An International Centre for Manatee Research

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Georgetown, Guyana

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AN INTERNATIONAL CENTRE FOR MANATEE RESEARCH

Report of a Workshop held
. 7 – 13 February 1974
Georgetown, Guyana
South America

Cosponsors:
National Science Research Council (Guyana)
National Academy of Sciences (USA)
International Development Research Centre (Canada)

Resumo em Portugués
Resumen en Español
Résumé en Français

The National Science Research Council Georgetown, Guyana 1974

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PREFACE

Aquatic vegetation causes serious problems for public health, fisheries, irrigation, transportation, and hydro-power generation in many tropical countries. Aquatic weed management and utilisation was the subject of a workshop held in Georgetown, Guyana, in March 1973, jointly sponsored by the National Science Research Council of Guyana and the National Academy of Sciences (USA). This workshop recommended, inter alia, exploring the potential use of manatees (**Trichechus spp**) for control of aquatic weeds in view of their voracious and rather indiscriminate consumption of aquatic vegetation.

Manatees are, however, in danger of extinction. They can become important for weed clearance in tropical waters only if their numbers are increased greatly. Survival and utilisation depend on increasing our knowledge of their reproduction, nutrition, and pathology to establish reliable methods of breeding and husbandry. Accordingly, a second workshop was convened to examine the need for, and feasibility of, establishing a Centre for manatee research; and, if such a Centre were justifiable, to indicate possible organisational structures and modes of operation. This second workshop, sponsored jointly by the National Science Research Council of Guyana, the National Academy of Sciences (USA), and the International Development Research Centre (Canada) met in Georgetown, Guyana, 7 - 13 February 1974. Forty-six participants from twenty-three institutions in eight countries were involved.

The deliberations in Georgetown occupied three 2-day stages. In the first stage technical discussions covered background information on manatees, aquatic weeds, and manatee-protection legislation worldwide. Research programmes on behaviour and ecology, nutrition, reproduction, general physiology, and domestication were outlined.

Complementing these deliberations, the second stage incorporated several field observations of manatees; demonstrations of weed clearing by manatees; a flight over the coastal region of Guyana; boat trips to observe natural manatee habitats and potential sites for a manatee research Centre; and visits to the University of Guyana, the Georgetown water works, the Museum, and Zoological Park.

Following this preparation, the third stage consisted of deliberations that led to the workshop's consideration of possible models for the structure of the Centre. After agreeing to recommend the establishment of a research centre, the workshop nominated Professor E.C. Amoroso, C.B.E., F.R.S., to chair an Interim Steering Committee to organise the research centre's establishment.

Workshop participants made specific suggestions on funding and facilities – including site requirements, future actions, a scheme of phased development, as well as detailed lists of needed experiments and basic equipment. The workshop participants welcomed the address by the Hon. Dr. Ptolemy A. Reid, at the time acting Prime Minister of Guyana, who stressed the desire of his Government to support fully the activities of a manatee research centre. He emphasised that the long-established interest in manatees in Guyana argued favourably for locating the Centre in Guyana. He further indicated that Guyana would be prepared to offer adequate land and to provide other services and facilities that would enable a centre to operate effectively and pursue serious scientific research in association with Guyanese laboratories and institutions, and still have autonomy and international liaison.

CONTENTS

Summary

RESUMO EM PORTUGUÊS

RESUMEN EN ESPAÑOL

RÉSUMÉ EN FRANÇAIS

Chapter	1	Manatees
	2	Manatees and Aquatic Weeds
	3	An International Centre for Manatee Research
	4	Suggestions for the Centre's Research Programme
Appendix	A	List of Participants
	B	Acknowledgements
	C	Guyana
	D	Selected Readings

SUMMARY

Tropical food production is often directly hampered by aquatic weed infestation in rivers, man-made lakes, and irrigation schemes. The weeds impede navigation, irrigation, drainage, and hydroelectricity production.

Manatees may offer a significant approach to overcome this problem. Native to more than 40 tropical countries of the Americas and Africa, manatees or sea cows are the world's only herbivorous, totally aquatic mammals. Their voracious appetite for plants has been turned to good use in Guyana, South America, where they have been introduced into canals and have effectively cleared aquatic weed infestations.

Manatees might, in future, prove to be important for aquatic weed control throughout the tropics, since many tropical waters in Africa, Asia, and the Americas are climatically suitable for them. There could be a consequent impact on water-borne diseases, drainage and irrigation, hydroelectric schemes, transportation, and fishing. At the same time, manatee meat is highly prized and holds promise of contributing to food supplies.

But manatees are almost extinct and their use will only become practicable when their reproduction and numbers are adequately assured and the danger of extinction is removed.

Scientists from 8 countries, representing 23 research institutions, considered comprehensively the status, utility, conservation, and biology of manatees at a workshop held in Guyana 7 - 13 February 1974. The participants included internationally recognised scientists with experience and knowledge encompassing manatee research, mammalogy, veterinary science, reproductive physiology and endocrinology, wildlife management, nutrition, organisation of science institutions in developing countries, operation of international organisations, and the utilisation of manatees for weed control.

It was concluded that research on manatees is urgently needed and is critical to the survival and utilisation of the species. Intensive involvement is required of a wide range of scientific disciplines including physiology, ecology, behaviour, and conservation. This can best be accomplished through establishment of a relatively small international centre for manatee research. Despite some difficulties Guyana offers incomparable opportunities as a location for such a manatee research centre.

Objectives of the proposed research centre include increasing manatee numbers, promoting their conservation and husbandry, investigating the use of manatees for aquatic weed control, and food, as well as contributing to mammology and tropical scientific research.

An interim steering committee has been appointed to consider the institutional structure and actions necessary to establish and operate a manatee research centre.

RESUMO

A produção de alimentos nos países tropicais é muitas vezes dificultada por infestações de ervas daninhas nos rios, represas e projetos de irrigação. Estas ervas daninhas impedem a navegação, irrigação, drenagem e produção de energia hidrelétrica.

O manatim poderá vir a solucionar este problema; tem o seu habitat natural em mais de 40 países tropicais na América e na Africa. Os manatins ou peixes-boi são os únicos mamíferos herbívoros totalmente aquáticos. O apetite voraz do peixe-boi por plantas aquáticas já foi utilizado pela Guiana, na América do Sul, na desobstrução de canais.

Os peixes-boi poderão vir a ser importantes no futuro para o controle de ervas daninhas aquáticas nos trópicos, visto que se poderiam aclimatar em muitos rios na África, Ásia e nas Américas. Também poderiam ter un considerável impacto sobre doenças transmitidas pela água, drenagem, projetos hidrelétricos, transporte aquático e pesca. A carne do peixe-boi é altamente apreciada e poderia vir a contribuir no suprimento de alimentos.

Atualmente os peixes-boi estão quase extintos e sua utilização só se tornará viável quando sua reprodução e números estiverem devidamente assegurados e fora do perigo de extinção.

Cientistas de oito países, representantes de 23 instituições científicas de pesquisa estudaram a fundo o problema da utilidade, conservação e biologia do peixe-boi, numa reunião realizada na Guiana de 7-13 de fevereiro de 1974. Entre os participantes encontravam-se cientistas de renome mundial, peritos no campo de pesquisa sobre o peixe-boi, estudos sobre mamíferos, ciências veterinárias, fisiologia e endocrinologia do sistema reprodutivo, manejo da fauna, nutrição, organização de instituições científicas em países em desenvolvimento, funcionamento de organizaçoes internacionais, e a utilizaçao do peixe-boi no controle às ervas daninhas.

Chegou-se à conclusão de que devem ser realizadas urgentemente pesquisas sobre o peixe-boi, de importância decisiva para a sua sobrevivência e utilização. Necessita-se de ampla participação de uma série de outras disciplinas científicas, tais como a fisiologia, ecologia, comportamento animal, e conservação. Pode-se atingir melhor este objetivo criando um pequeno centro de pesquisa sobre o peixe-boi. Apesar de algumas dificuldades, a Guiana oferece excelentes perspectivas para a construção de tal centro.

Os objetivos do referido centro abrangerão estudos sobre o aumento do número de peixes-boi, conservação, reprodução, e pesquisas sobre a sua utilização no controle às ervas daninhas, e o seu aproveitamento como fonte de alimentos; outrossim, o centro também contribuirá no setor de estudos sobre mamíferos e pesquisas científicas nos países tropicais.

