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Sirenian status and conservation efforts

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Abstract

The Order Sirenia is represented by only four living species: three species of manatee and the dugong. All are listed as vulnerable to extinction by the IUCN (IUCN 1990). The three species of manatees all belong to the family trichechidae: the Amazonian manatee, *Trichechus inunguis*, the West African manatee, *Trichechus senegalensis*, and the West Indian manatee, *Trichechus manatus*. There are two subspecies of the West Indian manatee: the Antillean manatee, *Trichechus manatus*, and the Florida manatee, *Trichechus manatus latirostris*. The dugong, *Dugong dugon*, is the only extant species of the family dugongidae. The status of manatees and dugongs is generally poorly known outside Florida and Australia. This review provides an overview of current estimation on their distribution and abundance and highlights recent conservation activities.

Introduction

The Order Sirenia is represented by only four living species: three species of manatees and the dugong. These large aquatic herbivores have become widely recognised as flagship species for coastal marine conservation efforts throughout their ranges.

All are listed as vulnerable to extinction by the IUCN (IUCN, 1990). The three species of manatees all belong to the family trichechidae: the Amazonian manatee, *Trichechus inunguis*, the West African manatee, *Trichechus senegalensis*, and the West Indian manatee, *Trichechus manatus*. There are two subspecies of the West Indian manatee: the Antillean manatee, *Trichechus manatus*, and the Florida manatee, *Trichechus manatus latirostris* (Fig. 1). The dugong, *Dugong dugon* (Fig. 2), is the only extant species of the family dugongidae. The other modern dugongid, the giant Steller's sea cow *Hyrodamalis gigas*, was exterminated by sealers in the late eighteenth century (Domning, 1978).

This account provides a brief overview of the status of the dugong and the three species of manatees, adding supplementary information where appropriate, and highlights recent conservation activities, which are encouragingly numerous.

Status

West Indian Manatee

Antillean subspecies

Caribbean Islands. The current, known distribution of the Antillean manatee in the Caribbean region is shown in Fig. 3. Except for rare sightings in the Virgin Islands, manatees have not been documented to occur in the Lesser Antilles since the eighteenth century. Based on interviews of fisherman, Estrada & Ferrer (1987) reported that manatees are still abundant along portions of the northwestern and southwestern coast of Cuba. Interview surveys conducted from 1984–1989 have indicated that manatees are moderately abundant along much of the Cuban coastline, particularly in estuaries and river mouths (L. T. Ferrer and A. R. Estrada, unpubl. ms.). In recent years, however, economic problems in Cuba threaten the security of manatees and other species (A. R. Estrada, pers. comm., 1994). The manatee has been legally protected in Cuba since 1936, and has been listed as a threatened species since 1973. Despite Cuba's being the largest of the Caribbean islands, Estrada and Ferrer note that it does not have a research or management program for manatees. They are concerned that increased development in coastal habitats could have a negative impact on manatees and other marine fauna. They acknowledge the important relationship between manatees and seagrasses, naming *Thalassia* and *Syringodium* as the most abundant species in the muddy bottoms along almost the entire coast of Cuba. They sum up the status of manatee conservation as a situation in which the policy for protection exists, but economic limitations prevent effective implementation of the policy. This describes well the status of Antillean manatee conservation efforts throughout the subspecies' range.

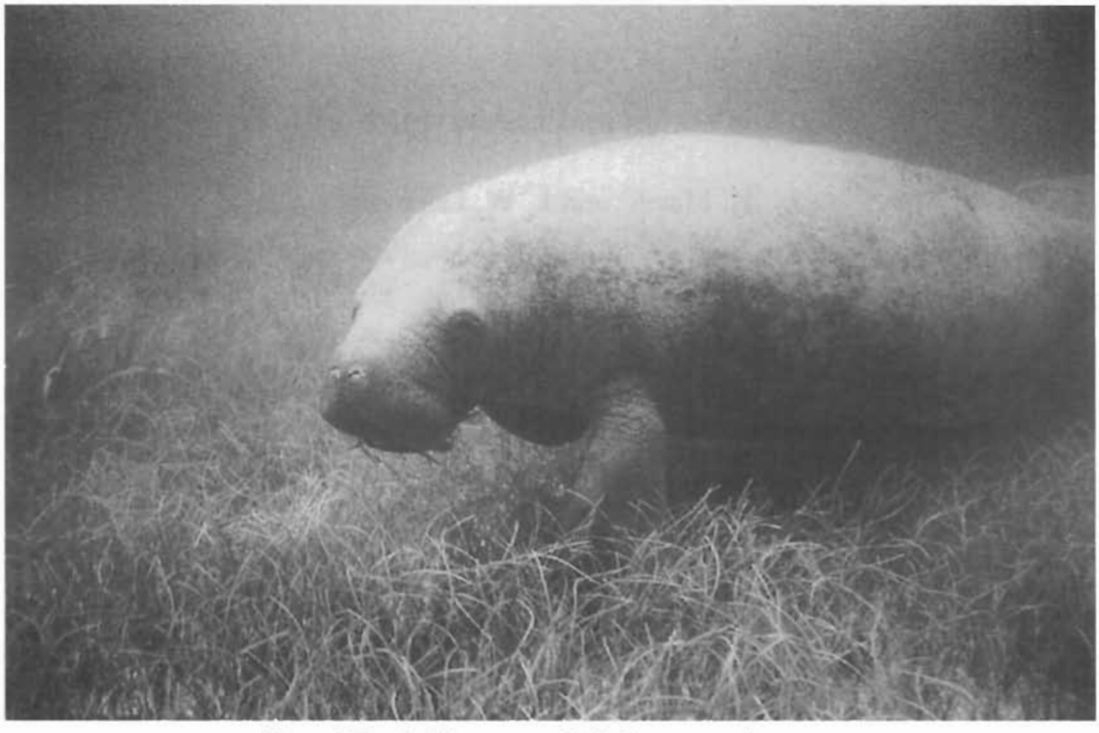


Figure 1. The Florida manatee, *Trichechus manatus latirostris*.

