reef structure as well as to oceanographic aspects of these regions (Taylor and Pearce 1999). Larger scale latitudinal influences may also be present, as latitudinal trends are clearly evident in the composition of assemblages inhabiting reef slopes which otherwise have a relatively high level of structural and oceanographic similarity (Fig. 15). Latitudinal distribution trends are well known at larger scales in fish from the WA coast for fish such as tuskfish (the southern Baldchin grouper (*Choerodon rubescens* 23° S to 34° S; Allen 1997) vs. the northern Blackspot tuskfish; Fig. 16, (*Choerodon schoenleinii*, 15° S to 26° S; Hutchins 2001)), as well as for key habitat forming taxa such as corals (Veron and Marsh 1988).

The demonstration of clear latitudinal variation in fish assemblages vindicates the extension of sanctuary zone protection to areas at the northern and southern extremities of the marine park that were previously not fully protected (Muiron Islands, Gnaraloo). The objectives for the re-zoning of Ningaloo were to achieve a more comprehensive, representative and adequate level of protection for habitats within the marine park. Although these zoning decisions were made on the basis of a precautionary approach, data now show that the level of protection from fishing afforded to fish assemblages is clearly now more comprehensive and representative than it was before the re-zoning that came into effect in 2006 (Anonymous 2005).

In addition to broad-scale regional differences, there were also highly significant differences in fish assemblage composition among reef habitats (Figs 10). Within regions key differences were present in functionally important species such as sharks (e.g. *Carcharhinus amblyrhynchos*), groupers (*Variola louti*) and scombrids (*Scomberomorus commerson*), key target species such as emperors (*Lethrinus nebulosus* and *L. atkinsoni*) and grazing species such as parrotfish (*Chlorurus sordidus* and *Leptoscarus vaigiensis*) and surgeonfish (*Naso unicornis).* Highly distinctive assemblages were found in lagoon, reef flat and reef slope habitats, yet reef slope (as well as other deeper water offshore habitats not covered in this study) were largely excluded from sanctuary zone protection in the previous zoning scheme. The recent re-zoning of the marine park has therefore greatly increased the comprehensiveness and representativeness of the marine park with respect to habitat, relative to previous zoning.

Zoning

The pre-existing Ningaloo Marine Park Sanctuary zones were established in 1987, and had been in effect for nearly 20 years at the time of the first surveys. Differences among zones in assemblage structure were significant, similar to experiences in other marine parks globally (Denny et al. 2003, Denny et al. 2004, Williamson et al. 2004, Friedlander et al. 2007, Meyer 2007, Russ et al. 2008) as well as within Western Australia (Watson 2007, Kleczkowski et al. 2008) that have been established for similar lengths of time. In these studies clear differences in assemblage structure, driven by angling target species and their prey, have been demonstrated. There are clear theoretical reasons to expect such differences since fishing removes target fish species from the environment and, as the fishing techniques generally employed in this region selectively target predatory species, cascading effects on prey species might also be expected. (Sala et al. 1998, Ashworth and Ormond 2005, Watson et al. 2007, although for some exceptions see Williamson et al. 2004, Tetreault and Ambrose 2007). It should be noted however that analyses of assemblages on a region by region basis showed that this effect was not uniform across all sanctuary zones, and that there may have been a range of factors, in addition to direct zoning effects, responsible for the overall trend.

Of the seven sanctuary zones established in 1987, only three (Bundegi, Mangrove and Mandu) showed significantly different fish assemblage structures between sanctuary zones and fished areas. At Bundegi species characterizing sanctuary zone habitats were not necessarily target or even by-catch species, suggesting the assemblage level differences may be related to differences in habitat between sanctuary and fished areas (Fig. 18). Target species were highly correlated with differences between sanctuary zones and fished areas at Mangrove (*Epinephelus rivulatus*, Figs. 19) and Mandu (*Lethrinus nebulosus* and *L. atkinsoni,* Fig. 20); however in these regions non-target species (scarids, acanthurids, and siganids) also dominated the list of taxa most closely associated with differences between zones. This also suggests that underlying habitat related differences, rather than management zoning, may explain differences in assemblage structure.

There are several possible explanations for the lack of a general effect of zoning on fish assemblage structure in the Ningaloo. Firstly, if there is little overall effect of fishing in the region, due to low current and historical fishing pressure, adding extra levels of protection should make little difference in the biomass of target species. However, recreational fishing pressure in the region seem to be substantial, at least in some areas of the marine park (Sumner et al 2002) and should be high enough to produce detectable gradients across fished and unfished areas. Bundegi, Mangrove and Mandu Sanctuary zones are all in the northern section of the park where fishing pressure is generally highest. Alternatively the zones may be too small, given the activity ranges of target species, to be effective. This scenario is unlikely, given the strong effects of zoning on assemblage structure and individual target species in much smaller sanctuary zones elsewhere (Halpern 2003). For example, the Leigh Marine Reserve in New Zealand is only 5 km^2 in area but twenty years after it was established densities of the pink snapper (*Pagrus auratus*) were nearly 40 times higher than in the surrounding areas open to fishing and the abundance of the lobster *Jasus edwardsii* increased by 5 to 11% per year (Kelly et al. 2000, Willis et al. 2000). Alternatively, levels of compliance with zoning regulations may be low, resulting in a low level of difference between fished and sanctuary areas, which would reduce the apparent level of effectiveness of the sanctuary zones.

A recent study of marine reserves in Italy showed that only 3 of the 15 reserves investigated had adequate levels enforcement and that the patterns of recovery of impacted populations of target fish species were directly related to enforcement level (Guidetti et al. 2008). Modelling studies conducted on the line fishery on the Great Barrier Reef have shown that marine reserves designed for the protection of coral trout (*Plectropomus leopardus*) were ineffective at conserving biomass when only limited infringement occurred in the reserve (Little et al. 2005).

Targetted species;

Zoning trends throughout the marine park

The biomass of key targeted species varied markedly among regions (Fig. 21). For some of these species regional trends were similar to those described for overall fish assemblages and appeared to be related to large-scale patterns in reef morphology and coastal morphology (i.e. proximity to Exmouth Gulf). For example *Epinephelus fasciatus*, which is largely restricted to reef slope habitats (Fig. 21), was more abundant in regions that lacked well developed lagoon and reef-flat systems. The reverse was true for species such as *E. rivulatus* and *Lethrinus atkinson*i that are typically associated with inshore/lagoon habitats and reef flats respectively (Fig. 21). Not all reef slope-associated species followed the same distribution trends as *E. fasciatus* however; serranids, trevallies, *Lutjanus carponotatus* and tuskfish, all varied differently in abundance among regions (Fig. 21).

Given the high levels of inherent variability expected in fish count data (Samoilys et al. 1995, Cappo and Brown 1996) and the additional variation at regional and habitat level, any overall differences in biomass between marine park zones would have to be substantial and consistent in order to be considered statistically significant. The fact that most of the key targeted species did not show significant differences between zones may be a result of high levels of variability. However, we should probably expect such a lack of effects across a wide range of species because of the fact that the pre-existing sanctuary zones did not extend seaward much beyond the surf zone. Therefore it is to be expected that species associated with reef slope habitats, such as *E. fasciatus, Gnathanodon speciosus*, *Lutjanus carponotatus*, trevallies, serranids, tuskfish, carcharhinid sharks, would be little influenced by zoning status.

Of the species that did show clear cut trends, several were actually more abundant outside pre-existing sanctuary zones than inside them. This can partly be explained on the basis that species such as *Choerodon schoenleinii*, *C. cyanodus* and *C. cauteroma* were most common around the northern tip of Northwest Cape which was not included in any sanctuary zone prior to 2004. These species are not sexually mature until between 2.3 (*C. cyanodus*) and 3.5 (*C. schoenleinii*) years of age (Fairclough 2004) and so population responses to zoning would not be expected for several years. Similarly in the southern parts of the park such as Pelican to Gnarraloo, reef flat and lagoon areas are generally reduced or absent, and where they do exist they have been deliberately included in sanctuary areas. Since tuskfish, including *C. rubescens*, are more common in reef slope habitats, the distribution of sanctuary and fished areas has the potential to produce results that show greater biomass outside sanctuary zones. These trends were present even when regions were restricted only to those regions with pre-existing sanctuary zones (Table 5a). A final possibility is that because the selection of zones was partly the results of a process which attempted to reduce the impact of zoning on fishers, areas with perceived high fishing value were often deliberately excluded from sanctuary zones. One potential interpretation of our results is that these perceptions have some basis in reality. Resolution of this question is only possible through a BACI type design and continued monitoring of newly established sanctuary zones that include significant areas of a full range of habitat. These are located in the northern and southern areas of the park (Lighthouse, Farquhar, Gnaraloo), where the present study has established baseline data that will serve as part of a BACI type comparison.

The yellow tailed emperor *Lethrinus atkinsoni* was the only species that occurred in with significantly higher density and biomass across all pre-existing sanctuary zones. This species was most abundant overall in the central part of the marine park from Mangrove to Maud, which is the region with the best developed reef flats (preferred by *L. atkinsoni*) and the largest area of pre-existing sanctuary zones. These factors as well as the overall abundance may well have increased our power to detect zoning-related changes in the population density and biomass of this species. The results for *L. nebulosus* were less clear, with significantly higher density in sanctuary zones only in the lagoon habitat. This may be partly explained by the over-dispersed nature of the distribution of *L. nebulosus* c.f. *L. atkinsoni* i.e. *L. nebulosus* tend to form schools while *L. atkinsoni* tends to be solitary.

Given the relatively weak and variable (both positive and negative) overall response of targeted species to zoning, it is reasonable to suggest that the observed range of results might have arisen by chance. More detailed examination of the response of *Lethrinus atkinsoni* and *L. nebulosus* populations to zoning suggest that the observed differences are consistent with a zoning effect rather than habitat or chance variation. For both species relative differences in density between pre-existing sanctuary zones and fished areas were greater for individuals above minimum legal size than for overall differences or individuals below minimum legal size (Figs. 24, 25). In the case of *L. nebulosus* the fact that there was a significant overall effect for individuals greater than minimum legal size, but not for those smaller than this, strongly suggests that zoning is having some effect on populations of this species. Analyses of residuals data for *L. nebulosus* further argue that there are no unaccounted-for habitat-related effects underlying this assessment. Power analysis of the data for *L. nebulosus* and *L. atkinsoni* confirm that the design of the sampling was more than adequate to detect overall trends as well as differences within regions.

There is a common perception that most Lethrinids range over reasonably large areas (Williams 2007) and it is perhaps surprising that we were able to demonstrate higher densities of legal-sized *L. nebulosus* within the protected zones. However data from *L. nebulosus* in northwest Australia were found to move less than 3 nautical miles over periods of up to three years, and up to 25% moved more than 25 nautical miles during this time (Moran et al 1993). Watson et al. (2007) showed higher numbers of *L. nebulosus* in sanctuaries in the Houtman Abrolhos Islands, but these sanctuaries were relatively large (13.7 to 27.4 km^2) compared to the pre-existing sanctuaries in the Ningaloo Marine Park (0.3 to 9 km^2).

Zoning and fishing pressure

The biomass of the most targeted fish species showed patterns that matched broad spatial patterns of fishing pressure (Fig. 27), in contrast to results for sanctuary zones. Six out of the twelve top taxa examined showed significantly higher biomass in areas with the least fishing pressure. These results show that there are significant effects of fishing in the marine park, and that our method is capable of detecting these trends. Potentially differences in biomass levels of 50% to 300% are evident for those species in which fishing effects are indicated, with the exception of *L.*

nebulosus where the effect size was smaller. The results also suggest that in the future we should expect greater abundance of these species in both pre-existing and new sanctuary zones to more closely reflect the levels of difference in abundance under different levels of fishing pressure. Gradients in fish biomass as a function of fishing pressure also beg the question of why the observed differences in biomass between pre-existing sanctuary zones and adjacent fished areas are not more general or of greater magnitude.

Possible explanations fall into the following categories:

1. Little overall effect of fishing
2. Adequate methods (variability, ability to detect)
3. Zone size
4. Zone configuration
5. Compliance

The first two possibilities can be discounted since we have detected significant effects of fishing pressure. Based on information from the literature, the size of the pre-existing sanctuary zones is likely to be adequate to protect many if not all of the key target taxa. Furthermore in this study we found no relationship between sanctuary zone size and effect size for key species that showed overall significant differences in abundance (Fig 29). Since a significant proportion of these groups are associated with reef slope habitats, and the configuration of the pre-existing zones was such that most of this habitat was excluded from sanctuary areas, the lack of representation of this habitat type is a likely explanation for weak effects in reef slope species and for results on reef slopes in other more widely distributed species such as *L. nebulosus* (Fig. 21*)*. However, for other species characteristic of lagoons and reef flats, such as *Epinephelus rivulatus* or *Lutjanus carponotoatus*, and some of the smaller lagoon-associated serranids, we might expect a clearer response to sanctuary zone protection. The remaining potential explanation, lack of compliance with zoning regulations, is the most likely reason for this. There are clear logical (Little et al 2007) and empirical (Robbins 2006, Ayling and Choat 2008) reasons to expect that lack of compliance with zoning will produce measurable reductions in zoning effectiveness. It is common to observe boats fishing within sanctuary zones in the Ningaloo Marine Park, while conversely it is rare to sight any vessels of the agencies responsible for ensuring compliance with the zoning provisions (authors' unpublished observations).