Foi eleito em caráter interino um comité diretivo para estudar a estrutura institucional e medidas necessárias para estabelecer e administrar um centro de pesquisa sobre o peixe-boi.

RESUMEN

Con frecuencia la producción de alimentos tropicales se ve directamente impedida por la proliferación de hierbas malas acuáticas en ríos, lagos artificiales y sistemas de regadío. La hierba mala impide la navegación, el regadío, la desecación y la producción hidroeléctrica.

Los manatíes pueden representar una excelente solución para eliminar este problema. Oriundos de más de 40 países tropicales de las Américas y Africa, los manatíes o vacas marinas son los únicos mamíferos herbívoros totalmente acuáticos. Su voraz apetito por las plantas se ha utilizado con éxito en Guayana, Sudamérica, donde se les ha introducido en canales para limpiar en forma efectiva las aguas infestadas de hierbas malas acuáticas.

El manati puede resultar en el futuro un elemento importante para el control de hierbas acuáticas en los trópicos debido a que muchas de las aguas tropicales en Africa, Asia y las Américas son propicias climáticamente para estos animales. Podrían ejercer un gran impacto en las enfermedades acuáticas, sistemas de riego y alcantarillado, sistemas hidroeléctricos, transporte fluvial y pesca. Al mismo tiempo, el precio del manatí es alto y representa una fuente de alimento.

Sin embargo, el manatí está casi extinto y su utilización solamente podrá ser practicable cuando su producción y número esté asegurada en forma debida y se haya eliminado el peligro de su extinción.

Científicos de 8 países, en representación de 23 organizaciones de investigación, consideraron ampliamente el estado, la conservación y la biología de los manatíes en un simposio celebrado en Guayana del 7 al 13 de febrero de 1974. Entre los participantes figuraron científicos de fama internacional con experiencia y conocimiento sobre investigaciones acerca del manatí, animales mamíferos, sicología veterinaria y endocrinología reproductiva, conservación de la fauna, nutrición, organización de instituciones científicas en países en desarrollo y utilización de los manatíes para el control de hierbas acuáticas.

Se llegó a la conclusión que la investigación sobre el manatí es un aspecto urgente y crítico para la supervivencia y utilización de la especie. Se requiere una extensa labor en una serie de disciplinas científicas, incluyendo fisiología, ecología, comportamiento y conservación. Esto se puede llevar a cabo en la mejor forma posible, estableciendo un centro internacional, relativamente pequeño, para la investigación del manatí. A pesar de algunas dificultades, Guayana ofrece oportunidades incomparables como lugar para establecer dicho centro de investigación de los manatíes.

Los objectivos del centro de investigación propuesto abarcan el aumento del número de manatíes, la promoción de su conservación y producción, la investigación del uso del manatí para el control de hierbas malas acuáticas, y como alimento, contribuyendo además a la investigación científica tropical y de animales mamíferos.

Se ha formado una comisión interina de iniciativas para considerar la estructura institucional y las disposiciones necesarias para constituir y operar un centro de investigación de los manatíes.

RÉSUMÉ

Dans les pays tropicaux, les cultures vivrières sont souvent mises en échec par l'envahissement des cours d'eau, des lacs artificiels et des réseaux d'irrigation par des herbes aquatiques. Ces dernières contrarient la navigation, l'irrigation, l'écoulement des eaux et la production de houille blanche.

Le lamantin, le seul mamifère herbivore complètement aquatique, qui est aborigène dans plus de quarante pays tropicaux de l'Amérique et de l'Afrique, pourrait offrir une démarche significative vers la solution de ce problème. On a mis à profit son appétit vorace pour les végétaux, en Guyane (l'ancienne Guyane anglaise) où il a été introduit dans des canaux qu'il a efficacement débarrassés d'herbes aquatiques proliférantes.

Dans l'avenir, les lamantins pourraient se révéler un important facteur permettant de contenir l'envahissement des herbes aquatiques de toutes les eaux tropicales. Ces dernières, en effet, qu'elles soient d'Afrique, d'Amerique ou d'Asie, sont climatiquement favorables à ces mamifères. Les conséquences sur les maladies transmises par l'eau, sur l'écoulement des eaux et l'irrigation, sur les projets de production de houille blanche, les transports et la pêche, pourraient être considérables. En outre, la chair du lamantin est très estimée et pourrait apporter sa contribution comme ressource alimentaire.

Malheureusement, les lamantins sont en voie d'extinction et leur utilization ne deviendra possible que lorsqu'on aura pu assurer leur reproduction en assez grand nombre pour garantir que le danger de disparition n'existe plus.

Des savants de huit pays, représentant 23 établissements de recherche, ont examiné de façon approfondie la condition, l'utilité, la protection et la biologie des lamantins à un colloque qui s'est tenu à Georgetown, en Guyane, du 7 au 13 février 1974. Parmi les participants se trouvaient des savants mondialement connus pour leur expérience et leur savoir sur la recherche sur le lamantin, la mammalogie, la science vétérinaire, la physiologie de la reproduction et l'endocrinologie, la protection de la nature, la nutrition, l'organisation d'établissements scientifiques dans les pays en voie de développement, la gestion d'organismes internationaux et l'usage du lamantin pour contenir la prolifération des herbes aquatiques.

A l'issue du colloque on a décidé que la recherche sur le lamantin était absolument nécessaire et urgente et qu'elle était vitale pour la survie et l'utilisation de l'espèce. Ce qu'il faut c'est l'appui sans réserve de toute une gamme de disciplines scientifiques, y compris la physiologie, l'écologie, l'étude du comportement animal et la protection de la nature. La meilleure façon d'atteindre ce but serait la création d'un centre international, relativement restreint, de recherche sur le lamantin. En dépit de quelques difficultés, la Guyane offre des possibilités exceptionnelles pour l'établissement d'un tel organisme.

Parmi les objectifs du centre proposé on relève : l'accroissement de la population des lamantins, leur protection, leur élevage, la recherche sur leur utilisation, non seulement pour enrayer la prolifération des herbes aquatiques, mais aussi comme ressource alimentaire et, enfin, une contribution à la mammalogie et à la recherche scientifique sur les pays tropicaux.

Un comité intérimaire de direction a été mis en place pour examiner la structure institutionnelle d'un centre de recherche sur les lamantins et les mesures nécessaires à son établissement et à son fonctionnement.

CHAPTER 1

MANATEES

Manatees are believed to share a common ancestry with elephants, dating back to the Eocene period, 50 million years ago. They were first described by Columbus during his first voyage, whose diary for Wednesday 9 January 1493 contains the following:

> ...On the previous day, when the Admiral went to the Rio del Oro, he saw three mermaids, which rose well out of the sea; but they are not so beautiful as they are painted, though to some extent they have the form of a human face ...[1]

Manatees belong to the order Sirenia which has two families, the Dugongidae (dugongs), with one species, and the Trichechidae (manatees), with three living species:[2] the Caribbean manatee, **Trichechus manatus**; the Amazonian amantee, **T. inunguis**; and the African manatee, **T. senegalensis**. Manatees are strictly tropical (see map, FIGURE 1). The Caribbean manatee is native to Florida and to the Gulf, Caribbean, and Atlantic coasts of Central and South America from Mexico to central Brazil. It is also widely distributed in the West Indies. The Amazonian manatee is confined to the Amazon River and its tributaries. The African manatee is found on the west coast of Africa from Senegal to Angola, mainly in the Senegal, Niger, Benue, and Congo river systems.

In the past, the three species of manatee were numerous, even abundant, along the shores and/or in the rivers of a score of countries on both the west and the east sides of the tropical Atlantic Ocean (see list, TABLE 1). Today, it is difficult to locate many places in those countries where a manatee can be readily seen in the wild. A notable exception is a small group of manatees that seasonally congregate in the clear water of the Crystal River in Florida (FIGURES 3, 4). This circumstance and the clarity of water there has enabled scientists to study these manatees in more detail than any others in the world.

Elsewhere, where once there were gregarious herds, populations have been so reduced, and in most places so endangered, as to be on the verge of extinction. The sight of one of these now shy animals is a matter of good fortune.

The largest known residual populations of manatees are the few hundreds in Florida waters, the fair numbers in the small territory of Belize, and the larger total (but probably less dense presence) in the much bigger Guyanese region.

Man appears to be their only predator; hunting is the major cause of their decline. Their meat has often been praised for its delicacy, flavour, and keeping qualities when salted or preserved in its own fat. Furthermore, 85 percent of the carcass can be used because, in addition to the meat,

> The skin can be processed into a tough leather;
>
> The blubber yields a clear, pleasant-flavoured oil; and
>
> The rib bones can be highly polished and used as a substitute for ivory.