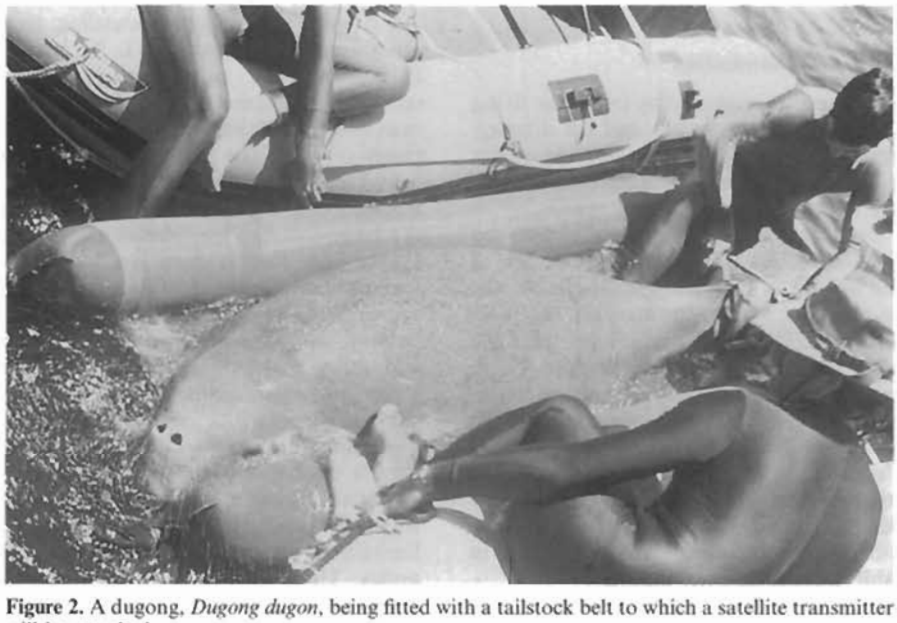


Figure 2. A dugong, *Dugong dugon*, being fitted with a tailstock belt to which a satellite transmitter will be attached.

Figure 3. Distribution of the Antillean manatee (*Trichechus manatus manatus*) in Mexico, Central America, and the Caribbean Islands. Areas where the manatee is likely to be present but its distribution in unconfirmed are indicated by ?

Prospective Ambiental Dominicana, with headquarters in Santo Domingo, Dominican Republic, is a non-profit organization which initiated manatee education and research programs in 1992. Aerial surveys have been conducted between Manzanillo and Puerto Plata, and a marine mammal stranding program has been started. This recent effort is the first in 16 years in the Dominican Republic, where the current status of manatees may be critical (J. A. Ottenwalder, pers. comm.). The future of manatees in neighbouring Haiti, reported as bleak based on ground and air surveys conducted in 1982 and 1983 (Rathbun *et al.*, 1985), is undoubtedly linked to their survival in the Dominican Republic.

Aerial surveys have been conducted in Jamaica between 1981 and 1983. Fairbairn & Haynes (1982) saw 1–13 ($\bar{x}=6.2$, $n=14$) manatees in any one survey of the entire coast of Jamaica, while T. Carr (pers. comm., 1994) saw 4 and 7 manatees during two surveys he conducted between Kingston and Montego Bay in April 1993. The Jamaica Natural Resources Conservation Authority, with the assistance of the Caribbean Conservation Corporation, is planning to remove two manatees trapped in the Alligator Hole River on the southern coast of Jamaica, where they have seriously depleted their food supply. They will be radio-tagged and released on the coast.

Red Caribeña de Varamientos, the Caribbean Stranding Network (CSN), based in Puerto Rico, has done a great deal to raise public awareness about manatees, and is serving a much needed role of coordination and training for biologists in the Caribbean region. The U.S. Sirenia Project initiated a satellite telemetry study of manatees in Puerto Rico in 1992, which has helped to document the important role of protected waters on the Roosevelt Roads Naval Station and nearby Vieques for manatees in eastern Puerto Rico. With the support and cooperation of the U.S. Fish and Wildlife Service and the National Biological Survey, C.S.N. successfully re-introduced to the wild an orphaned manatee, Moises, which they had reared in captivity for 2 years.

At the southern end of the Caribbean island chain lie Trinidad and Tobago, just off the Venezuelan coast and the Orinoco River Delta (Fig. 4). Manatees still occur in wetlands on these islands, particularly in Nariva Swamp on Trinidad, but the wetlands are in demand for agriculture, particularly rice farming. Boyle & Khan (1993) estimate that there is a population of possibly 25–30 manatees in Trinidad. Local Non-Government Organizations (NGOs) are trying to form the Trinidad and Tobago Conservation Trust Fund, to provide support and management plans for the conservation of Nariva Swamp and other natural areas.

Mexico, Central and South America. Manatees are still found in portions of their former range in Mexico, but may have been extirpated in northern Mexico. Estimates from recent aerial surveys by Colmenero & Zárate (1990) and Morales & Olivera (1991) in Chetumal Bay, just north of Belize, indicate that close to 100 manatees may occur in that region. Benjamín Morales and his colleagues in the

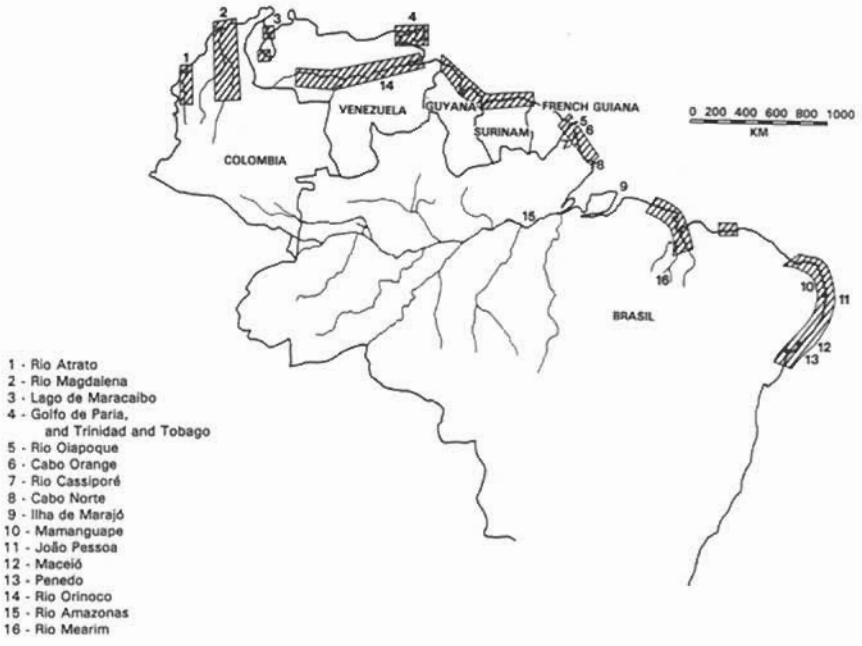


Figure 4. Distribution of the West Indian manatee (*Trichechus manatus manatus*) in South America.

Quintana Roo Research Center have begun an ambitious campaign of manatee conservation education in the state of Quintana Roo. They are also coordinating their proposed research program with their neighbours in Belize. Belize is a small country, but with its low human population and extensive, high quality habitat, it has been described by O'Shea & Salisbury (1991) as offering a last stronghold for manatees in the Caribbean region.