Zoning trends within regions

The absence of significant effects of zoning across all pre-existing zones does not necessarily mean that there are no real effects at the level of individual sanctuary zones. For example at

Bundegi, the biomass of the mangrove jack (*Lutjanus argentimaculatus*) was 34 times greater than in adjacent areas (Table 9), but this species was infrequently encountered in all other zones, so we could expect a meaningful outcome only in this region. When the seven pre-existing sanctuary zones were examined for zoning effects in eleven highly-targeted taxa (Tables 9-15) and the sign (+/-) of any significant difference between zones examined, two were consistently positive (greater biomass in the sanctuary zone) throughout, *L. atkinsoni* and *E. rivulatus*, while only one was consistently negative (carcharhinids).

Table 17. Top target taxa selected for statistical analysis of responses to sanctuary zoning Sanctuary Zones across Regions with pre-existing sanctuary zones. Bold text; $p < 0.05$. +; positive zoning effect, -; negative zoning effect, blank; no significant effect.

Species	**Net Sign**	**Bundegi**	**Mangrove**	**Mandu**	**Osprey**	**Cloates**	**Maud**	**Pelican**
Epinephelus fasciatus	–				–			–
Epinephelus rivulatus	+		+		+			
Serranids	–	+	–	–	–	–	–	–
Gnathanodon speciosus	–	–	–	–	+			–
Trevallies	–	–	–	–	+	–	–	
Scomberomorus commerson	–	–		–		+	–	–
Lutjanus carponotatus	–		–	–	+	–		–
Lethrinus nebulosus	+			+	+		+	
Lethrinus atkinsoni	+		+	–	+			
Tuskfish	–	–	–		+		–	–
Carcharhinids	–	+	–			–	–	–
Net sign		–	–	–	+	–	–	–

Overall the *net* sign of differences between zones was positive only for the lagoon or reef flat associated species *L. nebulosus*, *L. atkinsoni*, and *E. rivulatus* (Table 17). Most of the species with a net negative sign were reef slope species. Among regions, only one sanctuary zone showed consistently positive responses of fish populations to zoning. One explanation for this may be that in the pre-existing sanctuary zones the reef slope habitats were very poorly represented, if it was included at all, and the seaward boundary passed through relatively shallow waters adjacent to the reef crest, and there difficulty in either recognizing or enforcing this boundary is likely to have lead to a perception that it was acceptable to fish anywhere outside the reef. The fact that trends for many of these reef-front associated species actually did show trends in abundance related to variation in fishing pressure is consistent with this interpretation.

Temporal comparisons

The abundance and biomass of targeted fish species has not been extensively studied in the past, but some spatially restricted areas have been carried out at Sandy Bay on the northern margin of the Osprey sanctuary zone in 1987 (Ayling and Ayling 1987) and at Mandu, Osprey and Maud sanctuary zones in 2000 (Westera 2003). The availability of raw data in the Ayling and Ayling report enabled us to carry out a formal analysis for the Sandy Bay region, which indicated that the counts were significantly lower in 2006 than they were in 1987. Differences in counts are unlikely to be the result of seasonal patterns. In 2006 counts were made in March and April while those in 1987 were made in April. Westera et al. (2003) showed that, at least in 2000, there were no significant seasonal trends in abundance or biomass of lethrinids at Osprey or other reefs covered in that study. Presentation of data at the family level rather than species level in Westera et al. (2003) complicates comparisons with this study. Abundances reported from 2000 for lethrinids probably comprise mainly *L. atkinsoni* and *L. nebulosus*, therefore we have combined counts for these species using reef flat data only, to assess whether this study supports the possibility of a decreasing trend in fish abundance over time. Counts in these regions ranged from a low of around 3.8 per transect (1,000 m^2) for Maud to a high of 14 for Mandu and 9.7 for Osprey. After standardizing for the different 2500 m^2 transect size used by Westera et al. (2003) the average of mean counts presented for 2000 (Westera et al. 2003, Fig. 3) was around 14, with a minimum of 6 and a maximum of around 22. The figures for 2000 were therefore fractionally higher than those we have recorded in 2006-2007. While these comparisons are confounded by aspects of methodology and sampling design, the magnitude of the differences is substantial, providing some level of confidence that we are observing a genuine trend.

All of these comparisons suggest that the general levels of abundance of lethrinids targeted by fishers have decreased over time. Abundance of *L. nebulosus* has decreased by somewhere between 2 and 8 fold since 1987 at Osprey, and lethrinid abundance on reef flats more broadly may have decreased by around 2 fold since 2000. Data from the comparisons at Osprey suggest that these changes may have been buffered in sanctuary zones. Therefore despite a range of management steps that have been taken in order to limit the catch of fish on Ningaloo, including exclusion of commercial fishing, restriction of bag and possession limits, as well as other the gear restrictions and no-take zones, it seems the abundance of these key target species has continued to decline. Lethrinids are relatively long-lived species (40+yrs; Moran 1993) therefore their population structures may take some time to recover from any disturbance. The status of these populations should be monitored by both fisheries dependent and independent means in order to assess future trends.

RECOMMENDATIONS FOR FUTURE SAMPLING

Monitoring Sampling and Design

The nature of the reef fish assemblages at Ningaloo makes the design and implementation of ongoing sampling to detect trends in abundance a difficult challenge. The nature of this challenge is twofold, relating to the biology of individual species, as well as the extensive and remote nature of the Ningaloo reef tract. The biology of the species targeted by anglers makes it difficult to obtain precise estimates of their abundance. There are many rare species, any one of which may be encountered infrequently, and the most common species, *Lethrinus nebulosus*, is a schooling species which, when it occurs, can be present in larger numbers. Consequently there are many zero counts in the data and the variances around estimates of abundance are large. Sample sizes therefore also have to be large in order to have a reasonable chance of detecting real changes in abundance.

Collecting large numbers of samples across the entire marine park and all its habitats is difficult, time consuming and costly, due to the distances involved, wide range of habitats, and variable weather, as well as sometimes remote and difficult access. In order to ensure that a long term sampling program, such as that required for the adaptive management of the Ningaloo marine Park, is robust, affordable and sustainable, collecting enough data to reliably inform us of ecological processes in the park, without making undue demands on scarce resources by collecting more data than are required.

Common solutions to these sorts of problems involve strategies such as sampling at permanent sites and stratification of sampling by habitat, to minimize random spatial variation, as well as sampling more intensively at fewer sites or periodic sampling where sampling may be carried out every other year, or even less frequently in some cases. All of these solutions have potential drawbacks however, such as lack of flexibility, the potential to miss trends that are happening outside the sites targeted for intensive sampling, and the potential to miss short term temporal variations.

Sampling designs based on spatially balanced sampling derived from a Generalised Random Tessellation Stratification (GRTS) have been designed to overcome many of these problems and are becoming increasingly popular in North America where the USEPA has been a major user of this approach, incorporating it into its Environmental Monitoring and Assessment Program

(EMAP: http://www.epa.gov/emap/index.html). EMAP uses GIS-based tools in combination with other programs to select a pattern of sampling points. These spatially balanced designs capitalize on the pattern to produce again inefficiency.

EMAP's experience has been that a spatially balanced design is 2 to 10 times more efficient than simple random sampling, i.e. the same precision can be obtained with 30 to 70 percent less data (http://www.nwcouncil.org/fw/budget/innovate/narratives/920.doc). One of the strengths of GRTS and similar designs is that a sample of a specified size can be selected, along with an "over-sample" of extra sites. This capability is especially useful for developing and implementing field surveys because sampling frames (e.g., digital representations of the Marine Park Sanctuary network) are often imperfect, yielding sites that are non-target, or sites that are physically inaccessible due to reef topography or weather. The over-sample works as a buffer because each site rejected in the original sample can be replaced by a site in the over-sample, selected sequentially from the ordered list as needed. This process maintains the spatially balanced random sample. In a similar way sampling can be designed to incorporate stratified sampling or interval sampling in which a subset of the overall sites area sampled every few years. GRTS sampling has been adopted in other coral reef marine parks such as in the Florida Keys (http://www.cofc.edu/~coral/epacrmp/epawork.htm).

For the *Lethrinus nebulosus*, the data indicate that to detect an effect size of 50% with power of at least 80% across the Ningaloo marine park, a total sample size of at least 250 sites is required. Experience with GRTS designs suggests that this sampling could be at least halved, and staggered so that effort was spread across sampling with a set of core sites and a systematic rotation across the remainder of sites. This would allow the sampling to be continued with a lower level of annual effort than we have brought to bear on this study but to retain the ability to sample throughout the marine park as well as to detect trends within individual reserves. Smaller sample sizes (50 to 100 sites) are required to assess trends in individual Sanctuary Zones. Ultimately the mix of which zones should be sampled, and how many, as well as how these decisions play into the need to understand trends throughout the park, is a management question and the ongoing design must be developed in close consultation with park managers in order to effectively address management needs.

Methodology

The UVC sampling method used in these surveys is quick and relatively low cost, and can be conducted from small beach-launched boats, allowing rapid response and wide coverage. With minor variations, this is the most widely used technique for surveying fish faunas world wide and is supported by a significant body of literature. For these reasons it offers many advantages, including providing density/biomass estimates. While the method does require some training, this is not prohibitive, particularly where surveys are intended to assess key target species that are generally easily recognised. More detailed surveys (e.g. to examine indirect or ecosystem wide effects) may be conducted on a less frequent basis by more experienced staff.

A disadvantage of UVC is that it is restricted to relatively shallow water. Much of the marine park lies in waters more than 20m deep, beyond the reach of extensive or routine visual surveys. In such areas BRUV (Baited Remote Underwater Video) techniques have been used at Ningaloo to establish baseline data. Some BRUVs have been deployed in shallow water, however these have not been deployed in a systematic program designed for a cross calibration of the two techniques. BRUVs can provide a powerful tool assessing the relative density of fish however they do not provide density estimates as such, and there can be substantial overheads associated with their use in terms of equipment, analysis and even deployment. Calibration of the two methods for Ningaloo shallow waters would be valuable for a variety of reasons, including matching up data on system responses across both deep and shallow water and potential to relate BRUV counts to density, as well as to increase flexibility of future monitoring or research options. An opportunity to reduce the cost of this calibration exists while the CSIRO program at Ningaloo is still running as part of WAMSI Node 3.

Research

In many cases the rate of response of fish populations to protection from fishing has been shown to be rapid. The rate of response has the potential to provide significant information on the condition of the ecosystem, including resilience and response to disturbance. This means that there is a clear need to continue monitoring of at least a subset of sites if we are to be able to understand the nature of responses. The desirability of such data is well illustrated by reference to our measurements of change at Osprey reef. We know densities were different in 2006 than they were in 1987, but we have no idea what the densities were over the intervening 20 years. While the drop in fish density is consistent with an effect of fishing, this is essentially a regression on a two point data set; population levels could have been both higher and lower than those observed over the intervening period. We have no way of knowing whether 2007 was just a “low” year, or 1987 a “high” one. Regular and ongoing study is therefore essential for providing the system understanding required to underpin adaptive management.

Our UVC surveys have shown that populations of sharks may have been affected by fishing in some areas of the Ningaloo Marine Park. While this is important in its own right, it also has potentially serious ramifications for the wider ecosystem in the region. Elsewhere in the Indo-Pacific region, the depletion of sharks has had strong cascading effects throughout the ecosystem (Stevenson et al. 2007, Sandin et al. 2008) with the absence of sharks correlating with the dominance of small planktivorous fish, higher cover of algae and reduced coral recruitment. The current study was designed to assess the effectiveness of zoning on target species. We were fortuitously able to detect a fishing effect on sharks and some large fishes a broader scale however the study was not specifically designed to do this. Also because it was aimed at target species our study (with transects 100m long) could not include counts of small planktivorous fish species which have been found to be some of the key indicators of shark depletion elsewhere. Trophic cascades have been reported previously from the Ningaloo lagoon (Westera 2003) and we did count planktivorous fish, as well as collect detailed quantitative data on invertebrates, algae and coral cover in the lagoons as part of another WAMSI Node 3 study to investigate indirect effects of fishing. The potential for indirect effects to occur on reef slope habitats therefore remains to be investigated. Given the potential for serious cascading effects, this work should be a matter of priority in the near future. An opportunity may exist to combine this with the methodological calibration work described above.