1. Bourne, E.G. 1906. Journal of the First Voyage of Christopher Columbus (1492 – 1493). In **The Northmen, Columbus and Cabot 985–1503 AD.** Scribners, New York pp. 77-80.

2. The literature reports that the manatee native to Florida, USA, is a distinct subspecies of **T. manatus**, but this is doubted by modern researchers.

FIGURE 1 The worldwide distribution of manatees.

WORLDWIDE DISTRIBUTION OF MANATEES

Trichechus manatus

Country	Specific location cited in recent decades
U.S.A.	Florida
Mexico	Yucatan Peninsula
Belize	Rivers, e.g., Belize River
Guatemala	Peten region
Honduras	Caribbean coastal region
Nicaragua	Caribbean coastal region; Bluefield River
Costa Rica	Limon Province
Panama	
Colombia	Caribbean Coast
Venezuela	Lake Maracaibo, lower Orinoco
Guyana	See elsewhere in this report
Surinam	Coastal region
French Guiana	Coastal region
Brazil	Coastal rivers in the North East
Curacao	
Cuba	
Jamaica	
Haiti	
Dominican Republic	
Puerto Rico	
Other Caribbean Islands	

Trichechus inunguis

Colombia	Putumayo-Leticia Regions
Peru	Putumayo, Napo, Tigre, Maranon and Ucayali Rivers
Venezuela	Orinoco headwaters
Guyana	Rupununi and Essequibo headwaters (not confirmed)
Brazil	Lower reaches of Amazon main tributaries, e.g., Nhamunda, Tapajos Rivers

Trichechus senegalensis

Country	Specific location cited in recent decades
Senegal	Marigots from Senegal River south Casimance Region
Gambai	Gambai River
Portuguese Guinea	
Guinea	
Sierra Leone	mangrove swamps
Liberia	
Ghana	Volta River (above and below the dam); probably lower reaches of other rivers
Ivory Coast	Cavally River; probably lower reaches of other rivers
Togo	
Dahomey	
Mali	Segou, Lac Debo, Timbuktu, Ansongo, Gao
Nigeria	Mouth of the Niger River, Calabar; Coastal rivers in Western and Mid-western regions; Benue River e.g. at Numan
Chad	Lake Lere and Benue River
Cameroon	Mangrove regions
Rio Muni	
Gabon	Lower reaches of Gabon and Ogooue Rivers
Congo	Kouilou River
Zaire	Lower Zaire (Congo) from Banana to Chaudron d'Enfer, especially round Boma
Cabinda	
Angola	Coastal rivers north of the Cuanza

TABLE 1

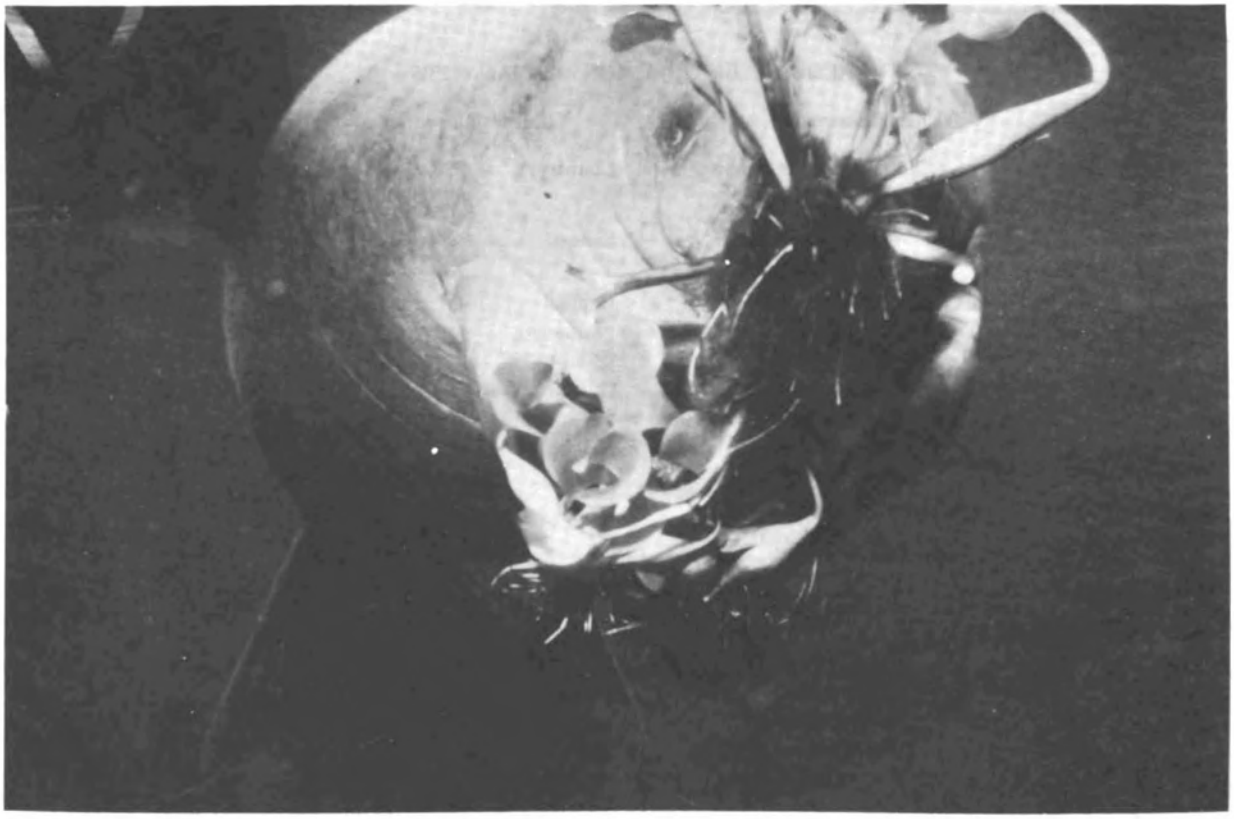

FIGURE 2 Holding several plants between flippers, a manatee feeds on water hyacinth. Spurning the roots, manatees eat the green, aerial parts, killing this, the world's most devastating aquatic weed. They prefer more succulant vegetation if available. (Hartman)

FIGURE 3 Dappled with sunlight, a large manatee swims in the water of Crystal River, Florida, one of the few places in the world where the animals can be seen in the natural state in clear water. Measuring up to 4 m long, manatees can weigh up to 500 kg. With their powerful tails they are strong swimmers. (Hartman)

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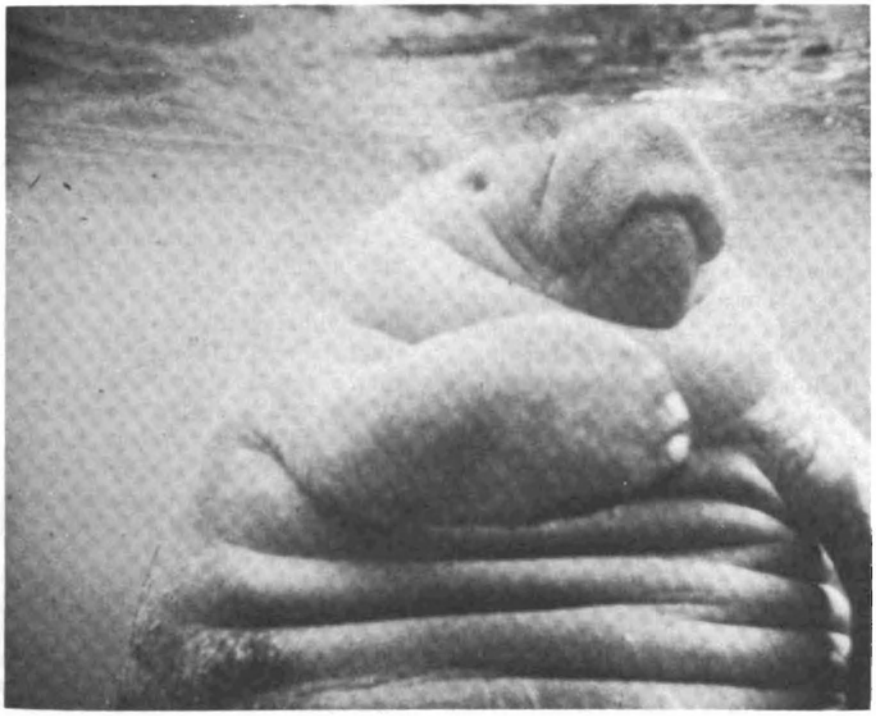

