Dugong (*Dugong dugon*) Management Plan for Western Australia 2007 – 2016

February 2007

Department of
Environment and Conservation

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Department of Environment and Conservation
Locked Bag 104, Bentley Delivery Centre WA 6983

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PREFACE

The Western Australian Department of Environment and Conservation has a legislative responsibility to manage wildlife on DEC managed lands and waters under the *Conservation and Land Management Act 1984* and to manage fauna for conservation state-wide under the *Wildlife Conservation Act 1950*. DEC is committed to preparing and implementing written management programs for specially protected species with the objective of ensuring the species concerned are conserved and not threatened due to human activities.

The Department of Environment and Conservation also has a recreation policy, the objective of which is to facilitate the public enjoyment of the natural attributes of public lands and reserves waters in a manner that does not compromise conservation and other management objectives. Management of dugong interactions in marine reserves requires an integration of DEC's conservation and recreation objectives, and the principal role of DEC in this respect is to manage the commercial and recreational activities of visitors.

Management plans outline the management actions that are required to address those threats most affecting the viability of fauna and to begin the management process. The completion of performance measures and the provision of funds necessary to implement actions is subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Management plans do not necessarily represent the views or the official position of individuals or organisations represented on the management team.

This wildlife management program has been approved by the Director General, Department of Environment and Conservation, the Marine and Parks Reserves Authority and the Minister for the Environment. Approved Wildlife Management Programs are subject to modification as directed by new findings, changes in the status of species and completion of management actions.

This management plan was prepared by Tamra Chapman, Species and Communities Branch, Department of Environment and Conservation. Information in the management plan was accurate at 23 February 2007.

ACKNOWLEDGEMENTS

This management program was reviewed by Department of Environment and Conservation staff and other stakeholders and I would like to thank the following people for co-ordinating reviews: Kevin Bancroft; David Charles; Tim Grubba; Dave Holley; Alan Kendrick; Suzanne Long; Roland Mau; Bob Prince; Chris Simpson; Troy Sinclair; Fran Stanley and Ian Walker. Peter Mawson supervised the development of the management program and commented on drafts.

CONTENTS

1. INTRODUCTION

This management program has been developed by the Department of Environment and Conservation (DEC) in response to a recognition that the management of dugong is a high priority for marine conservation and management in Western Australia (Simpson and Holley 2003). Although dugong monitoring and research has been undertaken in Western Australia since the early 1980s (e.g. Prince *et al.* 1981; Prince 1986; Preen *et al.* 1997; Prince *et al.* 2001; Berson 2004; Gales *et al.* 2004; Holley *et al.* 2006), this work has not previously been conducted as part of a state-wide strategic approach to conservation management.

This management program sets down management actions that are required to meet the aim, but DEC acknowledges that: a). the management actions can not be achieved by DEC alone; b). parties other than DEC will be interested in participating in a co-operative approach to management; and c). some of the management actions and performance measures will have to be modified as part of the adaptive management process. The priorities and responsibilities for the management actions are set out in Section 8, but these may also change as new information is gathered as part of the management process.

The following list, which is representative, but not exhaustive, includes groups that are likely to be interested in dugong management in Western Australia, and willing to participate in a co-operative approach to management. Some of these groups are already undertaking dugong monitoring, management and research programs and it is hoped that the results of this work can be incorporated into a state-wide co-operative approach to adaptive management of dugong and their habitats in Western Australia.

The main parties that are likely to be interested in participating in this management program with DEC include: indigenous people and their representatives; universities; nature-based tourism operators; mineral exploration and mining companies; residential and tourism development companies; local government authorities; State and Commonwealth government departments; co-operative research centres and; Commonwealth government organisations such as Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Australian Institute of Marine Science (AIMS). The means by which these parties might be involved in the implementation of the Recovery Plan will be discussed by the Dugong Management Team.

2. CONSERVATION STATUS

2.1. International

All extant members of the Order Sirenia are listed as vulnerable to extinction on the IUCN Red List of Threatened Animals (Baillie *et al.* 2004). The dugong is listed on Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), requiring signatories to conserve and actively manage the species, and listed on Appendix I of the Convention on International Trade of Endangered Species, requiring signatories to prohibit international trade of the species (CITES 1973). Australia is a signatory to both these treaties.

Shark Bay was inscribed on the World Heritage List on 13 December 1991 (CALM 2006). World Heritage areas are sites that have universal quality which transcends national values and belong to the peoples of the world to pass on to future generations (UNESCO 1972; CALM 2006). They are areas with exceptional natural and/or cultural values. The international importance of these sites is recognised through their inscription on the World Heritage List, which was established by the World Heritage Convention. The World Heritage Convention aims to promote co-operation among nations to protect and conserve natural and cultural heritage of world wide importance (UNESCO 1972; CALM 2006).

2.2. National

The dugong is protected under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, under which it is listed as a marine and migratory species. Thus, it is an offence to intentionally or recklessly kill, injure, trade, keep or move dugong unless authorised by a permit. The Australian Department of the Environment and Heritage (DEH) can set guidelines and approval conditions to assess risk levels and mitigation measures associated with mining, exploration and industrial developments.

Many of the seagrass beds in Shark Bay that are important habitat for dugong are on the Register of the National Estate. The Register of the National Estate is compiled by the Australian Heritage Commission and is an inventory of natural and cultural heritage places of value for preservation. Under Section 30 of the *Australian Heritage Commission Act 1975*, the Commonwealth Government is prohibited from taking any action which would adversely affect a place in the Register, unless there are no feasible and prudent alternatives to the

action. This constraint on the Commonwealth may sometimes affect the decisions of other government or business organisations where a Commonwealth decision is required for foreign investment or export approval.

2.3. State

In Western Australian State waters, the dugong is protected under the provisions of the *Wildlife Conservation Act 1950* as 'Other Specially Protected Fauna' (Schedule 4, *Wildlife Conservation (Specially Protected Fauna) Notice*, 8 February 2005) and in the marine reserve system under the provisions of the *Conservation and Land Management Act 1984*. Marine reserves protect environmental values and facilitate management of environmental resources for long-term ecological sustainability and equitable human usage (CALM 1994). Protection is intended to conserve biological diversity and to sustain populations of plants and animals, natural features and ecosystems that are valuable heritage or economic resources, such as nature based tourism and fisheries (CALM 1994).

The Government of Western Australia has a four-tiered marine reserve system, three reserve types are proclaimed under the *CALM Act 1984*: Marine Nature Reserves, Marine Parks and Marine Management Areas (CALM 1994). The fourth category of marine reserve, Fish Habitat Protection Areas, is gazetted under the *Fish Resources Management Act 1994*. This system of marine conservation areas is vested in the Marine Parks and Reserves Authority of Western Australia. Within the reserve system, four management zones can be created: sanctuary zones, recreation zones, general use zones and special purpose zones (CALM 1994). While protection for dugong is the same in all marine reserve zones, this system of zoning may protect important dugong habitat within multiple-use marine reserves from being impacted by activities such as trawling or industrial development (CALM 2005).

Petroleum drilling and production are excluded from marine nature reserves and from sanctuary, recreation and certain special purpose zones in marine parks, but can take place elsewhere in marine parks in appropriate zones, subject to Environmental Protection Authority assessment (CALM 1994). Drilling for petroleum exploration and production is not permitted in the Commonwealth and State waters of Ningaloo Marine Park (Commonwealth of Australia 2002; CALM 2005).

Dugong may be taken (the definition of 'take' includes to kill or capture, disturb or molest) under certain circumstances and for certain purposes in Western Australia (*Wildlife*

Conservation Act 1950). These purposes include licenced scientific research (Regulation 17, *Wildlife Conservation Regulations 1970*). In addition, the *Wildlife Conservation Act 1950* states that "a person of Aboriginal descent" (as defined in Section 4 of the *Aboriginal Affairs Planning Authority Act 1972*) may take dugong sufficient only for food for himself and his family (Section 23(1)). Dugong may not be sold, given to persons outside of the hunter's family, or taken from a Marine Park, Marine Nature Reserve or Marine Protected Area without a licence (Section 23(1) *Wildlife Conservation Act 1950*). In Western Australia, the governor may suspend or restrict the taking of dugong where harvesting is likely to cause the undue depletion of the species, or where the quantities taken exceed the amount required to feed an Indigenous person and the family of that person (Section 23(1) *Wildlife Conservation Act 1950*). Regulation 63 of the *Wildlife Conservation Regulations 1970* states that section 23(1) of the Act is suspended in respect to the taking of fauna which is likely to become extinct, or is rare or otherwise in need of special protection, other than dugong, turtle and crocodile.

3. BIOLOGY AND ECOLOGY

3.1. Taxonomic relationships

The dugong *Dugong dugon* is the only living species of the Family Dugongidae. The only other species in this Family was the Steller's Sea Cow *Hydrodamalis gigas*, which was hunted to extinction within 27 years of first being described from specimens collected in the northern Pacific in the 1700s (Stejneger 1887). The Order Sirenia comprises the families Dugongidae and Trichechidae. Manatees *Trichechus* spp.are confined to freshwater environments.

3.2. Description

The dugong is a large bulbous marine mammal with a horizontal fluke-like tail and paddle-like pectoral flippers (Nishiwaki 1972). The thick caudal peduncle (tail stem) and tail fluke are used for propulsion and the flippers are used for orientation and support on the sea floor (Nishiwaki 1972). The heavy bone structure of the dugong acts as a neutral buoyancy control and probably protects their vital organs during shark attacks (Anderson 1981). The neck is short and thick, limiting horizontal, vertical and rotational mobility of the head (Nishiwaki 1972; Anderson 1981).

Adults range from 2.2 to 3.1 m in length and 200 to 400 kg in weight (Nishiwaki 1972). Calves range from 1 to 1.2 m in length and 20 to 35 kg in weight at birth (Nishiwaki 1972; Marsh *et al.* 1984a). The skin of the dugong varies in colour from slaty grey to bronze to dark brown dorsally and the ventral parts are paler in colour (Nishiwaki 1972). Calves are usually paler than adults and darken as they mature (Nishiwaki 1972).

The eyes and ears of the dugong are small and the ears have no pinnae or outer ears (Nishiwaki 1972). While the eyesight of the dugong is considered poor, its hearing is considered excellent (Anderson and Barclay 1995). Dugong make whistling and chirping sounds that are audible to the human ear, and various hypotheses have been developed about the vocalisations (Anderson and Barclay 1995). Vocalisations may play a role in both the diurnal and nocturnal social organisation of the herd (Anderson and Barclay 1995).

The position of the nostrils on the snout allows the dugong to inhale air at the surface in calm water, but in rough sea conditions, it must position itself more vertically to breathe (Anderson and Birtles 1978). Dugong can probably hold their breath underwater for 8 to 11 minutes before they must surface for air (Anderson 1981; Anderson 1982; Smith 1989; Chilvers *et al.* 2004). The rostrum and mouth are directed downwards and this is presumably an adaptation to a diet of seagrass (Anderson 1981). The stiff whiskers which grow around the mouth are used to locate food (Marshall *et al.* 2003). The strong upper lip is used to harvest food, which is then ground by the rostra disk; a modified mouth structure of opposing horny pads on the lower lip (Marshall *et al.* 2003). The second pair of upper incisors grow continuously throughout life in both sexes and erupt to form chisel-like tusks which subsequently wear in 'teenage' males (approximately 14 to 17 years) and older females (Nishiwaki 1972).