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ANNEXURE 1.SAMPLING SITES 2005-2007. DATE AND COORDINATES (WGS 84) OF SAMPLING SITES FOR FISH ASSEMBLAGES IN THE NINGALOO MARINE PARK.

site	Date	Lat	Lon	Region	Status
39503	30/01/2006	-23.73789	113.56857	Gnarloo	GeneralUse
5787	8/03/2006	-23.1632	113.74605	Maud	GeneralUse
5926	8/03/2006	-23.15315	113.745067	Maud	GeneralUse
42465	8/03/2006	-23.09167	113.73845	Maud	OldSanctuary
42835	8/03/2006	-23.13506	113.76302	Maud	OldSanctuary
42835	8/03/2006	-23.13506	113.76302	Maud	OldSanctuary
14754	8/03/2006	-23.186017	113.753983	Maud	Recreation
5706	8/03/2006	-23.16905	113.74835	Maud	Sanctuary
42835	8/03/2006	-23.13506	113.76302	Maud	OldSanctuary
6091	8/03/2006	-23.14405	113.74338	Maud	GeneralUse
6208	8/03/2006	-23.13461	113.74135	Maud	GeneralUse
5675	8/03/2006	-23.18008	113.7535	Maud	Recreation
6415	8/03/2006	-23.1211	113.73126	Maud	GeneralUse
6529	8/03/2006	-23.113883	113.73745	Maud	OldSanctuary
42430	8/03/2006	-23.086233	113.734233	Maud	OldSanctuary
42465	8/03/2006	-23.09167	113.73845	Maud	OldSanctuary
42581	8/03/2006	-23.12399	113.74415	Maud	OldSanctuary
42635	8/03/2006	-23.1274	113.74886	Maud	OldSanctuary
42655	9/03/2006	-23.144083	113.750583	Maud	OldSanctuary
42756	9/03/2006	-23.156267	113.757717	Maud	OldSanctuary
14787	9/03/2006	-23.179567	113.760417	Maud	Recreation
14834	9/03/2006	-23.17755	113.755833	Maud	Recreation
66120	9/03/2006	-23.2566	113.768383	Pelican	Recreation
42821	9/03/2006	-23.126133	113.762217	Maud	OldSanctuary
14250	9/03/2006	-23.27238	113.77134	Pelican	Recreation
42630	9/03/2006	-23.1362	113.748833	Maud	OldSanctuary
14144	9/03/2006	-23.28865	113.77282	Pelican	Recreation
14126	9/03/2006	-23.29102	113.77165	Pelican	Recreation
14141	9/03/2006	-23.29166	113.77687	Pelican	Recreation
42679	9/03/2006	-23.153167	113.752	Maud	OldSanctuary
14196	9/03/2006	-23.2933	113.792067	Pelican	Recreation
42807	9/03/2006	-23.150367	113.761333	Maud	OldSanctuary
14305	9/03/2006	-23.26858	113.77585	Pelican	Recreation

14323	9/03/2006	-23.26513	113.77206	Pelican	Recreation
53588	9/03/2006	-23.162983	113.75505	Maud	Sanctuary
53602	9/03/2006	-23.165667	113.755067	Maud	Sanctuary
14784	9/03/2006	-23.18538	113.75989	Maud	Recreation
53582	9/03/2006	-23.1689	113.753217	Maud	Sanctuary
66119	9/03/2006	-23.2533	113.764633	Pelican	Recreation
66118	9/03/2006	-23.247217	113.76905	Pelican	Recreation
53570	9/03/2006	-23.167883	113.757267	Maud	Sanctuary
66117	9/03/2006	-23.237117	113.76725	Pelican	Recreation
14822	9/03/2006	-23.175033	113.757017	Maud	Recreation
65882	10/03/2006	-23.406817	113.777267	Pelican	OldSanctuary
65904	10/03/2006	-23.39766	113.77235	Pelican	OldSanctuary
65903	10/03/2006	-23.32437	113.78179	Pelican	Sanctuary
65880	10/03/2006	-23.29943	113.78966	Pelican	Sanctuary
65894	10/03/2006	-23.30875	113.773067	Pelican	Sanctuary
65881	10/03/2006	-23.298383	113.780517	Pelican	Sanctuary
65901	10/03/2006	-23.32207	113.77161	Pelican	Sanctuary
65895	10/03/2006	-23.332767	113.772133	Pelican	Sanctuary
65911	10/03/2006	-23.336967	113.780467	Pelican	Sanctuary
65902	10/03/2006	-23.34659	113.7833	Pelican	OldSanctuary
65896	10/03/2006	-23.34673	113.76882	Pelican	Sanctuary
65897	10/03/2006	-23.359783	113.771833	Pelican	Sanctuary
65898	10/03/2006	-23.368167	113.7697	Pelican	Sanctuary
65908	10/03/2006	-23.38455	113.773917	Pelican	OldSanctuary
65909	10/03/2006	-23.38859	113.77277	Pelican	OldSanctuary
65906	10/03/2006	-23.43097	113.77953	Pelican	Sanctuary
65905	10/03/2006	-23.419433	113.7803	Pelican	Sanctuary
65910	10/03/2006	-23.412217	113.777517	Pelican	Sanctuary
65989	11/03/2006	-22.942017	113.780117	Cloates	Recreation
65955	11/03/2006	-22.99667	113.8044	Cloates	Recreation
65957	11/03/2006	-22.94777	113.7965	Cloates	Recreation
65918	11/03/2006	-22.96827	113.7801	Cloates	Recreation
65956	11/03/2006	-22.9394	113.80073	Cloates	Recreation
65915	11/03/2006	-22.93114	113.79171	Cloates	Recreation
65917	11/03/2006	-22.94976	113.77674	Cloates	Recreation
65914	11/03/2006	-22.93055	113.78019	Cloates	Recreation
65916	11/03/2006	-22.92314	113.80818	Cloates	Recreation
65913	11/03/2006	-22.91849	113.78101	Cloates	Recreation
65928	11/03/2006	-22.90872	113.78614	Cloates	OldSanctuary

65925	11/03/2006	-22.90637	113.79611	Cloates	OldSanctuary
65974	11/03/2006	-21.97933	113.91794	Mangrove	Recreation
65926	11/03/2006	-22.90508	113.79075	Cloates	OldSanctuary
65921	11/03/2006	-22.87411	113.76625	Cloates	OldSanctuary
65990	11/03/2006	-22.929633	113.77925	Cloates	Recreation
65988	11/03/2006	-22.978683	113.779883	Cloates	Recreation
65961	12/03/2006	-21.95092	113.92074	Mangrove	Sanctuary
65964	12/03/2006	-21.95399	113.92129	Mangrove	Sanctuary
65973	12/03/2006	-21.97595	113.91755	Mangrove	Recreation
65984	12/03/2006	-21.99567	113.91279	Mangrove	Recreation
65985	12/03/2006	-22.00063	113.91297	Mangrove	Recreation
65987	12/03/2006	-21.99909	113.92794	Mangrove	Recreation
65986	12/03/2006	-21.99683	113.92354	Mangrove	Recreation
65975	12/03/2006	-21.9807	113.929617	Mangrove	Recreation
65970	12/03/2006	-21.97248	113.93086	Mangrove	Sanctuary
65969	12/03/2006	-21.97156	113.91899	Mangrove	Sanctuary
65968	12/03/2006	-21.96701	113.92131	Mangrove	Sanctuary
65966	12/03/2006	-21.96003	113.92037	Mangrove	Sanctuary
65958	12/03/2006	-21.94656	113.92033	Mangrove	Sanctuary
65976	12/03/2006	-21.94277	113.92203	Mangrove	Recreation
65979	12/03/2006	-21.93914	113.92292	Mangrove	Recreation
65982	12/03/2006	-21.9326	113.92658	Mangrove	Recreation
65981	12/03/2006	-21.93235	113.94504	Mangrove	Recreation
13274	13/03/2006	-22.36378	113.75061	Osprey	Recreation
31562	13/03/2006	-22.20151	113.84604	Osprey	Recreation
13234	13/03/2006	-22.36159	113.75227	Osprey	Recreation
13145	13/03/2006	-22.35782	113.76531	Osprey	Recreation
30015	13/03/2006	-22.05729	113.89375	Mandu	Recreation
13199	13/03/2006	-22.36235	113.76006	Osprey	Recreation
13258	13/03/2006	-22.36717	113.75679	Osprey	Recreation
13002	13/03/2006	-22.34561	113.77134	Osprey	Recreation
12946	13/03/2006	-22.34005	113.77374	Osprey	Recreation
12811	13/03/2006	-22.32937	113.78421	Osprey	Recreation
50697	13/03/2006	-22.31932	113.77855	Osprey	Sanctuary
50637	13/03/2006	-22.31723	113.7814	Osprey	Sanctuary
50338	13/03/2006	-22.30713	113.79385	Osprey	Sanctuary
56722	13/03/2006	-22.07669	113.89427	Mandu	Sanctuary
47164	13/03/2006	-22.29324	113.80093	Osprey	OldSanctuary
47115	13/03/2006	-22.28736	113.80438	Osprey	OldSanctuary

46815	13/03/2006	-22.24252	113.82305	Osprey	OldSanctuary
46805	13/03/2006	-22.23949	113.82363	Osprey	OldSanctuary
46748	13/03/2006	-22.22434	113.83052	Osprey	OldSanctuary
46742	13/03/2006	-22.2226	113.8318	Osprey	OldSanctuary
31483	13/03/2006	-22.22019	113.83257	Osprey	Recreation
31487	13/03/2006	-22.21801	113.83309	Osprey	Recreation
65967	14/03/2006	-21.96047	113.93747	Mangrove	OldSanctuary
47157	14/03/2006	-22.2953	113.80476	Osprey	OldSanctuary
50227	14/03/2006	-22.3124	113.79614	Osprey	Sanctuary
12901	14/03/2006	-22.34344	113.7918	Osprey	Recreation
31503	14/03/2006	-22.21572	113.83926	Osprey	Recreation
12850	14/03/2006	-22.33796	113.79277	Osprey	Recreation
31549	14/03/2006	-22.20386	113.84396	Osprey	Recreation
50522	14/03/2006	-22.31961	113.78425	Osprey	Sanctuary
50461	14/03/2006	-22.31783	113.78681	Osprey	Sanctuary
31494	14/03/2006	-22.21833	113.83904	Osprey	Recreation
50401	14/03/2006	-22.3165	113.78956	Osprey	Sanctuary
50284	14/03/2006	-22.31481	113.79395	Osprey	Sanctuary
49980	14/03/2006	-22.22222	113.83711	Osprey	Sanctuary
46737	14/03/2006	-22.22481	113.83445	Osprey	OldSanctuary
50340	14/03/2006	-22.3103	113.79398	Osprey	Sanctuary
50176	14/03/2006	-22.3084	113.79943	Osprey	Sanctuary
46744	14/03/2006	-22.22572	113.83355	Osprey	OldSanctuary
50173	14/03/2006	-22.30358	113.80184	Osprey	Sanctuary
46766	14/03/2006	-22.23271	113.83203	Osprey	OldSanctuary
46787	14/03/2006	-22.23875	113.82934	Osprey	OldSanctuary
47104	14/03/2006	-22.28857	113.80866	Osprey	OldSanctuary
46801	14/03/2006	-22.24316	113.82904	Osprey	OldSanctuary
47011	14/03/2006	-22.28326	113.82233	Osprey	OldSanctuary
46799	14/03/2006	-22.24139	113.8266	Osprey	OldSanctuary
47047	14/03/2006	-22.28045	113.81236	Osprey	OldSanctuary
46969	14/03/2006	-22.27849	113.82509	Osprey	OldSanctuary
46907	14/03/2006	-22.26112	113.82066	Osprey	OldSanctuary
65971	14/03/2006	-21.96631	113.93525	Mangrove	OldSanctuary
65962	14/03/2006	-21.95094	113.94454	Mangrove	OldSanctuary
65965	14/03/2006	-21.95528	113.94196	Mangrove	OldSanctuary
65959	14/03/2006	-21.94691	113.94711	Mangrove	OldSanctuary
65978	14/03/2006	-21.94321	113.94333	Mangrove	Recreation
65960	14/03/2006	-21.94708	113.94188	Mangrove	Sanctuary