FIGURE 4 Balancing on its tail, a manatee receives a pat from a swimmer at Crystal River, Florida. Some manatees here have become very tame and court the interest of swimmers. Fingernails on flippers are an indication of their terrestrial ancestors and are a feature used to distinguish T. inunguis, the Amazon manatee (which lacks them), from the other two species. Fleshy, bristle covered, lips are independently moveable and are used to "brush" food into the mouth. (Powell)

Because of the many products derived from manatees, they have been much exploited. Intensive slaughter in the Caribbean commenced with the Spanish colonists, who relished the meat and were allowed to eat it on religious fast days, and the buccaneers, who utilized it on extended voyages and expeditions.[3] Later, manatees were used to provide meat for workers in the new sugar plantations on the Caribbean islands. Trade in manatee hides and meat was active on the Amazon River, at least until 1945; in one 2-year period early in this century more than 8,000 were slaughtered[4] By 1964 it was reported that manatees had disappeared from many of the lower reaches of the Amazon.[5] In the early 1930s it was reported that hunting had all but exterminated manatees in the Congo, Gabon, and most of coastal Nigeria.[6]

Manatees are legally protected in almost every country in which they occur, but in remote areas enforcement of the law is ineffective. Furthermore, habitat destruction, wounding by boat propellers, and accidental drowning in nets are increasingly serious threats to survival. That there is little scientific knowledge about manatees also makes their conservation more difficult.

Scientific literature mainly describes the anatomy of various museum specimens and the palaeontology of fossil remains. A few recent papers deal with ecology, behaviour, physiology, and pathology. Knowledge of the animal's reproduction, digestion, respiration, circulatory and excretory processes, its population dynamics, and nutrition is relatively insignificant.

Manatees and dugongs are the only totally herbivorous aquatic mammals. Their ability to convert plants to meat places them in the same category as cattle – hence the common name "sea cow". It is

3. Esquemeling. 1678; Dampier. 1729. (See Selected Readings, p.33 .)

4. Personal communication from P.A. Machado to the workshop.

5. Crowe P.K. and I.R. Grimwood. 1972. Reported in **Red Data Book Vol. 1 (Mammalia).** (Page code 17.116.1.2 E) International Union for the Conservation of Nature and Natural Resources, 1110 Morges, Switzerland.

6. Hatt. 1934. (See Selected Readings. p. 33 .)

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particularly significant that they graze one of the most underutilised food resources: aquatic plants. Voracious feeders, they may consume as much as 20 percent of their body weight per day.

Manatees are remarkably nonselective in their choice of food. They prefer succulant vegetation but, if denied it, will consume almost any available aquatic or terrestial plants. Unlike the exclusively marine dugong, manatees move freely between fresh and salt water. The Amazon species of necessity lives exclusively in fresh water; the others seem to prefer rivers and estuaries to the sea, but their osmoregulatory (salt-balance) mechanisms have not been investigated.

Manatees are by nature slow-moving, shy, unobtrusive, and wary of anything nonaquatic. Nevertheless, they have proven docile and tractable in captivity. Some have appeared to show affection for divers; humanely treated, they can develop close associations with man. They are easily conditioned; in Guyana in both the Botanic Gardens and the Water Works they come to the same locations waiting to be fed lawn clippings (FIGURE 5). During the day they respond to the noise of the gardener sharpening his scythe and swim to the adjacent bank. In Florida they have also been trained to do such simple tricks as swimming through a hoop.

Florida manatees seem to have no distinct breeding season. A female in oestrus is followed by many males. Such a "mating herd" persists from 2 - 4 weeks, but the female is receptive only briefly during this period. Copulation is horizontal, usually in water deeper than 2 meters. During the period of receptivity the female is promiscuous. The presence of several males at oestrus may be a stimulus for normal reproductive responses in the female.

Gestation in T. manatus lasts more than 152 days and may be as long as 13 months.[7] Twins are extremely rare. The calf is born in the water, and the mother pushes it to the surface so it can take its first breath. The newborn rides on her back, and over a period of hours she conditions it to diving by submerging it for successively longer intervals. Calves are suckled at teats located at the junction of the flippers and body. Mother and young can submerge in perfect coordination while suckling. Maternal care lasts for months and possibly for a year or more.

The calf begins feeding on vegetation as early as one month old and intersperses suckling with grazing until weaning, perhaps as much as 2 years later. Manatees become sexually mature at 3 - 5 years of age.

7. Hartman. 1971. (See Selected Readings. p. 33.)

FIGURE 5 The Botanic Garden, in Georgetown, Guyana has had manatees on display since the 1880's. Feeding grass clippings to them has become a tradition with Guyanese children. Manatees have no teeth at the front of their mouths and are not aggressive. (Guyana Information Service)

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CHAPTER 2

MANATEES AND AQUATIC WEEDS

Infestation of aquatic weeds represents one of the most serious and increasingly recognized environmental problem throughout the tropical world. Aquatic weeds block waterways and impede navigation, hydroelectric generation, and fishing. They foster waterborne diseases, curtail rice cultivation in flooded paddies, and render irrigation projects useless (FIGURE 6). This last is a most serious concern in light of the current food shortages. If irrigation water is scarce, the yield and number of crops that can be grown in a year can be drastically reduced. Although aquatic weeds cause serious damage in temperate climates, they create special difficulties in the tropics where the warm waters encourage rapid growth. "Explosions" of aquatic weeds such as water hyacinth (**Eichhornia crassipes**), salvinia (**Salvinia auriculata**), and water lettuce (**Pistia stratiotes**) have occurred in many tropical countries:

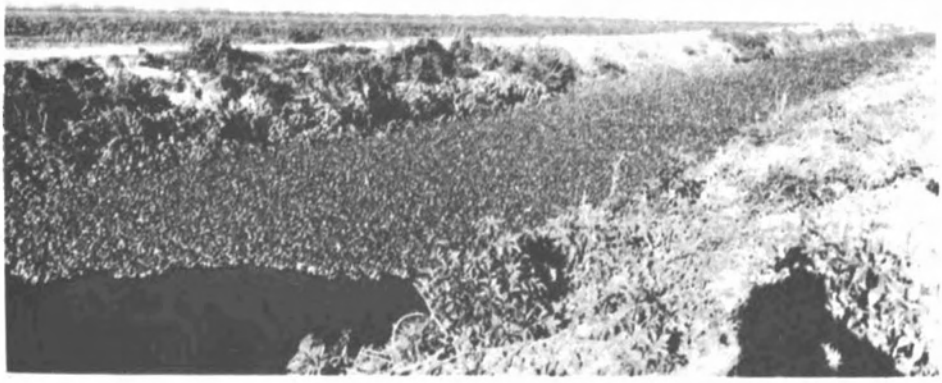

FIGURE 6 Developing countries can ill afford waterways infested with aquatic weeds. Here, in India, water hyacinth blocks and renders useless a canal designed to deliver water to an expensive irrigation scheme. With no inexpensive, effective solution to the problem many tropical countries are faced with serious economic loss caused by aquatic weeds. Furthermore, with increasing numbers of water projects in the tropics their devastating effects are certain to increase in the future. (Zettler)

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Appearing in the Sudan, water hyacinth was reported in 1958 as infesting 1,000 km of the White Nile; it may have attained this spread within a year.[8]

Introduced into Ceylon in the early 1950s, salvinia covered 8,800 ha of flooded rice fields and 800 ha of waterways within about 12 years.[9]

Water hyacinth was first reported in the lower Zaire (Congo) River in 1952; 3 years later it had reached Stanleyville (Kisangani) 1,600 km upstream. Today, some Zaire tributaries are impassable to small boats, and some riverine communities have had to be abandoned. In 1957 it was reported that (despite a U.S. $1 million control project) water hyacinth floated past Leopoldville at a rate of 136 tons/hour.[10]

In India, some expensive irrigation schemes constructed in the last decade have become so choked with weeds that the water flow is cut by 80 percent (FIGURE 6). Some of these canals are hundreds of kilometers long and, if unobstructed, could irrigate hundreds of thousands of hectares, producing large quantities of much needed food.[11, 12]

Water hyacinth reached Bengal in the 1920s. Today, it is estimated that water hyacinth prevents the cultivation of 12,000 ha of land in West Bengal and uncounted thousands of hectares in Bangladesh.[11]

Thousands of hectares of waterways in the southern United States are infested with aquatic weeds. In 1949 it was estimated that in Louisiana

> under good growing conditions, a mat migrates at the rate of 2 ft. per month and the plants double their numbers every 2 weeks by means of offshoots. At this rate 10 plants would produce 655,360 plants (a solid acre) in one growing season (Mar. 15 – Nov. 15).[13]

It was estimated then that the weeds were costing the state of Louisiana up to 15 million dollars annually.