The sex of individual dugong is difficult to determine under field conditions, but the relative position of the anus and genital opening provide visual evidence (Nishiwaki 1972). The umbilicus, anus and genital openings are located on the underside of the body and the anus is situated approximately two-fifths from the rear of the body (Nishiwaki 1972). In females, the genital opening is close to the anus and a single pair of mammary glands are located behind the pectoral flippers, but these are obscured when the flippers are folded against the body (Nishiwaki 1972). The appearance of these glands varies with maturity and sexual state and thus may be difficult to identify (Marsh and Glover 1981; Marsh *et al.* 1984b; Marsh *et al.* 1984c). In males, the penis is usually withdrawn into the body and the opening is about

halfway between the umbilicus and the anus (Nishiwaki 1972). The testes are located within the abdomen (Nishiwaki 1972).

3.3. Diet and feeding

Dugong feed primarily on seagrasses and their preferences appear to be based on the chemical and structural composition of the seagrasses (Lanyon 1991; Lanyon 1992; Marsh *et al.* 2002). They prefer seagrasses that are low in fibre and these are usually the ephemeral species that regenerate rapidly following disturbance (Lanyon *et al.* 1989; Preen 1993a; Preen 1993b). A study by Preen (1993a) in Moreton Bay, QLD found that dugong selected seagrass species in the following order of preference: *Homophile ovals; Halladale unnerves; Homophile spinals; Syringodium isoetifolium;* and the broad-leaf form of *Zostera capricorni*. Less favoured seagrasses and marine algae are also eaten, but probably only when favoured seagrasses are scarce (Spain and Heinsohn 1973; Anderson 1982; Lanyon *et al.* 1989).

Dugong are primarily dependent on particular seagrass habitats for food (Preen 1993b). They consume 25 to 40 kg of seagrass per day (Marsh *et al.* 1982; Lanyon *et al.* 1989) and may consume more than this (up to 156 kg per day) at times of year when favoured seagrasses are abundant (Masini *et al.* 2001). They will remove and eat both the above ground stem and leaves and the below ground rhizome of their favourite species, leaving long feeding trails (up to 8m long and 19 to 26 cm deep) winding through seagrass beds (Lanyon *et al.* 1989). Dugong will also eat less favoured seagrasses, with high fibre content, such as *Amphibolis antarctica*, but only the softer leaf cluster in the canopy is removed, leaving the stem and rhizomes (Anderson 1982; Lanyon *et al.* 1989). Dugongs sometimes concentrate their feeding in favoured seagrass habitat for long periods of time (up to 35 days), reducing the standing biomass of seagrass by as much as 95% (Preen 1993b; Masini *et al.* 2001). This selective 'cultivation grazing' influences the species composition, age structure and nutrient status of the seagrasses (Preen 1993b; Masini *et al.* 2001).

In the Darwin region, dugong have been observed feeding on patches of macro-algae on shallow intertidal rocky reefs (Whiting 2002). They may also deliberately forage for macro-invertebrates such as ascidians, polychaete worms, sea pens and mussels near the southern limits of their range (Anderson 1989; Preen 1993a). However, stomach and faecal samples suggest that dugong do not deliberately forage on macro-invertebrates in the more tropical areas of Australia (Preen 1993a).

3.4. Habitat

Habitat use by the dugong is associated with the distribution of their favoured seagrasses (Nishiwaki 1972) as well as other environmental factors. While dugong are commonly found in protected inshore areas and are most commonly encountered less than 3 m from the water surface (Chilvers *et al.* 2004), they may also be observed off-shore in deeper water (Marsh *et al.* 2002). For example, in the Torres Strait, significant numbers of dugong have been seen more than 10 km from land in shallow water, and in north Queensland, dugong were recorded approximately 58 km offshore in water up to 37 m deep (Marsh and Sinclair 1989; Marsh and Saalfeld 1991; Marsh *et al.* 2002). In the southern parts of their range (Shark Bay and Moreton Bay), dugong appear to use deeper waters as a thermal refuge (>18°C) from the cooler inshore waters during the winter months (Preen 1993a; Anderson 1994a; Marsh *et al.* 1994; Preen *et al.* 1997). Other factors that may influence the use of an area for habitat by dugong include predator avoidance, lekking sites, the presence of other animals and human activities (Hodgson 2004).

3.5. Life history

Much of the information on the demography of dugong has been obtained from animals that have beached or been taken by indigenous hunters, because the animals are difficult to observe in the field (Hodgson 2004). The methods used to obtain information as part of salvage operations and post mortems are discussed in a number of published accounts (Marsh 1981b; Marsh and Glover 1981; Marsh *et al.* 1984a; Marsh *et al.* 1984b; Marsh *et al.* 1984c; Marsh 1986). Age has been estimated by counting growth layers in the dentine of the tusks, but the tusks of males, and sometimes older females, become exposed and worn on the ends so that only a minimum age can be estimated (Marsh *et al.* 2002). The use of this technique thus results in a bias towards younger animals (Marsh *et al.* 2002).

The age frequency distribution of dugong populations can be modelled using a combination of behavioural studies and salvage analysis (Marsh 1986; Anderson 1994b). In Queensland, aerial surveys can usually identify the sex of animals because males are generally solitary, while females and calves are found in herds (Marsh 1986; Anderson 1994b). However, neither technique provides accurate information on the age structure of a population (Marsh 1986; Anderson 1994b). In addition, the allocation of sex to animals on the basis of herds may not apply in Western Australia, where mating behaviour consistent with lekking has been observed (Anderson 1997; Marsh *et al.* 2002). When lekking, males aggregate in display

areas that lack resources required by females and females visit the site exclusively to mate (Anderson 1997).

Dugong are long lived, have a low reproductive rate, a long generation time and invest considerable time and energy in raising young. They may live for up to 70 years in the wild (Marsh *et al.* 1984a). Dugong can begin to breed at nine years of age, but may be 17 years of age before they produce young (Marsh *et al.* 1984a). Females may have a number of sterile cycles during sexual maturation before pregnancy results (Marsh *et al.* 1984a; Marsh *et al.* 1984c). Males have a seasonal cycle of sexual activity, but not all males in the same area will be sexually active in a given period (Marsh 1981a). Males may experience long periods of sexual inactivity and for some individuals this occurs for the bulk of their adult lives (Marsh *et al.* 1984a; Marsh *et al.* 1984b). Mating behaviour varies between regions. For instance, males compete for oestrous females in northern Queensland (Marsh *et al.* 1999), but in South Cove in Shark Bay, dugong display lekking behaviour (Marsh *et al.* 2002).

The gestation period is 13 to 14 months, females usually have one calf per pregnancy and the period between calving varies from 3 to 7 years (Marsh 1986; Lanyon *et al.* 1989; Marsh *et al.* 2002). Although it begins grazing within a few weeks of birth, the calf also suckles for at least 18 months (Heinsohn 1983; Marsh *et al.* 1984a). From Townsville to Cairns and Mornington Island in the Gulf of Carpentaria (Queensland), dugong births occur from August to December (Lanyon *et al.* 1989). Reports of dugong giving birth in shallow and/or sheltered areas suggests that they may seek special areas for calving, possibly to avoid shark predation (Anderson 1981; Marsh *et al.* 1984a). Dugong herds may also employ protective group strategies against predators such as sharks (Hodgson 2004) and dolphins (Anderson 1981; Anderson 1982).

For 31 female dugong examined, a maximum of seven placental scars were found on the uterine walls of an individual aged 41 years, and nine scars were found on the uterine walls of one individual in Papua New Guinea (Marsh *et al.* 1984a; Marsh *et al.* 1984c). The proportion of dependent juveniles in Australian populations, determined from dedicated aerial surveys, ranges from 3% to 24% with no apparent median (Marsh *et al.* 1984a; Marsh *et al.* 1994).

The life history of the dugong makes its population(s) vulnerable to juvenile and adult mortality (Marsh 1995; Boyd *et al.* 1999; Berson 2004). Even a slight reduction in survivorship as a result of habitat loss, disease or drowning in nets can result in a chronic

population decline (Marsh *et al.* 2003). The sustainability of dugong populations may be lower where the reproductive period or calving interval is affected by food shortage and reduction in feeding time due to disturbances (Marsh *et al.* 2003). Food shortage can result from habitat loss due to severe weather events such as cyclones, or anthropogenic effects such as dredging, scallop fishing, seagrass dieback and nutrient changes (Marsh *et al.* 2003).

Population models have shown that even under ideal conditions and with a low mortality rate, dugong populations are unlikely to increase by more than 5% per year (Marsh 1995; Boyd *et al.* 1999). Natural and human induced mortality could reduce this growth rate to less than 1% of females per year, which is probably not sustainable and thus, is likely to result in a population decline (Marsh *et al.* 1984a).

4. DISTRIBUTION AND ABUNDANCE

4.1. Global

Globally, the dugong occurs between about 26° N and 27° S of the equator and its distribution includes at least 37 tropical and subtropical coastal and island countries (Nishiwaki and Marsh 1985). Dugongs occur from the east coast of Africa, throughout the Indo-Pacific region and on the north coast of Australia (Figure 1; Nishiwaki and Marsh 1985). Population dynamics are unknown for any country (Marsh *et al.* 2003), but Australia is considered to be the nucleus of the world's population (Marsh and Lefbvre 1994), primarily because other populations have declined and become fragmented (Marsh and Lefbvre 1994).

Molecular techniques, based on rapidly-evolving mitochondrial DNA, have been used to examine the structure of global dugong population(s) (Marsh *et al.* 2002). Preliminary results suggest that the haplotypes of dugongs from parts of southeast Asia (Indonesia, Thailand and the Philippines) are generally distinct from those from Australia, with an overlap at Ashmore Reef between Western Australia and Timor (Tikel 1997). This suggests there has been limited genetic exchange between dugong population(s) in Australia and Asia (Tikel 1997).

4.2. National

Aerial surveys of dugong populations in Australian waters indicate that around 85,000 dugong occur in the inshore waters of northern Australia (Marsh *et al.* 1999). The dugong occurs in northern Australian coastal waters (Marsh and Lefbvre 1994; Marsh *et al.* 1999) from Shark

Bay in the west to Moreton Bay in the east (Figure 2). It has also been recorded in the warm estuarine waters of New South Wales, north of Sydney (Allen *et al.* 2004).

Genetic studies have identified two distinct groups of dugongs in Australian waters. One group is geographically restricted to the coast of Queensland and into the Northern Territory (McDonald *et al.* Unpublished manuscript). Another widespread group occurs from Shark Bay in Western Australia to Moreton Bay in Queensland, across the entire range of dugong in Australia (McDonald *et al.* Unpublished manuscript). The group with restricted lineage has lower haplotypic diversity and nucleotide diversity than the group with widespread lineage (McDonald *et al.* Unpublished manuscript). These lineages most likely diverged during historical periods of low sea levels that would have reduced habitat for dugongs and produced geological barrier(s), such as the Torres Strait land bridge between northern Australia and Papua New Guinea (McDonald *et al.* Unpublished manuscript). Dugongs on the Sahul Banks (see Figure 3) are likely to be isolated from other groups by distance to the south and deep water to the north (Whiting 1999). Analysis from a single animal from Ashmore Reef has shown that these animals have a closer relationship with Asian than Australian dugong (Whiting 1999).

