RESERVE BOUNDARY PLANNING

FOR THE

JURIEN MARINE RESERVE:

AN ECOLOGICAL PERSPECTIVE

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Summary

The planning and design of multiple-use marine reserves in Western Australia must be based on ecological values, if their primary conservation objective is to be achieved. This paper identifies criteria that can be used for the planning and design of marine reserves and applies ecological criteria to the issue of reserve boundary setting for the Jurien Marine Reserve. The biogeographic and ecological importance of the Jurien Marine Reserve are reviewed, and the implications of a number of boundary extension options are discussed.

Introduction

The Western Australian Government is committed to the establishment of:

"a comprehensive and statewide system of multiple-use marine conservation reserves under the Conservation and Land Management Act 1984" (Government of Western Australia, 1994).

The Department of Conservation and Land Management (CALM) is the statutory body responsible for overall management of marine reserves in the State. With regard to the implementation and management of marine reserves, the State Government, via CALM, has conservation and multiple-use objectives that relate to the protection of the marine environment and management of human usage.

The conservation and multiple-use objectives of the marine reserve system are described in the State Government's *"New Horizons - the way ahead in marine conservation and management"* strategy (Government of Western Australia, 1998).

The conservation objective is:

- *"To preserve representative as well as special ecosystems in the marine environment";*

and the multiple-use objective is:

- *"To put a formal management framework in place to ensure the various uses of marine conservation reserves are managed in an equitable, integrated and sustainable manner."*

The primacy of the conservation objective reflects the dependency of most human usage on the maintenance of a 'healthy' natural environment. Preservation of representative ecosystems, as well as rare or unique species and biological communities, will contribute to the maintenance of biological diversity and ecosystem integrity.

There are a number of ecological and cultural (i.e. socio-economic) criteria that can be applied in the planning and design of multiple-use marine protected areas. First and foremost, however, the design of marine reserves for inclusion in the statewide representative system must be based on ecological values, otherwise these values may be compromised, undermining the conservation objective of a reserve. This could result in incorrect, costly and possibly irreversible decisions being made in the reserve planning process. During the planning and design stages of a reserve human usage must be considered within a framework of ecological sustainability, as maintenance of cultural (i.e. socio-economic) values is dependent on a 'healthy' natural environment.

The objectives of this paper are to identify criteria for the planning and design of multiple-use marine reserves and to apply ecological criteria to the ecological resource information available for the Jurien Marine Reserve, which will form part of the statewide, representative system of multiple-use marine reserves. The implications for reserve design, particularly with reference to reserve boundary determination, will be examined and discussed from an ecological perspective. This paper only considers ecological factors relating to reserve boundary planning for the Jurien Marine Reserve. Cultural (i.e. socio/economic) and management, or practical criteria, will be considered by members of the stakeholder advisory committee.

Criteria for selection and design of marine reserves

The World Conservation Union (IUCN) has developed a set of guidelines for the establishment of marine protected areas (Kelleher & Kenchington, 1992), which include ecological, social, economic and practical criteria that can be used in deciding whether an area should be included within a marine reserve. Some of these criteria can also be applied in determining appropriate boundaries for a marine reserve. The IUCN criteria are shown in Figure 1.

This paper applies the first two groups of IUCN criteria - that is, biogeographic importance and ecological importance, to the issue of reserve boundary identification for the Jurien Marine Reserve.

These criteria cover very different spatial scales:

1. the biogeographic approach is applied on a regional-provincial macroscale of hundreds to thousands of kilometres;

Biogeographic importance	-	either contains rare biogeographic qualities or is representative of a biogeographic "type" or types;
	-	contains unique or unusual geological features.
Ecological importance	-	contributes to the maintenance of essential ecological processes or life-support systems (e.g. source of larvae for downstream areas);
	-	contributes to ecological integrity - the degree to which the area, either by itself or in association with other protected areas, encompasses a complete ecosystem;
	-	preserves genetic diversity (i.e. is diverse or abundant in species terms);
	-	contains a variety of habitats;
	-	contains habitat for rare or endangered species;
	-	contains nursery or juvenile areas;
	-	contains feeding, breeding or nursery areas;
	-	contains rare or unique habitat for any species.
Naturalness	-	the extent to which the area has been protected from, or has not been subjected to, human-induced change.
Scientific importance	-	value for research and monitoring.
Economic importance	-	existing or potential contribution to economic value by virtue of its protection (e.g. protection of an area for recreation, subsistence, use by traditional inhabitants, appreciation by tourists and others, or as a refuge nursery area or source of supply for economically important species).
Social importance	-	existing or potential value to local, national or international communities because of its heritage, historical, cultural, traditional aesthetic, educational or recreational qualities.
International or national significance	-	is or has the potential to be listed on the World or a national Heritage List or declared as a Biosphere Reserve, or be included on a list of areas of international or national importance, or is the subject of an international or national conservation agreement.
Practicality/feasibility	-	degree of insulation from external destructive influences; social and political acceptability, degree of community support;
	-	accessibility for education, tourism, recreation;
	-	compatibility with existing uses, particularly by locals;
	-	ease of management, compatibility with existing management regimes.

Figure 1: IUCN criteria for the selection and design of marine protected areas (from Kelleher & Kenchington, 1992).