Historical evidence indicates that manatee numbers have probably declined in many Central and South American countries, particularly in Honduras, Costa Rica, Panama, Venezuela, and Brazil (Lefebvre *et al.*, 1989). Quintana-Rizzo (1993) recently estimated the manatee population size in Guatemala to be 53, based on aerial surveys conducted over almost all of the suitable manatee habitat in Guatemala. Most of the sightings were in two large, inland, sea-level lakes, Lago de Izabal and El Golfete. A manatee refuge, the Biotopo para la Conservación del Manatí Chocón-Machacas, was established in El Golfete in 1979. Quintana-Rizzo identified Lake Izabal as the most important manatee region in Guatemala. Carr (1994) surveyed 190 km of the Nicaraguan coastline within the Miskito Coast Protected Area (MCPA) (Fig. 3). He sighted 43 manatees in 11.7 survey hours in March 1992. This suggests a much higher density of manatees in Nicaragua than in neighbouring Honduras, where a total of 11 manatees was sighted during 13 survey hours in 1980 (Rathbun *et al.*, 1983). The largest proportions of sightings were in the two largest MCPA coastal lagoons, Bismuna (42%) and Waunta (45%).

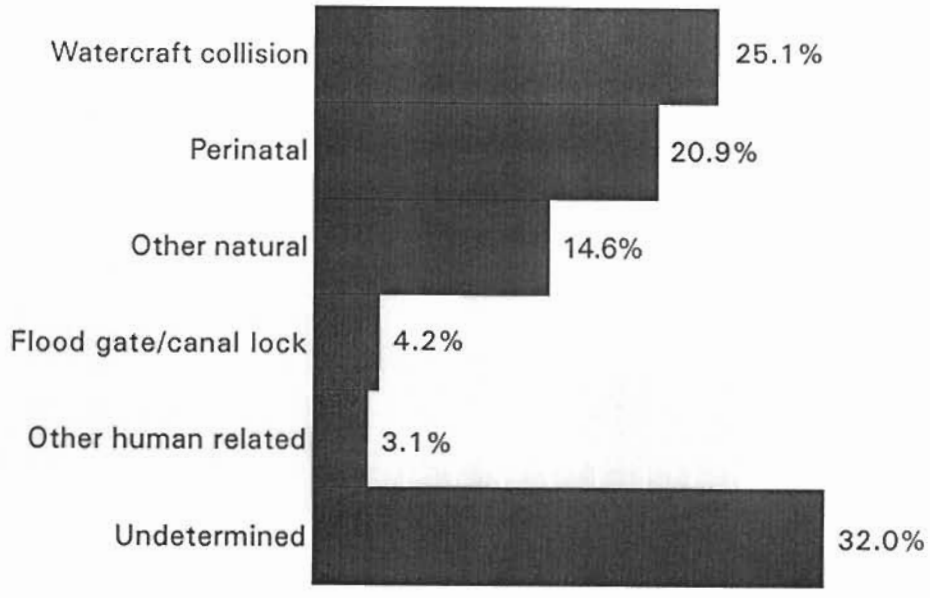
Manatees were commercially exploited in Surinam, Guyana, and Brazil for export to the West Indies during the seventeenth, eighteenth and nineteenth centuries, yet they may still be relatively abundant in Guyana and Surinam. Manatees have a disjunct distribution on the northern coast of Brazil (Fig. 4), and attempts to determine whether or not the ranges of *Trichechus manatus* and *Trichechus inunguis* overlap at the mouth of the Amazon have been inconclusive.

The most significant cause of mortality for the Antillean manatee is deliberate or incidental taking following entanglement in fisher's nets. Subsistence hunting still occurs in parts of Central and South America. Habitat destruction is a growing problem, as wetlands are increasingly being drained for agriculture and commercial development.

Florida subspecies

Of the trichechids, we know by far the most about the Florida manatee. An ambitious research and management program has been implemented over the past two decades to achieve the recovery of the Florida manatee.

Intensive aerial surveys are conducted to obtain an estimate of the minimum population size. The



Source: Florida Department of Environmental Protection and National Biological Survey

Figure 5. Cause of manatee mortality in Florida 1974–1993.

minimum number of Florida manatees is estimated to be 1,856, with approximately equal numbers on the East and West coasts of Florida (Ackerman, 1992).

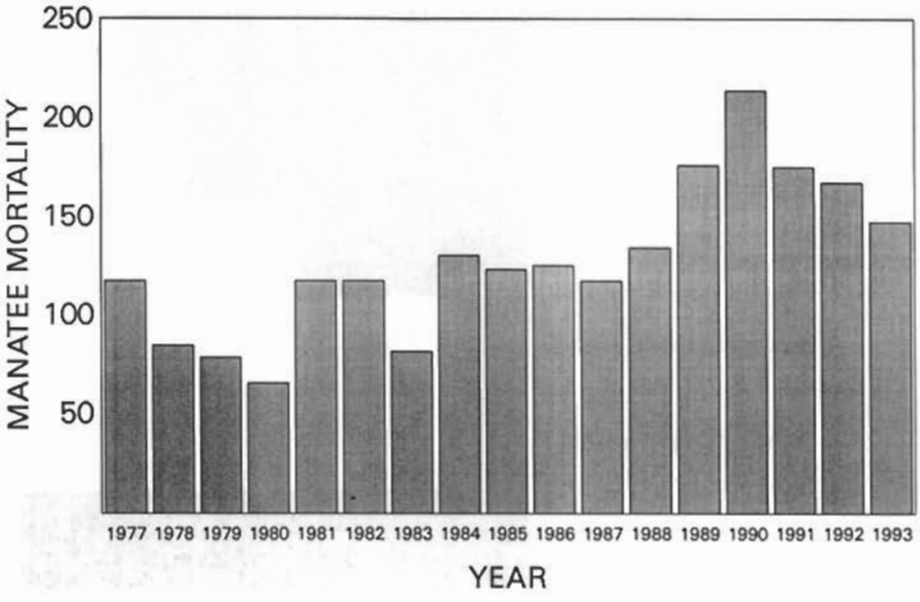
McClenaghan & O'Shea (1988) found that Florida manatees show no regional genetic differentiation. Their levels of observed genic variability suggest that this population has not been subjected to the loss of variability caused by bottlenecks in population size that are characteristic of some endangered species. Attributes which contribute to the manatee's adequate gene flow are: long distance seasonal migrations; lack of strongly seasonal breeding; large, overlapping ranges; and a promiscuous mating system.