In Florida water hyacinth covers some 80,000 ha of the state's waterways and the cost of controlling aquatic weeds in the state has soared to $7 million a year. Failure to keep the hyacinth in check could render Florida's rivers and lakes totally inaccessible to navigation within a few growing seasons.[14]

Problems in Aquatic Weed Control

Today, no single aquatic weed control method is wholly effective. Methods suitable for tropical countries, in particular, are lacking. Aquatic weeds can be physically removed from the waterways; they can be destroyed with chemicals (herbicides), eaten by animals (notably manatees, herbivarous fish, and insects), degraded by microorganisms, or displaced by species of less harmful plants.[15]

Biological controls are being studied but hold little hope for widespread, immediate use. Herbicides are available, but some have come under attack because of side effects on other species, and the tremendous cost of such aquatic weed control. The most effective commercial herbicide, 2,4-D, costs US$60 – $120 per ha to apply. Almost all developing countries, therefore, are forced to use physical removal as a weed-control measure. But this, too, is expensive and has drawbacks. For example, in India's Chambal irrigation system in Rajasthan State, the main canals (blocked up to 50 percent) and feeder canals (blocked 80 percent) have to be closed for weed clearing once a year. This reduces the number of annual crops that can be grown from three to two.[11] In other countries schistosomiasis and other waterborne diseases, or such unpleasant fish as electric eels, make this method less than ideal.

8. Gay, P.A. 1960. Ecological studies of **Eichhornia crassipes** Solms. in the Sudan. I. Analysis of Spread in the Nile. Journal of Ecology 48:183-91.

9. Williams, R.H. 1956. Salvinia auriculata Aublet: the chemical eradication of a serious aquatic weed in Ceylon. Tropical Agriculture. 33:145-57.

10. Lebrun J. 1959. Reported in Holm, Weldon and Blackburn. (See Selected Readings, p. 34.)

11. Tinker, J. 1974. Waterweeds: flies in the irrigation ointment. New Scientist 61:747-9.

12. Gupta. 1973. **Aquatic Weed Control.** Rajasthan College of Agriculture, Udaipur, India.

13. Penfound, W.T., and T.T. Earle. 1948. The biology of the water hyacinth. Ecological Monographs 18(4):447-72.

14. Personal communication. Aquatic Weed Control Division, Florida Game and Fresh Water Fish Commission.

15. For a summary, see **Some Prospects for Aquatic Weed Management in Guyana** (See Selected Readings, p. 34.)

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Manatees for Weed Control

It is abundantly clear that all methods of tropical aquatic weed control urgently need greater attention by the international scientific community. Yet Guyana is the only country in which manatees have been used for deliberate weed control; in the past 20 years over 200 manatees have been utilized and have proved highly effective.

In 1916, according to the Guyana National Archives, manatees were used for weed clearing in sugar-estate canals, but the practice apparently was not continued. In 1951 the Georgetown Water and Sewage Works built a water reservoir and settling basin (FIGURE 7), and J. Richardson, Deputy Chief Engineer, Georgetown Sewage and Water Commissioners, reported the following experiences to the workshop:

Within 6 weeks of constructing the earth-bottomed canal the quantity of aquatic weeds became so great that the flow rate dropped to less than 1 m per minute, and the water overflowed at the input end. Four men were put to work clearing the 600m long, 12 m wide canal, a job that took about 10 days. Within 2 months, the problem was back again.

In 1952 four manatees were introduced into the canal in a weed-control experiment. Weeds disappeared in about 8 weeks, and the manatees soon had to be fed with grass cut from the surrounding lawns. The government bacteriologist tested the water and declared that the extent of contamination by the manatees was not beyond the capacity of the normal sterilizing equipment of the final stages of the water-treatment plant.

During the 22 years the manatees have been in the canal there has been no weed problem. In this period three manatees have been replaced as they died.

The year 1972 began with only one manatee who alone easily kept the weeds down in a

FIGURE 7 The Georgetown Water and Sewerage Works, Guyana: Manatees have kept this waterway weed free for 22 years. Weed regrowth in this 400 m long, 10 m wide canal is insufficient to sustain even one manatee; the one in here has to be fed clippings daily. Note the cleanly cropped edges. (Vietmeyer)

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FIGURE 9 Before 1959 when two manatees were placed in this Three Friends Canal (see Guyana map, FIGURE 8) it looked like this and annually cost $1,500 (U.S. $750) to clear. . . . .

360 m long section of the canal. This animal died, however, and within a month the original weed problem was back. Two animals were then purchased for G$200.00 (US$100) each, and the weed problem was again solved.

In the mid-1950s the Drainage and Irrigation Department and Bookers Sugar Estates sought ways to control aquatic weeds in the canal system of Guyana. With the increasing use of fertilizers in cane and rice farming, aquatic weeds flourished, and the increasing use of herbicides to control them began to cause concern among the rural population, which used the water for domestic purposes. From 1959 to 1962 approximately 80 manatees were introduced into canals to test their weed-clearing ability. In 1962 the following results were reported:[16,17]

Four manatees cleared the Ruby/Boerasirie Distributary (surface area 3.1 hectares) of **Cabomba aquatica, Nelumbium speciosum, Paspalum repens**, and **Utricularia foliosa.**

- Four manatees could not eat all the **Cabomba, Nelumbium,** and **Luziola spruceana** in the Wales/Georgia Distributary (surface area; 9 ha).
- Two manatees found the quantity of weeds in the Craig Distributary (0,7 ha) insufficient and had to be transferred elsewhere.
- Four manatees kept another section of the Craig Distributary (3.1 ha) clear, but **Paspalum vergatum** persisted at the fringes.
- Four manatees cleared the Garden of Eden Distributary (5.7 ha), though regrowth of **Paspalum repens** was very rapid.
- Three manatees kept the Black Bush Polder channels (2.2 ha) free of aquatic plants.
- Two manatees placed in the Three Friends canal (3.8 ha) in 1959 cleared it of **Cabomba, Luziola,** and **Hymenachne amplexicaule** and have kept it clear since then (FIGURES 9, 10).

16. **Report on the Use of the Manatee in the Control of Undesirable Weeds in Drainage and Irrigation Canals in British Guiana.** 1962, Mineographed internal report issued by Agriculture and Drainage/Irrigation Departments. Reported by Allsopp. 1969. (See Selected Readings, p. 33.)

17. For locations see map, FIGURE 8.

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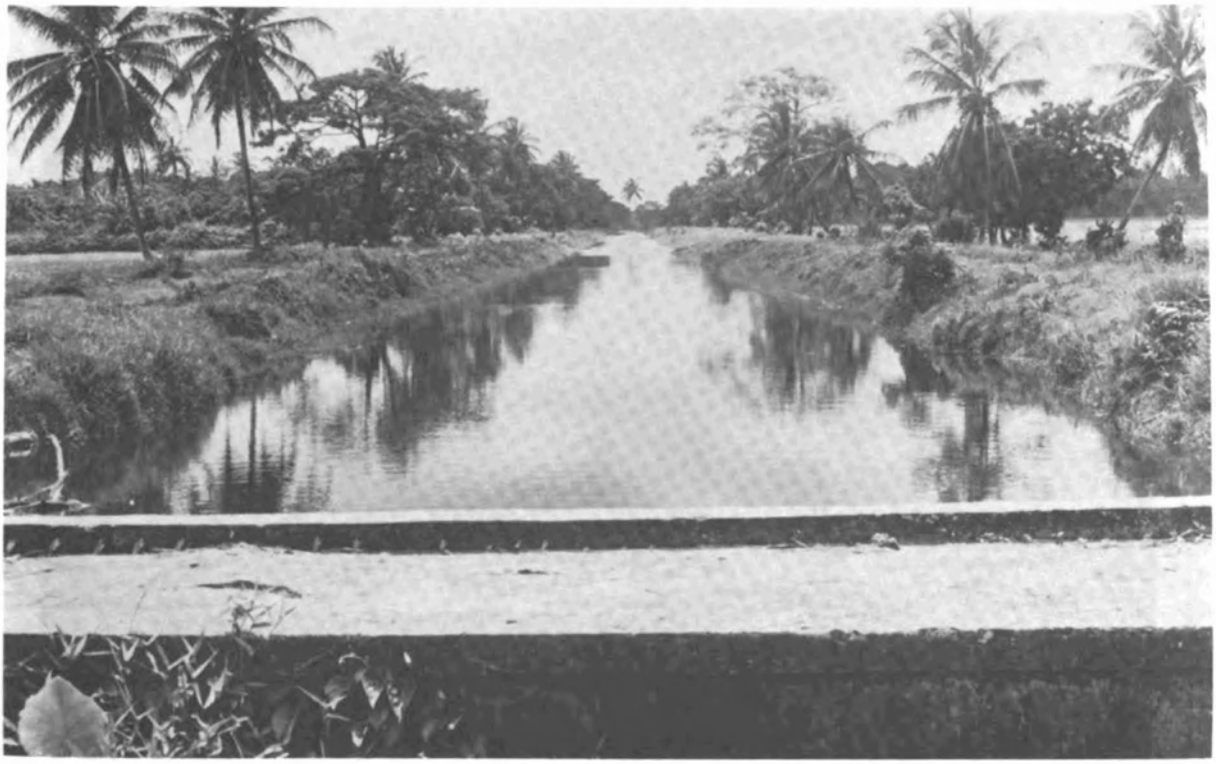