4.3. State

In Western Australia, the dugong occurs from Shark Bay to the Northern Territory border (Figure 2; Marsh *et al.* 1999). Shark Bay has Western Australia's and the world's largest population of around 13,000 dugong (Table 1). Surveys for dugong have been conducted for Shark Bay, Ningaloo Reef and Exmouth Gulf and the Pilbara coast (Table 1). The efficacy of aerial surveys from Port Hedland to the Kimberley coast is poor as a result of high water turbidity (Marsh *et al.* 1999) and consequently, the number, distribution and movements of dugong in these regions is poorly known (Marsh *et al.* 1999).

Surveys of the distribution and abundance of dugong in Ningaloo Reef and Exmouth Gulf found that the animals were mostly sighted on the eastern side of Exmouth Gulf (Preen *et al.* 1997) and coincided with the distribution of seagrass beds consisting of *Halodule* and *Halophila* (Marsh *et al.* 2002). The small number of dugong recorded in 1999 (Table 1) probably reflects the destruction of seagrass beds by tropical cyclone Vance in March 1999 (Prince *et al.* 2001).

A survey of the Pilbara coastal and offshore region (Exmouth Gulf to De Grey River) in 2000 (Table 1) estimated the dugong population in this area to be around 2,000 (Prince *et al.* 2001). This area has extensive areas of potential dugong habitat and coverage of seagrass meadows (Marsh *et al.* 2002). Dugong feeding trails have also been seen in beds of *Halodule* containing *Halophila* and *Cymodocea* between Middle and North Mangrove Islands (Pendoley and Fitzpatrick 1999).

Little is known about the distribution and abundance of dugong along the Kimberly coast, but small concentrations of dugong have been observed (Prince 1986). Dugong, including calves, have been recorded at Ashmore Reef on the Sahul Banks, north of the Kimberley coast (Whiting 1999), and a single adult has been recorded at Christmas Island, more than 120 km from the nearest major land mass (DEC, unpubl. data).

Table 1 Number and density (± s.e.) of dugong recorded in Western Australian coastal waters during aerial surveys.

Location	Date	Area	Population estimate	Density per km^2	Reference
Shark Bay	1989	14,906	10,146 ± 1,665	0.71 ± 0.12	(Marsh *et al.* 1994; Preen *et al.* 1997)
	1994	14,906	10,529 ± 1,464	0.71 ± 0.10	(Preen *et al.* 1997)
	1999	11,86	13,929 ± 1,652	0.98	(Gales *et al.* 2004)
	2002	14,905	11,021 ± 1,357	0.74	(Holley *et al.* 2006)
Ningaloo Reef and Exmouth Gulf	1989	3,735	1,696 ± 3,453	0.45 ± 0.09	(Preen *et al.* 1997)*
	1994	4,049	1,974 ± 588	0.49 ± 0.40	(Preen *et al.* 1997)
	1999	843	337 ± 115 (mean of two data points)	0.05	(Gales *et al.* 2004)
Exmouth Gulf	2004	273	441	1.6	(Jenner and Jenner 2004)
Pilbara Coast	2001	205	2,046 ± 376	0.10	(Prince *et al.* 2001)

* Only the northern half of Ningaloo Reef was surveyed in 1989.

Movements

Dugong appear to move in response to changes in the availability of seagrass forage (Marsh *et al.* 1994; Preen *et al.* 1997) and environmental factors such as temperature (Anderson 1986; Holley *et al.* 2006). For example, dugong moved to the deeper waters of Hervey Bay in Queensland during flooding events in 1999 due to increased turbidity and seagrass loss (Marsh *et al.* 2002).

The patterns of dugong movement in Western Australia are not well understood, but are the subject of study via radio-telemetry and satellite GPS technology (Gales *et al.* 2004). In the

Shark Bay area, the distribution and abundance of the dugong population appears to shift northward and westward on a seasonal basis (Anderson 1986; Holley *et al.* 2006). Surveys have indicated that in winter, dugong occur in the warmer waters of the western gulf of Shark Bay (Marsh *et al.* 1994; Preen *et al.* 1997). In the summer of 2002 summer, the distribution shifted south and east to Henri Freycinet Harbour and Hamelin Pool (Holley *et al.* 2006).

Some evidence has also been collected to show relatively large scale movements of dugong in Western Australian waters. For instance, in Shark Bay, the population increased by 40% from an estimated 10,000 in 1989 and 1994 (Marsh *et al.* 1994; Preen *et al.* 1997) to around 14,000 in 1999 (Gales *et al.* 2004). Gales *et al.* (2004) concluded that the most likely explanation for this was that the population had shifted south from Exmouth Gulf and Ningaloo Reef due to loss of seagrass habitat as a result of Tropical Cyclone Vance in March 1999. In support of this hypothesis, the population in Exmouth Gulf and Ningaloo Reef declined from around 1,000 in 1989 and 1994 (Preen *et al.* 1997) to only 337 animals in 1999 (Gales *et al.* 2004) and 441 in 2004 (Jenner and Jenner 2004).

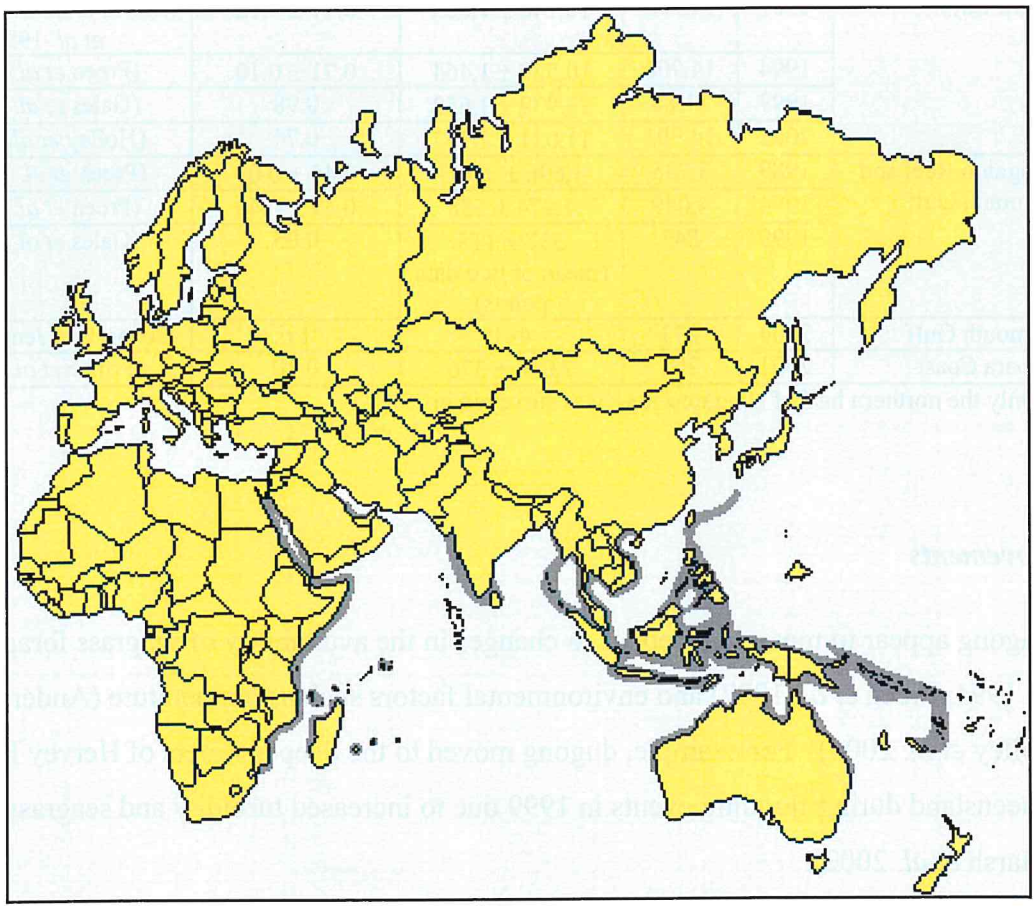

Figure 1 Global distribution of the dugong *Dugong dugon* (modified from Marsh *et al.* 2002).

Figure 2 Western Australia showing the regions in which dugong occur (modified from Marsh *et al.* 2002).

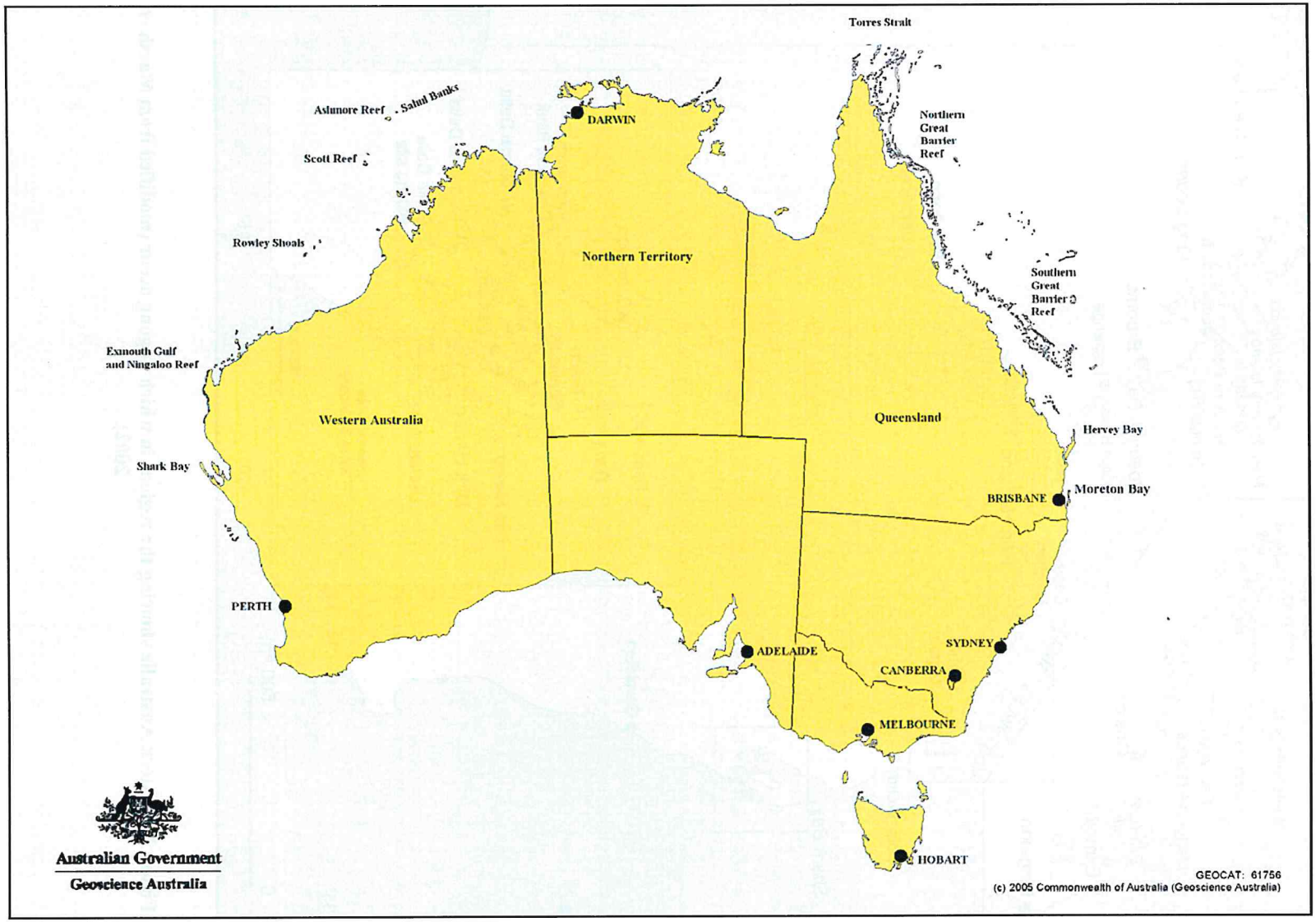

Figure 3 Map of Australia showing locations mentioned in the text.