2. the ecological importance criteria are applied at an ecosystem scale (i.e. tens to hundreds of kilometres); and

3. the habitat or biological community scale of a kilometre to tens of kilometres.

- its local representativeness - i.e. the degree to which local marine habitat and biological community types are represented in the area; and
- the physical heterogeneity (diversity) of the candidate area.

Biogeographic importance of the Jurien Marine Reserve

There are several different aspects that should be considered when examining the biogeographic importance of a candidate marine reserve area (Emanuel, *et al.*, 1992). These are:

- the regional representativeness of a candidate area;
- the need for conservation of the area in relation to other conservation measures that have already been put in place in the region;

The *Interim Marine and Coastal Regionalisation of Australia* (IMCRA Technical Group, 1997) provides an ecosystem-level regionalisation of Australia's coastal and marine environments (Figure 2). Western Australia has a total of 18 regions, with the west coast between Cape Leeuwin and North West Cape comprising 6 different marine bioregions. The Jurien area is located centrally in the Central West Coast (CWC) marine bioregion, which extends from Kalbarri and Rottnest Island. This bioregion contains one of the largest continuous, temperate limestone reef systems in Australia (Dongara to Trigg), comprising approximately 64 % of the State waters section of the CWC marine bioregion (Table 1).

Area	Approximate size (ha)	Percentage of CWC marine bioregion (State waters)	Percentage of CWC limestone reef system
CWC marine bioregion (State waters)	284,400		
CWC limestone reef system	182,300	64.0	
Candidate marine reserves areas in CWC marine bioregion (MPRSWG Report)			
Jurien	16,600	5.8	9.1
Beagle Islands.	23,800	8.0	13.0
Kalbarri	4,000	1.4	2.2
Existing marine reserves in CWC marine bioregion			
Marmion Marine Park	9,500	3.3	
Other WA marine reserves			
Shark Bay Marine Park	748,735		
Hamelin Pool Marine Nature Reserve	132,000		
Ningaloo Marine Park	225,564		
Rowley Shoals Marine Park	23,250		
Shoalwater Islands Marine Park	6,650		
Swan Estuary Marine Park	240		

Table 1:
Biogeographic representativeness of existing and proposed marine reserves within the CWC marine bioregion.

Continental shelf meso-scale regionalisation:

ABR Abrolhos Islands
ANB Anson Beagle
ARA Arafura
AWS Arnhem Wessel
BAT Batemans Shelf
BGS Boags
BON Bonaparte Gulf
BRU Bruny
CAB Cambridge-Bonaparte
CAN Canning
CAR Carpentaria
CBS Central Bass Strait
COB Cobourg
COR Coorong
CRF Central Reef
CVA Central Victoria
CWC Central West Coast
DAV Davey
ECY East Cape York
EMB Eighty Mile Beach
EUC Eucla
EYR Eyre
FLI Flinders
FRA Franklin
FRT Freycinet
GRO Groote
HAW Hawkesbury Shelf
KAN Karumba-Nassau
KIM Kimberley
KSD King Sound
LMC Lucinda-Mackay Coast
LNE Leeuwin-Naturaliste
MAN Manning Shelf
MCN Mackay-Capricorn
MUR Murat
NIN Ningaloo
NSG North Spencer Gulf
NWS North West Shelf
OSS Oceanic Shoals
OTW Otway
PEL Pellew
PIN Pilbara (nearshore)
PIO Pilbara (offshore)
PSS Pompey-Swains
RBN Ribbons
SBY Shark Bay
SCT Shoalwater Coast
SGF Spencer Gulf
SVG St Vincent Gulf
TMN Tweed-Moreton
TST Torres Strait
TWI Tiwi
TWO Twofold Shelf
VDG Van Diemens Gulf
VES Victorian Embayments
WCY West Cape York
WLY Wellesley
WSC WA South Coast
WTC Wet Tropic Coast
ZUY Zuytdorp

