Husbandry Guidelines
For

Dugong *(Dugong dugon)*
Mammalia: Sirenia: Dugongidae

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Disclaimer

These husbandry guidelines were compiled by Felicity Evans at TAFE NSW – Western Sydney Institute, Richmond College, NSW, Australia. The production of these guidelines was required as part of the assessment criteria for the Certificate III in Captive Animals, (Course Number 1068, RUV30204).

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Cover Photograph: Grazing *Dugong dugon*
Source: UAE Ministry of Environment and Water (2008)
http://www.uae.gov.ae/uaeagricent/fisheries/img/Dugong2.jpg

Occupational Health and Safety Risks

OHS Classification: Low Risk
Dugongs kept in captivity are unlikely to fatally or seriously injure a person and are therefore classified as Low Risk under the scheme developed by Bool and West (1992).

Potential Safety Risks
Dugong tusks:
Dugongs have short incisors which push through the gums of the upper jaw in adults and are exposed when the upper lip is bared (Reeves *et al.* 2002). Wild caught dugongs often bear scars from the tusks of other dugongs during interactions. Conflicts between rival males and male attempts to maneuver females in copulation frequently result in the body being scratched by tusks (Reeves *et al.* 2002). Similarly, these tusks may result in minor abrasions and bruising to keepers in direct contact with captive dugongs. Risks may be minimized by handling dugongs only when necessary, ensuring multiple trained staff are present during direct interactions, or by using operant conditioning to reduce aggressive or risky behaviour during handling sessions (as has been successful for the Florida manatee; MOTE Marine Laboratory).

Body size:
Adult dugongs are 3-4m long and may weigh up to 1000kg (Reeves *et al.* 2002); even newborn calves are 1m long and weigh around 30kg (Marsh 1991). There are no records of dugongs displaying aggression to wards keepers; however, the size of the animal may pose a threat to a keeper's safety. For example, a person could be accidentally crushed or drowned by being unable to maneuver the large animal easily. A harness and lift should be used to transport dugongs or move the between enclosure to reduce the risk of injury (Marsh *et al.* 1991).

Capture myopathy: (risk to dugong)
Dugongs are susceptible to stress during and after capture and handling. Previous studies have demonstrated that stress results in high levels of serum potassium levels in the blood, often resulting in death (Marsh 1983). Fatalities may be reduced by conditioning captive dugongs so that handling is not perceived as threatening, using unpowered boats (to reduce sound pollution) and controlling crowds at sites when interacting with wild dugongs, eliminating unnecessary sources of noise in captivity (at least initially for wild caught individuals).

Venom, bites and stings:
Dugongs are non-venomous, do not have a sting and are not known to bite (although beware of the tusks in adults).

Bristles:
Dugongs have no claws or spines but are sparsely covered in short bristles which are most dense around the muzzle (Reeves *et al.* 2002). When hand rearing dugongs in captivity, keepers should be aware of the potential irritation that bristles may cause to human skin (Marsh 1991). The irritation of bristles in conjunction with seawater may

cause minor skin irritation to keepers. Irritation may be avoided by wearing a full length neoprene wet suit while handling dugongs, showering after handling and applying a vitamin E lotion to skin after showering.

Aquatic environment:
Dugongs are exhibited in a marine aquarium. This exhibit type poses a risk of drowning (to staff and visitors), wet and slippery surfaces (trip hazards), potential electrocution, corrosion of equipment and fungal and bacterial build up. The exhibit should be enclosed to prevent public access and staff access should be under lock. Signage may be used to demonstrate the risk of drowning and current resuscitation protocols should be clear and placed by the pool. Slippery when wet signage should be used in staff areas which may become wet, such areas should be well ventilated so that they may dry quickly and mops and buckets kept at hand. Public access areas should be constructed at a gradient and with appropriate drainage so as to minimize the risk of public areas flooding. Electric cables should be cased in plastic and secured well above the water height, signs depicting electric shock may also be useful. Certified electricians only should carry out electrical maintenance. Saltwater may increase the rate of corrosion of some tools. Equipment should be checked regularly and replaced as necessary, rinsed with freshwater after each use, salt resistant materials should be used where possible. The exhibit should be cleaned regularly with an anti-bacterial and anti-fungal product to minimize bacterial and fungal build up.

Zoonoses:
Cryptospiridium hominis infects both dugongs (minor host) and humans (major host) causing Cryptospirosis (Smith *et al.* 2007). The risk to keepers of contracting Cryptospirosis from dugongs is minimal, since infection is by ingestion of infected dugong meat. Therefore the only groups at risk of contracting cryptospirosis from dugongs are indigenous groups which hunt wild dugongs for traditional purposes (Smith *et al.* 2007, Marsh 1991).

Chemicals:
Chlorine, bleach and disinfectant are required in the maintenance of dugong exhibits. These chemicals require MSDS (Material Safety Data Sheets) kept on site within 3m of where the product is stored. The package instructions should be closely followed for each product with regards to dilution, storage, usage and first aid treatment. A first aid kit and the Poisons Information Centre hotline number should be stored nearby to where the chemicals are used. Standard operating procedures should be in place for the use of these chemicals and personal protective equipment such as gumboots, gloves, a face mask and safety glasses should be worn.

Sun damage:
Dugongs are tropical marine species, in case of wild capture or release extra care should be taken by keepers to avoid UV damage to staff and animals. Keepers should wear a wide brimmed hat, sunglasses, long sleeved shirt, 30+ sunscreen and zinc. If the exhibit is external the above personal protective equipment should be worn wile working also.

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1 Introduction

Introduction

The dugong (*Dugong dugon*) is a large herbivorous marine mammal, belonging to the Order Sirenia. The most closely related species to the dugong are the several species of manatee, large omnivorous marine mammals belonging to the Family Trichechidae, Order Sirenia (Ripple 1999).

Dugongs feed on seagrass in tropical and subtropical waters and inhabit shallow coasts throughout the Indo-Pacific region (Reeves *et al.* 2002GBRMPA 2007). They mainly dwell in wide, shallow, protected bays but also utilise deep water habitats, feeding down to 30m (EPA 2007; GBRMPA 2007). Dugongs are entirely aquatic, rising to the water surface to breathe through paired nostrils every 2-3 minutes (Ripple 1999).

The dugong is the only extant species of the family Dugongidae, the other; Steller's Sea Cow was hunted to extinction in the 18th century (Figure 1), only 27 years after its discovery (Reeves *et al.* 2002; Gales *et al.* 2003; Marsh 1991; Sozzani 2008). The dugong is central to the myth of the mermaid; sailors mistook the magnificent marine mammal for the mythical mermaid, due to its fleshy appearance, swollen mammary glands and fluked tail (Gales *et al.* 2003; Marsh 1991). Eventually dugongs became known as an omen to sailors as they were believed to bewitch sailors with their song, causing men to throw themselves overboard or steer the ship to wreckage (Marsh 1991; Sozzani 2008). The myth of the dugong translated Scandinavian, Irish, British, German, Russian, Middle-Eastern and Asiatic mythologies (Sozzani 2008).

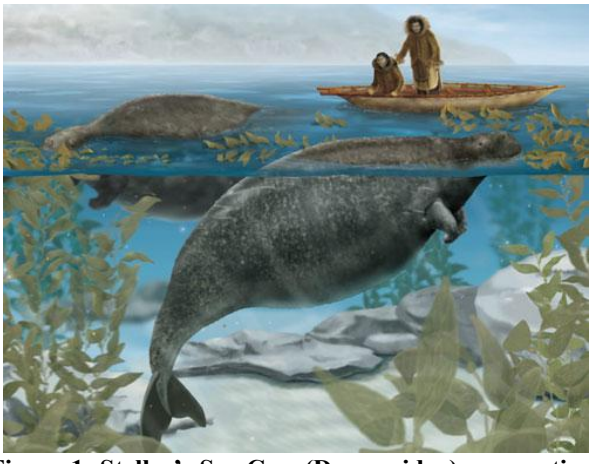

Figure 1: Steller's Sea Cow (Dugongidae), now extinct
Source: http://www.itsnature.org/rip/recently/sea-cow/

The dugong holds significance in Indigenous and Torres Strait Islander culture. Traditionally the dugong has been hunted for its' meat, oil and tusks (Marsh *et al.* 2001). Today, the main threats to the Vulnerable species are boat incidents, pollution and habitat degradation, entanglement in shark nets and hunting (Marsh *et al.* 2001). The impacts of

human activities on dugongs are pronounced because the species is slow to reproduce and its distribution coincides with large human settlements.

1.1 ASMP Category

There is currently no Australasian species management plan for the dugong. The dugong fits into the Marine Mammal TAG (Heukes & van Leeuwen 2008).

1.2 IUCN Category: Vulnerable (A2bcd)

The dugong is listed as Vulnerable to Extinction on the IUCN Rd List of Threatened Species (IUCN 2001). The criteria which place the dugong under this category are:
An observed, estimated, inferred or suspected population size reduction of ≥80% over the last 10 years or three generations, whichever is the longer**,** where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible**,** based on (and specifying) any of (a) to (e) under A1.
For the dugong, the relevant points from A1 are:
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation (IUCN Red List Version 3.1, 2001).

1.3 EA Category

State protection
The dugong is protected in NSW, Queensland, Northern Territory and Western Australia. Traditional Hunting for cultural purposes is under license only.

Threatened status
The dugong is listed as Vulnerable (IUCN 2001).

EA/State requirements/permits for movement or transfer
Dugongs may not be caught or transported without permits from the state of origin. Transfers require NPWS, QPWS and trained personnel.

1.4 NZ & PNG Categories and Legislation

Dugongs do not naturally occur around New Zealand, or at all 27º south of the equator (Marsh *et al.* 2001). The dugong is distributed throughout shallow coastal waters around PNG, population dynamics are poorly understood in this area. It is believed that populations have declined significantly and as a result the dugong and associated habitat is becoming increasingly protected (Marsh *et al.* 2001).

1.5 Wild Population Management

There is no wild population management program in place for dugongs. However; the dugong is protected throughout its Australian range and awareness and conservation of the dugong and its unique habitat is increasing throughout much of the Indo-pacific (Marsh *et al.* 2001).