65963	14/03/2006	-21.95186	113.93955	Mangrove	Sanctuary
65981	14/03/2006	-21.93235	113.94504	Mangrove	Recreation
65983	14/03/2006	-21.93474	113.9542	Mangrove	Recreation
28295	15/03/2006	-22.164225	113.853783	Mandu	Recreation
56751	15/03/2006	-22.15714	113.85969	Mandu	Sanctuary
31647	15/03/2006	-22.17832	113.8553	Mandu	Recreation
56753	15/03/2006	-22.15653	113.85687	Mandu	Sanctuary
31653	15/03/2006	-22.17598	113.85536	Mandu	Recreation
28060	15/03/2006	-22.178017	113.847483	Mandu	GeneralUse
31636	15/03/2006	-22.17879	113.85172	Mandu	Recreation
47249	15/03/2006	-22.14925	113.85954	Mandu	OldSanctuary
47250	15/03/2006	-22.1502	113.85873	Mandu	OldSanctuary
47268	15/03/2006	-22.14267	113.86226	Mandu	OldSanctuary
28161	15/03/2006	-22.17258	113.850417	Mandu	Recreation
47262	15/03/2006	-22.1338	113.8707	Mandu	OldSanctuary
47347	15/03/2006	-22.12021	113.8706	Mandu	OldSanctuary
47278	15/03/2006	-22.11848	113.87903	Mandu	OldSanctuary
47279	15/03/2006	-22.12052	113.878	Mandu	OldSanctuary
47234	15/03/2006	-22.1276	113.87768	Mandu	OldSanctuary
56756	15/03/2006	-22.15925	113.855283	Mandu	Sanctuary
47213	15/03/2006	-22.13087	113.87698	Mandu	OldSanctuary
31686	15/03/2006	-22.16363	113.85752	Mandu	Recreation
47215	15/03/2006	-22.13481	113.87486	Mandu	OldSanctuary
47208	15/03/2006	-22.15258	113.86208	Mandu	OldSanctuary
31680	15/03/2006	-22.1652	113.85784	Mandu	Recreation
47209	15/03/2006	-22.15409	113.86166	Mandu	OldSanctuary
31689	15/03/2006	-22.16411	113.85955	Mandu	Recreation
47185	15/03/2006	-22.15391	113.8653	Mandu	OldSanctuary
31679	15/03/2006	-22.16909	113.85753	Mandu	Recreation
47186	15/03/2006	-22.15648	113.86293	Mandu	OldSanctuary
56747	15/03/2006	-22.15809	113.86077	Mandu	Sanctuary
56748	15/03/2006	-22.15883	113.86169	Mandu	Sanctuary
56745	15/03/2006	-22.15899	113.86316	Mandu	Sanctuary
31655	15/03/2006	-22.173183	113.8546	Mandu	Recreation
29868	16/03/2006	-22.06293	113.89716	Mandu	Recreation
30176	16/03/2006	-22.0695	113.88725	Mandu	Recreation
56735	16/03/2006	-22.0731	113.886367	Mandu	Sanctuary
30175	16/03/2006	-22.06776	113.88763	Mandu	Recreation
56738	16/03/2006	-22.075517	113.88625	Mandu	Sanctuary

30172	16/03/2006	-22.061583	113.886683	Mandu	Recreation
47470	16/03/2006	-22.0784	113.88437	Mandu	OldSanctuary
47473	16/03/2006	-22.08347	113.88095	Mandu	OldSanctuary
30169	16/03/2006	-22.055767	113.888533	Mandu	Recreation
47409	16/03/2006	-22.1085	113.87218	Mandu	OldSanctuary
47317	16/03/2006	-22.11089	113.88024	Mandu	OldSanctuary
29707	16/03/2006	-22.05827	113.90095	Mandu	Recreation
47274	16/03/2006	-22.11327	113.88344	Mandu	OldSanctuary
30017	16/03/2006	-22.06079	113.8927	Mandu	Recreation
47338	16/03/2006	-22.10775	113.88055	Mandu	OldSanctuary
47393	16/03/2006	-22.08583	113.89081	Mandu	OldSanctuary
30021	16/03/2006	-22.06729	113.89052	Mandu	Recreation
47449	16/03/2006	-22.08439	113.88516	Mandu	OldSanctuary
47460	16/03/2006	-22.08024	113.887	Mandu	OldSanctuary
29793	16/03/2006	-22.0693	113.89646	Mandu	Recreation
47412	16/03/2006	-22.08166	113.89286	Mandu	OldSanctuary
30022	16/03/2006	-22.06915	113.89174	Mandu	Recreation
29794	16/03/2006	-22.07094	113.89679	Mandu	Recreation
56730	16/03/2006	-22.07456	113.88878	Mandu	Sanctuary
56731	16/03/2006	-22.07534	113.88929	Mandu	Sanctuary
56372	17/03/2006	-21.79264	114.14462	Lighthouse	Sanctuary
56480	17/03/2006	-21.7797	114.15964	Lighthouse	Sanctuary
31324	17/03/2006	-21.80257	114.10525	Lighthouse	Recreation
30826	17/03/2006	-21.79959	114.17939	Lighthouse	Recreation
31341	17/03/2006	-21.79964	114.10654	Lighthouse	Recreation
30838	17/03/2006	-21.79842	114.17656	Lighthouse	Recreation
31351	17/03/2006	-21.80093	114.11048	Lighthouse	Recreation
30848	17/03/2006	-21.79618	114.17906	Lighthouse	Recreation
31376	17/03/2006	-21.79807	114.11309	Lighthouse	Recreation
30861	17/03/2006	-21.79362	114.17542	Lighthouse	Recreation
31347	17/03/2006	-21.80575	114.11596	Lighthouse	Recreation
30894	17/03/2006	-21.78694	114.17578	Lighthouse	Recreation
31370	17/03/2006	-21.80524	114.12176	Lighthouse	Recreation
30899	17/03/2006	-21.7847	114.17928	Lighthouse	Recreation
30906	17/03/2006	-21.78303	114.17686	Lighthouse	Recreation
31395	17/03/2006	-21.80456	114.12659	Lighthouse	Recreation
30901	17/03/2006	-21.78436	114.17444	Lighthouse	Recreation
31394	17/03/2006	-21.80544	114.12741	Lighthouse	Recreation
56508	17/03/2006	-21.78084	114.16991	Lighthouse	Sanctuary

56514	17/03/2006	-21.77697	114.16958	Lighthouse	Sanctuary
56344	17/03/2006	-21.795083	114.139033	Lighthouse	Sanctuary
56495	17/03/2006	-21.78086	114.16693	Lighthouse	Sanctuary
56343	17/03/2006	-21.796883	114.14055	Lighthouse	Sanctuary
56498	17/03/2006	-21.77639	114.16319	Lighthouse	Sanctuary
56373	17/03/2006	-21.7899	114.14336	Lighthouse	Sanctuary
56472	17/03/2006	-21.78162	114.16035	Lighthouse	Sanctuary
56466	17/03/2006	-21.78172	114.15732	Lighthouse	Sanctuary
56465	17/03/2006	-21.7841	114.15785	Lighthouse	Sanctuary
56419	17/03/2006	-21.78774	114.15034	Lighthouse	Sanctuary
56449	17/03/2006	-21.78447	114.15544	Lighthouse	Sanctuary
56421	17/03/2006	-21.78629	114.14834	Lighthouse	Sanctuary
66224	6/04/2006	-22.24751	113.82702	Ayling	OldSanctuary
30217	24/04/2006	-21.87661	114.15555	Bundegi	Recreation
30223	24/04/2006	-21.87512	114.15595	Bundegi	Recreation
47606	24/04/2006	-21.87405	114.15809	Bundegi	OldSanctuary
47607	24/04/2006	-21.87122	114.15884	Bundegi	OldSanctuary
30218	24/04/2006	-21.87536	114.15472	Bundegi	Recreation
47591	24/04/2006	-21.87315	114.15427	Bundegi	OldSanctuary
47598	24/04/2006	-21.87293	114.15543	Bundegi	OldSanctuary
47652	24/04/2006	-21.85745	114.16912	Bundegi	OldSanctuary
47599	24/04/2006	-21.87099	114.15697	Bundegi	OldSanctuary
56273	24/04/2006	-21.86044	114.17484	Bundegi	Sanctuary
47611	24/04/2006	-21.86462	114.15659	Bundegi	OldSanctuary
56272	24/04/2006	-21.8589	114.175	Bundegi	Sanctuary
47623	24/04/2006	-21.86267	114.15951	Bundegi	OldSanctuary
56282	24/04/2006	-21.85694	114.17489	Bundegi	Sanctuary
66160	25/04/2006	-22.2238	113.83618	Ayling	OldSanctuary
66150	25/04/2006	-22.22556	113.84175	Ayling	Sanctuary
66162	25/04/2006	-22.22214	113.83501	Ayling	Sanctuary
66190	25/04/2006	-22.23628	113.83401	Ayling	OldSanctuary
66169	25/04/2006	-22.22027	113.82965	Ayling	GeneralUse
66170	25/04/2006	-22.22106	113.82969	Ayling	GeneralUse
66170	25/04/2006	-22.22106	113.82969	Ayling	GeneralUse
66193	25/04/2006	-22.23573	113.83325	Ayling	OldSanctuary
66166	25/04/2006	-22.221117	113.831717	Ayling	Recreation
66168	25/04/2006	-22.22065	113.82976	Ayling	GeneralUse
66165	25/04/2006	-22.22287	113.83499	Ayling	Sanctuary
66163	25/04/2006	-22.22246	113.83513	Ayling	Sanctuary

66158	25/04/2006	-22.22307	113.83653	Ayling	Sanctuary
66159	25/04/2006	-22.22343	113.83646	Ayling	Sanctuary
66161	25/04/2006	-22.22217	113.83553	Ayling	Sanctuary
66164	25/04/2006	-22.22285	113.83566	Ayling	Sanctuary
66160	25/04/2006	-22.2238	113.83618	Ayling	OldSanctuary
66159	25/04/2006	-22.22343	113.83646	Ayling	Sanctuary
66158	25/04/2006	-22.22307	113.83653	Ayling	Sanctuary
66141	25/04/2006	-22.22557	113.84433	Ayling	Sanctuary
66142	25/04/2006	-22.22597	113.84493	Ayling	Sanctuary
66143	25/04/2006	-22.22592	113.84462	Ayling	Sanctuary
66154	25/04/2006	-22.22443	113.83929	Ayling	Sanctuary
66151	25/04/2006	-22.2239	113.83965	Ayling	Sanctuary
66146	25/04/2006	-22.22471	113.84172	Ayling	Sanctuary
66147	25/04/2006	-22.22485	113.84217	Ayling	Sanctuary
66148	25/04/2006	-22.22534	113.84222	Ayling	Sanctuary
66149	25/04/2006	-22.22522	113.84189	Ayling	Sanctuary
66151	25/04/2006	-22.2239	113.83965	Ayling	Sanctuary
66182	26/04/2006	-22.23595	113.83515	Ayling	OldSanctuary
66189	26/04/2006	-22.23576	113.83383	Ayling	OldSanctuary
66191	26/04/2006	-22.23651	113.83356	Ayling	OldSanctuary
66201	26/04/2006	-22.23764	113.83411	Ayling	OldSanctuary
66202	26/04/2006	-22.23801	113.83413	Ayling	OldSanctuary
66205	26/04/2006	-22.2394	113.83378	Ayling	OldSanctuary
66218	26/04/2006	-22.24716	113.82875	Ayling	OldSanctuary
66220	26/04/2006	-22.24736	113.82901	Ayling	OldSanctuary
66227	26/04/2006	-22.24719	113.82501	Ayling	OldSanctuary
66234	26/04/2006	-22.24749	113.82349	Ayling	OldSanctuary
66148	26/04/2006	-22.22534	113.84222	Ayling	Sanctuary
66192	26/04/2006	-22.23605	113.83334	Ayling	OldSanctuary
66193	26/04/2006	-22.23573	113.83325	Ayling	OldSanctuary
66186	26/04/2006	-22.23476	113.83341	Ayling	OldSanctuary
66191	26/04/2006	-22.23651	113.83356	Ayling	OldSanctuary
66187	26/04/2006	-22.23508	113.83356	Ayling	OldSanctuary
66195	26/04/2006	-22.23519	113.83301	Ayling	OldSanctuary
66188	26/04/2006	-22.238167	113.838	Ayling	SpecialPurposeSBA
66194	26/04/2006	-22.23548	113.83316	Ayling	OldSanctuary
66198	26/04/2006	-22.2347	113.83085	Ayling	OldSanctuary
66197	26/04/2006	-22.23428	113.83093	Ayling	OldSanctuary
66200	26/04/2006	-22.23541	113.83081	Ayling	OldSanctuary