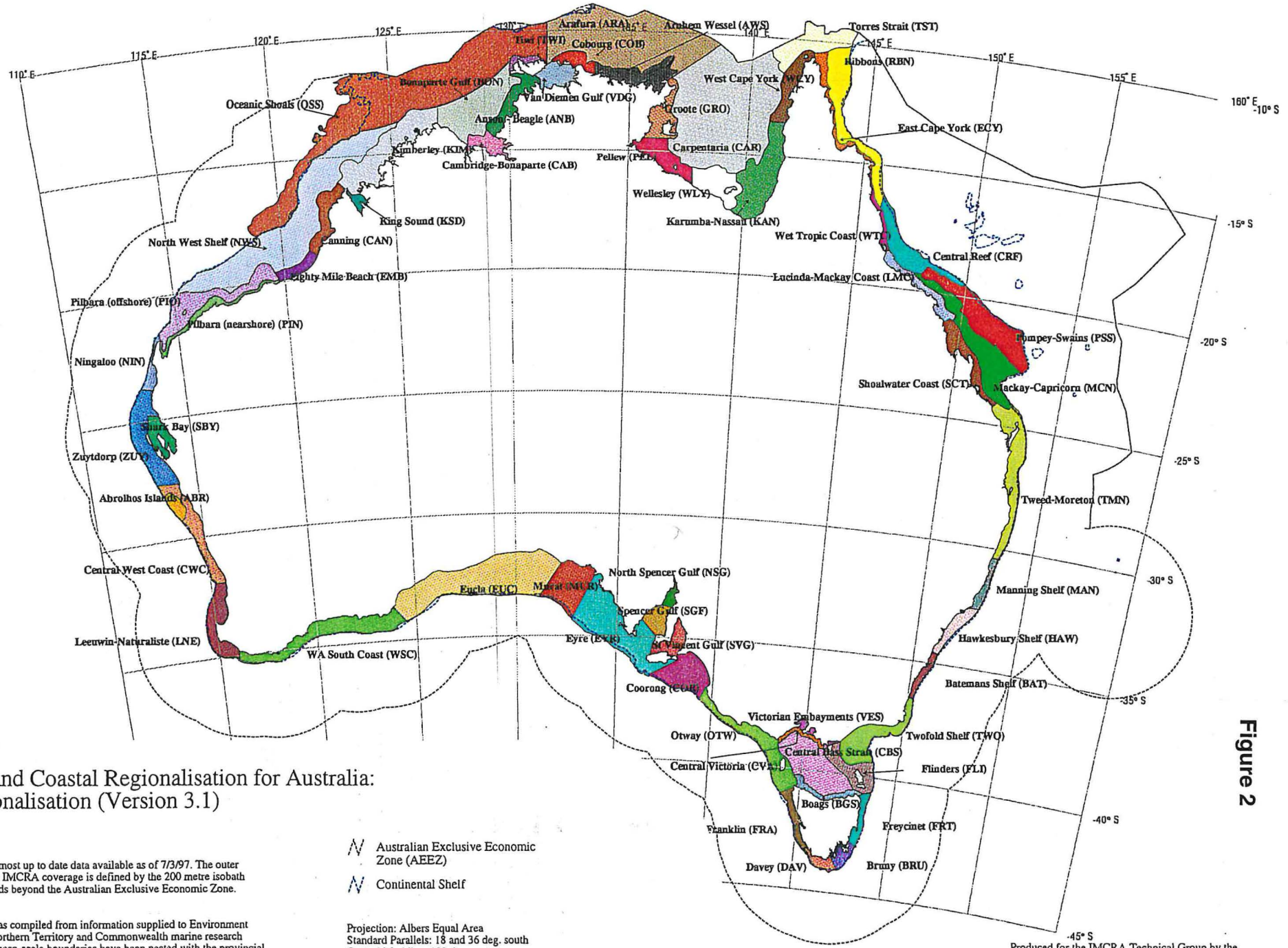

Figure 2

Map 1
Interim Marine and Coastal Regionalisation for Australia: Meso-scale regionalisation (Version 3.1)

BACKGROUND:
This map was compiled from the most up to date data available as of 7/3/97. The outer seaward extent for the meso-scale IMCRA coverage is defined by the 200 metre isobath except where this boundary extends beyond the Australian Exclusive Economic Zone.

SOURCES:
The meso-scale regionalisation was compiled from information supplied to Environment Australia by the relevant State, Northern Territory and Commonwealth marine research and management agencies. The meso-scale boundaries have been nested with the provincial level demersal regionalisation (Map 2).
AUSLIG (1995):"Australian Marine Boundary Information System (AMBIS)".
AUSLIG (1995): "Digital Coastline Dataset".

Australian Exclusive Economic Zone (AEEZ)

Continental Shelf

Projection: Albers Equal Area
Standard Parallels: 18 and 36 deg. south
Central Meridian: 132 deg. east
Australian Spheroid
Scale:1:17,000,000

Produced for the IMCRA Technical Group by the Biodiversity Group, ENVIRONMENT AUSTRALIA.

Date: 4 September 1997

Within the CWC marine bioregion there are a total of five areas that were recommended, in the report of the Marine Parks and Reserves Selection Working Group (MPRSWG), as worthy of consideration as marine reserves (CALM, 1994). These are Kalbarri (1.5 % of CWC marine bioregion), Port Gregory (>1 %), Seven Mile Beach (>1 %), the Beagle Islands (8 %) and Jurien (6 %).

The spatial extent of each of these candidate areas, as outlined in the MPRSWG report, is only indicative and consideration of boundaries is a key issue in the initial planning stages of each proposal. The Jurien marine reserve proposal encompasses an area of approximately 16,600 ha, which represents nearly six percent of the CWC marine bioregion (State waters) and about nine percent of the limestone reef system (Table 1). At present, only five percent of the limestone reef system is within a marine reserve (Marmion Marine Park). Other proposed marine reserves within the CWC marine bioregion would cover a further 28,000 ha. These proposals, in conjunction with the Jurien Marine Reserve would cover a total of approximately 44,500 ha, representing 15 % of the CWC marine bioregion and 24 % of the limestone reef system.

The Jurien Marine Reserve, at the indicative size in the MPRSWG report, would increase the percentage of the CWC marine bioregion that is incorporated within the statewide representative marine reserve system from the current three percent to nine percent. It would also increase the area of the limestone reef system that is protected and managed in multiple-use reserves from the current five percent to just over 14 % (Table 1).