1.6 Species Coordinator
The species coordinator for the dugong is unknown. Enquiries in Australia should be directed o Andrew Barnes, Marine Mammal Manager, Sydney Aquarium.

1.7 Studbook Holder
There is no studbook for captive dugongs at this stage. Enquiries in Australia should be directed to Andrew Barnes, Marine Mammal Manager, Sydney Aquarium.

2. Taxonomy
2.1 Nomenclature
Class: Mammalia
Order: Sirenia
Family: Dugongidae
Genus Species: *Dugong dugon* (Reeves *et al.* 2002)

Etymology
The word "dugong" means "lady of the sea" and comes from the Tagalog word *Dugong*, derived from the Malay *duyung* (Ripple 1999).

2.2 Subspecies
There are no subspecies of *Dugong dugon* and only one species belonging to the genus *Dugong* (Reeves *et al.* 2002; Gales *et al.* 2003).

2.3 Recent Synonyms
The dugong was initially classified as *Trichechus dugon*, a fourth species of manatee, by Phillip Ludwig Statius Muller in 1776 (Sozzani 2008). Bernard Lacepede later separated the dugong from the manatees and John Edward Gray allocated the dugong to a distinct family (Sozzani 2008).

2.4 Other common names
The term "sea cow" commonly refers to the dugong, however this term may also refer to any of the three species manatee (*Trichechus senegalensis, T. manatus or T. inunguis.*) or to the extinct Steller's Sea Cow (*Hydrodamalis gigas*). The terms "sea pig" and "sea camel" may also refer to the dugong, although these are less frequently used (Sozzani 2008; Gales *et al.* 2003).

3. Natural History
3.1 Morphometrics
3.1.1 Mass and Basic Body Measurements
Total Length: 2.5 - 4m (Reeves *et al* 2002)
Weight: 250 - 1000kg (Reeves *et al.* 2002)
Color: light brown – dark grey (Reeves *et al.* 2002)

There are external characteristics which separate the dugong from the manatees (Family Trichedae); these are outlined in Table 1.

Table 1: External characteristics of dugong and manatees (adjusted from Heukes van Leeuwen 2008)

Dugongidae (Dugong)	**Trichedae (Manatees)**
Tail whale-like (fluked)	Tail beaver-like (paddle shaped)
Forelimbs pointed, nails absent	Forelimbs with rounded tips, nails present
Skin unpleated, surface smooth	Skin heavily pleated, surface rough
Hairs on body short and rigid	Body hairs long and flexible
Ear openings large and easily visible	Ear openings small and indistinct
Nostrils behind muzzle tip	Nostrils at muzzle tip
Incisors tusk-like (up to 18cm long)	Incisor teeth absent in adults

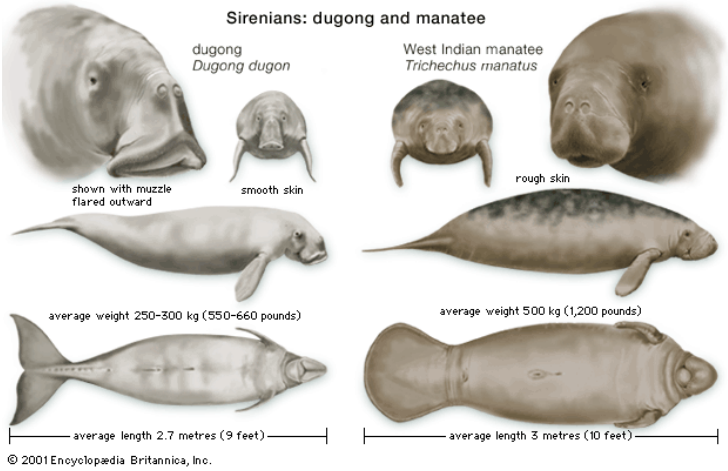

Figure 2: Morphological differences between Dugongs (Dugongidae) and Manatees (Trichedae) Source: Britannica Inc. (1995)

3.1.2 Sexual Dimorphism

There is no sexual dimorphism in dugongs. Tusks erupt in males from around ten years of age, but these are only evident under close inspection of the gums, and older females also develop tusks. Therefore that is an unreliable method of sexing dugongs. Male genitalia are only visible externally when aroused, however there is variation in the genital aperture of males and females which may assist sexing. The female genital opening is located ventrally close to the anus, whereas the male genital opening is located ventrally but further up the body toward the middle of the body. The mammary glands of females are variably pronounced, these are located immediately behind the pectoral fin.

Figure 3: Male dugong showing ventral surface and genital aperture anterior to the anal opening
Source: F. Evans (Sydney Aquarium)

Figure 4: Female dugong showing ventral surface and genital opening
Source: www.wildlifeextra.com

3.1.3 Distinguishing Features

Dugongs are brown to grey, torpedo-shaped and less streamlined than dolphins (Reeves *et al.* 2002). They have no dorsal fin, no hindlimbs, paddle-shaped forelimbs and a fluked tail which acts as a rudder (Gales *et al.* 2003). Dugongs are sparsely covered in hairs which are most dense around the muzzle and on the downward facing rostral disk, where they are used to manipulate food into the mouth (Reeves *et al.* 2002; Marsh 1991; Marsh *et al.* 2001).

Dentition is comprised of a total of six premolars and six molars as well as two incisors which usually erupt after puberty and are more pronounced in males than females (Reeves *et al.* 2002; Gales *et al.* 2003). The dugong remains buoyant by possession of thick heavy bones and the dorsal position of the large lungs and diaphragm (Reeves *et al.* 2002). The nostrils are located on the tip of the muzzle and concealed by two flaps of skin during submersion (Reeves *et al.* 2001). The ears are visible externally as two small holes on either side of the head (Gales *et al.* 2003).

Figure 5: Dugong. Source: Marsh *et al.* 2001

Both male and female genitalia are internalised, with the male genital aperture positioned ventrally around the middle of the stomach and the female genital aperture located ventrally near the anus, anterior to the caudal peduncle (tail stalk) (Reeves *et al.* 2002). There is no sexual dimorphism and the mating system is polygamous (Reeves *et al.* 2002; Gales *et al.* 2003). A single calf is born after a gestation period of 13-15 months suckled for 14-18 months and may remain with the mother for up to 3-4 years, thus, dugongs are slow to reproduce and sensitive to anthropogenic impacts (Reeves *et al.* 2002, Gales *et al.* 2003; Marsh 1991).

Dugongs feed almost exclusively on seagrass. Macroinvertebrates and algae are consumed occasionally, perhaps incidentally (Reeves *et al.* 2002; Gales *et al.* 2003; Marsh 1991; Marsh *et al.* 2001). Dugongs preferentially feed on seagrass species of *Halodule* and *Halophila*, which are lowest in fibre and high in available nitrogen, increasing the intake of nutrients over bulk (Reeves *et al.* 2002; Gales *et al.* 2003; Marsh 1991). Dugongs generally feed during the day; however in areas of high human activities dugongs have become increasingly active at night and in deeper water (Reeves *et al.* 2002; Gales *et al.* 2003).

Dugongs display more elaborate social behaviours than manatees and are frequently observed in groups of six or over hundred when feeding (Reeves *et al.* 2002). Dugongs are the natural prey of crocodiles, sharks and killer whales and are also threatened by human activities including traditional hunting, sound pollution, fishing practices, boating and terrestrial runoff (Reeves *et al.* 2002; Gales *et al.* 2003; Marsh 1991).

3.2 Distribution and Habitat

Dugongs inhabit shallow marine waters from east Africa to Vanuatu between 27°N and 27°S of the equator (Reeves *et al.* 2002). Figure 6 depicts the current distribution of dugongs (Marsh *et al.* 2001). They are the only Sirenians found in the Indian and Pacific oceans, and have the largest range of any Sirenia (Reeves *et al.* 2002). Dugongs are the only Sirenians which are exclusively marine; the three species of manatee depend on freshwater to varying degrees (Gales *et al.* 2003).

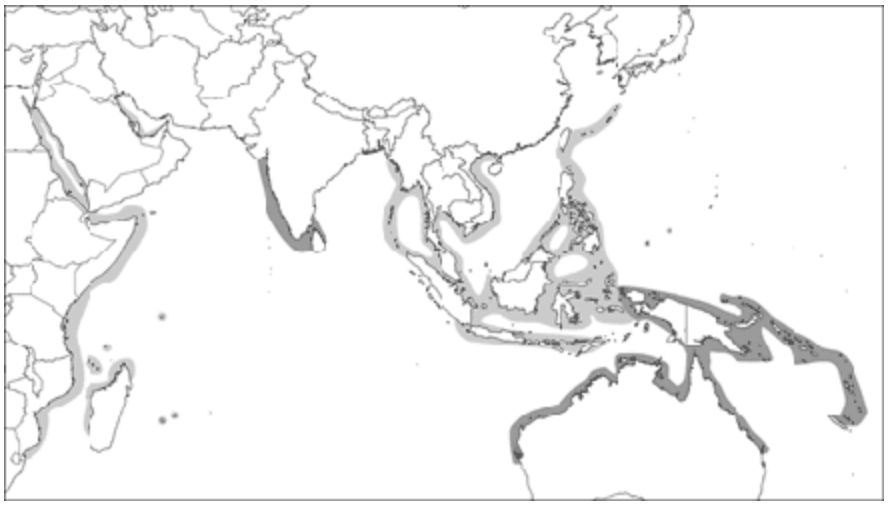

Figure 6: Current distribution of dugongs. Source: Marsh *et al.* 2001

The distribution of dugongs reflects the historic distribution of phanerogamous (seed bearing) seagrasses on which the dugong feeds (Reeves *et al.* 2002). Dugongs mainly inhabit shallow (0.9m deep) coastal and island waters but have also been documented in deeper offshore waters up to 30m deep (Reeves *et al.* 2002; Gales *et al.* 2003; Marsh *et al.* 2001).