66181	26/04/2006	-22.23597	113.83482	Ayling	OldSanctuary
66204	26/04/2006	-22.23899	113.83395	Ayling	OldSanctuary
66183	26/04/2006	-22.23621	113.83551	Ayling	OldSanctuary
66184	26/04/2006	-22.23678	113.83559	Ayling	OldSanctuary
66203	26/04/2006	-22.23843	113.83409	Ayling	OldSanctuary
66232	26/04/2006	-22.2471	113.82374	Ayling	OldSanctuary
66231	26/04/2006	-22.2469	113.82381	Ayling	OldSanctuary
66226	26/04/2006	-22.24722	113.82539	Ayling	OldSanctuary
66233	26/04/2006	-22.2474	113.8237	Ayling	OldSanctuary
66212	26/04/2006	-22.24773	113.83157	Ayling	OldSanctuary
66228	26/04/2006	-22.24739	113.82508	Ayling	OldSanctuary
66230	26/04/2006	-22.24763	113.82508	Ayling	OldSanctuary
66235	26/04/2006	-22.24777	113.82343	Ayling	OldSanctuary
66222	26/04/2006	-22.24716	113.82746	Ayling	OldSanctuary
66217	26/04/2006	-22.24759	113.8289	Ayling	OldSanctuary
66219	26/04/2006	-22.24774	113.82856	Ayling	OldSanctuary
66221	26/04/2006	-22.24717	113.82679	Ayling	OldSanctuary
66216	26/04/2006	-22.24768	113.82919	Ayling	OldSanctuary
66211	26/04/2006	-22.2475	113.83188	Ayling	OldSanctuary
66223	26/04/2006	-22.24781	113.82723	Ayling	OldSanctuary
66225	26/04/2006	-22.24766	113.82674	Ayling	OldSanctuary
66206	26/04/2006	-22.24758	113.83373	Ayling	Sanctuary
66214	26/04/2006	-22.24738	113.83234	Ayling	OldSanctuary
66213	26/04/2006	-22.24784	113.83216	Ayling	OldSanctuary
66215	26/04/2006	-22.24805	113.83213	Ayling	OldSanctuary
66209	26/04/2006	-22.24787	113.83375	Ayling	Sanctuary
65940	28/04/2006	-22.7867	113.76171	Cloates	OldSanctuary
65939	28/04/2006	-22.7952	113.71523	Cloates	OldSanctuary
66348	28/04/2006	-22.73975	113.683717	Cloates	Sanctuary
66349	28/04/2006	-22.741767	113.682017	Cloates	Sanctuary
65937	28/04/2006	-22.793967	113.70845	Cloates	OldSanctuary
66341	28/04/2006	-23.44135	113.7721	Pelican	Recreation
65945	28/04/2006	-22.72545	113.69406	Cloates	Sanctuary
65936	28/04/2006	-22.780517	113.700233	Cloates	OldSanctuary
65944	28/04/2006	-22.72702	113.6828	Cloates	Sanctuary
66343	28/04/2006	-23.45387	113.77382	Pelican	Recreation
66347	28/04/2006	-23.45145	113.77908	Pelican	Recreation
65938	28/04/2006	-22.7867	113.71613	Cloates	OldSanctuary
66350	28/04/2006	-22.724917	113.676	Cloates	Sanctuary

65946	28/04/2006	-22.77288	113.70393	Cloates	Sanctuary
66351	28/04/2006	-22.729033	113.669267	Cloates	Sanctuary
66352	28/04/2006	-22.724317	113.664617	Cloates	Sanctuary
65947	28/04/2006	-22.77358	113.72077	Cloates	Sanctuary
66353	28/04/2006	-22.719333	113.667567	Cloates	Sanctuary
66354	28/04/2006	-22.706983	113.658733	Cloates	Sanctuary
65948	28/04/2006	-22.77044	113.73136	Cloates	Sanctuary
66337	28/04/2006	-23.43909	113.7784	Pelican	Recreation
66355	28/04/2006	-22.699917	113.6618	Cloates	Sanctuary
66339	28/04/2006	-23.43892	113.78008	Pelican	Recreation
66340	29/04/2006	-23.43874	113.77243	Pelican	Recreation
66334	29/04/2006	-23.376067	113.769717	Pelican	Sanctuary
66335	29/04/2006	-23.38155	113.7691	Pelican	Sanctuary
66342	29/04/2006	-23.4511	113.77334	Pelican	Recreation
65886	29/04/2006	-23.385733	113.770267	Pelican	OldSanctuary
65888	29/04/2006	-23.38925	113.7699	Pelican	OldSanctuary
66346	29/04/2006	-23.45302	113.77797	Pelican	Recreation
65887	29/04/2006	-23.3932	113.76765	Pelican	Sanctuary
66345	29/04/2006	-23.4519	113.77775	Pelican	Recreation
65892	29/04/2006	-23.39715	113.767983	Pelican	OldSanctuary
66344	29/04/2006	-23.45065	113.77639	Pelican	Recreation
65889	29/04/2006	-23.401583	113.768067	Pelican	OldSanctuary
66338	29/04/2006	-23.44048	113.77923	Pelican	Recreation
65893	29/04/2006	-23.40445	113.76925	Pelican	OldSanctuary
65891	29/04/2006	-23.4131	113.7746	Pelican	Sanctuary
66336	29/04/2006	-23.43806	113.77857	Pelican	Recreation
65883	29/04/2006	-23.400683	113.77625	Pelican	OldSanctuary
49189	30/04/2006	-23.779683	113.52115	Gnarloo	Sanctuary
38250	30/04/2006	-23.732067	113.5618	Gnarloo	GeneralUse
40182	30/04/2006	-23.830817	113.5153	Gnarloo	GeneralUse
38688	30/04/2006	-23.73528	113.56255	Gnarloo	GeneralUse
40062	30/04/2006	-23.827667	113.515133	Gnarloo	GeneralUse
38687	30/04/2006	-23.73663	113.56047	Gnarloo	GeneralUse
39930	30/04/2006	-23.824567	113.515533	Gnarloo	GeneralUse
38670	30/04/2006	-23.79929	113.51644	Gnarloo	GeneralUse
39814	30/04/2006	-23.745617	113.568933	Gnarloo	GeneralUse
38888	30/04/2006	-23.80053	113.51797	Gnarloo	GeneralUse
39498	30/04/2006	-23.74563	113.56394	Gnarloo	GeneralUse
48994	30/04/2006	-23.75399	113.53659	Gnarloo	Sanctuary

38677	30/04/2006	-23.7535	113.549533	Gnarloo	GeneralUse
38671	30/04/2006	-23.796933	113.517467	Gnarloo	GeneralUse
38676	30/04/2006	-23.75402	113.5475	Gnarloo	GeneralUse
48982	30/04/2006	-23.753117	113.54215	Gnarloo	Sanctuary
49234	30/04/2006	-23.792867	113.517333	Gnarloo	Sanctuary
49226	30/04/2006	-23.79115	113.518367	Gnarloo	Sanctuary
48987	30/04/2006	-23.7549	113.5409	Gnarloo	Sanctuary
49221	30/04/2006	-23.78975	113.5185	Gnarloo	Sanctuary
49035	30/04/2006	-23.75841	113.53344	Gnarloo	Sanctuary
69009	30/04/2006	-23.75795	113.54335	Gnarloo	Sanctuary
49192	30/04/2006	-23.7758	113.531	Gnarloo	Sanctuary
38892	30/04/2006	-23.75959	113.54723	Gnarloo	GeneralUse
39106	30/04/2006	-23.76244	113.54678	Gnarloo	GeneralUse
49221	1/05/2006	-23.78975	113.5185	Gnarloo	Sanctuary
40299	1/05/2006	-23.840683	113.513233	Gnarloo	GeneralUse
40185	1/05/2006	-23.836583	113.515033	Gnarloo	GeneralUse
49189	1/05/2006	-23.779683	113.52115	Gnarloo	Sanctuary
40186	1/05/2006	-23.8189	113.516383	Gnarloo	GeneralUse
49173	1/05/2006	-23.776867	113.5212	Gnarloo	Sanctuary
39483	1/05/2006	-23.81	113.518317	Gnarloo	GeneralUse
49142	1/05/2006	-23.772633	113.524	Gnarloo	Sanctuary
39299	1/05/2006	-23.801383	113.518233	Gnarloo	GeneralUse
49025	1/05/2006	-23.76211	113.54471	Gnarloo	Sanctuary
39105	1/05/2006	-23.798167	113.518033	Gnarloo	GeneralUse
39106	1/05/2006	-23.76244	113.54678	Gnarloo	GeneralUse
49237	1/05/2006	-23.792717	113.518117	Gnarloo	Sanctuary
66357	1/05/2006	-23.756617	113.547083	Gnarloo	GeneralUse
49233	1/05/2006	-23.791183	113.518483	Gnarloo	Sanctuary
49224	1/05/2006	-23.788033	113.519433	Gnarloo	Sanctuary
66356	1/05/2006	-23.751917	113.544967	Gnarloo	Sanctuary
49221	1/05/2006	-23.78975	113.5185	Gnarloo	Sanctuary
66257	2/05/2006	-21.68561	114.31658	Muiron	GeneralUse
66270	2/05/2006	-21.675917	114.328217	Muiron	Sanctuary
66282	2/05/2006	-21.65845	114.34966	Muiron	GeneralUse
66280	2/05/2006	-21.65861	114.34738	Muiron	GeneralUse
66285	2/05/2006	-21.65472	114.34651	Muiron	GeneralUse
66281	2/05/2006	-21.658117	114.3485	Muiron	GeneralUse
66277	2/05/2006	-21.6609	114.340817	Muiron	Sanctuary
66274	2/05/2006	-21.66057	114.34436	Muiron	Sanctuary

66278	2/05/2006	-21.662033	114.339617	Muiron	Sanctuary
66275	2/05/2006	-21.66244	114.34231	Muiron	Sanctuary
66279	2/05/2006	-21.6632	114.3383	Muiron	Sanctuary
66276	2/05/2006	-21.66443	114.34059	Muiron	Sanctuary
66273	2/05/2006	-21.669733	114.331567	Muiron	Sanctuary
66268	2/05/2006	-21.67161	114.33292	Muiron	Sanctuary
66269	2/05/2006	-21.673233	114.33055	Muiron	Sanctuary
66272	2/05/2006	-21.672233	114.329933	Muiron	Sanctuary
66271	2/05/2006	-21.67485	114.326233	Muiron	Sanctuary
66264	2/05/2006	-21.67789	114.32085	Muiron	Sanctuary
66265	2/05/2006	-21.67875	114.323933	Muiron	Sanctuary
66266	2/05/2006	-21.6794	114.322417	Muiron	Sanctuary
66250	2/05/2006	-21.699717	114.302533	Muiron	GeneralUse
66267	2/05/2006	-21.681094	114.320929	Muiron	Sanctuary
66254	2/05/2006	-21.697217	114.304133	Muiron	GeneralUse
66255	2/05/2006	-21.695633	114.305467	Muiron	GeneralUse
66261	2/05/2006	-21.684583	114.3118	Muiron	GeneralUse
66256	2/05/2006	-21.68465	114.313767	Muiron	GeneralUse
66258	2/05/2006	-21.6853	114.31305	Muiron	GeneralUse
66360	2/05/2006	-21.691833	114.3124	Muiron	GeneralUse
30361	3/05/2006	-21.85323	114.17551	Bundegi	Recreation
47631	3/05/2006	-21.86495	114.162	Bundegi	OldSanctuary
66237	3/05/2006	-21.89274	114.154	Bundegi	GeneralUse
47638	3/05/2006	-21.864167	114.163017	Bundegi	OldSanctuary
66239	3/05/2006	-21.89323	114.15116	Bundegi	GeneralUse
66248	3/05/2006	-21.85601	114.16858	Bundegi	OldSanctuary
66249	3/05/2006	-21.86307	114.16326	Bundegi	OldSanctuary
66241	3/05/2006	-21.89277	114.14957	Bundegi	GeneralUse
66238	3/05/2006	-21.89093	114.15198	Bundegi	GeneralUse
47649	3/05/2006	-21.85888	114.16655	Bundegi	OldSanctuary
66236	3/05/2006	-21.89078	114.15437	Bundegi	GeneralUse
47639	3/05/2006	-21.86197	114.16284	Bundegi	OldSanctuary
47646	3/05/2006	-21.85735	114.1654	Bundegi	OldSanctuary
56281	3/05/2006	-21.85565	114.17481	Bundegi	Sanctuary
47650	3/05/2006	-21.85604	114.16593	Bundegi	OldSanctuary
56270	3/05/2006	-21.85592	114.17679	Bundegi	Sanctuary
30307	3/05/2006	-21.855	114.16915	Bundegi	Recreation
30385	3/05/2006	-21.85469	114.17814	Bundegi	Recreation
30386	3/05/2006	-21.8527	114.17753	Bundegi	Recreation