Ecological importance of the Jurien Marine Reserve

Ecological information relating to the Jurien Marine Reserve and adjacent areas has been collected at several different spatial scales. The major inshore benthic habitats have been mapped for the area of state waters extending from north of the Beagle Islands to south of Cervantes, a distance of about 100 kms. This represents about 30 % of the CWC limestone reef system. Species diversity and primary productivity of the biological communities have been examined for a study area extending between Green Head and Cervantes, a distance of about 40 kms. The majority of sampling sites for this biological survey are concentrated within the indicative boundaries for the Jurien Marine Reserve, which extends along about 20 kms of coastline (Figure 3).

Benthic habitat mapping between the Beagle Islands and Cervantes revealed the presence of eight broad habitat categories, reflecting the relatively heterogeneous (diverse) nature of the CWC limestone reef system.

These habitat categories are:

1. Dense seagrass (10 % of total study area).
2. Sparse seagrass, <10 m depth (10 %).
3. Sparse seagrass, >10 m depth (1 %).
4. Sand, with sparse seagrass cover (7 %).
5. Shallow water limestone pavement (1 %).
6. Deep water limestone pavement (33 %).
7. Shallow water reef platforms (5 %).
8. Subtidal reef (33 %).

All major habitats need to be included within the boundaries of a marine reserve to ensure local representativeness and the conservation of local biological diversity and ecological processes.

The majority of the eight habitat categories within the Beagle Islands to Cervantes study area are well represented within the indicative area for the Jurien Marine Reserve (Figure 4). However, category 5 is not represented within this section of coast, and is restricted to the relatively protected nearshore waters inside the reef break. It occurs only at the northern end of the study area, adjacent to the mainland to the east and north of the Beagle Islands. Shallow water reef platform habitat (category 7) can be sub-divided into three different types: 1) outer break reef platforms; 2) fringing island reef platforms; and 3) shoreline reef platforms. The first of these two types of reef platforms are well represented within the Jurien Marine Reserve's indicative boundaries. However, shoreline reef platforms are represented only by a small area around North Head, which is known (from anecdotal evidence) to include some unique coral communities, including *Porites* bommies. By comparison, there are large areas of this third type of shallow water reef platform north of the indicative northern boundary of the reserve, both between Sandy Point and the area north of Green