All populations have declined in the last one hundred years, due to human activities (hunted, watercraft collision, fishing trawls shark and turtle nets, oil spills) or natural hazards (cyclones, storm surges, parasites and predation) (Reeves *et al.* 2002; Marsh 1991). Australia governs the largest population of dugongs. An estimated 85000 dugongs inhabit coastal waters from Shark Bay in Western Australia to Moreton Bay in Queensland, with 12000 inhabiting the Torres Strait between Northern Australia and New Guinea (Gales *et al.* 2003). Smaller populations are located along the East coast of Africa (from the Persian gulf to Durban and including Madagascar), along some coasts of the Indian Ocean such as Sri Lanka and Okinawa in Ryukyu Islands and at similar latitudes off the coasts of China and Taiwan, in the Philippines and Palau, Papua New Guinea, New Caledonia and among Vanuatu Islands (Gales *et al.* 2003).

Dugongs commonly travel great distances in groups; however there are records of both sexes traveling hundreds of kilometers in solitude (Gales *et al.* 2003). Evidence from satellite transmitters confirms that dugongs can cross deep ocean trenches (Gales *et al.* 2003).

3.3 Conservation Status

Dugongs are listed as Vulnerable to extinction by the IUCN (2001). Threats include hunting, watercraft collision, fishing trawls, shark and turtle nets, oil spills and natural hazards such as storms, parasites and predation by crocodiles and sharks (Reeves *et al.* 2002; Marsh 1991).

3.4 Longevity

3.4.1 Wild

The maximum recorded life span for a dugong is 73 years. This specimen was a wild caught female, aged by dental analysis (Reeves *et al.* 2002; Gales *et al.* 2003).

3.4.2 Captive

Previous attempts to rear dugongs in captivity have had minimal success. Dugongs have only been housed in captive institutions since 1959 and in that time few have lasted longer than 12 months (Marsh 1991). The longest lasting captive dugongs were a pair kept in southern India which survived for only 11 years (Marsh 1991). A male dugong housed at Sydney Aquarium (raised at Seaworld, Gold Coast) turned 11 years old in November 2009 (A. Barnes *pers. comm*). The greatest complication in housing dugongs in captivity is provision of their seagrass diet.

3.4.3 Techniques used to determine age in adults

Pinnipeds, toothed cetaceans (Odontocetes) and elephants (closely related to dugongs) may be aged by observation of growth groups in the tusks (Gales *et al.* 2003). This technique has been modified to determine age in dugongs (Gales *et al.* 2003; Marsh 1991). Dugongs have three pairs of molars and three pairs of premolars in each jaw, as they age they lose the first set of premolars and the first pair of molars, remaining molars continue to grow (Gales *et al.* 2003). This is in contrast to the closely related manatees, which have one pair of premolars and three pairs of molars, which continue to grow and migrate anteriorly throughout the manatee's life (Gales *et al.* 2003). After puberty (10-17 years) both male and female dugongs develop incisors which push through the gums (but are not visible unless the mouth is opened) like tusks (Reeves *et al.* 2002; Marsh 1991).

4. Housing Requirements

4.1 Exhibit/enclosure design

Dugongs require a tropical marine exhibit. Ideally the exhibit should cater for above and below water surface viewing to best display the natural swimming and foraging behaviour of dugongs. This may be in the form of a floating oceanarium which has off display filtration equipment, secure keeper access and a gently sloping ramp which leads to underwater viewing tunnels with emergency exits.

The Canadian Association of Zoos and Aquaria (CAZA) recommend that enclosures designed for manatees (Trichedae) should be of a size that enables the animal to show natural behaviours, be large enough for the animals to achieve the full range of body motion and physical movements normally performed, and should contain furniture to physically and psychologically enrich the environment and stimulate normal physical movement and behaviour of the animals (Huekels & van Leeuwen 2008).

A wide variety of building materials can be used for the construction of the manatee pool (Huekels & van Leeuwen 2008). The principal requirements for Sirenian enclosures are that the pool should be water tight, non-abrasive, easily sanitized and resistant to puncture (CCAC, 1984). The minimum dimensions for a dugong tank are 5m deep x 8m wide x 16m long and must provide 49 square metres per animal housed (DPI 1994). Circular

pools have the advantage over angular pools as they provide better water flow which, in turn, tends to clean the pool (Huekels & van Leeuwen 2008). It is important to provide shelter for the animals for protection from natural conditions such as sun, rain and snow. (CAZA, 1975). A shelter is especially important when the animal is kept in an outdoor enclosure.

Underwater and air temperature should be monitored a minimum three times daily, water temperature should remain between 23-26ºC and air temperature at the water surface should be a minimum 18ºC, but up to 34ºC to reflect the natural tropical and subtropical temperature range for this air breathing mammal (A. Barnes *pers. comm.*).

For aquatic animals, water quality is an essential component of their environment (Huekels & van Leeuwen 2008). Dugong enclosures may be an open, semi-open or closed system. In an open system, the water supply is continuous and enters from a natural source, flows through the pool, and exits with no intentional recirculation (Dierauf and Gulland, 2001). The waste water in an open water system is replaced by fresh water from a natural water flow. One of the simplest solutions is pumping the water from a natural source (e.g. the sea) through the exhibit and the waste out or constructing the exhibit as a sea-pen or fenced off lagoon. Such facilities have to be located in coastal areas that are free of pollution. "Semi-open" and "closed" systems are more commonly used. Semi-open provides continuous partial replacement, or occasional replacement of water lost through evaporation and waste. In a closed water system, waste water is circulated. Closed systems require the most-intensive water treatment, since all the water is reused (Dierauf and Gulland, 2001). A water turnover rate of two hours or less is considered desirable for a closed or semi-closed system (CCAC, 1984).

Regardless of which system is adopted, high quality filtration should be in place for all marine exhibits holding dugongs. Ozone may be used to efficiently filter impurities from the water column as is done at Sydney Aquarium and previously at Seaword, Gold Coast (A. Barnes *pers. comm.*). Bromide, chlorine and salinity levels in the water should be measured at least twice and adjusted as necessary. In general the primary enclosure shall not contain water which would be detrimental to the health of the Sirenians contained therein (Table 2).

Table 2: Water quality parameters for housing Sirenians in captivity (Adapted from Huekes & van Leeuwen 2008)

Parameter	Level in a marine enclosure
NH_3	<0.05ppm
Carbonate hardness	6500mg/L most
Nitrite	<0.1ppm
Nitrate	<20ppm
O^2	>6mg/L
pH	7.9-8.4
Redox	340+/- 20mV
Salinity	27.5-32ppt
Specific gravity	1.022 – 1.025
Temperature – tropical	23-26ºC

Dugong displays provide the opportunity to present a rare insight into tropical marine habitat, and especially Great Barrier Reef ecology. This exhibit should be utilised to send a powerful conservation message to park visitors. The dugong exhibit should reflect the natural habitat of the dugong as best as possible with financial and practical constraints. The exhibit should be an accessible oceanarium comprised of white sand as the main substrate and seawater. The dugong's natural habitat is shallow coastal seagrass beds (Marsh *et al.* 2001). It is not feasible to reflect the seagrass habitat because dugongs will quickly exhaust seagrass beds in captivity. However; the shallow coastal habitat may be maintained with pockets of seagrass when available and lettuce feeding trays, as well as a combination of live rock and mock rock, mixed small tropical fish, eagle rays, anemones, corals and mixed marine invertebrate species (Table 3).

Table 3: Species to be considered in designing dugong exhibits for inclusion in exhibit

Recommended species	Species to avoid
Clown fish, blue tangs, dollar fish, brim, small trevally	Large tropical fish (>30cm long)
Eagle rays, Eastern shovel-nosed rays	Manta rays
Port Jackson sharks	All other shark species (aggression)
Coral anemones	Sea turtles (historically "played with" by captive dugongs)
All porifera	Toxic marine plants and corals
Soft corals	Oysters (sharp edged and proliferate)
Hard corals	

Dugongs are tactile animals. The exhibit design should incorporate variable furniture and surfaces which stimulate the tactile senses and create interest for the visitor. Mock rock may be used in conjunction with live rock to give the appearance of an exhibit full of

natural live rock, without the expense of live rock or the increased infection risks associated with adding live rock to a marine tank. Both types of rock will provide tactile surfaces for rubbing against and exploring and the combination of both increases the variability in the exhibit, making it more enriching for captive dugongs. A sunken shipwreck creates interest for visitors and may be tied to Australian history, while also providing habitat for many small fish, invertebrates and sea plants. This furniture provides enrichment for the captive dugongs as a play toy, mentally stimulation, a physical obstacle for swimming fitness and a varied tactile surface for scratching against (A. Barnes *pers. comm.*).

Figure 5: Captive dugong utilizing exhibit furniture
Source: F. Evans (Sydney Aquarium)

Dugong exhibits should embrace the opportunity to promote awareness and conservation messages. Exhibit graphics should convey information about dugong natural history in dot points with photographs, wild distribution with a map, indigenous significance and hunting, an explanation of the mermaid myth and a panel on marine or dugong conservation (see appendix). The conservation panel may include information regarding the dugong's current Vulnerable status, threats to the dugong (including habitat loss, increased water temperature, land clearing, boat traffic, entanglement in nets, hunting and slow reproductive rate) and ways in which visitors can help support the plight of the dugong (awareness, go slow zones, rubbish in the bin, recycling, reduce carbon footprint, financial support).

Dugongs are fed numerous times throughout the day and lettuce leaves which float free of trays to the water surface pose a threat to dugongs attempting to eat them (because they can trap air bubbles) (A. Barnes *pers. comm.*). Thus, keepers require convenient access to the dugong pool throughout the day. Keeper access should not interfere with public viewing or dugong behaviour and ideally may allow some sort of keeper presentation to promote the conservation message and teach visitors about the little known dugong. A wooden (treated) platform overlooking part of the pool enables keeper access and interaction (for conditioning and veterinary purposes). A pool scoop and

elongated pole with a hook may be used to place and remove lettuce feeding trays in the pool at regular intervals throughout the day, from the keeper platform. This are should be signed staff only and accessed via a gate under staff key so as to minimise the risk of visitors entering the area or falling in the pool.