66248	3/05/2006	-21.85601	114.16858	Bundegi	OldSanctuary
30293	3/05/2006	-21.85398	114.16484	Bundegi	Recreation
30308	3/05/2006	-21.85307	114.1666	Bundegi	Recreation
30417	3/05/2006	-21.8514	114.1771	Bundegi	Recreation
30343	3/05/2006	-21.85309	114.17157	Bundegi	Recreation
66245	3/05/2006	-21.84241	114.17405	Bundegi	Recreation
66246	3/05/2006	-21.841567	114.1739	Bundegi	Recreation
30344	3/05/2006	-21.85131	114.17097	Bundegi	Recreation
66247	3/05/2006	-21.83925	114.1746	Bundegi	Recreation
66242	3/05/2006	-21.84336	114.17542	Bundegi	Recreation
66243	3/05/2006	-21.84149	114.1766	Bundegi	Recreation
66244	3/05/2006	-21.84031	114.17547	Bundegi	Recreation
66283	5/05/2006	-21.65729	114.34317	Muiron	GeneralUse
14748	3/08/2006	-23.19245	113.76295	Maud	Recreation
14737	3/08/2006	-23.190233	113.757433	Maud	Recreation
30015	2/02/2007	-22.05729	113.89375	Mandu	Recreation
69069	7/02/2007	-22.769	113.759583	Cloates	Sanctuary
65975	26/02/2007	-21.9807	113.929617	Mangrove	Recreation
69050	26/02/2007	-21.9146	113.95732	Mangrove	Recreation
69052	26/02/2007	-21.9197	113.957	Mangrove	Recreation
65972	26/02/2007	-21.97687	113.92942	Mangrove	Recreation
65970	26/02/2007	-21.97248	113.93086	Mangrove	Sanctuary
65971	26/02/2007	-21.96631	113.93525	Mangrove	OldSanctuary
65983	26/02/2007	-21.93474	113.9542	Mangrove	Recreation
69057	26/02/2007	-21.97207	113.92577	Mangrove	Sanctuary
65978	26/02/2007	-21.94321	113.94333	Mangrove	Recreation
69056	26/02/2007	-21.9712	113.92187	Mangrove	Sanctuary
65969	26/02/2007	-21.97156	113.91899	Mangrove	Sanctuary
65968	26/02/2007	-21.96701	113.92131	Mangrove	Sanctuary
65959	26/02/2007	-21.94691	113.94711	Mangrove	OldSanctuary
65967	26/02/2007	-21.96047	113.93747	Mangrove	OldSanctuary
65960	26/02/2007	-21.94708	113.94188	Mangrove	Sanctuary
65962	26/02/2007	-21.95094	113.94454	Mangrove	OldSanctuary
65981	26/02/2007	-21.93235	113.94504	Mangrove	Recreation
30176	27/02/2007	-22.0695	113.88725	Mandu	Recreation
47473	27/02/2007	-22.08347	113.88095	Mandu	OldSanctuary
30175	27/02/2007	-22.06776	113.88763	Mandu	Recreation
47470	27/02/2007	-22.0784	113.88437	Mandu	OldSanctuary
30172	27/02/2007	-22.061583	113.886683	Mandu	Recreation

56738	27/02/2007	-22.075517	113.88625	Mandu	Sanctuary
30169	27/02/2007	-22.055767	113.888533	Mandu	Recreation
56735	27/02/2007	-22.0731	113.886367	Mandu	Sanctuary
66247	27/02/2007	-21.83925	114.1746	Bundegi	Recreation
66237	27/02/2007	-21.89274	114.154	Bundegi	GeneralUse
66239	27/02/2007	-21.89323	114.15116	Bundegi	GeneralUse
66241	27/02/2007	-21.89277	114.14957	Bundegi	GeneralUse
69033	27/02/2007	-21.84139	114.17629	Bundegi	Recreation
66240	27/02/2007	-21.89104	114.1493	Bundegi	GeneralUse
66246	27/02/2007	-21.841567	114.1739	Bundegi	Recreation
66244	27/02/2007	-21.84031	114.17547	Bundegi	Recreation
66238	27/02/2007	-21.89093	114.15198	Bundegi	GeneralUse
66245	27/02/2007	-21.84241	114.17405	Bundegi	Recreation
66236	27/02/2007	-21.89078	114.15437	Bundegi	GeneralUse
66242	27/02/2007	-21.84336	114.17542	Bundegi	Recreation
30228	27/02/2007	-21.87638	114.15873	Bundegi	Recreation
30217	27/02/2007	-21.87661	114.15555	Bundegi	Recreation
30417	27/02/2007	-21.8514	114.1771	Bundegi	Recreation
30211	27/02/2007	-21.87688	114.15329	Bundegi	Recreation
69034	27/02/2007	-21.8512	114.17574	Bundegi	Recreation
30218	27/02/2007	-21.87536	114.15472	Bundegi	Recreation
30386	27/02/2007	-21.8527	114.17753	Bundegi	Recreation
30223	27/02/2007	-21.87512	114.15595	Bundegi	Recreation
30308	28/02/2007	-21.85307	114.1666	Bundegi	Recreation
47591	28/02/2007	-21.87315	114.15427	Bundegi	OldSanctuary
30293	28/02/2007	-21.85398	114.16484	Bundegi	Recreation
47598	28/02/2007	-21.87293	114.15543	Bundegi	OldSanctuary
47650	28/02/2007	-21.85604	114.16593	Bundegi	OldSanctuary
47611	28/02/2007	-21.86462	114.15659	Bundegi	OldSanctuary
47646	28/02/2007	-21.85735	114.1654	Bundegi	OldSanctuary
66249	28/02/2007	-21.86307	114.16326	Bundegi	OldSanctuary
47639	28/02/2007	-21.86197	114.16284	Bundegi	OldSanctuary
30307	28/02/2007	-21.855	114.16915	Bundegi	Recreation
66248	28/02/2007	-21.85601	114.16858	Bundegi	OldSanctuary
30324	28/02/2007	-21.85414	114.17064	Bundegi	Recreation
30343	28/02/2007	-21.85309	114.17157	Bundegi	Recreation
47652	28/02/2007	-21.85745	114.16912	Bundegi	OldSanctuary
30344	28/02/2007	-21.85131	114.17097	Bundegi	Recreation
47651	28/02/2007	-21.85806	114.16905	Bundegi	OldSanctuary

30361	28/02/2007	-21.85323	114.17551	Bundegi	Recreation
47649	28/02/2007	-21.85888	114.16655	Bundegi	OldSanctuary
56281	28/02/2007	-21.85565	114.17481	Bundegi	Sanctuary
47638	28/02/2007	-21.864167	114.163017	Bundegi	OldSanctuary
30385	28/02/2007	-21.85469	114.17814	Bundegi	Recreation
56270	28/02/2007	-21.85592	114.17679	Bundegi	Sanctuary
47631	28/02/2007	-21.86495	114.162	Bundegi	OldSanctuary
56282	28/02/2007	-21.85694	114.17489	Bundegi	Sanctuary
47606	28/02/2007	-21.87405	114.15809	Bundegi	OldSanctuary
56272	28/02/2007	-21.8589	114.175	Bundegi	Sanctuary
47599	28/02/2007	-21.87099	114.15697	Bundegi	OldSanctuary
56273	28/02/2007	-21.86044	114.17484	Bundegi	Sanctuary
47607	28/02/2007	-21.87122	114.15884	Bundegi	OldSanctuary
36094	1/03/2007	-23.64396	113.60292	Farquhar	GeneralUse
31324	1/03/2007	-21.80257	114.10525	Lighthouse	Recreation
69035	1/03/2007	-21.80015	114.10321	Lighthouse	Recreation
31351	1/03/2007	-21.80093	114.11048	Lighthouse	Recreation
31341	1/03/2007	-21.79964	114.10654	Lighthouse	Recreation
69036	1/03/2007	-21.79729	114.10911	Lighthouse	Recreation
31376	1/03/2007	-21.79807	114.11309	Lighthouse	Recreation
69038	1/03/2007	-21.80397	114.11839	Lighthouse	Recreation
31395	1/03/2007	-21.80456	114.12659	Lighthouse	Recreation
69039	1/03/2007	-21.80379	114.13053	Lighthouse	Recreation
31347	1/03/2007	-21.80575	114.11596	Lighthouse	Recreation
31394	1/03/2007	-21.80544	114.12741	Lighthouse	Recreation
31370	1/03/2007	-21.80524	114.12176	Lighthouse	Recreation
69041	1/03/2007	-21.80006	114.13487	Lighthouse	Sanctuary
69040	1/03/2007	-21.79659	114.1347	Lighthouse	Sanctuary
56343	1/03/2007	-21.796883	114.14055	Lighthouse	Sanctuary
56373	1/03/2007	-21.7899	114.14336	Lighthouse	Sanctuary
56421	1/03/2007	-21.78629	114.14834	Lighthouse	Sanctuary
56344	1/03/2007	-21.795083	114.139033	Lighthouse	Sanctuary
56372	1/03/2007	-21.79264	114.14462	Lighthouse	Sanctuary
56465	1/03/2007	-21.7841	114.15785	Lighthouse	Sanctuary
56419	1/03/2007	-21.78774	114.15034	Lighthouse	Sanctuary
56480	1/03/2007	-21.7797	114.15964	Lighthouse	Sanctuary
56472	1/03/2007	-21.78162	114.16035	Lighthouse	Sanctuary
69042	1/03/2007	-21.77942	114.16419	Lighthouse	Sanctuary
56514	1/03/2007	-21.77697	114.16958	Lighthouse	Sanctuary

69043	1/03/2007	-21.77751	114.16636	Lighthouse	Sanctuary
56514	1/03/2007	-21.77697	114.16958	Lighthouse	Sanctuary
69044	1/03/2007	-21.78393	114.17044	Lighthouse	Sanctuary
56508	1/03/2007	-21.78084	114.16991	Lighthouse	Sanctuary
69046	1/03/2007	-21.78592	114.17347	Lighthouse	Recreation
30894	1/03/2007	-21.78694	114.17578	Lighthouse	Recreation
30901	1/03/2007	-21.78436	114.17444	Lighthouse	Recreation
30861	1/03/2007	-21.79362	114.17542	Lighthouse	Recreation
69047	1/03/2007	-21.79581	114.17616	Lighthouse	Recreation
30838	1/03/2007	-21.79842	114.17656	Lighthouse	Recreation
69060	2/03/2007	-21.98161	113.91785	Mangrove	Recreation
65974	2/03/2007	-21.97933	113.91794	Mangrove	Recreation
65973	2/03/2007	-21.97595	113.91755	Mangrove	Recreation
65966	2/03/2007	-21.96003	113.92037	Mangrove	Sanctuary
47393	2/03/2007	-22.08583	113.89081	Mandu	OldSanctuary
47412	2/03/2007	-22.08166	113.89286	Mandu	OldSanctuary
69055	2/03/2007	-21.95765	113.92306	Mangrove	Sanctuary
56722	2/03/2007	-22.07669	113.89427	Mandu	Sanctuary
65964	2/03/2007	-21.95399	113.92129	Mangrove	Sanctuary
47449	2/03/2007	-22.08439	113.88516	Mandu	OldSanctuary
65964	2/03/2007	-21.95399	113.92129	Mangrove	Sanctuary
47460	2/03/2007	-22.08024	113.887	Mandu	OldSanctuary
65958	2/03/2007	-21.94656	113.92033	Mangrove	Sanctuary
65976	2/03/2007	-21.94277	113.92203	Mangrove	Recreation
56731	2/03/2007	-22.07534	113.88929	Mandu	Sanctuary
56730	2/03/2007	-22.07456	113.88878	Mandu	Sanctuary
69058	2/03/2007	-21.95808	113.9416	Mangrove	OldSanctuary
30022	2/03/2007	-22.06915	113.89174	Mandu	Recreation
65965	2/03/2007	-21.95528	113.94196	Mangrove	OldSanctuary
65963	2/03/2007	-21.95186	113.93955	Mangrove	Sanctuary
30021	2/03/2007	-22.06729	113.89052	Mandu	Recreation
65982	2/03/2007	-21.9326	113.92658	Mangrove	Recreation
29868	2/03/2007	-22.06293	113.89716	Mandu	Recreation
30017	2/03/2007	-22.06079	113.8927	Mandu	Recreation
69053	2/03/2007	-21.91731	113.95494	Mangrove	Recreation
29707	2/03/2007	-22.05827	113.90095	Mandu	Recreation
69051	2/03/2007	-21.91829	113.95895	Mangrove	Recreation
69011	2/03/2007	-22.05586	113.8964	Mandu	Recreation
69049	2/03/2007	-21.91167	113.95537	Mangrove	Recreation