5. PROGRAM MANAGEMENT, EVALUATION AND REVIEW

The implementation, evaluation and review of this management plan will be carried out by a Dugong Management Team. The team will include, but not be restricted to, DEC staff representing: the Science Division; the Nature Conservation Division (Species and Communities Branch and Marine Policy and Planning Branch); Parks and Visitor Services Division; and DEC Districts and Regions. The management actions required under this program, and the coastal waters within the range of dugong have been divided into five Dugong Management Units, shown in Table 2.

Table 2 Dugong management units as illustrated in Figure 4.

Management Unit	Number	Location	DEC Region	DEC Office
Shark Bay	1	Emu Proof Fence to Amherst Point	Midwest	Shark Bay
Exmouth	2	Amherst Point to the Ashburton River, including Exmouth Gulf and Ningaloo Reef	Pilbara	Exmouth
Pilbara	3	Ashburton River to Shire of East Pilbara's eastern boundary (approximately 30 km east of Cape Keraudren)	Pilbara	Karratha
West Kimberley	4	Shire of East Pilbara's eastern boundary to Doubtful Bay	Kimberley	Broome
East Kimberley	5	Doubtful Bay to the Northern Territory border	Kimberley	Kununurra

The Dugong Management Team will:

1. Conduct a risk assessment for the management issues (threats) for each of the DEC regions and the State of Western Australia.

2. Set priorities for the management actions.

3. Establish and maintain contact with interested parties to maintain a cross-regional, cross-cultural adaptive management approach to the management of dugong in Western Australia.

4. Determine interested parties who may take responsibility for conducting each of the management actions.

5. Set time frames for the completion of the management actions.

6. Cost the management actions.

7. Seek the funding required to complete the management actions.

8. Ensure that the management actions are commenced, carried out and completed within the set time frames.

9. Evaluate progress on management actions and modify the approach as part of an adaptive management process.

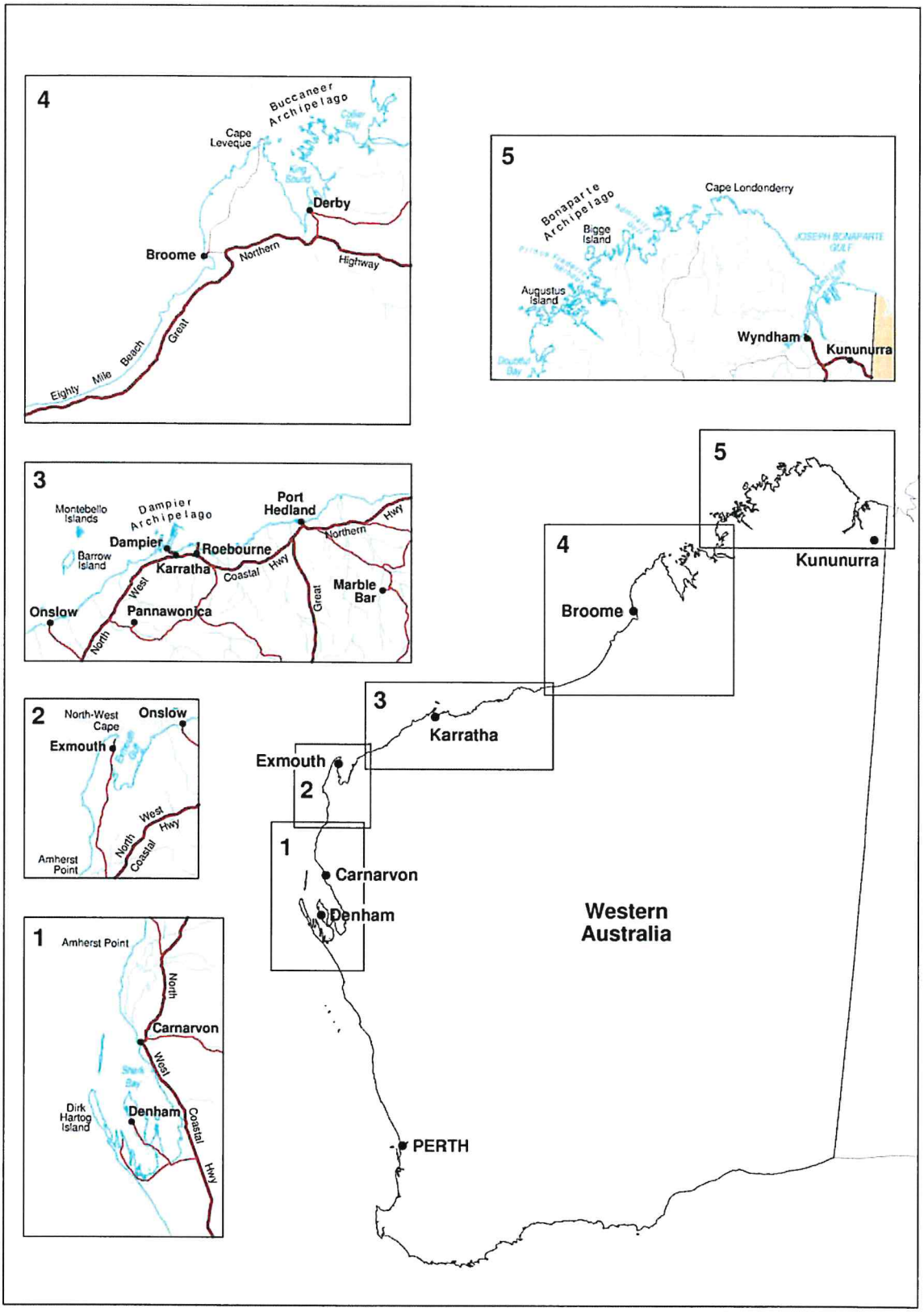

Figure 4 Dugong management units for Western Australia.

6. AIMS

The broad aim of this plan is to maintain a viable dugong population throughout its present range in Western Australia. The management actions outlined in this plan will ensure that human activities are not detrimental to the long-term conservation and viability of the dugong throughout its range, and in particular, Western Australian waters. The specific aims are to:

1. Gain a thorough understanding of dugong population size(s), distribution, composition, movements, habitat use and relatedness.

2. Produce an atlas of important habitats for dugong.

3. Predict, monitor and manage the effects of climate change on dugong in Western Australia.

4. Minimise the incidence of boat strike, incidental mortality, disturbance and displacement of dugong due to private and commercial marine vessel activity.

5. Provide adequate protection for dugong and their habitat in marine reserves.

6. Minimise the impact of recreational and commercial fishing bycatch and fishing debris on dugong.

7. Minimise the impacts of industrial, residential and tourism development on dugong and their habitat.

8. Ensure that the use of dugong for traditional and cultural purposes is sustainable and minimise illegal harvest.

9. Provide educational materials on the biology, ecology and conservation needs of dugong to the wider community.

7. MANAGEMENT ACTIONS

Each of the following management actions begins with a statement of what work must be undertaken to achieve the aims. This is followed with an explanation of how this work will contribute to our understanding of the threats to dugong in Western Australia. Gaps in our

knowledge are then identified and the possible means of collecting this information are discussed. Specific management actions are then listed, followed by simple performance measures that can be used to monitor the progress of the management actions.

7.1. Survey, monitor and study dugong population(s).

Research into dugong population(s) is required to determine population size(s), composition, habitat use and movements in Western Australia. This information will allow managers to detect temporal and spatial changes in population(s) and will assist in the setting of management priorities.

At present, little is known about the size, demography, habitat use and movements of dugong in Western Australian waters. Studies of dugong numbers and movements have been carried out for limited areas of Western Australia; principally the Shark Bay and Exmouth Gulf – Ningaloo Reef areas (see Sections 3.4 and 4.3). However, a state-wide program is needed to set priorities for survey and monitoring of dugong population(s) in Western Australian waters.

The techniques that can be used to achieve this management action will be constrained by a range of factors, including environmental conditions, funding, co-ordination of personnel and access to expertise. Thus, development of a dugong population research program will require close consultation with local communities, indigenous communities and their representatives and researchers, such as those based at the School of Tropical Environmental Studies and Geography based at James Cook University, QLD and the Great Barrier Reef Marine Park Authority, QLD.

The established techniques used to survey and monitor dugong populations are aerial surveys, tracking studies, genetic profiling and data collection as part of stranding and salvage operations. Records of opportunistic sightings may also be collected during other activities such as DEC patrols, recreation, tourism, indigenous hunting and marine research projects.

Aerial surveys

In Western Australia, aerial survey techniques have successfully been applied in the Shark Bay and Exmouth Gulf - Ningaloo Reef areas (Preen *et al.* 1997). The composition, distribution and demography of the population varied in response to seasonal changes in water temperature in Shark Bay (Holley *et al.* 2006) and probably also the Exmouth Gulf - Ningaloo Reef area (Preen *et al.* 1997). Summer surveys are therefore required to complement the

winter data (Holley *et al.* 2006). However, water and weather conditions make summer surveys more difficult than winter surveys (Holley *et al.* 2006). Aerial surveys are most likely to detect small and large scale changes in distribution if conducted in summer and winter, at five year intervals (Marsh *et al.* 2002; Holley *et al.* 2006).

The efficacy of aerial surveys in the Kimberley management units is likely to be variable as a result of water turbidity (Marsh *et al.* 1999) and the mega-tidal, semi-diurnal tidal regime. Previous observations have been made as part of Australian Coastwatch surveillance aircraft activities (Whiting 1999; Prince *et al.* 2001) and there may be opportunities to develop a program of recording sightings as part of aircraft and vessel based coastal surveillance in this region. Complex corrections for environmental conditions and the diving behaviour of dugong have been formulated (Marsh *et al.* 1994), but these were developed in Moreton Bay in Queensland, and since conditions may differ in the Kimberley region, these may require adjustment. The efficacy of aerial surveys in the Pilbara management unit has not previously been assessed.

A program of regular aerial surveys of dugong is needed for more extensive, but selected, areas of Western Australia where dugong are known to occur in each of the dugong management units. Guidelines for Improving the Accuracy of Aerial Surveys for Dugongs over large areas have been produced by the Australian Fisheries Management Authority (Pollock *et al.* 2006) and should be incorporated into survey design where appropriate.