4.2 Holding Area Design

One or more holding pools should be provided to allow separation of animals before shows, for feeding, for the introduction of new animals, for veterinary reasons and as a precaution for calving (DPI 1994). The holding pool should be an adjunct of the main pool where possible so that the animals may move freely between both pools when division is not required (DPI 1994). The minimum dimensions for holding pools will vary depending on the function of the holding pool (DPI 1994). Holding facilities should cater for the lowering of water levels for routine treatment and examinations (DPI 1994). At least one isolation pool should be provided for the separation of sick or new animals; the isolation pool should meet minimum space requirements and be operated and filtered independently of other pools (DPI 1994). Isolation pools must not be narrower than 7m or shallower than 2m and must provide 49 square metres per animal housed (DPI 1994).

4.3 Spatial Requirements

T. truncatus may be up to 4m long and weigh up to 400kg (Edgar 2001). In contrast *D. dugon* can be up to 3m long and also weigh up to 400kg (GBRMPA 2007). The spatial requirements of *D. dugon* will vary from that of the bottle-nosed dolphin (*Tursiops truncatus*) due to differences in behaviour between the two species. Enclosures housing *D. dugon* will contain a pool of water and may consist entirely of a pool of water (DPI 1994). Sufficient space shall be provided both horizontally and vertically to enable the animals to exercise, to protect them from undue dominance or conflict and to provide for their social, breeding and husbandry needs (DPI 1994). For *T. truncatus*, at least one primary pool will provide a minimum of 1400 cubic metres pool space in which up to five animals may be held; an additional 300 cubic metres of pool space must be provided for each additional animal housed above five animals (DPI 1994). The primary pool must not be narrower than 14m or shallower than 2.5m and at least half the pool will be at least 3m deep for *T. truncatus.* These depths may vary slightly for *D. dugon*, given that dugongs are less acrobatic than dolphins. The minimum surface area for each animal will be 49 square metres (DPI 1994).

4.4 Position of Enclosures

The enclosure must be constructed in such a way as to minimise the entry of predators of animals in the enclosure, pests and wild animals of the same or similar species (DPI 2004). The standards for exhibiting bottle-nosed dolphins do not stipulate a preference for the orientation or position of pools (DPI 1994). Attention should be paid to the provision of sufficient filtration and temperature regulation systems for pools enclosing dugongs. This equipment should be within close range of the pool for convenience and cost efficiency and not in direct sunlight.

4.5 Weather Protection
Appropriate shaded, covered or sheltered areas must be provided to protect the animals from adverse ambient conditions caused by weather, sunlight or artificial lighting, glare or other environmental factors including wind, rain and extremes in temperatures (DPI 1994; DPI 2004).

4.6 Temperature requirements
The air temperature in indoor enclosures must be controlled so that animals do not suffer from heat or cold, as determined by experienced veterinary advice. Rapid changes in air temperature must be avoided (DPI 1994). The water temperature for pools containing *T. truncatus* must be no less than 10°C and no more than 28°C and protection should be provided against rapid changes in water temperature (DPI 1994). *T. truncatus* inhabit temperate and sub-tropical coastal waters around Australia and Tasmania, thus they are adapted to cooler temperatures than dugongs which inhabit only warmer sub-tropical waters (GBRMPA 2007; Edgar 2001). The recommended water temperature for pools housing dugongs is 24ºC (A. Barnes *pers. comm.*).

4.7 Substrate
Pools should be constructed from materials that are durable, water tight, non-porous, non-toxic and easily cleaned and disinfected (DPI 1994). Exhibit pools may be constructed from concrete and painted with a non-toxic, textured (non-slip) paint for marine mammals which utilise the substrate (Tate *pers. comm.*). Dugongs are coastal bottom feeders and a replenishable supply of beach sand (mainly coral and quartz) is recommended for exhibits (A. Barnes *pers. comm.*).

4.8 Nestboxes and Breeding Material
No nest boxes or breeding material is required for bottle-nosed dolphins (DPI 1994). Nest boxes are not required for dugongs, as calves begin swimming with their mothers immediately after birth, suckling and feeding on seagrass (Ripple1999). In the wild, dugongs are born in shallow coastal embayments, this reduces the risk of predation (not usually an issue in captivity) and assists the juvenile in taking its first breath.

4.9 Enclosure Furnishings
Enclosures should include naturalistic furniture and items to encourage natural behaviour (DPI 2004`). Bare and or sharp projections and edges, loose air or water hoses, cables or restraining nets and fences in poor repair are hazardous to marine mammals and must be avoided in all pools (DPI 1994). No objects, furniture, apparatus, decoration, plants or other items which could interfere with the welfare of the animals or the efficient husbandry shall be kept or allowed to remain in the immediate surroundings of the pools (DPI 1994). Stilted rubber plates or weights may be used to secure seagrass in food provision as described for the rescue and rehabilitation of a dugong calf in Singapore (Chua *et al.* 2001).

5. General Husbandry

5.1 Hygiene and Cleaning

Particulate animal and food waste, trash or debris that enters the pool must be removed as often as possible to maintain the required water quality and to prevent health hazards to the marine mammals (DPI 1994). The walls and floor of the pools shall be cleaned as often as necessary to maintain proper water quality. Buildings and grounds as well as exhibit areas shall be kept clean and in good repair, fences shall maintain good repair (DPI 1994). All boots, aprons, food buckets and receptacles must be kept clean (DPI 1994). The configuration of a pool shall provide for ease of cleaning, draining and maintenance of adequate water quality (DPI 1994).

Cleaning regime

Nesting material and branches are not required for dugong exhibits. Particulate animal and food waste, trash or debris should be removed daily. Water quality parameters must be measured at least three times daily: pH (should average 7.9-8.4), temperature (23°C - 26°C), salinity (27.5-32ppt) and bacterial coliform counts. (For more detail see Table 2 in the Chapter 4 Housing) The coliform bacteria count of the primary enclosure pool shall not exceed 1000 MPN (most probable number) per 100 ml of water (Huekes & van Leeuwen 2008). In the case of chemical additives, tests should be conducted at least four times a day (DPI 1994). If disinfection is required to maintain safe coliform counts, free residual chlorine (hypochlorous acid) may be used (DPI 1994).

5.2 Record Keeping

Establishments shall keep records of all animals on an individual basis that are quick and easy to examine, analyse and compare with those kept by other establishments (DPI 1994). All papers and other information pertaining to each animal from previous locations must be kept safely. Permanent back-up copies of all records will be kept and stored safely. Animals moving to new locations will be accompanied by copies of all records relevant to those animals (DPI 1994). A daily report must be prepared and include the following:

- Clinical data, treatments and medications
- Behavioural observations at training, breeding and any unusual behaviours
- Transfers of animals between enclosures
- The results of water quality tests (pH, temperature, salinity, coliform counts)
- Routine weight and length measurements
- Time, type and amount of food at feeding, behavioural; observations at feeding
- Births and deaths and arrivals and departures
- Maintenance carried out or required
- Measures to control pests
- Staff members on duty

The consolidated records for each animal must contain the following (DPI 1994):

- Correct identification, scientific name, personal name and identity number
- Origin of the individual
- Dates and circumstances of acquisition and disposal

- Date, or estimated, date of birth
- Clinical data, growth and development
- Social behaviour
- Breeding and offspring details
- Date of death and post mortem records

5.3 Methods of Identification
Individuals may be discerned visually by body markings, scars and flipper or tail tears (GBRMPA 2007).

5.4 Routine Data Collection
Weight and length measurements will be made regularly. Calves may be measured and weighed daily to monitor feeding and development (Chua *et al.* 2001).

6. Feeding Requirements
6.1 Diet in the Wild
Dugongs are strictly bottom feeders, feeding almost exclusively on seagrass (Ripple 1999; Marsh *et al.* 2001). Research has shown that in Australia dugongs prefer seagrass species that are low in fibre and high in available nitrogen, meaning that dugongs obtain a greater amount of energy and less bulk in their diet (Marsh *et al.* 2001). The preferred species of seagrass belong to the genera *Halodule* and *Halophila,* which are softer than some other species and more suited to the dugong's peg-like teeth. Where possible the whole plant is uprooted, else only the leaves are eaten, hence, the leaves, stems and rhizomes of the plant are eaten (Ripple 1999; Reeves *et al.* 2002).

Figure 6: *Halophila ovalis,* one of the preferred species of seagrass consumed by dugongs
Source: DPI (2005)

Dugongs will occasionally feed on algae if seagrass becomes scarce (Gales *et al.* 2003). Macroinvertebrates have been recorded in dugong faeces, it is unclear however if these are consumed incidentally or intentionally (Reeves *et al.* 2002; Marsh *et al.* 2001). Preen suggests that ascidians (sea squirts) are consumed during the winter and early spring when seagrass productivity is low, to account for the dugongs protein requirements

(Preen 1995). During summer and autumn, seagrass productivity is high and dugongs preferentially feed on new *Halophila* and *Halodule* shoots (Preen 1995). Variation in seasonal feeding strategies is less pronouncd in tropical areas compared to subtropical areas because seagrass beds are generally productive year round in tropical waters (Preen 1995). Thus, a captive diet does not need to reflect seasonal fluctuations unless food supplies become limited.

Dugongs generally feed during the day; however in areas of high human activities dugongs have become increasingly active at night (Reeves *et al.* 2002; Gales *et al.* 2003). In captivity, food is provided for dugongs over an eighteen hour period (A Barnes *pers. comm.*).

6.2 Captive Diet

Ideally seagrass beds could be cultivated in captivity and dugongs could be moved between separate pools containing these seagrass beds, using remote operated slides. In this way there would be an "on" and an "off" pool, where seagrass beds are given the chance to regenerate before being grazed by dugongs. Two dugongs kept at Toba Aquarium (Japan) were fed eelgrass (*Zostera marina*) and maintained a healthy weight over two years (Aketa *et al.* 2003). Thus, *Z. marina,* although not a preferred food item in Australian waters is a suitable food source for captive dugongs. Unfortunately the cultivation of seagrass beds is seldom feasible. For many institutions, the on/off seagrass pool system may be difficult to maintain and perhaps only employed occasionally when facilities are available as enrichment. Thus, alternative diets must be supplied.