The greatest identifiable cause of death for Florida manatees is boat strikes (Fig. 5). The second largest category of mortality is perinatal, followed by other natural causes. Mortality caused by crushing or drowning by flood gates or canal locks, while relatively low overall, has been a recurring problem in some years.

The number of dead manatees recovered each year has steadily increased, from close to 100 in the early years of the salvage program, to close to 200 in recent years (Fig. 6). The number of deaths in 1990 was boosted by severe cold-related mortality. Managers were encouraged by a moderate reduction in the number of boat-related deaths in 1992 and 1993; however, the number of these deaths is dramatically on the rise again (36 from January through July 1994, compared with 16 during the same period in 1993; S. D. Wright, Florida Department of Environmental Regulation, pers. comm., 1994). We will inevitably lose more manatees in some years because of unusually severe winters or other natural causes. Thus it is critical that human-related mortality be controlled.

Marmontel (1993) determined that the manatee survivorship curve is consistent with those of other long-lived mammals, but lacks a plateau through middle age. This is attributed to boat-strike related mortality of adults. She used the computer program VORTEX to model manatee population viability under various sets of reproductive and mortality parameters. She determined that there is a high probability of manatee population persistence for 1000 years, if mortality does not increase and reproduction does not decline. Under a more realistic set of conditions, allowing for some variability in mortality, the probability of long-term survival was not high.

High adult survival rates are vital to population maintenance in species with life history traits similar to manatees. Monitoring adult survival probabilities will be one of the most important tools in evaluating the effectiveness of manatee protection strategies.



Source: Florida Department of Environmental Protection and National Biological Survey

Figure 6. Annual fluctuations in documented manatee mortality in the southeastern United States 1977–1993.

Amazonian Manatee

The Amazonian manatee is the only sirenian living entirely in freshwater and the smallest of the living species (Rosas, 1994). It inhabits rivers and floodplain lakes of the Amazon basin, primarily in Brazil; it is rare to uncommon in Colombia, Peru, and Ecuador (Reynolds & Odell, 1991). The total population size is unknown and would be very difficult to estimate, given the size of the Amazon and its tributaries (7 000 000 km^2), the turbidity of its waters, and the manatees' secretive behaviour (Rosas, 1994). There are two Brazilian research groups studying Amazonian manatees: Projeto Peixe-Boi, initiated in 1975 and centred in Manaus, and the more recently established Projeto Mamirauá, based in Tefé. The Amazonian manatee has been successfully kept in captivity since 1974 by the National Institute of Amazonian Research in Manaus (Rosas, 1994). Projeto Mamirauá, the first large-scale research program on free-ranging manatees, was facilitated by the creation of a protected area of 1 124 000 ha (Estacao Ecologica do Lago Mamirauá) in Western Brazilian Amazonia (Marmontel, 1994). Miriam Marmontel, with Projeto Mamirauá, is currently working on the IUCN Action Plan for the Amazonian manatee and the Antillean manatee. She emphasizes the importance of integrating the principles of biological conservation with the rights of local peoples, for whom large wildlife species, such as the manatee, are often important sources of animal protein. Hunting, deforestation, and pollution threaten the long-term survival of the Amazonian manatee.

West African Manatee

The West African manatee, like the West Indian, lives in a range of coastal and riverine habitats. It occurs in over a dozen countries, from Senegal to Angola. Reynolds & Odell (1991) note that the West African manatee is the least studied sirenian. James Powell, with the Wildlife Conservation Society, has initiated research and conservation programs on the West African manatee, including a radio tracking study in Ivory Coast, and has drafted an IUCN Action Plan for this species. Manatees are still hunted in many parts of West Africa, and are also affected by human-caused habitat alteration and drought.

Dugong

Dugongs occur in the tropical and sub-tropical shallow coastal and island waters of the Indo-Pacific, between about 27°N and 27°S (Fig. 7). Their historic distribution was broadly coincident with the tropical Indo-Pacific distribution of their food plants, the seagrasses of the families Potamogetonaceae and Hydrocharitaceae (Husar, 1978). It is

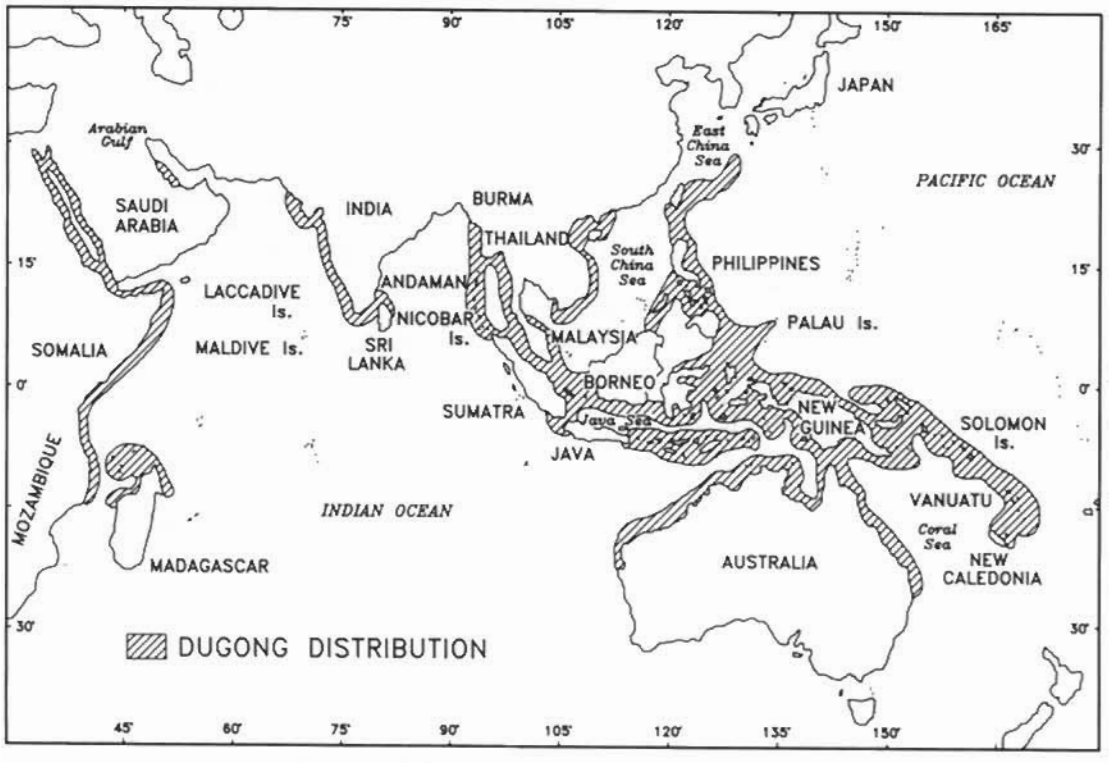


Figure 7. Distribution of the dugong in the Indo-Pacific.

believed that over much of this area the dugong is now represented by relict populations separated by large areas where it is close to extinction or extinct. The degree to which dugong numbers have dwindled, and their range fragmented, is not known. Although some aerial surveys have been carried out, most comprehensively in Australia and Saudi Arabia, over most of its range the dugong is known only from incidental sighting, accidental drowning, and the anecdotal reports of fishers. Most reports are out of date and there has been little modern research on dugongs in most countries in their range. The relative importance of various causes of mortality is generally not known. However, there are persistent reports of accidental drowning of dugongs in fisher's gill nets from many countries. Subsistence hunting persists in some areas including northern Australia.