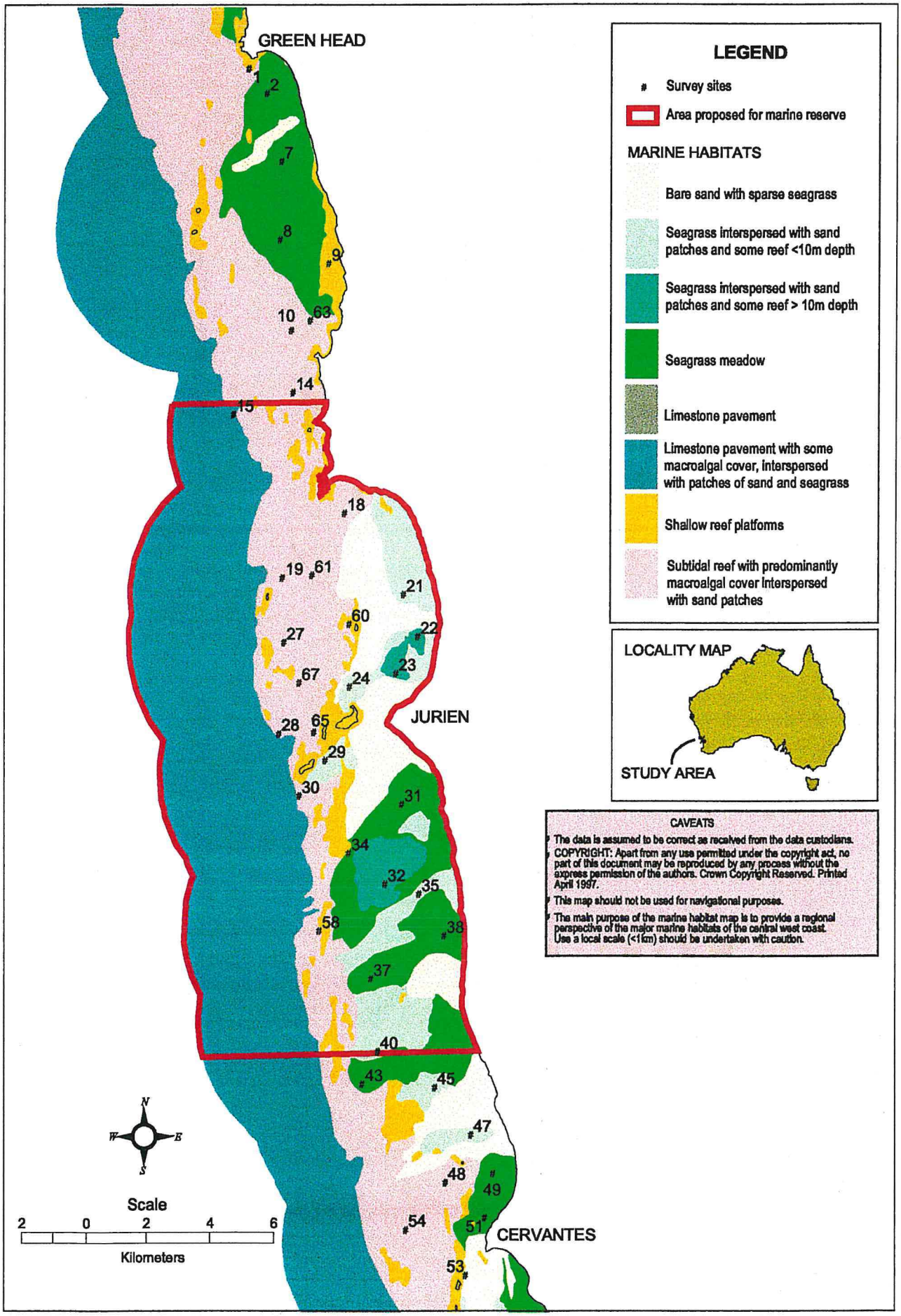

Figure 3. Location of sampling sites, and map of the major benthic habitat categories in the study area.

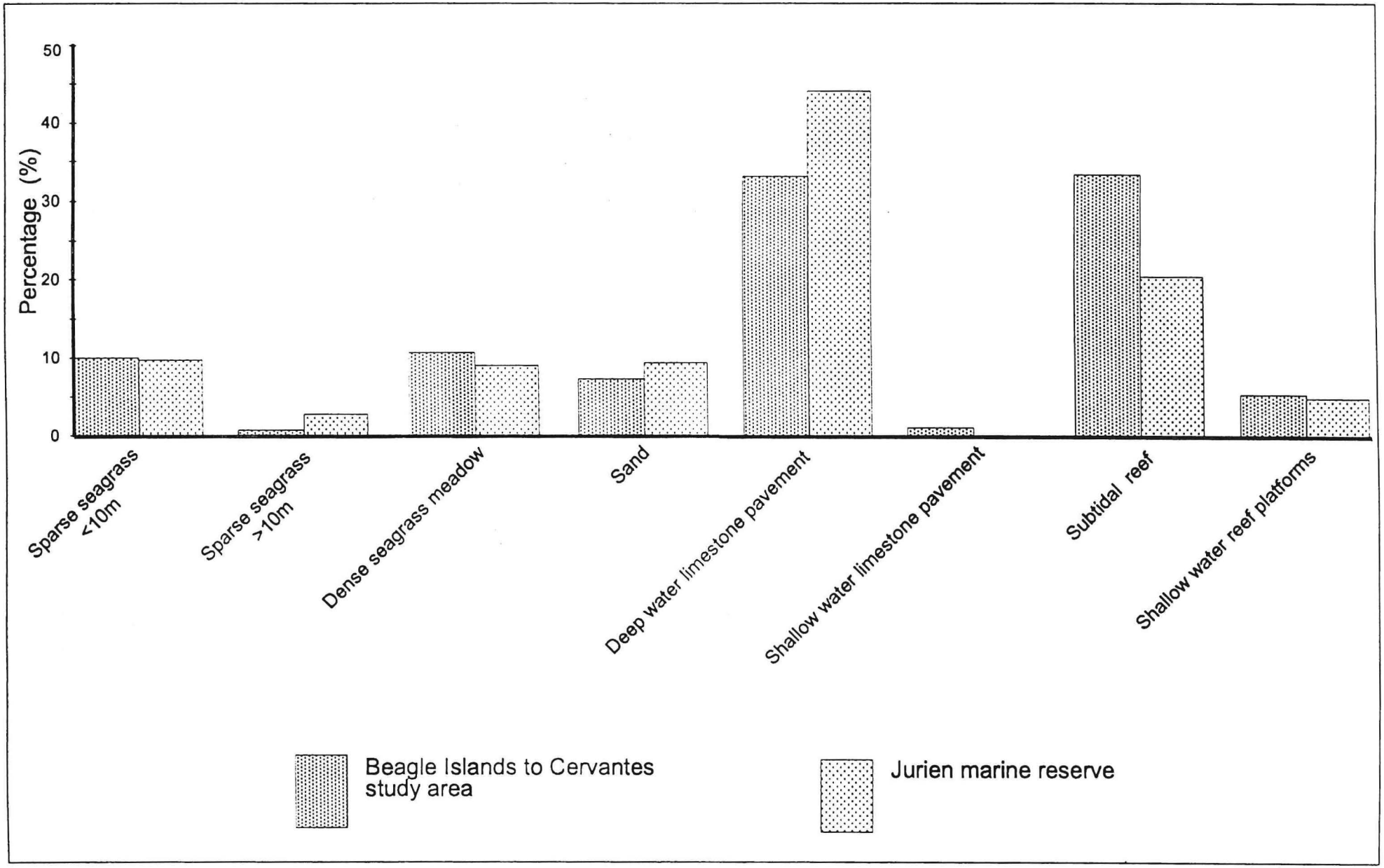

Figure 4: Representativness of the Jurien Marine Reserve - the relative areas of the major habitat categories

Head and along the shoreline adjacent to, and north of, Leeman.