In keeping with the dugong's natural preference for high nitrogen low fibre vegetation, captive dugongs may be fed a selection of green lettuce. Lettuce may be grown hydroponically on site to reduce costs and improve sustainability. Iceberg, butterhead or endive lettuces are ideal because they are soft and easily consumed. These varieties are lower in fibre and higher in nitrogen than cos lettuce (University of Massachusetts 2008). However, Sydney Aquarium has trialed a range of green lettuce species, spinach, bok choy and found that cos lettuce is the preferred species for two captive dugongs housed there (A. Barnes *pers. comm.*). A mixture of lettuce species and green leaves (spinach, bok choy) should be fed to captive dugongs. Dugongs are obligate bottom feeders; therefore leaves should be presented in trays weighed down to sit on the substrate so that they are accessible to dugongs (Marsh 1991).

Dugongs naturally graze over the full twenty four hours of a day (although preferentially during daylight hours) and an adult dugong can weigh up to 400kg (Ripple 1999; Marsh *et al.* 2001). Thus, large quantities of food are required to sustain dugongs in captivity. A single adult dugong should be fed around 100kg of lettuce daily. This mass should be split among multiple trays which should be fed out two at a time and replaced as each one is consumed. The weight of lettuce consumed and the rate of consumption should be monitored daily, so that the diet may be adjusted as necessary, preferences determined and behavioural indicators of potential illness or stress recognized quickly (A. Barnes *pers. comm.*).

In addition to seagrass and lettuce mixes, dugongs should be provided with a selection of foramnifera, ascidians and small gastropods (especially during winter) for enrichment (Table 4). These items provide additional protein, enrichment and replicate the natural foraging behaviour and diet of dugongs. Around 500g of foramnifera or gastropods and 2kg of ascidians should be provided 1-2 times per week.

Dugongs do not have a distinct breeding season (Ripple 1999). Seawater temperature affects food availability in the wild and creates slight (species of seagrass consumed) seasonal variations in dugong diet through some of the dugong's distribution. Since diet and water temperature are controlled in captivity the captive diet should not vary throughout the year, except for enrichment and for gestating or calving females. In the case of reproductive females, the diet should be increased and closely monitored to determine possible preference, the rate of feeding and the amount of food consumed so as to satisfy the increased dietary requirements (A. Barnes *pers. comm.*).

6.3 Supplements

Macroinvertebrates such as ascidians, small gastropods and foramnifera may provide added protein and calcium. In captivity, these nutritional requirements may be met by frequently scattering a selection of foramnifera, barnacles, sea snails and sea squirts among trays of lettuce. Behavioural observations should be made to determine the degree to which these are consumed given the uncertainty of the role these food items play in the wild dugong diet (Preen 1995). This practice may aid nutritional value as well as enrichment and encourage natural foraging behaviour.

6.4 Presentation of Food

Dugongs forage leisurely over the twenty four hour period of a day, unless disrupted by human activities, predation or other disturbances (Ripple 1999). This natural behaviour is best encouraged by scattering the lettuce and macroinvertebrates on the substrate. Food should not be provided for the full twenty four hour period, or dugongs may eat to excess and become overweight. Several 30 minute rest periods should be maintained throughout each day at random (A. Barnes *pers. comm.*).

It may be necessary to anchor large clumps of lettuce at various points in the exhibit to prevent them floating away. To do this, lettuce could be threaded through straps stretched over a metal frame as is done at Sydney Aquarium (Figure 6). The frames may be placed in the exhibit pool and will sink to the bottom, where they may be foraged by dugongs. Empty trays should be removed (A. Barnes *pers. comm.*).

Dugongs are intelligent animals that are good candidates for conditioning when housed in captivity. Lettuce leaves may be hand fed by keepers once a relationship has been established (A. Barnes *pers. comm.*).

Insert photos of feeding trays here.

Figure 7: Lettuce trays used to feed dugongs at Sydney Aquarium

Table 4: Weekly diet schedule for dugong. Provide over minimum 6 feeds per day, seagrass is whichever seagrass or seagrasses are available at the time

DAY	SEAGRASS	BUTTER-HEAD	ICEBERG	COS	FORAM MIX	SEA SQUIRT
Monday	5kg	10kg	20kg	70kg	-	2kg
Tuesday	5kg	10kg	20kg	70kg	500g	-
Wednesday	5kg	10kg	20kg	70kg	-	2kg
Thursday	5kg	10kg	20kg	70kg	-	-
Friday	5kg	10kg	20kg	70kg	500g	2kg
Saturday	5kg	10kg	20kg	70kg	-	-
Sunday	5kg	10kg	20kg	70kg	500g	-

Menu

Seagrass lettuce mix

Combine 5kg of seagrass species if any is available with 100kg of mixed lettuce species. The species listed may be replaced or made up with endive, bok choy and spinach. Various species of lettuce and green leaves should be trialed with different captive individuals to determine preferences. This is by no means an exclusive list of leaves to be fed out.

Foramnifera gastropod mix

Weigh out 500g of foramnifera, barnacles, sea snails and other marine gastropods as they are available. Avoid toxic species such as dog whelks and cone shells. Provide a mix of different species for enrichment and nutritional diversity.

Ascidians

Place up to 2kg of ascidians into the pool on the days listed as they are available.

7. Handling and Transport

7.1 Timing of Capture and Handling

Dugongs are susceptible to capture myopathy (Marsh 1983). For this reason they should be captured and restrained as little as possible. Dugongs are intelligent animals which makes them good candidates for operant conditioning which would reduce the stress of handling and veterinary examination in captivity (Ripple 1999). Where possible dugongs should be captured and restrained in the morning to avoid the heat of the day and so the individuals may be monitored throughout the day for signs of stress. As for most species, capture or restraint of individuals when they are reproductively active should be avoided, due to increased aggressive behaviour (Kleimann *et al.* 1996). Note: it is important to keep the nostrils above water to allow breathing, but dugongs should remain wet during transport (A. Barnes *pers. comm.*).

7.2 Catching Bags

No catching bags are required for handling dugongs (IATA). A canvas stretcher, winch and transport box may be utilized.

7.3 Capture and Restraint Techniques

Dugongs are generally a slow moving species; however, individuals are capable of swimming up to 25km/hr over short distances (Ripple 1999). Dugongs may be caught in shallow water using the rodeo technique, whereby the individual is closely followed by a boat and then gripped around the peduncle region by a diver (Lanyon *et al.* 2006). This method of capture may induce a stress response in wild dugongs (Marsh 1983). Alternatively, dugongs may be herded into a canvas stretcher, although this can be problematic, time consuming and result in capture myopathy (A. Barnes *pers. comm.*).

7.4 Weighing and Examination

Examination of dugongs must happen in the water as the species is aquatic and will dehydrate if removed from water. Using the rodeo technique to restrain an individual, morphological measurements and general veterinary assessments including blood sampling can be performed without containing or anaesthetizing the dugong (Lanyon *et al.* 2006).

Dugongs may be weighed by raising them out of the water using a canvas stretcher and winch. The winch should have a weight capacity of at least 800kg to cater for the up to 44kg of dugong, water weight and equipment (A. Barnes *pers. comm.*). *More specific details and step by step instructions of weighing procedure will be incorporated here after November 2009 when "Pig" is weighed at Sydney Aquarium.*

7.5 Release

Dugongs may be released by lowering the transport container into the water, opening the door and releasing the canvas stretcher so that the individual can move freely in the water. Dugongs swim by undulating the fluked tail (Ripple 1999), so the tail area should be the last to be released. Once the tail is freed the individual will swim out of the stretcher without further assistance (A. Barnes *pers. comm.*).

Wild release of captive dugongs has been unsuccessful to date. "Pig" a juvenile male dugong, beached in south east Queensland was rehabilitated at Seaworld, Gold Coast. Initial release attempts were to release Pig into an enclosed bay, so that he could habituate to the water temperature, tidal fluctuations, wildlife and independence under some supervision. The attempt to catch up Pig and release him from the bay into open water was unsuccessful and Pig was beached within a few days. Further complications deemed him unreleasable and he has been housed in captivity for the 9 years since (A. Barnes *pers. comm*).

This experience with Pig has some key points for future release attempts. Individuals that have been hand reared and heavily imprinted are unlikely good candidates for release, dugongs should be released on the outgoing tide to reduce the risk of beaching, release sights should provide ample food supply and minimal disturbance (eg: boat traffic), the site should be monitored to no-invasively document dugong behaviour. Ideally, dugongs released to the wild are of a young age and can be released into a small herd which may incorporate the ex-captive individual and condition more natural dugong behaviour. This

is not always feasible and care should be taken in observing potential aggression between wild dugongs, especially males and the ex-captive individual.

7.6 Transport Requirements

Dugongs are aquatic animals that breathe air through nostrils at the top of the muzzle (Ripple 1999). During transportation, dugongs must remain submerged in seawater, maintained at 23-26ºC (DPI 1994). However, to breathe, sufficient space must be provided within the container above the water level so that individuals can raise their muzzle out of the water.

Adult dugongs may weigh up to 400kg and be over 3m long (Ripple 1999). Thus, they are a cumbersome species and multiple staff will be required to move a single dugong. Heavy lifting equipment including a winch, harness and canvas stretcher are required to move dugongs.

7.6.1 Box Design

Dugongs require specialized transport containers which include an interior and exterior water tight box. The container should be built from sturdy materials such as wood, fibreboard or a heavy duty plastic. It must be long enough to cater for the animal to be transported from tip to tail when fully outstretched and allow at 10cm either end. It should be wide and high enough to cater for the width and height of the individual to be transported, without allowing 180º rollover. The dugong to be transported should be able to move 10cm in any direction to allow natural breath and comfort, however, rolling onto the back should be inhibited due to the risks of crushing.

Dugongs are to be transported with weight resting on the ventral surface. This position is the safest to allow natural breath. Dugongs have large, elongated lungs which are encased in a rib cage down the length of the torso dorsally, but only anteriorly on the ventral surface (personal observation, dugong post mortem November 2009). The weight of the dugong will likely crush the lungs if it were to be positioned ventral side up out of the water column.