Tracking studies

Techniques for Conventional and Satellite Radio Tracking Techniques for Studying Dugong Movements and Habitat Use have been developed (Marsh and Rathbun 1990) and these may have application in Western Australia. Patterns of large-scale movement by dugong between the Shark Bay and Exmouth Gulf - Ningaloo Reef areas are beginning to emerge as a result of aerial surveys and tracking studies involving radio-telemetry and satellite GPS technology (Gales *et al.* 2004). However, more extensive long-term studies are required to confirm small and large scale movements and to identify the factors influencing dugong distribution, movements and habitat use in Western Australia (Holley *et al.* 2006).

Opportunistic observations

Dugong sightings could be recorded via questionnaire surveys or record data sheets as part of other activities in Western Australia. Potential sources of information include aircraft or

vessel operators involved in the following activities: recreational and commercial tourism; coastal surveillance; fishing; aquaculture; fauna surveys for coastal residential and industrial development proposals; activities of indigenous persons; patrols by DEC Wildlife Officers; marine research etc. Any program of recording opportunistic observations will have to be well planned, co-ordinated, executed, managed and evaluated in each of the management units. The program must also include a means of regular analysis and reporting of data via a centralised database.

Genetic profiling

At present the relationship between dugong in Western Australia, other parts of Australia and other parts of the world is not known. Preliminary studies suggest dugongs from parts of south-east Asia are generally distinct from those from Australia, with overlap at Ashmore Reef between Western Australia and Timor (Tikel 1997). Microsatellites are currently being used to identify individuals, estimate relatedness within herds and indicate the amount of male-mediated gene flow between Australian populations (McDonald *et al.* Unpublished manuscript). Genetic studies have thus far identified two distinct groups of dugongs in Australian waters and these data are summarised in Section 4.2. The results of this study will allow for the identification of large areas of coastal habitats important for the sustainability of the dugong population in Australian waters (McDonald *et al.* Unpublished manuscript).

Studies of genetic variation for Western Australian dugongs would be useful to determine which populations or meta-populations may be inter-related and which are isolated. This will help to establish which populations or meta-populations may be more likely to be impacted by local threatening processes and which may travel long distances and thus be affected by threatening processes in other regions. This information will be useful for the identification of important habitats for conservation. Genetic profiling for dugong can be achieved via skin samples collected as part of genetic research programs, strandings or indigenous take (Marsh *et al.* 2002) or by collecting faecal samples from feeding trails (Tikel *et al.* 1996).

Stranding and salvage

Data collected from stranded animals and dugong carcasses can provide information on life history, feeding biology, genetic structure of populations and the effects of factors such as contaminants, heavy metals, diseases, parasites and habitat change (Eros *et al.* 2000). A stranding and salvage program, based on Eros *et al.* (2000), could feasibly be developed for Western Australia.

An effective dugong stranding and salvage program could include the following (after Eros *et al.* 2000, pg 3):

- A system for allowing quick reporting of live stranded, sick, injured or dead animals, such as a telephone 'hotline';
- An emergency response team to respond to reports of stranded live or dead animals;
- Reporting procedures allowing for organised and standardised data collection;
- A system allowing for effective necropsy of dead animals by trained personnel *in situ*;
- Logistic support and equipment for retrieval and transport of live animals or carcasses (if required);
- A facility for medical treatment and rehabilitation in the case of live strandings;
- A centralised and institutionalised facility for the permanent storage of data, photographs and specimen material.

Where feasible, information on longevity, fecundity, sex ratio, age structure, genetics, physiology and anatomy of populations should be gathered and processed using procedures described by Marsh (1984a; 1984b; 1984c) and Marsh (1986). The results should be periodically summarised into a report similar to the annual Marine Strandings reports currently published online by the Queensland Environmental Protection Agency.

Management actions

a). Develop and conduct a program of regular aerial surveys of dugong in Western Australia.

b). Undertake tracking studies of dugong using radio-telemetry and satellite GPS technology in Western Australia.

c). Conduct research into the genetic profile of dugong in Western Australia and determine their relationship to dugong in other parts of Australia and the world.

d). Develop a dugong stranding and salvage program for Western Australia.

e). Develop a program to collect, analyse and report opportunistic observations of dugong in Western Australia.

Performance measures

a). A long-term dataset of information on dugong numbers, distribution, movements and important habitats collected via regular aerial surveys of dugong in Western Australia.

b). A dataset of information on dugong movements and habitat use in Western Australia as a result of tracking studies.

c). A genetic profile of dugong in Western Australia which shows their relationship to dugong in other parts of Australia and other parts of the world.

d). An established program of collecting, analysing and reporting data on opportunistic sightings of dugong in Western Australia.

e). An established program for managing dugong strandings and salvage in Western Australia, including a centralised data-base and regular reporting of results.

f). A thorough understanding of dugong population size(s), distribution, composition, movements, habitat use and relatedness in Western Australia.

7.2. Identify, protect and manage important dugong habitats.

Little is known about important habitats for dugong in Western Australia, but some important habitats have been identified in Shark Bay (see Section 4.3). Important habitats for dugong are likely to include areas used for: feeding; lekking; travel; shelter from weather; thermal refuges; calving; protection form predators; and refuges in the event of habitat change e.g. due to climate change or weather events such as cyclones and flooding. The identification, mapping and/or modelling of important habitats is needed to identify and protect sites for the benefit of dugong conservation in Western Australia.

In addition to a literature review, important habitats for dugong could be identified via the techniques outlined in Management Action 7.1. Another valuable source of information would be documenting of local knowledge from stakeholder groups including: indigenous peoples and their representatives; local shire residents; commercial and recreational fishers; commercial tourism operators; development companies; and aircraft and vessel operators.

Important dugong habitats must be mapped over time to take into account seasonal changes in movement and distribution, climate change and long-term changes due to catastrophic events such as cyclones and flooding. Information on important habitats for dugong can then be taken into account for designating marine protected areas (Management Action 7.6).

Management actions

a). Develop an atlas of important dugong habitat for Western Australia.

b). Make information on important dugong habitats available to regulatory authorities and developers.

c). Provide advice to planning agencies to minimise the effects of land use and coastal development on important dugong habitat in Western Australia.

Performance measures

a). A dynamic atlas of important dugong habitat for Western Australia.

b). An understanding of the seasonal and long-term use of important habitats by dugong in Western Australia.

c). Information and advice on important dugong habitats made available to regulatory authorities and developers.

7.3. Monitor and manage the effects of climate change on dugong biology, ecology and habitat.

Analyses of the potential effects of climate change have predicted more frequent and intense tropical cyclones and precipitation events (Pittock 2003). This will result in more frequent and intense flooding and coastal habitat damage (Pittock 2003). The effects of climate change on dugong biology, ecology and habitat must be monitored and managed as a matter of priority. It appears unlikely that the effects of climate change will be reversed in the short-term and thus, it would be prudent to monitor the effects of climate change and to prepare for its predicted consequences.

Dugong appear to move in response to changes in the availability of seagrasses (Marsh *et al.* 1994; Preen *et al.* 1997) and water conditions, particularly temperature (Anderson 1986; Holley *et al.* 2006), as summarised in Section 3.4. In Western Australia, a series of cyclones appears to have resulted in the movement of dugong from Exmouth Gulf to Shark Bay between 1989 and 1999 (Prince *et al.* 2001; Gales *et al.* 2004; Holley *et al.* 2006). The potential consequences of increased frequency and intensity of catastrophic events such as cyclones, are likely to include increased levels of freshwater and sediment loads resulting in increased smothering and loss of seagrass habitat (Marsh *et al.* 2003). This may result in changes in the frequency and distance of dugong movements in Western Australia and potentially, between States. It will also result in changes in dugong biology, ecology and habitat use over time. Consequently, dugong habitat that is currently protected in reserves at

present may not adequately meet the needs of dugong in the future. Management planning should thus focus on predicting and monitoring the effects of climate change on dugong habitats, movements and demographics.

Management actions

a). Develop a model to predict the effects of climate change on important dugong habitat in Western Australia.

b). Develop a model to predict the effects of climate change on dugong numbers, movements, habitat use and demographics.

c). Monitor the effects of climate change on dugong numbers, movements, habitat use and demographics.

d). Develop and implement strategies to manage the effects of climate change on dugong numbers, movements, habitat use and demographics.

Performance measures

a). An understanding of the likely effects of climate change on important dugong habitat in Western Australia.

b). An understanding of the likely effects of climate change on dugong numbers, movements, habitat use and demographics.

c). A long-term dataset of information on the actual effects of climate change on dugong numbers, movements, habitat use and demographics.

d). An adaptive management program which takes climate change into account as part of the broader management program.

7.4. Monitor and manage the use of dugong for traditional and cultural purposes to ensure the harvest is sustainable and minimise illegal harvest.

Monitoring of the use of dugong for traditional and cultural purposes is needed to determine if the harvest is sustainable in Western Australia. Management strategies can then be developed to ensure the harvest is maintained, or regulated, to levels that are sustainable. At present, in Western Australia dugong may not be sold, given to persons outside of the hunter's immediate family, or taken from a Marine Park, Marine Nature Reserve or Marine Protected Area without a licence (Section 23(1) *Wildlife Conservation Act 1950*).

Indigenous hunting is often perceived to be a significant threat to dugong populations (Bomford and Caughley 1996), but current harvest levels and the sustainability of the harvest is unknown for Western Australia. Berson (2004) argued that habitat loss and degradation

were more important threats than indigenous hunting, based on models of populations in the Northern Territory and Queensland. However, the effects of indigenous hunting in Western Australia were not taken into account in Berson's (2004) study. In addition, the efficacy of the models used was hampered by lack of life history data and the extreme sensitivity of the model to changes in juvenile and adult survivorship (Berson 2004). More information on life history of the dugong, and the age and sex of animals that are targeted by indigenous hunters, is needed to accurately predict the effects of the removal of these animals on the viability of dugong population(s).

Little is known about the number of dugong taken for traditional and cultural purposes in Western Australian waters at present. No dugong are currently taken from the Ningaloo Reef – Exmouth Gulf area (Marsh *et al.* 2002), because there are few indigenous people living there. Dugong are hunted in small numbers in Shark Bay, including illegal hunting in Shark Bay Marine Park (Marsh *et al.* 2002). Research was undertaken into indigenous hunting in this region, in conjunction with the local Yadgalah Aboriginal Community in the early 2000s. The aim of this program was to develop community based management of dugong hunting (Gales, Holley & Lawler unpubl. data). Estimates of dugong take from the Yadgalah community in Denham, Shark Bay varied from 30 – 100 animals per year, depending on local conditions, dugong abundance and traditional practices (D. Holley pers. comm.). The Yadgalah community commonly targets small animals rather than large (potential breeding) animals, because the quality of the meat is better in smaller animals (D. Holley pers. comm.).

The extent of hunting that takes place north of Carnarvon is unknown (D. Holley pers. comm.). Limited boat ownership in this area may restrict hunting and indigenous family and group members in this area probably source meat from members of the Denham community (D. Holley pers. comm.). However, the number of dugong harvested may be higher in years when members from other communities enter the Shark Bay region and take animals from south of Carnarvon the region at the Wooramel Seagrass Bank on the eastern side of Shark Bay (D. Holley pers. comm.). Liaison with members of the Denham community in 2003 suggested that dugong meat fetched $40 per kilogram on the black market (D. Holley pers. comm.).