FIGURE 10 . . . . In the 15 years since that time nothing has been spent on weed control. Today, the canal has three manatees (one of the first cases of a birth in semi-confinement) and it looks like this. (Works and Communications Ministry, Guyana)

In 1962 it was noted that the pair had increased to four, one of which has subsequently died.

This canal has not only been clear of weeds during the 15-year interval since the manatees were introduced, but has required no expenditure for weed clearing and no maintenance of the manatees. Before 1959 weed clearing in this canal cost $1500 (US$750) per year; since then nothing at all has been spent on it.

It should be recognized that in these experiments the manatees were placed in weed-infested waterways and the areas represent their weed-clearing ability. It is not known what area of water a manatee can maintain weed free if it must eat regrowth only, but it must be much greater than the figures quoted.

Manatees appear to be very systematic as weed-clearing agents. They begin at a point in the weed patch and move in consort, eating at the edges until the patch is consumed. Canal banks are cleared right up to the soil line (FIGURES 11, 12), but there is no erosion damage due to interference with the soil.

Advantages

Manatees have many advantages as weed-control agents. They are docile, unobstrusive, and harmless to man. They are rather unselective in the food they accept, though they prefer submerged and softer plants. Manatees adapt readily to confinement when provided with adequate food, and can survive in tropical waters whether fresh, saline, acid, alkaline, turbid, or clear. If undisturbed, they remain passive and immobile when out of water (FIGURE 13). Thus, compared with other wild animals of their size and weight, they are fairly easy to transport.

Sometimes called sea cows, manatees convert aquatic plants into protein that could be used for human consumption. Perhaps it is not too far-fetched to note that a single manatee can furnish as much meat as a steer; it can gain weight as rapidly, is as easily cared for, and may prove to be less expensive to rear. Manatees could turn to benefit waters that now are unproductive and, at the same time, relieve the destruction and disease caused by weeds.

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FIGURE 11 This canal in the Botanic Gardens, Georgetown, Guyana, exemplifies the infestation of rooted aquatic weeds (as opposed to floating weeds, as in FIGURE 6) in shallow tropical waterways. It should be compared with. . . .

FIGURE 12 . . . . A neighbouring canal in which a manatee has been placed for the purpose of weed control. (Vietmeyer)

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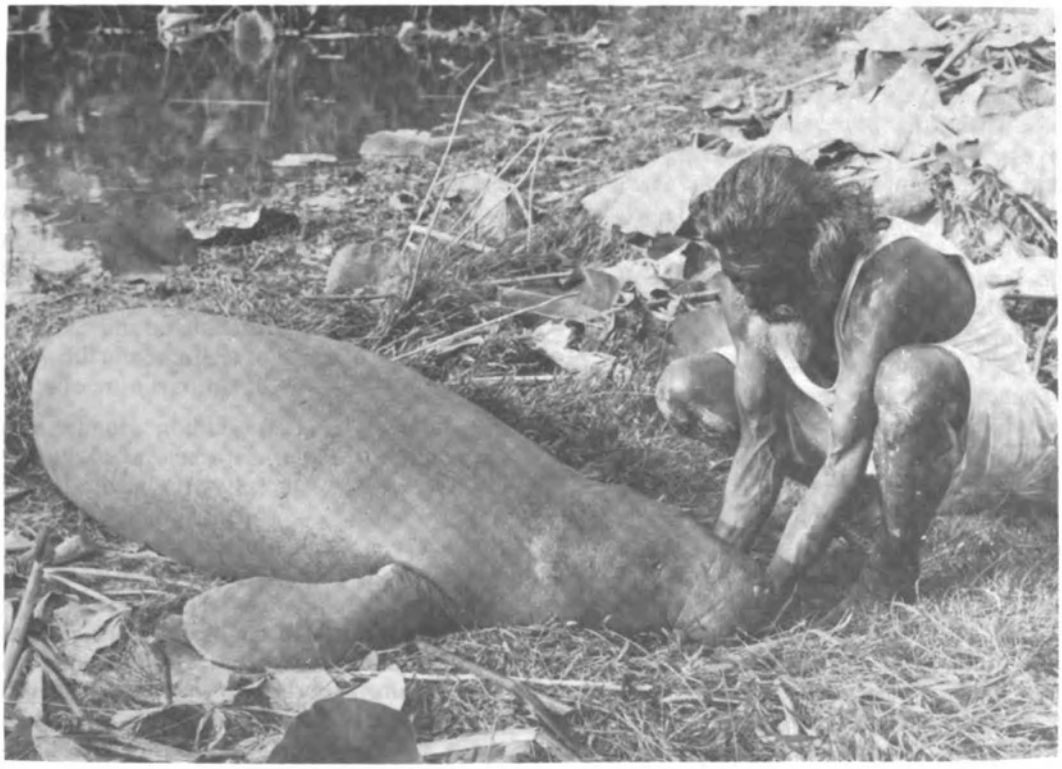

FIGURE 13 Manatees can be kept out of water for days if necessary, but their skin must be kept moist. Compared with other wild animals of their size manatees are easy to handle; if undisturbed, they remain motionless when out of water. During 20 years Datakaran Jeetlall has captured from one stretch of Guyana's Abary River over 70 manatees for weed-control programmes. (Guyana Information Services)

Before biological control agents are introduced into a new area, they must be thoroughly investigated for possible undesirable side effects on plants and animals. Manatees, however, because of their size, and restriction to waterways, make it unlikely that they will become problems themselves.

Disadvantages

Manatees do have some disadvantages as weed-control agents. They breed poorly in confined areas and have a slow rate of reproduction even in the wild. They also present other difficulties:

Because of their docility and their habit of returning to the same weed patch day after day, manatees are highly vulnerable to poaching and vandalism, particularly in narrow channels.

They can easily be injured or even killed unless special care is taken in their transport.

Because of their strength they are not easy to confine in a given waterway, and precautions must always be taken to prevent manatees from entering culverts, sluices, or lock gates where, without access to air, they drown.

In navigable waterways manatees can be fatally injured by boat propellers.

Once established, they are not easy to locate or recapture if the waterway is extensive.

Aquatic weed control by manatees may prove expensive. To breed and rear them, at least at first, will be costly, as will transporting them between countries.

Experience in Florida has shown that the range of their usefulness can only be extended to the subtropics if warm water refuges are available for their use when water temperatures drop below 18°C for long periods.[18]

18. Sguros, P.L. 1966. **Research Report and Extension Proposal Submitted to the Central and Southern Florida Flood Control Board on the Use of the Florida Manatee as an Agent for the Suppression of Aquatic and Bankweed Growth in Essential Inland Waterways.** Department of Biological Sciences, Florida Atlantic University, Baco Raton, Florida.