7.6.2 Furnishings

There are no furnishings required for dugong transport. The box should remain as hazard free as possible, and no additional weight is recommended given the size of the species. Dugongs should be wetted down with seawater during transport where possible and fresh air flow provided.

7.6.3 Water and Food

The dugong is an aquatic air breathing mammal. During transport, dugongs should be wetted down with seawater for as much of the journey as possible and closely monitored for dehydration or stress (erratic breathing, slowed breathing, heart rate). Fresh air must be provided and sufficient space for the individual to breathe through the nostrils.

Although dugongs graze throughout the day, it is not recommended to provide food during transport. Dugongs are unlikely to respond to food in the varied environment,

feeding naturally takes place underwater and plant material is suspended. The provision of dry lettuce leaves is unlikely to produce a feeding response in dugongs. Dugongs should be fed a generous meal prior to transport and provided food on arrival in the new aquatic environment. For trips exceeding 24hours, dugongs should be allowed a 4 hour rest period where they are allowed to swim in a pool and feed is provided and feeding behaviour closely monitored. This is important for the dugongs health, weight strain, feeding and to prevent travel sores.

7.6.4 Animals per box

Dugongs must be transported as a single animal per box. Multiple animals per box is unsafe due to the risk of them crushing each other and the excessive strain to keepers. (Weight bearing and separation of individuals). Furthermore, dugongs are prone to capture myopathy and transporting multiple individuals together may increase the incidence of stress if one animal becomes stressed, others may stress as a result. Human company during transport is sufficient to satisfy the sociality of dugongs.

7.6.5 Timing of Transportation

Transport should occur in the early morning during the cooler time of the day. This allows monitoring of the dugong over the day to quickly detect any stress responses or health problems.

7.6.6 Release from Box

Dugongs may be released from the transport box by raising out of the box on a canvas stretcher using a winch. Then lowered into the water. Six to eight trained staff should assist the lowering of the stretcher nto the water and free the pectoral flippers and muzzle. The tail should be freed of the canvas stretcher last, as it will greatly aid propulsion, which is unsafe if any part of the dugong remains entangled in the stretcher (A. Barnes *pers. comm.*).

8. Health Requirements

Maintaining healthy captive dugongs begins with preventative medicine and good planning. Where possible individuals should be acquired that are of good health and the health history of the individual acquired as well as its parents, siblings, offspring and previous co-exhibited individuals should be investigated (Kleimann *et al.* 1996). In most cases, captive dugongs may be sourced from the wild, especially in the form of individuals for rehabilitation and thus health histories may not be available (GBRMPA 2007). In such cases it is especially important to record all information pertaining to the individual's health, to develop a reliable history for the future care of the individual described and subsequent captive dugongs.

8.1 Daily Health Checks

A distant examination should be conducted daily before beginning husbandry duties ad disturbing the dugongs. On approaching the exhibit keeper should be aware of the position of the individual dugongs:

- in relation to each other

- position within the exhibit (dugongs will spend the majority of time in a preferred are of the exhibit)
- any unusual behaviour or lethargy
- interactions between individuals (especially unusual interactions or potentially aggressive interactions such as head butting or striking with tusks)
- individuals lying still on the floor of the exhibit for extended periods
- excess left over food
- Appetite

On closer inspection, keepers should check for:

- Unusual or lethargic behaviour
- General body condition: smooth skin, whiskers around the muzzle (no bald patches), no body lesions, no new tusk injuries from co-exhibited individuals, blistering on the skin, normal range of movement of flippers and tail.
- Algal build up on the body or in the water or exhibit
- Barnacle load (increased barnacle settlement, or barnacle settlement interfering with a normal range of movement)
- Cloudy eyes (or encrustation around eyes)
- Secretions from the nostrils, ears or eyes
- Unusual faeces (or reduced faecal load suggesting constipation)
- Any unusual vocalizations
- Increased or decreased rate of breathing at the surface
- Increased agitated activity (usually suggestive of stress or reaction to medication/chemicals)

Often on approaching the exhibit, dugongs will move and orientate themselves toward the keeper (the arrival of a keeper in uniform is an antecedent for the arrival of food). Thus, it is important to make observations before approaching the exhibit (Tait *pers. comm.* 2009).

8.2 Detailed Physical Examination

Dugongs are naturally social and inquisitive creatures (GBRMPA 2007). In captivity individuals will approach keepers willingly, however wild individuals are greatly prone to capture myopathy (Chua *et al.* 2001).

8.2.1 Chemical Restraint

Chemical restraint involves the use of drugs to sedate or reduce the movement of an animal. In order to safely administer drugs to a dugong, its weight must be known. A dugong can weigh over 100 kg within twelve months and adults can weigh up to 400kg, thus presenting logistical issues for regular weighing (Seaworld 2006). Juvenile dugongs should be weighed fortnightly (more often if the individual is ill, suckling or being weaned) and adults may be weighed every 3-4 weeks (Seaworld 2006). A dugong may be weighed by herding the individual onto a canvas stretcher slung between two poles, and then lifting the stretcher onto scales (either with multiple staff for small dugongs or with the use of a crane or pulley system if necessary).

If sedation is required, drugs should be prescribed and administered by a veterinarian. Medicines may be administered by an intramuscular injection posterior to the pectoral fin (Seaworld 2006). Care should be taken to monitor to the animals breathing, maintaining the nostrils above the waters surface to prevent drowning.

Dugongs are good candidates for conditioning, especially individuals that are rehabilitated in captivity from a young age (Seaworld 2006). The use of conditioning reduces the need for chemical restraint and may be safer for captive dugongs, although individual stress should be monitored closely at all times through behavioural observation and heart rate monitoring increased heart rate is indicative of increased stress levels (Seaworld 2006).

What if any health procedures can only be performed under GA?

8.2.2 Physical Examination

Estimated weight

Weight does not need to be recorded daily for an animal of this size (unless monitoring growth or condition in juvenile or ill individuals). Individuals should be weighed every 3-4 weeks (every fortnight at least for juveniles or ill individuals). Individuals can be weighed by herding a single dugong onto a canvas stretcher slung between two horizontal poles, and lifting the stretcher with a crane or pulley (fully grown dugongs may weigh up to 400kg).

Measurements

At weighing, a series of morphological measurements should be taken to assist future weight estimates based on body size. Physical measurements may include:

- Total body length (muzzle to tip of tail) (a)
- Circumference at anterior base of tail (b)
- Pectoral circumference (c) (Seaworld 2006)
- *Include information on bloods, ultrasound, sample collection (faecal sample), wound scraping (glass slide)at a later date*

INSERT DIAGRAM to demonstrate healthy and unhealthy cells at a later date!

Biofouling

Algal growth on the skin of dugongs is natural and not generally problematic. Keepers should be aware of algal growth and barnacle settlement on dugongs in captivity. The per cent coverage of algae and barnacles should be recorded daily and if fouling becomes excessive or begins to affect the range of movement barnacles should be removed. Chlorine may be included in water treatment to reduce algal establishment and barnacle settlement. Care should be taken with chlorine so as not to contaminate food sources (lettuce leaves and seagrass) or overdose the water.

Other examinations

- Dental examination and tusk inspection (dugongs may be conditioned to present an open mouth to inspect molars and tusks)
- Body check for lesions (dugongs may be conditioned to station and roll so that entire body may be viewed)
- Flipper mobility (dugongs may be conditioned to present flippers as well as keepers observing regular range of movement)
- Lip mobility
- Whisker condition (whisker loss, keepers should be aware of any natural bald patches as whiskers are critical to dugong feeding)
- Eyes, ears, nostrils should be checked daily for any abnormalities or discharge. Any abnormalities should be recorded and monitored, lacerations, discharge or any other observations of concern should be assessed by a vet, care should be taken to ensure the airways remain clear.

8.3 Routine Treatments

Water temperature

Dugongs have a thick layer of blubber which insulates them against cool water, however captive exhibits should maintain a preferable water temperature of around 29ºC (Seaworld 2006). The preferable water temperature minimizes stress and maximizes immune defence and efficient metabolism.

Water quality

Chlorine may be used in the water to decrease algal load and barnacle settlement. Care should be taken to dilute chlorine sufficiently (as per container instructions) and keepers should monitor any potential adverse reactions to chlorine (Tait *pers. comm.*. 2009). Possible reactions may include respiratory problems, skin irritation (itchy, lumpy or reddened skin) and loss of appetite. Water should be chlorinated at the time of filling the water body to effectively dilute and spread `the chemical. Water treatment should not be conducted at the time of feeding due to potential contamination of food, or disturbance to feeding behaviour.

Dietary supplements

Dugongs naturally feed exclusively on seagrass. In captivity this diet may be supplemented with Lucerne pellets and salad vegetables, mainly various types of lettuce (Seaworld 2006). This diet is high in fibre and low in available nutrients. In the wild dugongs are known to consume cunjevoi and other marine invertebrates in small quantities; however it is unclear whether this consumption is nutritionally beneficial or occurs incidentally (Edgar 2001). This food source should be provided as per the diet schedule in chapter … or a protein supplement provided to reduce the risk of malnutrition.

Juvenile dugongs should be fed a low lactose simple formula and weaned onto a variety of lettuce, Lucerne pellets, invertebrate mixture (see chapter on feeding) and seagrass to maintain a healthy diet and provide sufficient nutrition (Seaworld 2006).

Find information regarding worming and vaccines (Larry Vogelnest Australian Mammal Medicine text, 2009)

8.4 Known Health Problems

Bacterial

Viral

Protozoan

Cryptospiridium parvulus and *C. duodenalis* cause diarrhoeal disease in dugongs and may be passed to humans through the feacal oral route (Smith *et al.* 2007). (That is by keepers not washing hands after coming in contact with infected dugong fecal matter). The disease is not usually fatal to dugongs unless the infected individual suffers severe malnutrition or a secondary infection as a result of a compromised immune system (Seaworld 2006).

Fungal

Parasites

Flukes are known to infect dugongs (Sangster *pers. comm.*).