Of the eight broad habitat categories described above, the only one found uniquely within the indicative area for the Jurien Marine Reserve (i.e. not found elsewhere in the Beagle Islands to Cervantes study area) is category 3 (sparse seagrass, >10 m depth). This habitat category is restricted to the two deep water basins, located in the southern part of Jurien Bay and to the south of Island Point, in the central area of the Hill River lagoon. Within the indicative boundaries for the reserve, category 1 habitat (dense seagrass meadows) is restricted to the Hill River lagoon area, extending from just south of Island Point down to a point just north of Black Point. Apart from the category 3 habitat discussed above, it is likely that the broad habitat categories found in the study area are highly representative of the entire CWC limestone reef system, and consequently are also highly representative of the biotic communities found on the Central West Coast.

The Jurien marine biological study was carried out, during April and May 1997, to obtain more detailed information on the visually obvious marine flora and fauna of the Jurien area. During the survey, a total of 39 sites were sampled in inshore waters between Green Head and Cervantes (Figure 3). The majority of these sites were located within the indicative boundaries of the marine reserve (23 sites), with eight sites sampled in the area north of the northern indicative boundary to Green Head and a further eight south of the southern indicative boundary to Cervantes (Figure 3). The majority of sampling sites were located in subtidal reef and seagrass meadow habitat (categories 1, 2 and 8), and no sites were sampled in the category 6 habitat (deep water limestone pavement) or category 7 habitat (shallow water reef platform), as a result of poor weather and sea conditions during the survey period. Preliminary analyses of survey results indicate that the varied habitats of the inshore limestone reef system supports diverse marine communities. A total of over 400 species were recorded, including nine species of seagrasses, 134 species of large algae, 205 invertebrate species and 63 species of fish. Approximately 35 % of the marine plants and animals recorded were tropical species.

Physical heterogeneity (diversity) of the seabed is an important issue when considering the conservation values of a candidate area. More physically varied areas support a wider range (species diversity) of biotic communities, than relatively homogeneous areas. As would be expected, for the visually obvious marine biota examined during the Jurien biological survey, the highest species richness was found in the subtidal reef habitat (329 species), followed by seagrass meadows (148 species) and bare sand (78 species).

Numerical analyses of algae and invertebrate data indicated that, for subtidal reef habitats, most sites across the study area were essentially similar in terms of species richness and diversity - i.e. sites at the northern end of the study area were as diverse and abundant, in species terms, as those in the central or southern areas. The same was found to be true of algae and invertebrate species richness and diversity in seagrass habitats. At the spatial scale of the study area (40 kms north to south), it would be unlikely to find any large scale differences in biological community diversity within each of the major benthic habitats. Finer scale differences in species diversity/abundance were found to occur between sites, and these relate to a number of different factors including water depth, seabed roughness, and wave exposure. Measurements of the biomass of algae and seagrasses throughout the biological survey area indicated that there were no obvious differences in primary productivity of the algal communities and seagrass meadows - i.e. sites at the northern end of the study area had similar algae and seagrass biomass values to those in the central or southern areas.

Unique or rare species

The endemic Australian sea-lion (*Neophoca cinerea*) breeds on several islands along the Central West Coast. Of these, the Beagle Islands, North Fisherman Island and Buller Island are the main pupping sites, with several very small colonies at the Abrolhos Islands. The species exhibits a 17-18 month, non-seasonal breeding cycle, with the four to five month pupping season synchronised at North Fisherman Island and the Beagle Islands (Gales, *et al.*, 1992). During the 1989 breeding season, the highest level of pup production was recorded at the Beagle Islands (79 pups), compared to 63 pups for

North Fisherman Island, 39 for Buller Island and an estimated 20 pups at the Abrolhos (Gales, *et al.*, 1992). Therefore, during that one season the North Fisherman Island colony accounted for approximately 30 % of pup production for the whole west coast population. Sea-lions breed one month later at Buller Island but do not breed on islands further south adjacent to the Perth metropolitan area. Seal, Carnac, Dyer, Little Islands and Burns Rocks are all haulout sites for sea-lions and it has been established, by paint-marking studies, that mature males (bulls) travel from these sites north to the Beagles, North Fisherman and Buller Islands during the breeding season, a distance of over 200 kms (Gales, *et al.*, 1992). The nearest breeding colony south of Buller Island is at Haul-off Rock on the south coast of Western Australia, a distance of approximately 1,000 kms, and it is believed that the west coast colonies of Buller, North Fisherman and the Beagles may represent a genetically separate sub-population (Gales, *et al.*, 1992).

The Australian sea-lion is listed as a "specially protected" species under the *Wildlife Conservation Act 1950*, in recognition of the view that it is an uncommon animal that is likely to have declined significantly in abundance after European settlement of Australia. Population estimates suggest that the total Australian population of this species is of the order of 10,000 to 12,500, with perhaps 2,600-3,400 in Western Australia (Gales, *et al.*, 1994). Of the Western Australian population, approximately 800-1,000 occur on the west coast and 1,900-2,400 on the south coast. At present, there are a total of 30 confirmed breeding sites for sea-lions in Western Australia (CALM, 1997b), and the Central West Coast breeding colonies of the Beagles, North Fisherman and Buller Islands are the main centre for this species on the entire west coast of the State.

These three locations have been identified as key sites for abundance monitoring of sea-lions in CALM's draft Pinniped Management Program (CALM, 1997b), as a result of their importance as breeding and haulout sites, their accessibility, the existence of relatively long-term records of pupping seasons and surveys for these locations, and the high levels of human activity in surrounding areas. The timing of breeding seasons for all known breeding sites throughout the sea-lion's breeding range (Western Australia and South Australia) is recorded relative to the breeding season at the reference colony, North Fisherman Island.