In the Pilbara, some hunting of dugong takes place in the Dampier Archipelago by Torres Strait Islanders (Marsh *et al.* 2002). There are no records of hunting at Onslow and Port

Hedland, because the indigenous people in these regions are less reliant on marine resources than those in other coastal regions (Marsh *et al.* 2002).

Hunting activity on the Kimberley coast extends from north of the Buccaneer Archipelago, east to Eighty Mile Beach (Marsh *et al.* 2002). The area between One Arm Point and Sunday Island has a relatively large Aboriginal population which has a tradition of using the marine environment to gather resources (Marsh *et al.* 2002). Torres Strait Islanders and Aborigines from other regions also live and hunt in this region (K. Miller, DEC pers. comm.). The number of dugong taken in this region is relatively high and has been considered to be unsustainable in the past (Prince 1986). In the mid to late 1980s, dugong were hunted between One Arm Point and Sunday Island (Marsh *et al.* 2002), at Lagrange (Prince 1986), Roebuck Bay (N. Mckenzie, DEC pers. comm.), Beagle Bay and Thomas Bay (Prince 1986). The number of dugong taken increased at One Arm Point during the mid 1980s (Prince 1986) and mid 1990s, apparently as a result of an increase of dugong in the area (Rouja 1998).

The methods for hunting dugong by the Bardi people at One Arm Point have changed since European settlement in Western Australia. For example, the traditional Bardi hunting season was restricted to the months of May, June and July (Berson 2004). Dugong were hunted using a double raft, either via spear or by stuffing grass up the dugong's nose to drown it (Berson 2004). Selected people (young men) were allowed to hunt, older female dugongs were preferred over calves, breeding females and males and the meat was distributed to the family according to tradition (Berson 2004). Dugong are now hunted using a dinghy with outboard motor and harpoon (Berson 2004) and the cultural aspects of the hunt have also changed (Z. Carr, Edith Cowan University unpubl. data). It is not known if these changes in technology and cultural factors have affected the number of dugong taken (Berson 2004).

A national approach to sustainable and legal take of dugong has been developed in Australia, because the dugong harvest in one region may affect populations in other regions (NRMMC 2005). This document, titled Sustainable harvest of marine turtles and dugongs in Australia – a national partnership approach, recognises the significance of dugong for indigenous people and the need for any action to be taken in partnership with indigenous communities involved in traditional harvest (NRMMC 2005).

Negotiated agreements must be made between indigenous communities (and/or their representatives) and wildlife management agencies that acknowledge customary and statutory law and promote the recovery of species (AFMA 2003). Agreements should reflect local

conditions and allow these to influence management regimes, with all parties fulfilling their respective roles of resource managers and community leaders (AFMA 2003).

A combination of customary, State and possibly Commonwealth law is recommended to achieve the objective of a customary harvest that ensures the long-term survival of dugong in the wild and that does not contribute to the decline of the dugong in State and Commonwealth waters. The tools recommended by AFMA (2003) to manage indigenous take to sustainable levels include management and/or regulation of:

- Vessels and equipment used for hunting;
- Season in which dugong may be hunted;
- Members of the community who are permitted to hunt;
- Division, use and distribution of the meat;
- Sex and size of the animals that are permitted to be hunted;
- Traditional and ceremonial basis for hunting;
- Restriction of hunting in specific areas to local indigenous groups; and
- Cultural alternatives to hunting such as becoming involved in research (e.g. tagging) and management.

Research has been undertaken into hunting of dugong in Queensland waters, in particular the Torres Strait and the Great Barrier Reef areas, where the sustainability of harvests has been assessed using population models based on aerial surveys and knowledge of dugong life history (Marsh 1996; Bomford and Caughley 1996; Marsh *et al.* 1997; Kwan 2002; Ross *et al.* 2004; Heinsohn *et al.* 2004). These programs may serve as models for research into the sustainability of indigenous hunting in Western Australia until more information on the harvest and dugong population dynamics in this State is known.

In Western Australia, a harvest monitoring and management strategy must be developed in consultation and co-operation with indigenous communities and/or their representative bodies, such as: Yamatji Marlpa Barna Baba Maaja Land and Sea Council and the Kimberley

Land Council (KLC). Communication strategies will also be needed to increase cross-cultural and cross-regional information sharing (KLC 2006).

In 2006, the North Australian Indigenous Land and Sea Management Alliance (NAILSMA) developed a draft activity plan for the Kimberly Land Council as part of their broader dugong and marine turtle project (KLC 2006). The regional activity plan was prepared on behalf of the Bardi Jawi and Mayala peoples who's combined country covers the northern part of the Dampier Peninsula and surrounding islands in Pender Bay, King Sound and the Buccaneer Archipelago south to Deepwater Point (KLC 2006). The indigenous peoples of these regions have aspirations to hunt turtle and dugong at sustainable levels while maintaining their culture (KLC 2006). The aims of the project are to quantify the harvest, transfer traditional management practices to young people, conduct hunting workshops and maintain cross-regional and cross-cultural information sharing (KLC 2006). This kind of sustainable hunting program would be most valuable if conducted throughout the State.

One of the potential confounding factors in regional regulation of dugong hunting is harvest of dugong by peoples not indigenous to the area. This is not currently an offence under the provisions of the *Wildlife Conservation Act 1950*. DEC Wildlife Officers will continue to investigate reports of illegal take of dugong in Western Australian waters and recommend prosecution where warranted.

Management actions

a). Develop and conduct a program to monitor harvest of dugong for traditional and cultural purposes throughout the State, in co-operation with relevant indigenous communities and their representatives.

b). Model the effects of dugong hunting by indigenous peoples in Western Australia on dugong population viability.

c). Devise strategies to ensure the harvest of dugong for traditional and cultural purposes in Western Australia is sustainable.

d). Develop cross-regional and cross-cultural communication strategies to educate the indigenous communities and the wider community on the benefits of sustainable harvest management.

e). Investigate and record the details of reports of illegal harvest and trade and recommend prosecution where warranted.

f). Assess and, if necessary, amend the legislation to limit traditional harvest to relevant indigenous community members at a local scale.

Performance measures

a). A long-term state-wide dataset of information on the harvest of dugong for traditional and cultural purposes.

b). An understanding of the effects of indigenous hunting on dugong population viability in Western Australia.

c). An established program for maintaining traditional practices and regulating dugong harvest to a sustainable level.

d). A record of the details of reports of illegal harvest and trade of dugong in Western Australia.

e). Prosecutions of persons unlawfully hunting or trading in dugong in Western Australia.

f). Amend the legislation to limit traditional harvest to relevant indigenous community members at a local scale if considered necessary.

7.5. Monitor and manage vessel operation to minimise dugong boat strike, disturbance, displacement and habitat damage.

Increasing residential and industrial development, tourism and boat ownership in north-west Western Australia is likely to lead to an increase in the impact of vessels on dugong and their habitat in Shark Bay, Exmouth Gulf, and some areas of the Pilbara and Kimberley coasts. The effects of vessel operation on dugong and their habitat must be monitored and managed to collect data on the nature of vessel-dugong interactions and to minimise the effects of vessel operation on dugong and their habitat.

At present only a small amount of information has been collected on the effects of recreational vessels on dugong. Similarly, little is known about the impacts of shipping and other boating activity on dugong and their habitat in Western Australia. Gerrard (1999) studied dugong interaction tourism in Shark Bay in 1997 and Hodgson (2004) studied the effects of vessel activity on dugong in Moreton Bay, QLD. The outcomes of this research are discussed in the context of licence conditions below. However, more research is needed to quantify the impact of recreational boats and industrial vessels on dugong and to manage vessel operations to minimise the potential impacts in Western Australia.

Interest in dive tours and marine day trips is increasing in north-west Western Australia (Gerrard 1999; Marsh *et al.* 2002). Boat traffic is high in Shark Bay as a result of private and commercial recreation, fishing and commercial filming of dugong and so too is the potential for dugong disturbance, boat strike and habitat damage. At least two dugong have been killed

by boat strikes as a result of shallow-draft boats travelling over seagrass and banks off Monkey Mia (Marsh *et al.* 2002). Up to ten film crews are licensed for commercial filming of dugong in Shark Bay each year (Marsh *et al.* 2002) and this filming is likely to disturb dugong, but the impacts have not been quantified (Marsh *et al.* 2002).

There are currently only two (reduced from a high of five in 2002) commercial interaction licences held for boat-based dugong watching tours operating out of Monkey Mia. Both tour operators have been prosecuted for non-compliance with licence conditions, including separating a mother from her calf (Gerrard 1999) and approaching too close to dugong (Marsh *et al.* 2002). Although dugong are disturbed from their daily activities during 37% of encounters on these tours (Gerrard 1999), it is not known if these short-duration disturbances are likely to affect the sustainability of the populations in the long-term.

During recreational fishing surveys within Shark Bay for the Department of Fisheries, fishers were asked if they had encountered dugong during their fishing activity (D. Holley pers. comm.). Over a 10 month period in 2000, two boats had moved through large aggregations of dugong, and the fishers reported that they had struck an object which they had presumed to be a dugong (D. Holley pers. comm.). Since this survey was a random sample and vessel operators were under no obligation to divulge this information, it may be expected that this may occur more frequently than reported (D. Holley pers. comm.). In addition, two satellite tags deployed in 2000 and 2002 were retrieved without the harness system, with what appeared to be propeller marks along the tether (D. Holley pers. comm.). This indicated that boats had hit and severed the tethers, releasing the tag and leaving the harness attached to the dugong (D. Holley pers. comm.).

Due to the close proximity of the reef to the shore, dugong and their habitat are at risk from boating activity in the Ningaloo Reef – Exmouth Gulf area (Marsh *et al.* 2002). Over 100 tour operators are licensed to conduct tours in areas of dugong habitat recognised in the management plan for Ningaloo marine reserves (CALM 2005). Tour operations in the areas on the north-west side of North West Cape and between Coral Bay and Point Cloates could potentially result in dugong boat-strike, disturbance, displacement and habitat damage.

Recreational fishing vessels and nature-based tours are the most likely to pose a threat to dugong and their habitat in the Pilbara and Kimberley regions, because many of the islands of the Dampier Archipelago have shacks that are used by residents of Karratha and Dampier

(Marsh *et al.* 2002). Dugong are also occasionally also killed via collisions with industrial ships in this area (Marsh *et al.* 2002).

Commercial tourism interactions with dugong are licensed by DEC under a Regulation 15 (*Wildlife Conservation Regulations 1970*) Marine Mammal (Dugong) Interaction Licence. If the tours are conducted within DEC managed land, the operator must also hold a Commercial Operators licence to operate sightseeing boat tours (Regulation 94, *CALM Regulations 2002*) within specified areas. The conditions of the Marine Mammal (Dugong) Interaction Licence regulate the interaction with dugong in accordance with the *Wildlife Conservation (Close Season for Marine Mammals) Notice 1998*. This notice stipulates that the licencee shall not: restrict the normal behaviour of; herd or chase or feed; separate a herd or come between a mother and calf. The conditions also stipulate the speed of approach toward and departure from dugong, minimum approach distance and maximum duration of interactions. Other tour operators and private recreational boaters, who are not specifically licensed to watch dugong and who may also encounter dugong in Western Australian waters, are bound by the same conditions specified in the Close Season Notice.