The waters of northern Australia are considered to be the dugong's stronghold and most modern research has been conducted in Australia. A draft IUCN Action Plan has been developed by Australian researchers. Resident dugong populations occur around the coast from Shark Bay in Western Australia to Moreton Bay in Queensland (Fig. 8). Molecular techniques are being used to investigate the stock structure of dugongs in Australian waters (Dani Tikel, pers. comm., 1994). No population specific markers have been identified to distinguish dugongs from Moreton Bay at the southern limit of its range on the east coast from those from Torres Strait. However, the animals from Moreton Bay have less genetic variation than those from Torres Strait. Preliminary data suggest partial isolation of the Moreton Bay dugongs from the Torres Strait animals and a possible unidirectional gene flow in a southern direction along the east coast. The sample size of dugongs from several sites along the east coast of Queensland is being increased to strengthen these interpretations.

The most recent population estimates for Shark Bay, Ningaloo and Exmouth Gulf in Western Australia, the entire coast of the Northern Territory, the Wellesley Island region of the Gulf of Carpentaria, Torres Strait and the east coast of Queensland (Table 1, Fig. 8) sum to about 85 000 dugongs. These estimates are likely to be underestimates as the correction for the number of animals which are not available to observers due to water turbidity is probably conservative (Marsh & Sinclair, 1989). The regional surveys of Shark Bay, Torres Strait and the Great Barrier Reef have been

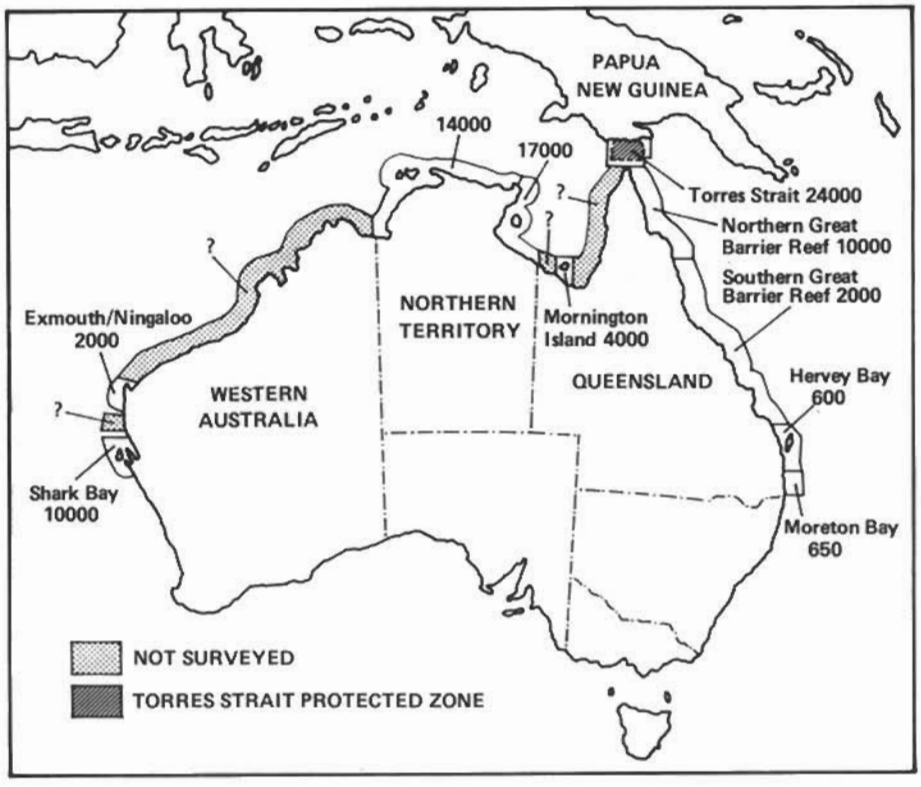


Figure 8. Distribution and abundance of the dugong in Australia. The numbers for each region are the latest mean aerial survey estimates (see Table 1). Areas where dugongs are likely to be present but population size has not been estimated are indicated by ?

Table 1. Most recent estimates of the dugong population in various parts of northern Australia (see Fig. 8)

Location	Date	Area km^2	Population estimate ± S.E.	Reference
Shark Bay WA	July 1994	14 906	10 126 ± 1665	A. R. Preen *et al.*, unpubl.
Exmouth Gulf–Ningaloo WA	July 1994	28 746	1974 ± 588	A. R. Preen, unpubl.
North coast Northern Territory	Dec. 1983	28 746	13 800 ± 2683	Bayliss 1986 Bayliss & Freeland 1989
Western Gulf of Carpentaria	Feb. 1985	27 216	16 846 ± 3257	Bayliss & Freeland 1989
Mornington Island Area	Nov.	8848	4067 ± 723	Marsh & Lawler 1992b
Torres Strait	Nov.–Dec. 1991	30 560	24 225 ± 3276	Marsh & Lawler 1992a
Northern Great Barrier Reef	Nov. 1990	31 288	10 472 ± 1579	Marsh *et al.* 1993
Southern Great Barrier Reef	Nov. 1992	39 396	1857 ± 292	Marsh *et al.* 1994a
Hervey Bay	Nov. 1993	4371	600 ± 126	Preen & Marsh, submitted
Moreton Bay	Apr. 1993	1400	664	Preen & Marsh, submitted

repeated at intervals of four to six years after the initial surveys in the late 1980's. There is no evidence of a decline in dugong numbers in remote areas such as Shark Bay (A. R. Preen *et al.*, unpubl.), Torres Strait (Marsh & Lawler, 1992a) and the northern Great Barrier Reef (Marsh *et al.*, 1993). However, there are indications of a decline along the urban coast of Queensland where dugongs are caught incidentally in fishing gear and where habitats are threatened by coastal development (Marsh *et al.*, 1994a; Preen & Marsh, submitted).