Implications for reserve design

The indicative western boundary of the Jurien Marine Reserve is delineated by the seaward limit of State waters (three nautical miles from the territorial sea baseline). The indicative northern and southern boundaries for the Jurien Marine Reserve, as outlined in the MPRSWG report (CALM, 1994), are shown in Figure 3. With reference to ecological criteria for reserve design there are a number of other boundary options that should be considered. These boundary options, which would result in the inclusion of additional areas within the reserve, are:

1. the extension of the northern boundary north to the area of Green Head, inclusive of the Fisherman Islands;

2. the extension of the southern boundary south to Black Point, inclusive of Outer Rocks; and

3. the extension of the southern boundary south to the area of Hansen Head, inclusive of Outer Rocks, Ronsard Rocks and the Cervantes Islands.

Options 1 and 3 represent areas of significant size compared to the area encompassed by the original indicative boundaries (16,600 ha - see Table 1). With regards to biogeographic representativeness, for example, the inclusion of the Fisherman Islands/Green Head area would increase the area of the Jurien Marine Reserve to approximately 27,850 ha. This would increase the area of the CWC marine bioregion in the marine reserve system from about nine percent to 13 %, and the area of the CWC limestone reef system in marine reserves from 14 % to 20 %. Extension of the reserve north towards Green Head would also increase the feasibility of extending the southern boundary of the Beagle Islands proposal, to connect it to the Jurien Marine Reserve. A combined Beagle Islands and Jurien marine reserve, inclusive of both of the indicative areas outlined in the MPRSWG report together with the area of State waters between them, would comprise a total area of approximately 50,200 ha, equivalent to about 18 % of the CWC marine bioregion and nearly 28 % of the CWC limestone reef

system (Table 2). Inclusion of the area south to the Cervantes Islands would result in a marine reserve of 60,000 ha in area, extending over about 100 kms of coastline and representing 21 % of the bioregion and about one third of the limestone reef system (Table 2).

The inclusion of the area between the northern indicative boundary of the Jurien Marine Reserve and Green Head would significantly increase the extent of category 1 habitat (dense seagrass) within the reserve, as it includes the extensive seagrass meadows between Sandy Point and Green Head. It would also increase the relative area of shallow water, shoreline reef platform within the reserve. From both ecological and management perspectives, boundaries for the reserve should not bisect large areas of major benthic habitat, as this makes it difficult to manage threats to, and competing uses of, that habitat. The southern indicative boundary divides the seagrass meadow just to the north of Black Point roughly in half (Figure 3). Moving the southern boundary further to the south would ensure that the entire area of this meadow is included within the reserve.

Several features of the Australian sea-lion's behaviour and breeding/feeding biology are significant when considering the possible inclusion of North Fisherman Island within the Jurien Marine Reserve. Sea-lions are particularly vulnerable to disturbance from humans at locations where they haulout to rest or breed, and there is also the potential for the species to come into conflict with some fishing activities. The disappearance of sea-lion breeding colonies from islands in the Perth metropolitan area is most likely due to the extermination of resident populations during the sealing activities of the early 1800's (Gales, *et al.*, 1992). The re-establishment of these colonies has not occurred as a result of their proximity to areas with high levels of human activity. North Fisherman Island is only seven kms from the settlement of Green Head and has a sheltered sandy beach, allowing easy access for small boats. By comparison, the Beagle Islands are more remote, lack easy access areas and consequently landings on the islands are relatively infrequent. In addition, female sea-lions (cows), when attended by their pups are highly aggressive if approached and there have been several attacks on the Central West Coast, some resulting in serious injuries.

During the pupping season the cows come ashore to give birth, leaving the new born pups when they are about 10 days old to return to the water for foraging trips. Research on sea-lion cows at Kangaroo Island in South Australia, has indicated that these feeding trips last from two to four days, the animals began diving as soon as they left the beach, spent 50-60 % of their time at sea

Area	Approximate size (ha)	Percentage of CWC marine bioregion (State waters)	Percentage of CWC limestone reef system
Jurien indicative northern boundary to Green Head	11,250	4.0	6.2
Jurien indicative southern boundary to Cervantes Islands	9,850	3.5	5.4
Jurien plus Green Head extension	27,850	9.8	15.3
Jurien plus Green Head and Cervantes extensions	37,700	13.2	20.7
Jurien plus Beagle Islands proposals	40,400	14.2	22.2
Beagle Islands to Jurien (incl.)	50,200	17.7	27.5
Beagle Islands to Cervantes Islands (incl.)	60,050	21.1	32.9

Table 2: Implications of boundary extensions for the Jurien Marine Reserve and Beagle candidate marine reserve area.

underwater where they appeared to feed predominantly on, or close to the sea bed (Costa, *et al.*, 1991). The cows tended to follow the sea bed contour out to shelf waters adjacent to the colony, where their dives reached an average depth of 67 m and a maximum depth of 92 m (Gales & Costa, 1997). The Australian sea-lion has a broad and perhaps largely opportunistic diet, with benthic and demersal fish, squid, octopus and crustaceans being well represented. It is believed that the west coast sea-lion population exhibits similar diving and feeding behaviour and prey selection to the South Australian animals (N. Gales, pers. comm.), although more research is required to gain a better understanding of the west coast sea-lion population. They are known to feed on the western rock lobster (*Panulirus cygnus*) (Gales & Cheal, 1992). It is likely that animals leaving North Fisherman Island will commence diving and feeding in the immediate vicinity of the island, and will continue to do so as they swim offshore. Therefore, the waters surrounding the Fisherman Islands could represent a significant feeding habitat for this animal.