69012	2/03/2007	-22.0543	113.89688	Mandu	Recreation
69031	2/03/2007	-22.23107	113.83291	Osprey	OldSanctuary
31653	3/03/2007	-22.17598	113.85536	Mandu	Recreation
47209	3/03/2007	-22.15409	113.86166	Mandu	OldSanctuary
28060	3/03/2007	-22.178017	113.847483	Mandu	GeneralUse
47250	3/03/2007	-22.1502	113.85873	Mandu	OldSanctuary
28161	3/03/2007	-22.17258	113.850417	Mandu	Recreation
47249	3/03/2007	-22.14925	113.85954	Mandu	OldSanctuary
28295	3/03/2007	-22.164225	113.853783	Mandu	Recreation
47268	3/03/2007	-22.14267	113.86226	Mandu	OldSanctuary
56756	3/03/2007	-22.15925	113.855283	Mandu	Sanctuary
47347	3/03/2007	-22.12021	113.8706	Mandu	OldSanctuary
56753	3/03/2007	-22.15653	113.85687	Mandu	Sanctuary
47409	3/03/2007	-22.1085	113.87218	Mandu	OldSanctuary
31636	3/03/2007	-22.17879	113.85172	Mandu	Recreation
31647	3/03/2007	-22.17832	113.8553	Mandu	Recreation
31655	3/03/2007	-22.173183	113.8546	Mandu	Recreation
69017	3/03/2007	-22.10334	113.87925	Mandu	OldSanctuary
69016	3/03/2007	-22.10584	113.87848	Mandu	OldSanctuary
31679	3/03/2007	-22.16909	113.85753	Mandu	Recreation
31680	3/03/2007	-22.1652	113.85784	Mandu	Recreation
69015	3/03/2007	-22.10828	113.87799	Mandu	OldSanctuary
31689	3/03/2007	-22.16411	113.85955	Mandu	Recreation
47338	3/03/2007	-22.10775	113.88055	Mandu	OldSanctuary
69014	3/03/2007	-22.11096	113.87831	Mandu	OldSanctuary
28329	3/03/2007	-22.15985	113.85955	Mandu	Sanctuary
47317	3/03/2007	-22.11089	113.88024	Mandu	OldSanctuary
56748	3/03/2007	-22.15883	113.86169	Mandu	Sanctuary
47274	3/03/2007	-22.11327	113.88344	Mandu	OldSanctuary
47278	3/03/2007	-22.11848	113.87903	Mandu	OldSanctuary
56745	3/03/2007	-22.15899	113.86316	Mandu	Sanctuary
56747	3/03/2007	-22.15809	113.86077	Mandu	Sanctuary
47279	3/03/2007	-22.12052	113.878	Mandu	OldSanctuary
56751	3/03/2007	-22.15714	113.85969	Mandu	Sanctuary
47234	3/03/2007	-22.1276	113.87768	Mandu	OldSanctuary
47213	3/03/2007	-22.13087	113.87698	Mandu	OldSanctuary
47215	3/03/2007	-22.13481	113.87486	Mandu	OldSanctuary
47208	3/03/2007	-22.15258	113.86208	Mandu	OldSanctuary
47185	3/03/2007	-22.15391	113.8653	Mandu	OldSanctuary

47186	3/03/2007	-22.15648	113.86293	Mandu	OldSanctuary
66250	4/03/2007	-21.699717	114.302533	Muiron	GeneralUse
66253	4/03/2007	-21.69674	114.31007	Muiron	GeneralUse
66254	4/03/2007	-21.697217	114.304133	Muiron	GeneralUse
66255	4/03/2007	-21.695633	114.305467	Muiron	GeneralUse
66261	4/03/2007	-21.684583	114.3118	Muiron	GeneralUse
66283	4/03/2007	-21.65729	114.34317	Muiron	GeneralUse
66261	4/03/2007	-21.684583	114.3118	Muiron	GeneralUse
66264	4/03/2007	-21.67789	114.32085	Muiron	Sanctuary
66277	4/03/2007	-21.6609	114.340817	Muiron	Sanctuary
66259	4/03/2007	-21.683875	114.31315	Muiron	GeneralUse
66278	4/03/2007	-21.662033	114.339617	Muiron	Sanctuary
66262	4/03/2007	-21.681683	114.31635	Muiron	Sanctuary
66279	4/03/2007	-21.6632	114.3383	Muiron	Sanctuary
66263	4/03/2007	-21.67977	114.3186	Muiron	Sanctuary
66271	4/03/2007	-21.67485	114.326233	Muiron	Sanctuary
66273	4/03/2007	-21.669733	114.331567	Muiron	Sanctuary
66272	4/03/2007	-21.672233	114.329933	Muiron	Sanctuary
66271	4/03/2007	-21.67485	114.326233	Muiron	Sanctuary
66312	4/03/2007	-21.65214	114.37479	Muiron	Sanctuary
66333	4/03/2007	-21.63704	114.39038	Muiron	GeneralUse
66307	4/03/2007	-21.655633	114.374517	Muiron	Sanctuary
66332	4/03/2007	-21.63828	114.38936	Muiron	GeneralUse
66315	4/03/2007	-21.65737	114.36943	Muiron	Sanctuary
66331	4/03/2007	-21.63953	114.38809	Muiron	GeneralUse
66304	4/03/2007	-21.66145	114.37375	Muiron	Sanctuary
66327	4/03/2007	-21.64435	114.38219	Muiron	GeneralUse
66306	4/03/2007	-21.65268	114.36926	Muiron	Sanctuary
66295	5/03/2007	-21.65182	114.36009	Muiron	GeneralUse
66296	5/03/2007	-21.65096	114.36046	Muiron	GeneralUse
66297	5/03/2007	-21.65106	114.36171	Muiron	GeneralUse
66326	5/03/2007	-21.64605	114.381	Muiron	GeneralUse
66322	5/03/2007	-21.64607	114.37596	Muiron	GeneralUse
66325	5/03/2007	-21.64635	114.38015	Muiron	GeneralUse
66308	5/03/2007	-21.65227	114.37094	Muiron	Sanctuary
66311	5/03/2007	-21.65072	114.37235	Muiron	Sanctuary
66310	5/03/2007	-21.64979	114.37285	Muiron	Sanctuary
66314	5/03/2007	-21.64891	114.3774	Muiron	Sanctuary
66309	5/03/2007	-21.64812	114.37405	Muiron	Sanctuary

66313	5/03/2007	-21.6505	114.3763	Muiron	Sanctuary
66323	5/03/2007	-21.64512	114.37731	Muiron	GeneralUse
66324	5/03/2007	-21.64369	114.37891	Muiron	GeneralUse
66291	5/03/2007	-21.67041	114.35262	Muiron	GeneralUse
66302	5/03/2007	-21.65922	114.35981	Muiron	Sanctuary
66303	5/03/2007	-21.66362	114.35965	Muiron	Sanctuary
66290	5/03/2007	-21.67252	114.35103	Muiron	GeneralUse
66289	5/03/2007	-21.67433	114.34925	Muiron	GeneralUse
66300	5/03/2007	-21.66102	114.35835	Muiron	GeneralUse
66299	5/03/2007	-21.65876	114.35842	Muiron	GeneralUse
66301	5/03/2007	-21.66111	114.35992	Muiron	Sanctuary
66287	5/03/2007	-21.67261	114.34666	Muiron	GeneralUse
66288	5/03/2007	-21.67055	114.3487	Muiron	GeneralUse
66301	5/03/2007	-21.66111	114.35992	Muiron	Sanctuary
66286	5/03/2007	-21.66819	114.35074	Muiron	GeneralUse
66294	5/03/2007	-21.65193	114.358	Muiron	GeneralUse
66321	5/03/2007	-21.653583	114.375433	Muiron	Sanctuary
66293	5/03/2007	-21.65116	114.35668	Muiron	GeneralUse
69063	7/03/2007	-22.73036	113.72564	Cloates	Sanctuary
69065	7/03/2007	-22.717083	113.709017	Cloates	Sanctuary
69066	7/03/2007	-22.720283	113.712533	Cloates	Sanctuary
69064	7/03/2007	-22.73375	113.72543	Cloates	Sanctuary
69068	7/03/2007	-22.763317	113.75545	Cloates	Sanctuary
69067	7/03/2007	-22.75831	113.75127	Cloates	Sanctuary
69109	7/03/2007	-22.804917	113.717117	Cloates	OldSanctuary
69074	7/03/2007	-22.8651	113.796267	Cloates	OldSanctuary
69110	7/03/2007	-22.810717	113.71405	Cloates	OldSanctuary
69073	7/03/2007	-22.877083	113.784333	Cloates	OldSanctuary
69111	7/03/2007	-22.84095	113.730767	Cloates	OldSanctuary
69112	7/03/2007	-22.845483	113.733983	Cloates	OldSanctuary
65925	7/03/2007	-22.90637	113.79611	Cloates	OldSanctuary
69108	7/03/2007	-22.9074	113.766067	Cloates	OldSanctuary
65928	7/03/2007	-22.90872	113.78614	Cloates	OldSanctuary
69113	7/03/2007	-22.909969	113.764208	Cloates	OldSanctuary
65934	7/03/2007	-22.874817	113.764083	Cloates	OldSanctuary
65924	7/03/2007	-22.86573	113.78249	Cloates	OldSanctuary
69072	7/03/2007	-22.84281	113.76016	Cloates	OldSanctuary
65940	7/03/2007	-22.7867	113.76171	Cloates	OldSanctuary
65941	7/03/2007	-22.79797	113.76109	Cloates	OldSanctuary

69090	8/03/2007	-22.735493	113.667367	Cloates	Sanctuary
65948	8/03/2007	-22.77044	113.73136	Cloates	Sanctuary
69091	8/03/2007	-22.735317	113.66695	Cloates	Sanctuary
69071	8/03/2007	-22.78013	113.71865	Cloates	OldSanctuary
69092	8/03/2007	-22.724333	113.658767	Cloates	Sanctuary
65938	8/03/2007	-22.7867	113.71613	Cloates	OldSanctuary
69093	8/03/2007	-22.720817	113.65675	Cloates	Sanctuary
65937	8/03/2007	-22.793967	113.70845	Cloates	OldSanctuary
69094	8/03/2007	-22.708933	113.648567	Cloates	Sanctuary
65936	8/03/2007	-22.780517	113.700233	Cloates	OldSanctuary
69095	8/03/2007	-22.70485	113.6431	Cloates	Sanctuary
65946	8/03/2007	-22.77288	113.70393	Cloates	Sanctuary
69070	8/03/2007	-22.76911	113.71039	Cloates	Sanctuary
65947	8/03/2007	-22.77358	113.72077	Cloates	Sanctuary
65946	8/03/2007	-22.77288	113.70393	Cloates	Sanctuary
66348	8/03/2007	-22.73975	113.683717	Cloates	Sanctuary
69106	8/03/2007	-22.7993	113.7721	Cloates	OldSanctuary
66349	8/03/2007	-22.741767	113.682017	Cloates	Sanctuary
69107	8/03/2007	-22.82085	113.782617	Cloates	OldSanctuary
65944	8/03/2007	-22.72702	113.6828	Cloates	Sanctuary
66350	8/03/2007	-22.724917	113.676	Cloates	Sanctuary
66351	8/03/2007	-22.729033	113.669267	Cloates	Sanctuary
66352	8/03/2007	-22.724317	113.664617	Cloates	Sanctuary
66353	8/03/2007	-22.719333	113.667567	Cloates	Sanctuary
66354	8/03/2007	-22.706983	113.658733	Cloates	Sanctuary
66355	8/03/2007	-22.699917	113.6618	Cloates	Sanctuary
65915	9/03/2007	-22.93114	113.79171	Cloates	Recreation
65913	9/03/2007	-22.91849	113.78101	Cloates	Recreation
65916	9/03/2007	-22.92314	113.80818	Cloates	Recreation
65990	9/03/2007	-22.929633	113.77925	Cloates	Recreation
65989	9/03/2007	-22.942017	113.780117	Cloates	Recreation
65956	9/03/2007	-22.9394	113.80073	Cloates	Recreation
65917	9/03/2007	-22.94976	113.77674	Cloates	Recreation
65918	9/03/2007	-22.96827	113.7801	Cloates	Recreation
65957	9/03/2007	-22.94777	113.7965	Cloates	Recreation
65988	9/03/2007	-22.978683	113.779883	Cloates	Recreation
65954	9/03/2007	-22.99245	113.80524	Cloates	Recreation
69075	10/03/2007	-23.082767	113.7403	Maud	OldSanctuary
53570	10/03/2007	-23.167883	113.757267	Maud	Sanctuary