The status of the dugong in Torres Strait is uncertain. The estimated dugong catch of traditional hunters in the Protected Zone (Fig. 8) between June 1991 and May 1993 was equivalent to 1226 ± 204 S.E. dugongs per year (Harris *et al.*, 1994). This is about 5% of the most recent estimate of the dugong population (24 225 ± 3276 S.E., Table 1). Population simulations indicate that even with the most optimistic combinations of life history parameters (e.g. adult survivorship >0.95 p.a. and no human-induced mortality), a dugong population is likely to increase at less than 5% per year (Marsh *et al.*, 1984; Marsh, 1986). Given that the catches do not include returns from Papua New Guinea or from the Australian communities outside the Protected Zone, the closeness of these harvest statistics to the estimated maximum annual increase for the population is a concern. It is impossible to evaluate the situation more accurately without: (1) absolute estimates of dugong numbers; (2) additional catch statistics; and (3) current life history statistics for dugongs in Torres Strait.

Beyond Australian waters dugongs appear to be much less abundant although this conclusion may be at least partially attributable to the different survey techniques used in different areas. A postal survey in 1973–74 revealed the occurrence of dugongs around the entire coast and islands of Papua New Guinea (Hudson, 1976). Groups of 20–50 were reported around Manus Island, in the vicinity of Madang, in parts of West New Britain and the Northern Solomon Islands, from the mouth of the Fly river along the coast to the Indonesian border, and along the northern coast from the border to the mouth of the Sepik River. An aerial survey in 1975 recorded only 186 dugongs in the following regions of Papua New Guinea: (1) the Daru-Warrior Reef area, (2) the south-east Papuan coast, (3) the Lae area and the northwest coast of West New Britain Province and (4) the northwest coast (Ligon & Hudson, 1976). However, this result was not corrected for biases inherent in the survey technique, and so cannot be compared with the aerial survey estimates from Australia.

The main dugong populations in Indonesia are believed to occur along the south coast of Irian Jaya and in the Aru Islands in the Moluccas (Smiet & Siallagan, 1981). Smaller populations are found in Kupang Bay (Timor), Bali, Bangka Island and West Java and at several sites around Sulawesi (Hendrokusomo *et al.*, 1981). Recent aerial surveys have been conducted along the coastline of the Lease Islands in East Indonesia. The minimum population was estimated to be between 22 and 37 animals (Hans de Iongh, pers. comm., 1994). The dugong was listed as extinct in the waters of Borneo by Husar (1978), although its presence on the west coast was reported to Nishiwaki *et al.* (1979).

Twenty-six dugongs were seen during an aerial survey of the waters of the Palauan Archipelago in 1991 (Marsh *et al.*, in press). Dugongs are still hunted openly in Palau despite legislative protection. The New Caledonian population was estimated at 2000–3000 individuals on the basis of 89 sightings (Martini, 1976).

In 1987, a postal questionnaire and qualitative aerial survey were carried out to assess the status of the dugong in Vanuatu. Dugongs were reported to occur in nearly 100 localities including all the major islands and most of the small islands in Vanuatu (Chambers *et al.*, 1989). Most people reported that numbers were either unchanged or increasing.

Seagrass beds become less frequent and poorer in species diversity eastwards across the Pacific, placing a natural barrier to eastward extension of the dugong's range.

Nishiwaki *et al.* (1979) report that the dugong occurs around the islands of Palawan, Polillo and Cebu, and near the towns of Tacloban, Iloio, Zamboanga and Manila in the Philippines. Aragones (in press) monitored dugongs at Calauit Island near Palawan over the period from March 1989 to May 1990. Up to 15 animals were sighted in a single day.

Single animals are occasionally reported in Malaysian waters (e.g. Langham, 1974). Sixty-one dugongs including eight cow-calf pairs were sighted in 1992 during an aerial survey in the region of Had Chaio Mai National Park on the Andaman coast of Thailand (Suwan Pitaksintorn, pers. comm., 1994).

According to Jones (1981), dugongs occur along the entire Burmese coast except for near the mouth of the Irrawaddy River; but are more numerous on the Tennesserim coast from Moulmein and down the Malay Peninsula to the Kra Isthmus. Reports of dugongs from the Moiscal Channel of Bangladesh (Aminul Haque, 1976) were ascribed by Jones (1981) to strays from the Arakan coast.

A substantial dugong population is claimed to occur off the south China coast, particularly in the Gulf of Tonkin and around Hainan Island (Dong, 1983). The 'China Daily' (July 16 1990) reported that dugongs 'swarm' in groups of up to 100 every spring and autumn along the Gulf of Tonkin coast.

Leatherwood did not see dugongs in the Palk Bay–Gulf of Mannar region between India and Sri Lanka during an aerial survey in 1983 (see Leatherwood and Reeves, 1989) despite local opinion that this region probably supports the most important remaining population in the middle part of the dugong's range (Jones, 1981). Dugongs were also not sighted during an aerial survey of extensive seagrass meadows in Western Sri Lanka in 1983 (Leatherwood *et al.*, 1984). Dugongs still occur in the Gulf of Kutch (Frazier and Taej Mundkur, 1991).

The Arabian Gulf still supports significant dugong numbers. Using the aerial survey techniques developed in Australia, Preen (1989) estimated a minimum population of over 7000 dugongs, with the main habitat areas being the Gulf of Salwa and west of Abu Dhabi. He estimated the Red Sea population to be about 4000 dugongs. Dugongs are no longer hunted in the Arabian Gulf or the Red Sea. Their long-term survival is threatened by pollution (especially oil pollution), habitat destruction and incidental drowning in gill nets (Preen, 1989).

Patchy records of single animals and small groups indicate that dugongs still survive along the east African coast, however, it is impossible to assess their contemporary status without a comprehensive aerial survey. Herds of up to 500 were reputed to occur in Somalia (Husar, 1975). Sightings have been reported from Israel (Lipkin, 1975), Djibouti (Robineau & Rose, 1982), Ethiopia (Yalden *et al.*, 1986) and Kenya (Ligon, 1976). Recent aerial surveys in Mozambique indicate that dugongs are locally abundant in several areas (Vic Cockcroft, pers. comm., 1994) with up to 140 animals sighted in Bazaruto Bay. At least seven (and possibly up to 13) dugongs and a dead dugong on a beach were sighted during a comprehensive survey of the Kenyan coast out to the 30 m isobath in 1994 (Rod Salm, pers. comm., 1994). A recent questionnaire survey of 291 fishermen in Zanzibar suggested that the dugong is uncommon around that island despite its many seagrass beds (Clark & Khatib, 1994). However, there are reports of several tens of dugongs on the east coast of Madagascar (Vic Cockcroft, pers comm., 1994)

Conservation Efforts

Manatees and dugongs have protected status in most of the countries throughout their ranges, however, enforcement of regulations is a problem everywhere.