Other

- Captive stress/capture myopathy – may be reduced by providing preferable water temperature (29ºC) and simplifying the exhibit (Seaworld 2006). Adult dugongs especially should be caught up as minimally as possible and slowly conditioned to reduce stressful keeper interactions.
- Water quality sensitivity – chlorine should be included in water treatment to fight bacterial growth and reduce algal and barnacle settlement (Tait *pers. comm.* 2009).
- Malnutrition – a sufficient and varied diet should be presented to the dugong on the bottom of the exhibit pool since dugongs are obligate bottom feeders (Edgar 2001). This may be in the form of lettuce leaves weighed down on frames and Lucerne pellets (which sink). Weight should be monitored to ensure the dugongs are eating and retaining nutrition.

8.5 Quarantine Requirements

Wild caught dugongs may ring diseases into the park and should be quarantined initially and closely monitored for signs of disease or illness. Quarantine considerations include:

- Isolated aquatic exhibit required to quarantine dugongs
- Quarantine pool requires an independent filtration system
- Full PPE (gloves, gumboots, safety glasses, face mask, overalls and full length wetsuit) are required for use in and around the quarantine pool only (equipment not to leave the quarantine area)
- Foot baths with disinfectant at entry/exit to pool (these should be changed weekly)
- Chlorine with MSDS for cleaning and maintaining water quality

- Handwashing facilities with antibacterial soap are required around the quarantine area
- Quarantine period should be a minimum 28 days of clean feacal samples testing for parasitic infection.
- Quarantine pools should meet the minimum holding pool requirements described in chapter 4 Housing. Quarantine pools must cater for the natural range of movement of the individual housed and have independent filtration

9. Behaviour

9.1 Activity

Natural Behaviour

Dugongs are creatures of habit. They develop daily activity patterns, influenced by tides, hunting pressure and water temperature in the wild. For example, in areas where traditional hunting pressure is great, grazing occurs mainly at night; where hunting pressure is minimal and tides allow, grazing of shallow seagrass beds occurs throughout the day and night (Ripple 1999). Since the pressure of traditional hunting and tides are not relevant in captivity, grazing opportunity should be provided throughout the day and night to encourage optimum feeding.

Dugongs locomote by undulating the fluked tail, when cruising the pectoral flippers are held up against the body. Dugongs generally swim slowly (3.2-6.4km/hr) but can swim up to 25km/hr in short bursts. Dugongs use their flippers to brake, turn, steady themselves while grazing and to keep the nostrils above the water when surfacing (Ripple 1999). In captivity, dugongs may display stress by swimming at an increased pace in repetitive patterns (personal observation).

Dugongs surface to breathe every minute or so, rarely remaining submerged for more than three minutes. Dugongs are not prone to prolonged exertion. The majority of time is spent grazing; tidal variation, currents, water turbidity, disturbance (such as human interference), wind speed and direction affect dugong grazing behaviour (Ripple 1999). The type of seagrass available affects the style of feeding. Short growing grasses are uprooted and the entire plant, rhizomes, stems and leaves are eaten. Tall growing seagrasses are stripped of their leaves only; the rhizomes are left in place (Ripple 1999). Lettuce leaves fed out from submersible trays in captivity will be eaten in their entirety. If seagrass is intermittently available it should be fed in conjunction with more readily available lettuce leaves in tact, to encourage natural feeding behaviour.

Captive Behavioural Needs

Dugongs are sensitive to cool water during winter in the southern limits of their range (Marsh …). In captivity dugong exhibits should be kept at a minimum 21ºC, ideally 24-26ºC (A. Barnes *pers. comm.*). The exhibit design must allow for both shallow (<1m deep) and deeper (>10m deep) grazing to reflect natural dugong foraging behaviour. Breeding dugongs require a shallow bay area as part of the captive environment, and should not be on display to minimize disturbance. In the wild, blood and other birthing fluids attract predators, so calving females seek shallow protected bays to give birth

(Ripple 1999). Reproductive and juvenile dugongs should not share a pool with potential predators such as sharks.

A sandy substrate enables natural uprooting behaviour and avoids health issues such as callus development on the pectoral fins. Natural water movement may be replicated in captivity by underwater refill valves in the dugong pool. Routine dropping of pools for maintenance may simulate tidal fluctuations (but can not feasibly be conducted every twelve hours in tune with natural tidal variations).

Dugongs display more elaborate social behaviours than manatees and are frequently observed in groups of six or more (Reeves *et al.* 2002). Groups of over 100 may congregate to feed with individuals swimming at a leisurely 10km/hr and covering around 25km a day (Gales *et al.* 2003). Dives usually last only 1-2 minutes but may last up to 8 minutes (Marsh 1991).

9.2 Social Behaviour

Social structure/intraspecific compatibility

Dugongs form loose social grouping, influenced by food availability, reproductive behaviour, environmental conditions and hunting pressure in the wild. Kinship is not as evident as with other marine mammals (Marsh 1991). The only solid social relationship is between mother and calf; vision and hearing are thought to aid mother-calf bonds (Ripple 1999). As a result, captive dugongs may be kept in solitude, however; compatible pairing is preferable. Dugongs that are housed individually require grater keeper interaction and may become anti-social with staff and future additions to the collection.

Competition among males for mating rights is believed to be stronger among dugongs than the closely related manatee, however; institutions holding manatees in the US report concerns of male-male combat in captivity (Huekes & van Leeuwen 2008). Such captive observations raise concerns for housing male dugongs together, however; there is insufficient data on captive dugongs to confirm.

Figure 8: Aerial photo of a dugong herd grazing in QLD
Source: GBRMPA 2007

9.3 Reproductive Behaviour

Male dugongs gather in herds around estrous females and compete to mate in the wild. In some areas males perform lek displays to attract females for mating. During the suckling period (18 months) the female is protective of the calf; who remains within 1-2m of the mother and is commonly piggy backed initially (Ripple 1999). These social interactions

have implications for group housing of dugongs in captivity; for more information on reproductive behaviour see Chapter 10 Breeding.

9.4 Bathing

Dugongs are marine mammals which spend all of their time in the water, coming to the surface to breathe (Ripple 1999). Only the nostrils are exposed at this time, thus dugongs should stay submerged at all times.

9.5 Behavioural Problems

The most commonly seen stereotypic behaviour in the few dugongs kept in captivity is swimming in repetitive patterns. This can be distressful to the dugongs, other animals in the exhibit, staff and members of the public. This behaviour may be reduced by conditioning dugongs to a varied environment to desensitize them to disturbance, or by rearranging exhibit furniture regularly to break swim patterns while minimizing potential disturbances.

9.6 Signs of Stress

Dugongs are prone to capture stress. In the wild they swim slowly and can only maintain speed over very short distances. There are frequent reports of dugongs dying during hunting pursuits without being touched by the hunter (Ripple 1999). Thus, it is important in captivity to develop positive relationships between keepers and dugongs, and where possible to condition dugongs to participate in routine health checks rather, to reduce stress.

Calves and mothers that have been separated have displayed signs of stress, which include pacing, swimming routine laps repetitively, tail thrashing, erratic and frequent surfacing followed by quick dives (Huekels & van Leeuwen 2008). In captivity, dugongs may display stress by swimming at an increased pace in repetitive patterns (personal observation). Rescued orphan calves should be awarded a nanny (if a compatible adult female dugong is available) or kept in extremely close contact with a keeper and bottle fed every two hours (Seaworld 2006).

9.7 Behavioural Enrichment

Dugongs are intelligent mammals requiring constant stimulation in captivity. In the wild dugongs show great interest in boats and loud watercraft; to the point that the species is now threatened in part due to watercraft collisions (Marsh *et al.* 2001). A submerged shipwreck may be incorporated into an exhibit pool to create interest for visitors and dugongs as well as providing shelter for small fish. Small dinghies or motorized boats may sailed across the surface occasionally for enrichment. Small and detachable parts of such objects should be removed as dugongs may chew or manipulate objects in play.

Large robust toys such as traffic witches hats, plastic buoys, pool noodles, pool fetch sticks or rings, basketballs can be placed in the exhibit on a rotating basis, as part of an enrichment schedule. Care should be taken that toys can not be broken up or include small pieces which may be consumed incidentally.

Dugongs are incredibly tactile creatures (Ripple 1999). Short bristles are densest around the muzzle, which is used to sense the environment. Any objects or exhibit furniture which is of varied texture is stimulating to captive dugongs. For example, smooth mock rock may be used in constructing the exhibit pool, with a sandy substrate, a submerged wooden shipwreck, rough edged coral heads, succulent marine plants, piles of pebbles and an oyster shell encrusted rock provide a variety of textures to stimulate the dugong's tactile sensitivity and reflect the natural habitat.

Dugongs have displayed great curiosity and interest in divers cleaning the exhibit pool at both Sydney Aquarium and Seaworld, Australia (A. Barnes *pers. comm.*). They have showed interest in bubbles rising from dive equipment and frequently rub up against the diver's wetsuit. Captive dugongs have demonstrated keen interest in keepers, especially during feeding and conditioning sessions. This behaviour corresponds with the suggestion that dugongs are intelligent and curious marine mammals (Ripple 1999).

9.8 Introductions and Removals

Introducing new dugongs into an exhibit already containing dugongs should occur gradually and be closely monitored. Dugongs should be observed for signs of stress or aggression. Signs of stress may include, inappetite, repetitive swimming patterns, banging against the wall of the tank. Signs of aggression include rapid swimming, directed swimming at a second individual, attempts at mounting or clutching with the flippers, tail thrashing, mouthing another individual.

When introducing a new individual into an exhibit, they should first be placed within the exhibit in a visually separated area and then gradual exposed to the conspecifics. Similarly for removals, if two individuals have been housed together for a period of over a week, a social bond will likely have developed. Thus, to reduce stress, the pair should be separated for short periods at a time and allowed to adjust to the separation. Close behavioural observations should be made to ensure that stress does not develop. At each stage if stress is not observed and natural behaviour is observed in both individuals, then the removal may be progressed.

9.9 Intraspecific compatibility

Dugongs form loose social groups in the wild therefore can be housed together with sufficient space and food resources (Marsh *et al.* 2001). Behavioural observations should be made to ensure that there are no signs of stress or aggression as described above in any of the captive individuals.