69096	10/03/2007	-23.093417	113.737733	Maud	OldSanctuary
42430	10/03/2007	-23.086233	113.734233	Maud	OldSanctuary
53602	10/03/2007	-23.165667	113.755067	Maud	Sanctuary
42465	10/03/2007	-23.09167	113.73845	Maud	OldSanctuary
53588	10/03/2007	-23.162983	113.75505	Maud	Sanctuary
42756	10/03/2007	-23.156267	113.757717	Maud	OldSanctuary
69097	10/03/2007	-23.10315	113.74005	Maud	OldSanctuary
42679	10/03/2007	-23.153167	113.752	Maud	OldSanctuary
69024	10/03/2007	-23.15454	113.75121	Maud	OldSanctuary
69098	10/03/2007	-23.108533	113.741933	Maud	OldSanctuary
42581	10/03/2007	-23.12399	113.74415	Maud	OldSanctuary
69023	10/03/2007	-23.1524	113.75092	Maud	OldSanctuary
69158	10/03/2007	-23.12985	113.751767	Maud	OldSanctuary
69022	10/03/2007	-23.14998	113.7512	Maud	OldSanctuary
42821	10/03/2007	-23.126133	113.762217	Maud	OldSanctuary
69021	10/03/2007	-23.14886	113.75135	Maud	OldSanctuary
42835	10/03/2007	-23.13506	113.76302	Maud	OldSanctuary
42807	10/03/2007	-23.150367	113.761333	Maud	OldSanctuary
42655	10/03/2007	-23.144083	113.750583	Maud	OldSanctuary
69137	10/03/2007	-23.140533	113.758533	Maud	OldSanctuary
65903	11/03/2007	-23.32437	113.78179	Pelican	Sanctuary
69080	11/03/2007	-23.351467	113.78175	Pelican	OldSanctuary
65911	11/03/2007	-23.336967	113.780467	Pelican	Sanctuary
65902	11/03/2007	-23.34659	113.7833	Pelican	OldSanctuary
37354	12/03/2007	-23.64687	113.61113	Farquhar	GeneralUse
69085	12/03/2007	-23.62387	113.61854	Farquhar	Sanctuary
69084	12/03/2007	-23.62157	113.62116	Farquhar	Sanctuary
48942	12/03/2007	-23.63543	113.60991	Farquhar	Sanctuary
48396	12/03/2007	-23.5934	113.63517	Farquhar	Sanctuary
48960	12/03/2007	-23.63752	113.60641	Farquhar	Sanctuary
48515	12/03/2007	-23.59941	113.62791	Farquhar	Sanctuary
36597	12/03/2007	-23.64565	113.60619	Farquhar	GeneralUse
37356	12/03/2007	-23.64356	113.61338	Farquhar	GeneralUse
48963	12/03/2007	-23.638967	113.613983	Farquhar	Sanctuary
48953	12/03/2007	-23.63827	113.61183	Farquhar	Sanctuary
48977	13/03/2007	-23.64071	113.60234	Farquhar	Sanctuary
48929	13/03/2007	-23.63217	113.6049	Farquhar	Sanctuary
41561	13/03/2007	-23.558883	113.70505	Farquhar	Recreation
36089	13/03/2007	-23.6527	113.593317	Farquhar	GeneralUse

41565	13/03/2007	-23.553667	113.706967	Farquhar	Recreation
36592	13/03/2007	-23.652233	113.600617	Farquhar	GeneralUse
41543	13/03/2007	-23.56199	113.70379	Farquhar	Recreation
36591	13/03/2007	-23.65474	113.59943	Farquhar	GeneralUse
47664	13/03/2007	-23.567483	113.701517	Farquhar	Sanctuary
37828	13/03/2007	-23.67474	113.5953	Farquhar	GeneralUse
38056	13/03/2007	-23.676483	113.595117	Farquhar	GeneralUse
36836	13/03/2007	-23.66855	113.589283	Farquhar	GeneralUse
35838	13/03/2007	-23.6527	113.594767	Farquhar	GeneralUse
47682	13/03/2007	-23.56555	113.6876	Farquhar	Sanctuary
47724	13/03/2007	-23.566333	113.686983	Farquhar	Sanctuary
37587	13/03/2007	-23.67587	113.5926	Farquhar	GeneralUse
37344	13/03/2007	-23.67417	113.59231	Farquhar	GeneralUse
69099	13/03/2007	-23.566933	113.686667	Farquhar	Sanctuary
38250	14/03/2007	-23.732067	113.5618	Gnarloo	GeneralUse
39106	14/03/2007	-23.76244	113.54678	Gnarloo	GeneralUse
49025	14/03/2007	-23.76211	113.54471	Gnarloo	Sanctuary
69164	14/03/2007	-23.38677	113.77519	Pelican	OldSanctuary
69122	15/03/2007	-23.790697	113.523325	Gnarloo	Sanctuary
38687	15/03/2007	-23.73663	113.56047	Gnarloo	GeneralUse
69123	15/03/2007	-23.786158	113.525415	Gnarloo	Sanctuary
69127	15/03/2007	-23.721575	113.576152	Gnarloo	GeneralUse
69124	15/03/2007	-23.78162	113.528603	Gnarloo	Sanctuary
69128	15/03/2007	-23.71699	113.578315	Gnarloo	GeneralUse
69129	15/03/2007	-23.708633	113.583053	Gnarloo	GeneralUse
69131	15/03/2007	-23.70374	113.58554	Gnarloo	GeneralUse
69126	15/03/2007	-23.767678	113.538712	Gnarloo	Sanctuary
69103	16/03/2007	-23.96122	113.46968	Farquhar	Sanctuary
6091	11/04/2007	-23.14405	113.74338	Maud	GeneralUse
6529	11/04/2007	-23.113883	113.73745	Maud	OldSanctuary
6415	11/04/2007	-23.1211	113.73126	Maud	GeneralUse
6208	11/04/2007	-23.13461	113.74135	Maud	GeneralUse
5787	11/04/2007	-23.1632	113.74605	Maud	GeneralUse
14784	12/04/2007	-23.18538	113.75989	Maud	Recreation
14737	12/04/2007	-23.190233	113.757433	Maud	Recreation
14754	12/04/2007	-23.186017	113.753983	Maud	Recreation
5675	12/04/2007	-23.18008	113.7535	Maud	Recreation
5706	12/04/2007	-23.16905	113.74835	Maud	Sanctuary
69018	12/04/2007	-23.18027	113.75936	Maud	Recreation

69020	12/04/2007	-23.17787	113.75999	Maud	Recreation
14787	12/04/2007	-23.179567	113.760417	Maud	Recreation
14822	12/04/2007	-23.175033	113.757017	Maud	Recreation
14834	12/04/2007	-23.17755	113.755833	Maud	Recreation
65906	13/04/2007	-23.43097	113.77953	Pelican	Sanctuary
66343	13/04/2007	-23.45387	113.77382	Pelican	Recreation
66342	13/04/2007	-23.4511	113.77334	Pelican	Recreation
66345	13/04/2007	-23.4519	113.77775	Pelican	Recreation
66346	13/04/2007	-23.45302	113.77797	Pelican	Recreation
66344	13/04/2007	-23.45065	113.77639	Pelican	Recreation
66347	13/04/2007	-23.45145	113.77908	Pelican	Recreation
66338	13/04/2007	-23.44048	113.77923	Pelican	Recreation
66337	13/04/2007	-23.43909	113.7784	Pelican	Recreation
66336	13/04/2007	-23.43806	113.77857	Pelican	Recreation
66341	13/04/2007	-23.44135	113.7721	Pelican	Recreation
66340	13/04/2007	-23.43874	113.77243	Pelican	Recreation
65905	13/04/2007	-23.419433	113.7803	Pelican	Sanctuary
69082	13/04/2007	-23.41525	113.77655	Pelican	Sanctuary
69083	13/04/2007	-23.41729	113.77472	Pelican	Sanctuary
69081	13/04/2007	-23.41402	113.77166	Pelican	Sanctuary
65893	13/04/2007	-23.40445	113.76925	Pelican	OldSanctuary
65908	14/04/2007	-23.38455	113.773917	Pelican	OldSanctuary
69163	14/04/2007	-23.3847	113.77265	Pelican	OldSanctuary
69172	14/04/2007	-23.38936	113.77239	Pelican	OldSanctuary
65909	14/04/2007	-23.38859	113.77277	Pelican	OldSanctuary
69165	14/04/2007	-23.38925	113.77556	Pelican	OldSanctuary
65904	14/04/2007	-23.39766	113.77235	Pelican	OldSanctuary
65883	14/04/2007	-23.400683	113.77625	Pelican	OldSanctuary
69173	14/04/2007	-23.40163	113.78056	Pelican	OldSanctuary
65882	14/04/2007	-23.406817	113.777267	Pelican	OldSanctuary
69174	14/04/2007	-23.40665	113.78054	Pelican	OldSanctuary
31494	21/05/2007	-22.21833	113.83904	Osprey	Recreation
46737	21/05/2007	-22.22481	113.83445	Osprey	OldSanctuary
49980	21/05/2007	-22.22222	113.83711	Osprey	Sanctuary
46744	21/05/2007	-22.22572	113.83355	Osprey	OldSanctuary
69025	21/05/2007	-22.21809	113.83757	Osprey	Recreation
69029	21/05/2007	-22.2278	113.83302	Osprey	OldSanctuary
69030	21/05/2007	-22.2298	113.83263	Osprey	OldSanctuary
31503	21/05/2007	-22.21572	113.83926	Osprey	Recreation

69031	21/05/2007	-22.23107	113.83291	Osprey	OldSanctuary
69032	21/05/2007	-22.23254	113.83289	Osprey	OldSanctuary
69026	21/05/2007	-22.21327	113.84093	Osprey	Recreation
46787	21/05/2007	-22.23875	113.82934	Osprey	OldSanctuary
69027	21/05/2007	-22.20675	113.84227	Osprey	Recreation
46799	21/05/2007	-22.24139	113.8266	Osprey	OldSanctuary
69028	21/05/2007	-22.20514	113.84329	Osprey	Recreation
46801	21/05/2007	-22.24316	113.82904	Osprey	OldSanctuary
46808	21/05/2007	-22.24517	113.82739	Osprey	OldSanctuary
31549	21/05/2007	-22.20386	113.84396	Osprey	Recreation
46969	21/05/2007	-22.27849	113.82509	Osprey	OldSanctuary
31562	21/05/2007	-22.20151	113.84604	Osprey	Recreation
47011	21/05/2007	-22.28326	113.82233	Osprey	OldSanctuary
31483	22/05/2007	-22.22019	113.83257	Osprey	Recreation
46815	22/05/2007	-22.24252	113.82305	Osprey	OldSanctuary
46805	22/05/2007	-22.23949	113.82363	Osprey	OldSanctuary
46748	22/05/2007	-22.22434	113.83052	Osprey	OldSanctuary
46742	22/05/2007	-22.2226	113.8318	Osprey	OldSanctuary
31487	22/05/2007	-22.21801	113.83309	Osprey	Recreation
69178	22/05/2007	-22.20555	113.83667	Osprey	GeneralUse
69180	22/05/2007	-22.20064	113.83848	Osprey	GeneralUse
47047	22/05/2007	-22.28045	113.81236	Osprey	OldSanctuary
47104	22/05/2007	-22.28857	113.80866	Osprey	OldSanctuary
13274	23/05/2007	-22.36378	113.75061	Osprey	Recreation
13234	23/05/2007	-22.36159	113.75227	Osprey	Recreation
13258	23/05/2007	-22.36717	113.75679	Osprey	Recreation
13199	23/05/2007	-22.36235	113.76006	Osprey	Recreation
69175	23/05/2007	-22.3616	113.76331	Osprey	Recreation
13145	23/05/2007	-22.35782	113.76531	Osprey	Recreation
13002	23/05/2007	-22.34561	113.77134	Osprey	Recreation
12946	23/05/2007	-22.34005	113.77374	Osprey	Recreation
12901	23/05/2007	-22.34344	113.7918	Osprey	Recreation
12850	23/05/2007	-22.33796	113.79277	Osprey	Recreation
12811	23/05/2007	-22.32937	113.78421	Osprey	Recreation
69176	23/05/2007	-22.32688	113.79465	Osprey	Recreation
47115	23/05/2007	-22.28736	113.80438	Osprey	OldSanctuary
47164	23/05/2007	-22.29324	113.80093	Osprey	OldSanctuary
47157	23/05/2007	-22.2953	113.80476	Osprey	OldSanctuary