Gerrard (1999) recommended changes to the licence conditions for tour operators to minimise the short-term disturbance of dugong based on quantitative observations of tour interactions. These were that dugong must may be approached at speeds ≤ 2 knots and no closer than 25 metres, regardless of whether the approach is motor- or wind- driven (Gerrard 1999). Hodgson (2004) recorded a reduction in feeding activity of herds when boats passed within 50m. No effect of speed was evident in controlled experiments, but the small sample size limited the ability to detect differences (Hodgson 2004). These studies require detailed assessment by DEC and consideration should be given to modifying licence conditions in Western Australia.

Educational materials, based on license conditions, are needed to ensure commercial tour operators and other people who may encounter dugong have an understanding of their responsibilities when 'interacting' with dugong. The educational materials should, where appropriate, take the national Code of Practice for the Sustainable Management of Dugong and Marine Turtle Tourism (Dugong and Turtle Tourism 2005) into consideration. The materials must include both legal requirements and suggestions on responsible actions to minimise dugong disturbance, boat strike and habitat destruction. A good model of education materials to protect dugong from boating operations, Protected Species Awareness

Information for Professional Fishermen, is available in the Northern Territory (NTSC 2002). The Australian Government also has a Natural Resource Management Program to investigate death of marine mammals due to boat strike (and other factors) as part of its Resource Condition Indicators program. These resources could be used as a model for developing educational materials for use by commercial and recreational fishers, industrial ships and other vessels operating in Western Australian waters.

Management actions

a). Review and where appropriate, modify the conditions of the *Wildlife Conservation (Close Season for Marine Mammals) Notice 1998.*

b). Produce and distribute educational materials to commercial tourism licence holders outlining the conditions which must be adhered to when 'interacting' with dugong as part of commercial tours to reflect the Close Season Notice.

c). Investigate breaches of licence conditions and disturbance of dugong due to recreational activity and recommend prosecution where warranted.

d). Produce and distribute educational materials outlining legal requirements, and including suggestions on responsible actions, to minimise disturbance and the chances of boat strike by persons operating vessels in Western Australian waters.

e). Investigate and record the details of incidents of boat strike and damage to dugong habitat by vessels.

f). Assess the risk of dugong boat strike and habitat damage in selected areas of Western Australian waters and develop strategies to minimise the risk.

Performance measures

a). *Wildlife Conservation (Close Season for Marine Mammals) Notice 1998* conditions which minimise the effects of tours and vessels on dugong.

b). Educational materials outlining conditions which must be adhered to when interacting with dugong (in accordance with the Close Season Notice) made available to commercial licence holders and recreational boat operators.

c). Prosecutions of persons unlawfully disturbing dugong in Western Australian waters.

d). A dataset of information on incidents of boat strike and damage to dugong habitat by vessels.

e). An understanding of the likelihood of dugong boat strike and habitat damage in selected areas of Western Australian waters.

f). An adaptive management strategy to minimise the risk of boat strike and habitat damage in selected areas of Western Australian waters.

7.6. Adequately conserve dugong habitat in marine protected areas.

Preen (1998) assessed Marine Protected Areas (MPA) and suggested that the MPAs in Western Australia at that time were too small to adequately protect dugong and their habitat. In addition, activities that threaten dugong such as commercial and recreational fishing, seismic surveys, petroleum drilling and production and tourism activities are allowed in the majority of these areas (Preen 1998). While the aim is to select a representative reserve system (CALM 1994), Preen (1998) pointed out that this will not necessarily coincide with important habitat for dugong and that MPAs should be selected on the basis of conserving biodiversity to meet the needs of species such as dugong.

In Western Australia, marine reserves protect environmental values and facilitate management of environmental resources for long-term ecological sustainability and equitable human usage (CALM 1994). Protection is intended to conserve biological diversity and to sustain populations of plants and animals, natural features and ecosystems that have value as heritage or economic resources (e.g. nature based tourism and fisheries) (CALM 1994).

The appropriate declaration and management of marine reserves can assist in achieving healthy, sustainable populations of dugong in Western Australia (Preen 1998). Dugong are identified as a value in many of Western Australia's marine reserves and zoning is used to regulate the use of particular areas within the reserves (refer to Section 2.3). However, as more information is collected, it is emerging that important habitat for Dugong occurs outside existing marine reserve boundaries (Preen *et al.* 1997; Preen 1998; Holley *et al.* 2006). In addition, Whiting (2002), who observed feeding on patches of macro-algae on shallow intertidal rocky reefs near Darwin, pointed out the need to conserve travel routes as well as feeding areas. In Western Australia, important habitats used for a range of purposes by dugong (as outlined in Section 3.4 and Management Action 7.2) would also represent high priority areas for protection, since they are essential to meet the needs of dugong.

Management actions

a). Assess the efficacy of Western Australia's marine reserve system for conserving the dugong and their habitat.

b). Ensure that Western Australia's marine reserve system adequately protects dugong and their habitat.

Performance measures

a). A marine reserve system that adequately protects dugong and their habitat in Western Australia.

7.7. Monitor and modify fishing practices to minimise the effects of bycatch and fishing debris on dugong.

Bycatch of dugong is uncommon in Western Australian waters (Fisheries WA 2003), principally because trawling is restricted from dugong habitat in marine reserves and the majority of trawling occurs in deeper waters where dugong are less commonly encountered (Marsh *et al.* 2002). However, the incidence of dugong deaths is likely to be under-reported in Western Australia because no systematic effort has been made to collect or collate data on dugong bycatch by professional or recreational fishers. Nor is there any mandatory requirement for reporting of marine mammal bycatch Western Australia. Thus, there is a need to quantify the impact of fishing bycatch on dugong in Western Australia and to develop a program to minimise it effects.

According to the State of Fisheries Report 2004/05, the impact of fishing on the dugong population is currently negligible as a result of a shift from demersal gill netting to wetlining for a number of fisheries in northern waters (Penn *et al.* 2005). No dugong bycatch was reported in any WA fishery during the 2004/05 period (Penn *et al.* 2005). However, un-reported dugong bycatch is still likely occur in small recreational and commercial shore netting operations, particularly within the Kimberley region (D. Holley pers. comm.). Recreational gill netting is permitted in Western Australia, but requires net attendance and thus is not considered a threat, provided the nets are used as instructed (Department of Fisheries WA 2006).

Dugong have previously been killed as a result of trawling for prawns and scallops in Shark Bay, but permanent and seasonal closures in shallow coastal areas provide good protection for dugong (Marsh *et al.* 2002). Commercial line and beach fishing charters occur in Shark Bay, but these pose little danger to dugong (Marsh *et al.* 2002).

Prawn trawlers operate in the Ningaloo Reef – Exmouth Gulf area, but not in the shallow waters preferentially inhabited by dugong (Marsh *et al.* 2002). Permanent and seasonal closures that protect prawn nurseries are also likely to protect dugong and their habitat (Marsh *et al.* 2002). Cases of accidental drowning of dugong in legally and illegally set fishing nets

are known to occur in the Ningaloo Reef – Exmouth Gulf area and trawl fisheries and pearl farms are a potential threat in Shark Bay and the Pilbara (Marsh *et al.* 2002). Apart from a small area north of Broome, all coastal waters are closed to trawling off the Kimberley coast. Dugong feed on *H. spinulosa* and *H. ovalis* in the deep waters of this region (Marsh *et al.* 2002) and they also feed on the species rich reef-top communities in the Buccaneer Archipelago (Walker and Prince 1987). Trawling occurs in the Kimberley region, in deeper waters off the coast and anecdotal reports suggest dugong are occasionally killed by fishing bycatch in this area (Marsh *et al.* 2002).

The Commonwealth Government published a National Policy on Fisheries Bycatch in 2000 which sets out guidelines for developing a Bycatch Action Plan (AFMA 2000). The objective of the policy is to ensure that bycatch species and populations are maintained in fisheries managed by the States and Territories. In June 1999, the Western Australian Minister for Fisheries adopted the National Policy on Fisheries Bycatch as the Western Australian Policy on Fisheries Bycatch. The Department Fisheries of Western Australia is currently preparing Bycatch Action Plans which document bycatch issues, set priorities, examine options and recommend management actions. Bycatch Action Plans are fishery-specific (e.g. Bunting 2002) and are in preparation in order of priority, beginning with the Shark Bay Prawn and Scallop Managed Fisheries, Exmouth Prawn Trawl Managed Fishery and the Pilbara Fish Trawl Managed Fishery. To date, the Draft bycatch action plan for the Shark Bay prawn managed fishery (Bunting 2002) has been published.

The Department of Fisheries in Western Australia follows the Commonwealth Guidelines for the Ecologically Sustainable Management of Fisheries (Environment Australia 2001) and has an objective to ensure that the fisheries are conducted in a manner that avoids mortality of and injuries to endangered, threatened and protected species. A risk assessment found that the risk of dugong mortality as a result of bycatch was low (Stobutzki *et al.* 2000). However, no protocols are in place for the systematic collection of information on marine mammal bycatch in Western Australian fisheries. The Department of Fisheries is investigating mechanisms to record interactions with threatened species, but is constrained by lack of resources and lack of information by fishers on best practice in the use of nets and what to do in the event of an accidental capture. The Department of Fisheries licences recreational net fishing in restricted areas of Western Australia and provides comprehensive guidelines on the regulations for Recreational Net Fishing (Department of Fisheries WA 2006). However, no information on what to do in the event of an accidental capture of dugong is available to recreational fishers.

The aims of a bycatch monitoring and management program are to determine the levels of mortality in commercial and recreational fishing and to develop and implement methods to reduce the risk of mortality. Since bycatch is currently considered a low level risks in Western Australian waters, this could be achieved via education of commercial and recreational fishers similar to the Australian Government's Marine Protected Species Identification Guide and Notification program.

Habitat damage as a result of fishing may also reduce the amount of habitat available to dugong. In addition, gear loss and marine debris has caused dugong mortality and is likely to continue to affect dugong in Western Australia. For example, an autopsy conducted on a dead male dugong collected by DEC Wildlife Officers from Exmouth District in 2000 revealed fishing line throughout the length of the intestine of the animal (D. Holley pers. comm.). A program of regular clean up of debris along the coastline adjacent to areas where dugongs are known to aggregate e.g. Dirk Hartog Island and Gladstone in Shark Bay, may assist in reducing the debris load and limiting the risks associated with fishing debris to dugong (D. Holley pers. comm.).

Management actions

a). Ensure that bycatch of dugong is addressed as part of Bycatch Action Plans produced by the Department of Fisheries, Western Australia.

b). Develop a program to monitor dugong interactions with commercial and recreational fishers in Western Australia.

c). Model and assess the impacts of commercial and recreational fishing bycatch and related debris on dugong in Western Australia.

d). Develop and implement strategies to minimise the effects of recreational and commercial fishing bycatch on dugong in Western Australia.

e). Produce and distribute educational materials outlining legal requirements and including suggestions on responsible actions in the event of bycatch of dugong in Western Australia.

f). Develop a community-based program to collect fishing (and other) debris from areas of coastline where dugong are known to aggregate.