Sea-lions are known to utilise the islands on which they breed at all times during their reproductive cycle, with maximum use occurring during the pupping season (Gales, *et al.*, 1992). The cows will continue to suckle their pups for 15-18 months and during this period the distance and duration of foraging trips increases until the cows return to land for the next breeding season. Pups will also generally remain at the island they were born on during this period, with pups over four to five months old starting to move further away, usually accompanied by their mothers. Pups tagged on North Fisherman Island have been found on Sandland Island (11 kms south) and North Essex Rocks (27 kms south). There is some evidence of negative impacts on the sea-lion population from the rock lobster industry, with occasional cases of pups and juveniles drowning in lobster pots (N. Gales, pers. comm.). It is apparent that the sea-lion maintains an asynchronous, non-seasonal 17-18 month breeding cycle that is unique to each of the breeding colonies (Gales, *et al.*, 1992). The non-seasonal cycle means that each of the Central West Coast breeding locations will, over the course of several years, be utilised for pupping and subsequent breeding throughout all months of the year.

Discussion

When considering the ecological criteria for the establishment of boundaries for marine reserves (such as representativeness, uniqueness, species or habitat rarity, and biological diversity) it is apparent that they should be applied at two different scales, both macroscale (regionally, nationally) and mesoscale (locally) (Emanuel, *et al.*, 1992). Local variability in communities may not show up on a broad regional scale, and conversely local variability may be so large as to obscure large-scale patterns. With regard to the criteria of representativeness, it would be misleading to select an area as a marine reserve solely on the basis that it is representative on a biogeographic scale, if that area contains only one or a few of the locally occurring habitat and community types. This could mean that the reserve was not representative on a local scale. Also, if the area is fully representative on a local scale its protection within a marine reserve should be viewed against the larger picture of regional, national, international and global needs for conservation (Emanuel, *et al.*, 1992).

From an ecological perspective, the relatively small spatial scale of the area encompassed by the indicative boundaries for the Jurien Marine Reserve dictates that, with these boundary options, the reserve's primary function will be the management of multiple-use in an ecologically sustainable framework. The maintenance of local biological diversity and ecosystem integrity, as well as the conservation of representative species and communities, will be secondary functions of this reserve. The scales of fundamental ecosystem processes, such as population replenishment, are so large that reserves of this size cannot hope to encompass them. In general, therefore, reserve designs should err on the side of protecting the largest possible area.

Similarly *no take* areas (sanctuary zones), within a reserve of the size delineated by these indicative boundaries, are likely to be too small to function as significant replenishment sources (an area that provides surrounding exploited areas with a source of larvae, spores and eggs). The primary function of sanctuary zones in this reserve will be the provision of monitoring sites that facilitate the investigation of natural levels of change in undisturbed habitats. These sites will also function as reference sites for

management. Certainly, in the longer term at least, the reserve will contribute to the maintenance of ecological integrity, particularly if other areas of the CWC limestone reef system, such as the Beagle Islands proposal, are included in the marine reserve system. The ecological integrity of the limestone reef ecosystem will be enhanced if reserves within the system are linked wherever possible. The biological connectivity (movement of adults and larvae, spores, eggs etc.) between these reserves will be further enhanced if adequate replenishment sources (i.e. appropriately sized sanctuary zones) are incorporated into the network of reserves.

Along the coast in this region, the three town sites of Jurien, Cervantes and Green Head represent the three focal points of human impacts on the inshore marine environment. The inclusion of the waters adjacent to each of these population centres would ensure improved (i.e. ecologically sustainable and equitable) management of existing and potential threats to the marine environment across this area of the Central West Coast. The inclusion of the waters surrounding the offshore island nature reserves of the Fisherman Islands, Outer Rocks, Ronsard Rocks and the Cervantes Islands would ensure that both terrestrial and marine environments are managed within an integrated management framework.

It is clear that North Fisherman Island and surrounding waters represents a highly significant habitat, particularly during the breeding season, for the Australian sea-lion. The exact status of the geographically isolated west coast population is unclear. Currently, it is not known whether numbers are gradually increasing but it is clear that the population has been, and will continue to be, placed under considerable pressure in terms of competition for available island habitat and for food resources (Gales, *et al.*, 1992), particularly as the population centres of Cervantes, Jurien, Green Head and Leeman continue to expand. North Fisherman Island is already part of the Fisherman Islands Nature Reserve, an 'A' Class Nature Reserve. Inclusion of the waters surrounding the Fisherman Islands within the Jurien Marine Reserve would further ensure that activities that potentially compete with this highly significant colony of sea-lions are placed within a multiple-use management framework, and that detrimental impacts on this population are minimised, wherever possible.

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