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CHAPTER 3

AN INTERNATIONAL CENTRE FOR MANATEE RESEARCH

Workshop participants unanimously agreed that the establishment of an international centre for manatee research is not only desirable but necessary. Despite its utility and the intriguing research opportunities that the animal affords, no institution in the world today has the equipment and facilities required. The participants also firmly believe that it is not only feasible to do research on manatees in captivity, but because of the manatee's docility and adaptability to confinement, it would be less difficult than comparable research on seals, dolphins, and other marine mammals already under detailed investigation. Participants believe that the Centre should be international in concept and operation because manatees occur in about forty countries and because it has potential utility for weed control throughout the tropics. They believe that the advantages of Guyana over other possible sites for a centre are impressive and that a manatee research facility is substantially less likely to succeed if located elsewhere.

Participants and sponsors of the workshop recommended that the Centre should be an institute of advanced research designed to meet the highest international standards and enjoy close cooperation with the scientific community in South America, the Caribbean, and other regions of the tropics (both where manatees now occur and where they could be used in future).

Objectives

An international centre for manatee research should accept four broad objectives:

1. **Basic research**: To sponsor, promote, and coordinate activities that will advance knowledge of manatee biology, with particular emphasis on fundamental questions in physiology, endocrinology, anatomy, reproductive biology, biochemistry, ethology (behaviour), ecology, and related disciplines. This will also develop the manatee as a research animal for many basic life science studies.
2. **Aquatic weeds**: To examine available information and assess the effectiveness of using manatees as aquatic weed-control agents in Guyana and to evaluate their potential for use in other countries.
3. **Conservation**: To develop ways to produce more manatees, to develop programmes for repopulating depleted habitats, and to promote the conservation of manatees wherever they are now threatened with extinction, and indeed to foster their domestication as with cows.
4. **Tropical science**: To provide guidance in planning and in techniques of advanced mammalian research. At the same time the closer research liaison between universities and research institutions of the developed world and those of Guyana, the Caribbean, South America, and other tropical regions would promote the growth of scientific communities in regions where manatees now occur and where they could be established.

These interests are obviously complementary and interdependent. The programmes are likely to develop at different rates, but for the long-term effectiveness

of the Centre, none should be considered of conspicuously higher priority than another. In other words, the Centre should not become overly concerned with weed control or with basic research.

This four-pronged approach has the advantage that should any of its objectives not be achieved promptly, the Centre would remain viable because of achievements in others. For example, it may prove impracticable to accelerate manatee reproduction, yet the basic physiological, behavioural, and environmental information gained in reproduction studies may still prove critical to manatee conservation and to aquatic weed control.

Because almost nothing is known about the basic biology of the manatee, initial exploration of these subjects must surely advance our knowledge. On the other hand, a realistic appraisal of the potential of using manatees for general aquatic weed control in the tropics indicates that it could take many years to establish enough numbers, because of the manatee's long gestation period and slow reproduction rate and the substantial time consequently needed to do the basic research for successful manatee husbandry. The proposed four-pronged approach should produce an effective blend of short-term (less than 3 years) and long-term (10 years or more) benefits.

The Centre should be organised and staffed with the four programme interests explicitly in view. The results derived from any one endeavour will contribute to progress in the other three. The impact of multidisciplinary research within the Centre will be substantial, because of the cumulative effect of scientists from various disciplines working in association. Data on nutrition, for instance, are likely to have a direct bearing on understanding of reproduction, particularly if it turns out that nutrition is in part responsible for poor breeding performance.

Advantages for the Tropics

The participants felt that a manatee research centre would have particular advantages for tropical countries. Although almost nothing is known of their thermoregulatory physiology, future utilisation of manatees can only be considered for regions with a year-round tropical climate, because of the manatee's intolerance to cold water.

Because manatee research promises to yield certain practical consequences, its research results would be made available to organisations throughout the tropical world that are concerned with the control of harmful aquatic weeds and the production of protein, and the centre would cooperate, as appropriate, with institutions that have similar concerns.

The Centre could have an impact on world opinion from the outset, and, as research results are obtained, government officials and research workers in tropical countries will, it is hoped, be interested in applying the Centre's results to their own situations in, for example:

> Countries within the manatee's range of occurrence that have current or potential weed problems, such as: Brazil, Colombia, Costa Rica, French Guiana, Panama, Peru, Mexico, Surinam, Venezuela, the Cameroons, Ghana, Ivory Coast, Nigeria, Senegal, and Zaire.
>
> Other countries outside the range of the manatee's occurrence but within its temperature range that have infestations of aquatic weeds. These include Kenya, Sudan, Uganda, Bangladesh, Fiji, India, Indonesia, Malaysia, the Philippines, Sri Lanka, and countries of Indochina.

It is anticipated that several of the countries just listed would from time to time contribute staff to the Centre's advisory bodies and join in complementary and collaborative research.

The Centre should encourage a scholarship programme for able younger scientists from less developed countries to work on the biology of manatees at the Centre or in their own countries.

At the Centre students from tropical countries would gain experience in fields of biological research, without the necessity of going to Europe or North America. Furthermore, their training would become more relevant and their return home more likely once they had conducted biological research of an internationally acceptable calibre within the same climatic zone as their home country.

The existence of a centre of excellence such as that proposed could benefit other areas of tropical research: It would provide basic training and research in such fields as nutrition, husbandry, endocrinology, functional anatomy, mammalogy, aquatic biology, weed control, and water-quality management.

A fairly logical broadening in the scope of research might be expected in the future, once the Centre has proven itself. Foreseeably, the Centre could evolve into a broadly oriented tropical biology research facility that capitalizes on the scientifically attractive biota and environment of Guyana.

Organisation

Workshop participants considered several alternative affiliations and organisational systems. Proposed models included national organisations, multigovernmental schemes, a nonprofit corporation, or a university-affiliated unit. The workshop participants were informed of the example of the International Centre for Insect Physiology and Ecology (ICIPE) recently established in Nairobi, Kenya. This particular autonomous, nongovernmental research institute is located on the campus of the University of Nairobi, has loose ties to the university, and is committed to the development of science in Africa. ICIPE was initiated by national science councils or science academies;[19] these scientific institutions are represented on the International Advisory Committee to ICIPE. The ICIPE research and training collaboration in Africa is guided by the African Committee.

The research at ICIPE is supervised by Directors of Research selected by the Governing Board for their established excellence and international reputation, upon the advice of the International Committee. They are required to make a long-term commitment to the Centre, demonstrated by the agreement to make two annual visits and to participate in the Annual Directors of Research Conference. The research is done by their students, who as resident scientists rotate in spending a normal postdoctoral term (2 - 3 years) at ICIPE. The students' salaries are paid from postdoctoral fellowships obtained in their native countries or from project grants to ICIPE from the United Nations Development Program. African scientists spend resident terms at the Centre as well often under the guidance of a Research Director.

The advantage of the ICIPE model is that it demonstrates how a research station, with participation by highly competent researchers, can be established in a less developed country without incurring the time-consuming construction of a research infrastructure or a fulltime budget commitment. It does not require as much financing as would a facility with a permanent staff; and it can be more open to changes in research priorities because of the rotating staff.

The workshop participants finally agreed that the most practicable and suitable mode for the manatee research centre was a nongovernmental, autonomous, internationally supported organisation, one that reflects the needs of the international community within the context of the laws of the host country. It is suggested that the Government of Guyana should accept the International Centre for Manatee Research as an institution of higher learning or as a nonprofit institution.

A board of trustees should be appointed and given responsibility for the general guidance of the Centre. The board of trustees should seek funds and should be responsible for fiscal policy and for accounting to donors and funding agencies. It should appoint a scientifically qualified person as director of the Centre for such a period and on such terms as it may determine.

The board might well benefit from participation by two specific consultative and advisory bodies: (1) a host-country advisory council and (2) an international advisory committee. The host-country advisory council should represent Guyanese interests, such as those of the university and the governmental departments whose work can facilitate the development of the Centre and whose interests relate to its programme. It would advise the governing board on national regulations, relationships with neighbouring countries, and on cooperative programmes between the Centre and other research and teaching institutions in the country.

The international advisory committee should be composed of representatives from international organisations and national scientific bodies that have demonstrated a special interest in the Centre. It would advise the governing board on: stimulating international interest in the Centre; the scientific programme; membership of the governing board and senior staff of the Centre; and procurement of funds for developing the Centre. National research councils, science academies, and other scientific bodies might be used to appoint representatives to the international advisory committee.

It was recommended that representatives on these committees be individuals working in fields related to the Centre's interests and objectives. The director would be an ex officio member of all committees of the Centre.