Manatees in Florida and Puerto Rico are protected by the U.S. Marine Mammal Protection Act of 1972 and the U.S. Endangered Species Act of 1973. Under the Endangered Species Act, recovery of a listed species is guided by a recovery plan.

The goal of the Florida Manatee Recovery Plan is to downgrade the species' listing from 'endangered to threatened' and eventually remove manatees from the Endangered Species List. There are three major criteria for downlisting:

(1) the population must be growing or stable,
(2) mortality factors must be decreasing or controlled at acceptable levels, and
(3) habitats must be secure, with threats to habitats controlled or decreasing.

In addition, the Florida Manatee Sanctuary Act of 1978 established all of Florida as a manatee sanctuary. Under this act, slow and idle speed zones have been established in many Florida waterways to protect manatees from boat collisions. The Act also provides for protection of manatee habitat.

The importance of the Recovery Plan cannot be overestimated, because it serves as a coordinating tool for all of the agencies that have jurisdiction over activities that impinge on the welfare of manatees. Without this coordinated approach, problems could be identified and remedies suggested, but there would be no management framework in which to act.

In Australia, the major contemporary challenge is to develop conservation strategies that contribute to maintaining dugong populations at current or higher levels while providing for their traditional use by Aborigines and Torres Strait Islanders. This requires a dual approach to management involving:

(1) the empowerment of Aborigines and Torres Strait Islanders to manage their dugong harvest; and
(2) the introduction of measures which require other stakeholders such as coastal developers and fishers to reduce their adverse impacts on dugongs.

Co-management arrangements for dugong hunting are being developed in the Great Barrier Reef region using Councils of Elders to represent local Indigenous peoples. The Council of Elders in the city of Mackay handles individual applications for traditional hunting of dugongs and is responsible for issuing Authorities to hunters (Fig. 9). The hunters are required to submit data returns to the Council which passes them to the relevant government management agencies which in turn supply the Council with data about dugongs (Cook, 1994). Another Council of Elders in the town of Bowen has recently banned dugong hunting believing that numbers in the area are too few to sustain hunting.

The Nature Conservation Act 1992 (Qld) gives all Aboriginal and Torres Strait Islander peoples the right to take native wildlife subject to certain provisions including conservation plans for protected species such as the dugong. The dugong conservation plan being developed under this legislation will extend the co-management approach being developed in the Great Barrier Reef region to most other parts of Queensland. Traditional Use Authorities will be issued only to a corporation whose members represent an appropriate community or group of Aborigines and/or Torres Strait Islanders. These corporations will serve as foci for joint monitoring, transfer of technical information, advice on the nature of Indigenous traditions and

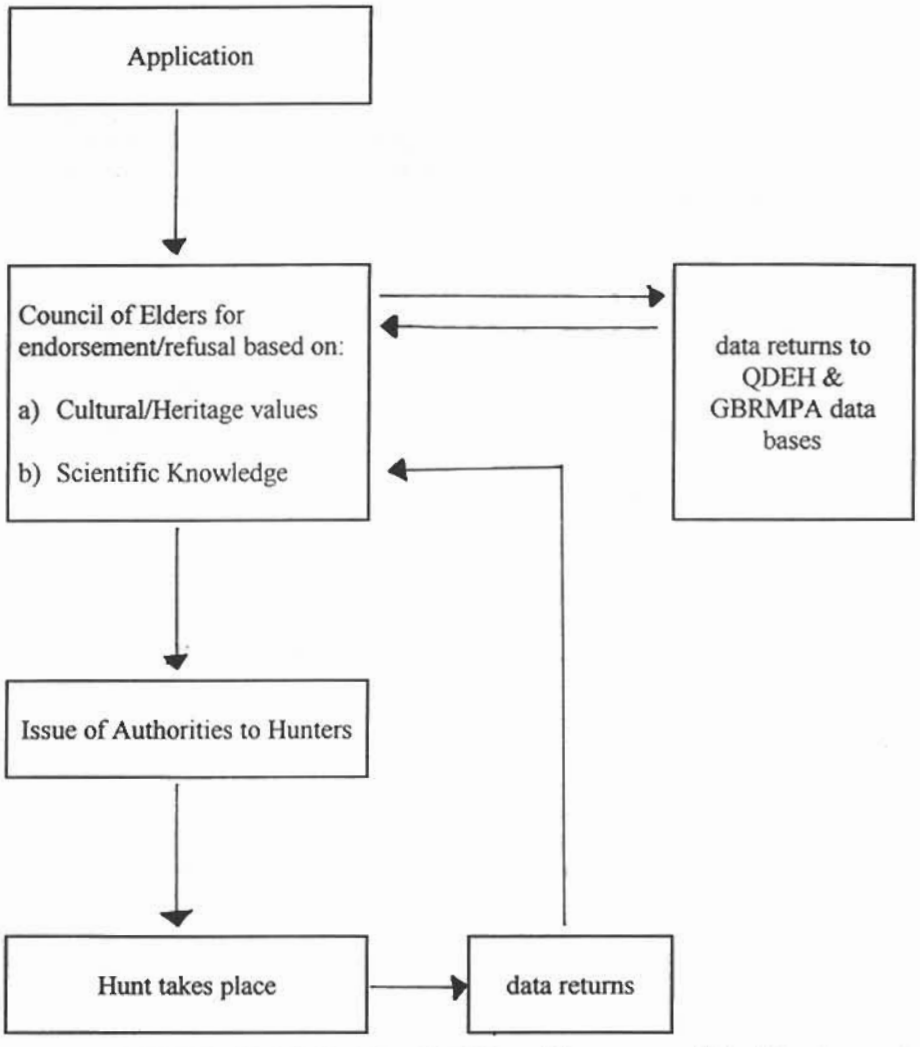


Figure 9. The operation of the Mackay Council of Elders with respect to traditional hunting permits (redrawn from *Reef Research* with permission).

the assumption of group responsibility for the traditional take of dugong.

Sirenia Specialist Group Recommendations

At the International Theriological Congress held in Sydney, Australia, in July 1993, the Sirenia Specialist Group met and developed research priorities for regions which are just starting to assess the status of their sirenian populations.

The Group recommended a step-wise approach to research, that does not necessarily require high levels of funding nor extensive technological expertise. They also recommended the development of education programs that accompany the research, to encourage public interest and involvement in recovery efforts.