9.10 Interspecific compatibility

Dugongs are entirely herbivorous in the wild and do not pose a predatory threat to marine animals. In captivity dugongs may be housed with most marine fish, rays and invertebrates. Sharks should not be kept in the same pool as dugongs, especially young calves because they pose a predatory risk to the dugong. Some bottom feeding species such as the Port Jackson shark may be compatible (A. Barnes *pers.comm.*).

Dugongs will potentially destroy marine plants kept in the exhibit. Display plants should be positioned among rock ledges, where they are less accessible to bottom feeding dugongs and where possible be distasteful but never toxic.

9.11 Suitability to Captivity

Dugongs are not very well suited to captivity due to high cost in maintaining exhibit (more so in temperate climates), high cost and specificity of diet. If wild caught, an adult may never become accustomed to eating lettuce and will starve in captivity.

10. Breeding

10.1 Mating System

Dugongs are polygamous and polyandrous, there are no accounts of monogamy observed in wild dugongs (Ripple 1999). Both males and females become reproductively active at 10 years of age and mating occurs year round (Marsh *et al.* 2001). Groups of males gather around estrus females and compete for copulation; males display intense activity including tail thrashing, splashing and twisting, followed by attempts to clasp the female from underneath until copulation is successful or the female evades her suitors (Reeves *et al.* 2002). Anecdotal evidence of lekking has been reported for dugong populations in Western Australia (Reeves *et al.* 2002).

If copulation is successful, a single calf is born after a gestation period of 13-15 months suckled for 14-18 months and may remain with the mother for up to 3-4 years (Reeves *et al.* 2002, Gales *et al.* 2003; Marsh 1991). There is a calving interval of 2.5-7 years; thus, dugongs are slow to reproduce making them sensitive to external pressures (Reeves *et al.* 2002).

10.2 Ease of Breeding

No dugongs have been bred successfully in captivity. Currently Sydney Aquarium houses a male and female dugong, both close to reproductive age that they are not hopeful of breeding due to the spatial and financial requirements of housing dugongs in captivity, as well as the low success rate of raising calves (A. Barnes *pers. comm.*).

10.3 Reproductive Condition

10.3.1 Females

Female dugongs are reproductively mature from 10 years but may not conceive until they are up to 17 years of age (Marsh *et al.* 2001). Males detect when females are in estrous, most likely through chemical signals, however this is area is poorly understood.

10.3.2 Males

Male dugongs are reproductively mature at 10 years of age. Groups of males will gather around estrous females in the wild and display tail thrashing behaviour in attempts to mate with her. Sexual selection provides for the strongest male in such lek displays (Marsh *et al.* 2001).

10.4 Techniques used to Control Breeding

There are currently no chemical or hormonal contraceptives employed for captive dugongs. The best method of contraception is separation of the sexes. This is recommended as amorous males can inflict flesh wounds on females in attempts to breed. In captivity especially it is hard for the female to evade a male.

Investigate the options for contraception used in the manatees housed in captivity in the United States. Will include information here.

10.5 Occurrence of Hybrids

The most closely related species to the dugong is the manatee. In the wild there is no overlap in distribution between these two species, therefore there is no known natural hybrid. There has been no attempt to cross breed dugongs and manatees to date, and the outcome of crossbreeding is unclear.

10.6 Timing of Breeding

Dugongs, like manatees are known to breed all year round, with no distinct peak in breeding (Ripple 1999). In cooler waters dugongs are most likely to breed during the warmer months (September - March). Manatees display a peak period of sperm production in March to November (the warmer months) according to Huekels & van Leeuwen (2008).

10.7 Age at First and Last Breeding

First breeding for males and females 10 years, but may be as late as 17 years in some individuals (Ripple 1999). The oldest known dugong was 73 years old; it is not known how late in life males and females are reproductively active.

10.8 Ability to Breed Every Year

Dugongs do not display a distinct breeding period. A single female will only breed every 3-5years, after gestation, suckling and weaning (Ripple 1999).

10.9 Ability to Breed more than Once per Year

Dugongs are unlikely to breed more than once per year. The life strategy is to invest a great amount of energy and resources into a single calf. Calves remain with the mother for around three years (Ripple 1999).

10.10 Nesting, Hollow or Other Requirements

Dugongs do not build nests or establish hollows, in the wild females give birth in shallow protected bays (Marsh *et al.* 2001). This is thought to avoid predation and improve the success of the calf's first breath. In captivity, if breeding dugongs, it is best to provide a shallow sheltered area within the enclosure to cater for this instinctive behaviour and improve the likelihood of a successful birth.

10.11 Breeding Diet

No special dietary requirements are known for breeding dugongs as they have not been previously bred in captivity. It is important to provide a generous diet of seagrass or

substitute lettuce, high in nitrogen and low in fibre to meet the nutritional requirements of the dugongs and calf (A. Barnes *pers. comm.*).

10.12 Oestrous Cycle and Gestation Period
The gestation period for dugongs is estimated to be 13-14months (Ripple 1999).

10.13 Litter Size
Dugongs give birth to a single calf every 3-5 years (Ripple 1999).

10.14 Age at Weaning
Dugongs suckle their young for up to 18 months. The calf begins to eat seagrass almost immediately after birth, but relies on its mother milk for most nutrition (Ripple 1999). After weaning, a calf may stay with the mother for up to 3-4 years, dugongs are protective of their calves (Ripple 1999).

10.15 Age of Removal from Parents
Wild dugong calves remain with the mother for up to 3-4 years. There are no accounts of wild dugongs fostering orphaned calves (Ripple 1999). There have been no attempts to breed dugongs in captivity, two dugong calves have been raised with some success after stranding but future breeding attempts of captive dugongs should opt to leave mother and calf together for as long as possible, under supervision for successful rearing (A. Barnes *pers. comm.*).

10.16 Growth and Development
Calves are around 1m long and 100kg at birth (Marsh *et al.* 2001). They swim, breathe air and eat seagrass immediately after birth, small calves may be "piggy-backed" by the mother in the wild but are capable of swimming (Ripple 1999). Calves rely on the mother's milk for nutrition but eat seagrass in addition to suckling and grow quickly.

11. Artificial Rearing of Mammals
11.1 Housing
The housing requirements for juvenile dugongs reflect the housing requirements laid out in Chapter 4 of this manual. If the calf is to be parent reared (recommended for greatest success rate) then the housing is required to be large enough to cater for two dugongs. If the juvenile is to be hand reared, a smaller pool may be provided, so long as the free range of natural movement for the growing individual is allowed.

11.2 Temperature Requirements
The water temperature of dugong pools should be 23-26ºC, the adjacent air temperature should be 18-34ºC (Huekels & van Leeuwen 2008). Minimal variation in water and air temperature are preferable (A Barnes *pers. comm.*).

11.3 Diet and Feeding Routine
Dugongs should be fed a low lactose formula, warmed to body temperature eight times a day. The formula should be delivered via a bottle attached to a leather patch to resemble

the dugong teat and encourage natural feeing behaviour. This method was successful in raising “Pig”, a rescued juvenile male dugong raised at Seaworld, Gold Coast (Seaworld).

Seagrass or the substitute lettuce should be provided in the exhibit throughout the day as described in chapter 7 Feeding, to encourage natural feeding behaviour and provide enrichment.

11.4 Specific Requirements
Dugongs should be fed every two to three hours to reflect the grazing nature of this herbivore.

11.5 Data Recording
There is minimal data on hand rearing dugongs in captivity, and few examples of success in raising Sirenians. Any future attempts to raise dugongs should be meticulously documented to assist the development of procedures for artificial rearing. Dugongs naturally feed over the course of the day, therefore, many small meals should be provided every two to three hours. Behavioural data, blood samples, feacal analysis, body temperature and dietary intake should be recorded as minimum.

11.6 Identification Methods
Dugongs may be distinguished by scratches on the skin or the position and shape of sunspots. Alternatively, notches may be punctured in the tail flukes if essential, although this opens the opportunity for infection. Tags should not be used as they are likely spots for infection and snag.

Insert photo ID to separate Pig (notches in tail) and Waru (Dark sun spot on peduncle) at Sydney Aquarium.

11.7 Hygiene
Artificially raised dugongs should be kept in quarantine pool. Since the composition of dugong mammary milk is poorly described it is unclear how much immune defence is provided in especially the initially days of suckling. Exposure to potential pathogens should be minimised as much as possible in this critical period.

The pool should have independent filtration, be accessed by minimal staff. Staff must wear PPE, wash before and after time in the quarantine facility, all equipment should be stored within the quarantine facility and cleaned before and after each use.

11.8 Behavioural Considerations
Dugongs are a social animal, isolation stress may be prevalent in calves. Toys should be provided to eleviate this concern. If the animal is considered to be a candidate for release then minimal human interaction should occur to avoid imprinting. If the individual is to kept in captivity, human interaction is acceptable and may provide benefits for conditioning, and reduction of isolation stress.

11.9 Use of Foster Species

There is no record of an orphaned dugong being fostered in the wild or in captivity (Ripple 1999). Manatees are the most closely related species to dugongs, these are the only option for consideration in choosing a foster species, however, little is known regarding manatee mammary products and their similarity to dugongs. There are other dietary and behavioural differences between manatees and dugongs which suggest that it is not a good match for a foster species.

11.10 Weaning

Juvenile dugongs should be weaned after 12 months of age, but as late as 13-14months old. They may be offered seagrass and lettuce supplements immediately after birth to encourage natural feeding behaviour (Ripple 1999).

11.11 Rehabilitation and Release Procedures

There has been minimal success in rehabilitating and releasing dugongs back into the wild (Seaworld 2006). This species is not recommended for rehabilitation and release until we have a better understanding of the composition of mammary products, immune system, social behaviour and stress response.

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15. Glossary

anterior

dextral

phanerogamous

posterior

turnover rate- The turnover rate is the amount of time it takes for a treatment system to pass the volume of a pool through its system once (Huekes & van Leeuwen 2008).

ventral

16. Appendix

eg: equipment details, suppliers and drug details.