Performance measures

a). Bycatch of dugong addressed as part of Bycatch Action Plans for all relevant Western Australian trawl fisheries.

b). A data-base of information on dugong interactions as a result of commercial and recreational fishing in Western Australia.

c). An analysis of the impacts of commercial and recreational fishing bycatch and related debris on dugong in Western Australia.

d). A community-based program of collecting fishing debris from coastlines where dugong are known to aggregate.

e). Minimal mortality and injury of dugong due to commercial and recreational fishing bycatch and related debris on dugong in Western Australia.

f). Educational materials outlining legal requirements and including suggestions on responsible actions in the event of bycatch of dugong in Western Australia made available to fishers.

g). Educational materials on marine debris management to minimise its affects on dugong in Western Australia made available to fishers.

7.8. Monitor and minimise the impacts of industrial, residential and tourism development on dugong and their habitat.

Dugong and their habitat are threatened by increasing industrial, residential and tourism development in coastal north-west Western Australia, because of they are a long lived species and depend on coastal habitats and seagrasses (Marsh *et al.* 2003). Developments and proposals for development can include oil, gas and petroleum exploration and mining, salt mining, aquaculture, tourist resorts and expansion of townships. Industrial, residential and tourism development may result in dugong habitat loss and degradation and increased fishing bycatch, boat strike and disturbance by acoustic devices and vessels (Marsh *et al.* 2003).

Seagrass beds may be destroyed directly by mining or lost through the effects of disturbances such as dredging, inland and coastal clearing, land reclamation, erosion from agricultural activities and oil spills (Kirkman 1997). These activities cause an increase in sedimentation and turbidity which degrades the seagrasses by smothering out light and reducing oxygen supplies (Kirkman 1997). Eutrophication (increased dissolved nutrients) causes algal blooms which smother seagrass (Kirkman 1997). Agriculture (fertilisers), residential developments (fertilisers and inadequate sewerage systems) and industries, including some forms of aquaculture, may also cause eutrophication. Other threats include herbicide run off and input of detergents, heavy metals and hyper-saline water (from desalination plants) into the sea (Kirkman 1997). While some seagrass habitats used for feeding by dugong have been protected in reserves in Western Australia, little work has been carried out to minimise the effects of development on dugong habitat (Marsh *et al.* 2003).

One example of development impacting of dugong in north-west Western Australia is salt mining, which is a threat to dugong in the Shark Bay area and a potential threat in Exmouth Gulf. A sea wall constructed by Shark Bay Joint Venture Ltd isolated a 26 km^2 area of Useless Inlet, but this area is not known to be important dugong habitat (Marsh *et al.* 2002). Shark Bay Salt has a proposal to construct additional crystalliser ponds, which threatens 40 ha of seagrass (Marsh *et al.* 2002) and if the area of salt mining infrastructure increases, dredging for shipping channels could destroy seagrass banks east of Dirk Hartog Island (Marsh *et al.* 2002). These banks lie within Shark Bay Marine Park and World Heritage Area and are important habitat for dugong in winter (Anderson 1994a). A proposal has been made for salt mining in Exmouth Gulf and at present, little is known about the distribution and movements of dugong in this area (Marsh *et al.* 2002), but the company has recently funded aerial surveys of dugong (Jenner and Jenner 2004).

Development companies must submit an application for works under the *Environmental Protection Act 1986* administered by the Western Australian Department of Environment and Conservation. A fauna survey is then required as part of the Environmental Impact Assessment (*Environmental Protection Act 1986*) to determine if the area proposed contains Fauna listed under the State *Wildlife Conservation Act 1950* or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.* If listed fauna inhabit the proposed site, companies must refer any proposed impacts to the federal Department of Environment and Heritage (DEH). The proponent must determine if the proposal will or is likely to have a significant impact on matters of 'National Environmental Significance' under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* and then make a referral to the Commonwealth Environment Minster for assessment (Ferdinando 2004). As part of arrangements with the Environmental Protection Authority (EPA), the DEH will refer the assessment of the impacts to the State of Western Australia, based on the EPA assessment process under the *Environmental Protection Act 1986*, for the approval, management or off-set of the proposed impacts.

Mining takes precedence over conservation in Marine Protected Areas (MPA) in Western Australia (Preen 1998). Mineral and petroleum resources must be assessed in a region before MPAs can be created and any reserve or zone must have the consent of the Minister for Mines (Preen 1998). At the request of the Minister for the Environment, the EPA makes an assessment of the compatibility of exploration and mining activity with the environmental values of selected areas (e.g. EPA 2003) and makes recommendations to the Minister.

However, since proposals are assessed on a case-by-case basis (EPA 2003), the protection of dugong and their habitat may be best achieved with the use of regulations and impact management and mitigation advisories during proposed mineral and petroleum exploration and mining projects.

Application for approval of exploration and mining projects must also be made to the Western Australian Department of Industry and Resources (DOIR) and this must be accompanied by an environmental plan and an oil spill contingency plan (Ferdinando 2004). DOIR then seeks advice from agencies including DEC and the Department of Fisheries and makes an assessment based on environmental risk management proposal (Ferdinando 2004). If the environmental affects can be managed or mitigated satisfactorily, approval may be given with conditions (Ferdinando 2004). Guidelines on minimising acoustic disturbance to marine fauna for petroleum exploration and mining have been produced by DOIR (DOIR 1997) and mining companies should follow these at all times.

Minimising the impacts of industrial, residential and tourism development on dugong and their habitat could be achieved by a number of means, including regulation and prosecution of offenders under the relevant legislation. Conducting research to monitor impacts will glean additional information which can be used to develop management programs to minimise the impacts. Finally, it will be important to make information on dugong biology, ecology, important habitats and threats available to government regulators and developers to ensure that the impacts are minimised.

Management actions

a). Monitor the effects of development on dugong and their habitat.

b). Make information on dugong populations and their habitats readily available to regulatory authorities and developers.

c). Provide the advice needed to enable applicants proposing developments to minimise or manage potential impacts on dugong and their habitat.

d). Regulate development under relevant legislation to minimise or manage impacts on dugong and their habitat.

e). Prosecute those unlawfully impacting on dugong and their habitat by non-approved development and associated activities under the provisions of the relevant legislation.

Performance measures

a). An understanding of the impacts of development on dugong and their habitat in Western Australia.

b). Information on dugong and their habitats made readily available to regulatory authorities and developers.

c). Regulation of development under relevant legislation and advice provided to developers to minimise or manage impacts on dugong and their habitat.

d). Prosecution of those impacting on dugong and their habitat by non-approved development and associated activities under the provisions of the relevant legislation.

7.9. Develop and expand education programs to encourage awareness and understanding of the biology, ecology and conservation needs of dugong throughout the community.

Little or no information on the biology and conservation status of the dugong is available for tour operators, commercial fishing companies, mining companies, land developers, local government authorities, recreational fishers, park visitors, indigenous people and their representatives, schools and the general public in Western Australia at present. Surveys of tourists who participated in dugong-watching activities at Shark Bay have shown that they have a low awareness of dugong and a low level of knowledge of dugong ecology (Gerrard 1999). The value placed on dugong conservation and the demand for information, however, was very high (Gerrard 1999). Wildlife tourism has the potential to educate the public on the ecology of the animal, threats to wildlife populations and to promote conservation efforts (Davies 1990).

There is an urgent need for improved public understanding of, and support for, the dugong and its conservation to gain the support needed for dugong related research and management programs in Western Australia. Educational materials could be distributed via DEC offices, the Naturebase website (and other government agency websites) and as part of other marine based activities.

Management actions

a). Promote the dugong Management Plan through a high profile media launch.

b). Contribute to conferences and workshops relating to dugong research and management.

c). Maintain information on the achievements as part of the Dugong Management Plan on the Naturebase website and link to other government agency websites.

d). Produce written materials, such as a fact sheet, brochure or booklet, on the biology, ecology and conservation of the dugong in Western Australia. Distribute to commercial tourism and fisheries operators and the general public via regional and district offices, Marine Parks and Reserves and the Naturebase website.

e). Develop dugong related interpretive displays, signs and multi-media presentations at relevant sites.

Performance measures

a). A media launch of the DEC Dugong Management Program.

b). Contribution of dugong management team to scientific conferences and workshops relating to dugong research and management.

c). A webpage dedicated to the research and management of dugong in Western Australia on the Naturebase website, with links to other stakeholders.

d). Educational materials on the biology, ecology and conservation of the dugong in Western Australia made available to the general public.

e). Interpretive displays, signs and multi-media presentations at relevant sites.

8. PRIORITIES FOR MANAGEMENT

Table 3 Priorities and responsibilities for management actions.

Management Action	Page	Priority	Responsibility
7.1 Survey, monitor and study dugong population(s).	19	High	Department of Environment and Conservation Western Australia, Universities, Research Institutes
7.2 Identify, protect and manage important dugong habitats.	23	High	Department of Environment and Conservation Western Australia
7.3 Monitor and manage the effects of climate change on dugong biology, ecology and habitat.	24		Department of Environment and Conservation Western Australia, Universities, Research Institutes
7.4 Monitor and manage the use of dugong for traditional and cultural purposes to ensure the harvest is sustainable and minimise illegal harvest.	25	High	Department of Environment and Conservation Western Australia, Indigenous Groups and Representatives, Universities, Research Institutes
7.5 Monitor and manage vessel operation to minimise dugong boat strike, disturbance, displacement and habitat damage.	30	Medium	Department of Environment and Conservation Western Australia, Department of Fisheries Western Australia, Department for Planning and Infrastructure Western Australia
7.6 Adequately conserve dugong habitat in marine protected areas.	34	Medium	Department of Environment and Conservation Western Australia
7.7 Monitor and modify fishing practices to minimise the effects of bycatch and fishing debris on dugong.	35	Medium	Department of Environment and Conservation Western Australia, Department of Fisheries Western Australia
7.8 Monitor and minimise the impacts of industrial, residential and tourism development on dugong and their habitat.	38	High	Department of Environment and Conservation Western Australia, Environmental Protection Authority of Western Australia, Department for Planning and Infrastructure Western Australia, Department of the Environment and Water Resources Australia
7.9 Develop and expand education programs to encourage awareness and understanding of the biology, ecology and conservation needs of dugong throughout the community.	41	Low	Department of Environment and Conservation Western Australia

Table 4 Assessment and prioritisation of threats to dugongs and their habitats by management unit in Western Australia (ratings after FRDC 2004).

Threat	Shark Bay	Exmouth	Pilbara	West Kimberley	East Kimberley	Mean	Priority
Boat strike	5	5	4	3	3	4.00	4
Climate change	5	5	5	5	5	5.00	1
Fishing bycatch	2	2	2	2	2	2.00	7
Residential, Industrial and Tourism Development	3	4	5	4	4	4.00	4
Illegal hunting	3	0	4	3	4	2.80	6
Inadequate protection in reserves	5	5	4	4	4	4.40	3
Indigenous hunting	3	1	4	5	5	3.60	5
Lack of knowledge of dugong and important habitats	4	4	5	5	5	4.60	2
Mean	3.75	3.25	4.13	3.88	4.00		
Priority	4	5	1	3	2		

Rating: 0. Not applicable; 1. Remote = Never heard of, but not impossible; 2. Rare = May occur in exceptional circumstances; 3. Possible = Some evidence to suggest this is possible here; 4. Likely = May occur; 5. Almost certain = Is expected to occur.

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