UNEP Caribbean Regional Coordinating Unit Workshop

A workshop sponsored by the regional coordinating unit of the United Nations Environment Program was held in Kingston, Jamaica, in early March 1994. The major objective of the meeting was to coordinate the manatee protection efforts of countries throughout the Caribbean. Miriam Marmontel, who is drafting the Antillean Manatee Recovery Plan, was also asked by UNEP to draft a regional management plan for manatees in the

Table 2. An evaluation of the relative merits of techniques used to study Sirenians and their habitats. (Produced by the Sirenian Research Workshop, 14–16 March 1994, Gainesville, Florida)

Technique	Satellite tracking	VHF tracking	Aerial survey	Carcass analysis	Habitat evaluation	Interview survey
Information obtainable	●locations ●movements ●habitat use ●activity	●locations ●movements ●habitat use ●activity ●behaviour of tagged animals	●distribution ●relative abundance ●'absolute' abundance ●population trends ●habitat use ●extent of potential habitat ●similar information for other marine mammals, sea turtles, sea birds	*Decomposed carcasses:* ●measurenents ●skeleton ●stomach contents ●reproductive status ●photographs *Moderately fresh carcasses:* above plus ●organ samples ●skin for DNA ●organ samples for microscopic and gross anatomy ●contaminants ●parasites *Fresh carcasses:* above plus ●pathology ●virology ●bacteriology ●blood for genetics	*Qualitative* ●rapid ecological assessment–species of SAV[1] present ●identification of critical areas ●basis for zoning *Quantitative* ●physical geography of area ●physiochemical parameters of water and benthos ●bathymetry SAV diversity, biomass, productivity ●temporal trends	●sources and levels of mortality ●hunting methods ●awareness of legislation and other conservation initiatives ●distribution ●relative abundance ●qualitative assessment of temporal trends ●biology and ecology especially at local scale e.g. food, breeding season, movements
Type of technical expertise required	●knowledge of animal radio-tracking ●access to well-equipped workshop ●experience in marine mammal capture ●knowledge of ARGOS system	●basic knowledge of animal radio-tracking ●access to well-equipped workshop ●experience in marine mammal capture	●ability to identify species from the air ●statistical skills ●cartographic skills ●good pilot ●crew not susceptible to air-sickness	●basic knowledge of anatomy and priorities for carcass salvage	*Essential* ●ability to recognise species of SAV ●knowledge of equatic ecology *Desirable* ●GIS expertise ●access to aquatic chemists, coastal engineers and social scientists	●good interpersonal skills ●knowledge of local language or access to interpreter ●knowledge of questionnaire design and interview techniques

Equipment required	●capture and handling gear ●transmitter attachments ●transmitters ●receivers ●antennas ●tracking platforms–boats, vehicles ●computer and modem	●capture and handling gear ●transmitter attachments ●transmitters ●receivers ●antennas ●tracking platforms–boats, vehicles, aircraft, fixed stations	*Essential* ●high wing light aircraft ●crew of at least 3 plus pilot ●maps ●data sheets ●polaroid sunglasses *Desirable* ●tape recorder ●intercom ●binoculars ●GPS ●radar altimeter ●stop watch ●computer ●cameras	necropsy kit with ●collecting containers ●preservatives ●surgical gear ●proformas ●specimen labels	*Essential* ●diving gear for ground-truthing *Desirable* ●satellite imagery ●sonar for bathymetry ●climatic data ●aerial photography	●vehicle, boat ●tape recorder ●camera ●writing materials ●maps ●photographs of animals ●interpreter
Cost of equipment	transmitters ++++ other gear +++	transmitters + other gear +++	air time ++++	basic gear + transport ++	++ to ++++ depending on degree of quantification	travel ++
Cost of labour	++	++++	field + lab +++	collection + analysis ++++	++ to ++++ depending on extent and level of resolution	+
Application	●high budget ●large area ●large number of observations	●medium budget ●small area ●detailed observations of individuals required ●less suitable in salt than in freshwater	*Most applicable* ●large areas ●clear water ●information required at large spatial scale ●animals dispersed *Least applicable* ●small areas ●dark and deep water ●overhanging vegetation	●easily accessed areas where anthropogenic mortality is high	*Most applicable* ●situations where most information already exists ●information required at local scale *Least applicable* ●little known area ●very large scale integration of information desired	●reconnaissance ●identify 'hot spots' to focus efforts ●initial education ●assess conservation interest ●assess impact of project

[1]Submerged aquatic vegetation.

Caribbean. This workshop was an important first step in developing effective plans.

First International Manatee and Dugong Research Conference and Sirenian Research Workshop

The Sirenia Specialist Group emphasized the importance of developing a network among the many scientists and managers committed to sirenian conservation. The 'First International Manatee and Dugong Research Conference', hosted by the University of Florida's College of Veterinary Medicine, was a significant contribution towards achieving this objective. The conference was held in Gainesville, Florida, from 11–13 March 1994. Over 200 scientists from 17 countries attended the conference. This diverse group of experts presented new information on sirenian evolution and genetics, monitoring sirenian distribution and trends in abundance, manatee immunology, anatomy and behaviour, manatee hearing and response to boats, management challenges, and the impact of coastal zone degradation on sirenians throughout their range. In many of the 65 countries where sirenians still occur, gillnetting, deforestation, and poor agricultural practices have contributed to declining quality and diversity in coastal marine systems. Seagrass losses have been documented on both coasts of Florida and in Australia, and there is growing concern in countries such as Mexico and Belize that nearshore plant and animal communities will disappear as human populations and coastal development expand.

Twenty-three biologists stayed on after the conference to attend the Sirenian Research Workshop, hosted by the Sirenia Project, National Biological Survey. The purpose of the workshop was to train biologists in sirenian research methods. It covered such topics as aerial survey methods, capture methods, food habits techniques, building VHF radio tag assemblies, satellite telemetry and System ARGOS, environmental education, and the geographic information system and salvage and necropsy programs maintained by the Florida Department of Environmental Protection in St Petersburg. Captive husbandry techniques were explained to participants during a visit to Sea World of Florida.

The workshop participants extended the discussion on research techniques that had been conducted at the International Theriological Congress in Sydney. They conducted an exercise to help determine the relative cost, expertise required, logistic difficulty, and applicability of various methodologies. The results are summarized in Table 2. The objective was to provide researchers with some guidance regarding what projects are feasible and appropriate, given specific levels of available funding, labour, expertise, and the information needed.

Conclusions

The listing of the four species of sirenia as vulnerable to extinction is an expression of concern for their status and not a definitive diagnosis (or a cure!). The status of dugongs and manatees is unknown throughout most of their ranges and likely to remain so for the foreseeable future. The conservation of these species will require an international commitment. The recent international meetings have emphasised the need for coordinating efforts to study and protect manatees and dugongs across international boundaries. They have also laid the foundation for transferring knowledge and technology developed in Florida and Australia to sirenian researchers worldwide.

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