Staffing

It is envisioned that the Centre will begin in a modest way, with a small staff of about five scientists with supporting technicians and administrative staff. As research programmes progress, and as the potential for manatee utilisation becomes clearer, the numbers may ultimately increase to about

19. Of Australia, Czechoslovakia, Denmark, Germany, Hungary, Israel, Japan, Kenya, the Netherlands, Norway, Sweden, Switzerland, Tanzania, United Kingdom, United States, and Zambia.

25 or 30 professionals by the time the first self-perpetuating manatee "farm" is established (possibly by 1985).

If the ICIPE model is adopted, the permanent staff of the manatee centre would be limited to the director, a financial manager, support-service personnel, and a few permanent researchers. The research, in the main, would be undertaken by graduate and postdoctoral students under the guidance of directors of research who would be required to visit the Centre at frequent intervals to supervise the work. Apart from this, each resident scientist or team would be largely self-directed.

A rotating cadre of young, highly trained researchers, ambitious to build a career, is an important asset. Under this scheme, the Centre is less likely to become scientifically inbred. It should, of course, strive to involve substantial numbers of Latin American, Caribbean, and West African students and research directors.

Guyana as Site for the Centre

The participants of the workshop agreed that Guyana was one of the few regions where sufficient numbers of manatees are available to provide the necessary large stock for research and attempts at domestication.

Trichechus manatus thrives in all the large coastal rivers, namely the Essequibo, the Demerara, Berbice, and Corentyne and in the smaller rivers of the Mahaica, Mahaicony, and Abary. It is found primarily in the lower reaches of all of them. Manatees occur above the waterfalls in the Berbice and Essequibo rivers and their tributaries, but the species has not been clearly identified. In the Essequibo it is probably **T. inunguis** because this species occurs in the tributaries of the Amazonian rivers, Branco and Negro, which, during flood periods, become almost continuous with the tributaries of the Essequibo River.

Guyana has an ideal climate and temperature for rearing manatees. The coastal region is dissected by several thousand miles of canals for irrigation, drainage, and transport, in which water weeds occur (see FIGURE 8) and experiments could be conducted. Also, there is not only governmental scientific interest, but also a substantial public interest in protecting the animals. Governmental interest has expressed itself in a commitment to provide suitable sites and services, and to collaborate with the Centre through the National Science Research Council, the University of Guyana, and agricultural and veterinary research Institutions.

As a research base, coastal Guyana also provides a pleasant, healthful climate and locale for visiting scientists; it has no serious waterborne human health hazards, and is easily accessible within a day's air transportation from Europe or North America. Noteworthy considerations for an international centre, is that Guyana enjoys excellent relations with countries where manatees occur, in both South America and West Africa. The cost of living and animal maintenance and support services are also favourable.

The workshop participants acknowledged certain difficulties inherent in Guyana. There are the difficulties of maintaining delicate scientific equipment in a tropical climate, the lack of postgraduate science instruction at the university, and the absence of a well-developed research infrastructure, of specialised maintenance services, or experienced personnel. The need to import scientific supplies necessitates long-range planning. Certain natural circumstances also provide some obstacles; for example, the turbidity of the water which makes observations difficult. The occurrence of electric eels, piranha, caimans, etc., is less important.

With careful planning and the cooperation of the government, the disadvantages of Guyana could be overcome. The workshop participants therefore recommended Guyana as a highly suitable site for an International Centre for Manatee Research. They stressed, however, that the Government of Guyana has a critical role to play in ensuring the Centre's viability: for example, by allowing the Centre the privileges that normally apply to international organisations, such as exemption from import regulations from taxes on equipment, supplies, and services. These are considered essential for the efficient, minimal-cost-operations of internationally funded research investigations.

Facilities

Four facilities are needed to integrate the research efforts best and to attain the Centre's objectives most efficiently:

1. A laboratory and close-confinement facility, where detailed experimental work can be pursued in clear-water tanks
2. Controlled canals where field trials for aquatic weed control and manatee management techniques can be conducted and where semi-domestication would be fostered
3. A body of water, such as a conservancy, where the manatees would exist in a near-natural, though confined, state

4. A "wild area," where manatees under natural, unrestricted conditions can be studied and their population, it is hoped, increased.

The laboratory facility will be costly, but essential, for a wide range of experimental studies that require close confinement of the experimental animals. At first a few, but later a score or more, animals would be required at any one time. A high-quality, well-equipped laboratory will be a necessary incentive for overseas experts; it will have to develop into a centre of excellence.

Phasing

It is important to realise that to develop effective manatee husbandry will take time. Because the approximately 1-year gestation period cannot be circumvented, herd production will be slow despite the possibility of running several reproduction experiments concurrently. The Centre's phasing may involve an initial period of 1 - 3 years and more years of qualitative and quantitative biological study before successful rearing in confinement or in a managed population can be achieved. In practical terms, it seems unlikely that an operational manatee "farm" can be established in Guyana in less than 10 years and that the first successful manatee farm elsewhere might be established 3 - 5 years later.

CHAPTER 4

SUGGESTIONS FOR THE CENTRE'S RESEARCH PROGRAMME

The widespread use of manatees to control weeds in waterways is contingent on their being available in large numbers. This, in turn, depends on accumulating sufficient knowledge of their physiology, nutrition, reproductive biology, and ethology to permit development of effective husbandry.

Research on manatees will not be easy. They weigh up to 500 kg (1,200 lbs) and remain submerged most of the time. Their reproductive rate is comparatively slow; few specimens are available; and their endangered status dictates that very few be sacrificed during experimentation. Furthermore, because the animal's native habitat is in tropical countries, most research must be done where facilities and equipment are not readily obtainable and are difficult to maintain. It will probably have to be done in a newly established institution, which circumstance has its own inherent problems.

The following are long-term research needs:

- Development of breeding colonies.
- Effective handling and management of manatees for aquatic weed control
- Artificially stimulated reproduction and careful husbandry of young manatees
- Advancement of mammalogy through study of the basic biology of this species
- Replenishment of depleted habitats throughout the tropical world
- Improvement of protection for the native manatee herds now approaching extinction in at least 40 nations (see list, Table 1)

Because so little is known about manatees, opportunities abound for important research findings. Application of newer techniques already used successfully with other animals may provide speedy results with manatees.

Important comparative biological and behavioural information might be gained if the Centre were to maintain more than one species of manatee.

General Techniques

Methods must be developed for the humane handling of manatees, for identifying individual animals, for feeding them, for preventing disease, and for protecting them from poachers, vandals, and accidental drowning. Much ingenuity will be required. The animal's natural seclusion and limited emergence in turbid or discoloured water also presents a special problem.

Complete autopsies should be conducted on all animals that die, to learn more about their anatomy, physiology, and disease processes. Tissue and fluid samples should be collected to provide basic data in haematology, blood chemistry, endocrinology, microbiology, pathology, etc. Better methods for the capture, transport, and physical restraint of the animals need to be developed.

Reproduction

Little is yet known about the manatee's breeding habits and reproduction. The gestation period, age at sexual maturity, length of the reproductive cycle, frequency of reproduction, and life expectancy are

all undetermined. They apparently lack a defined breeding season, and have a slow reproductive rate A female probably breeds at no less than every 2 years – and more likely every 2.5 - 3 years. Manatees have seldom bred in captivity; hence, one of the first research objectives should be to ascertain the nature of the underlying factors – whether nutritional, environmental, behavioural, or endocrinological.

Regardless of the root cause for reproductive failure under captive conditions, manatees in the wild should be closely observed over protracted periods of at least 2 years (if necessary by underwater surveillance) to study their social organisation and sexual behaviour, particularly cyclic sexual behaviour. Special consideration should be given also to the means of intercommunication (olfactory, auditory, etc.), to the circumstances attending any mating attempts, and to whether the sexes segregate at any time or season. Knowledge of this kind is basic to the provision of conditions suitable for reproduction in a confined area.

Without killing the animal, much valuable information can perhaps be obtained about the length of oestrus, time of ovulation, length of gestation, attainment of puberty, etc., by measuring pituitary and steroidal hormones in the blood. The recent development of radioimmunoassay, which is capable of detecting minute quantities of these hormones, makes such assessments possible with small samples of blood.

The interval between individual breeding cycles is regulated by the time required to wean a calf. Thus, the development of a weaning food could speed manatee reproduction in semi-domestication by allowing the mother to be freed of the calf after a much shorter interval than is now the case.

Health Care

A veterinary medical programme in a manatee research centre is essential to provide health care for the animals. Besides qualified veterinary personnel, necessary veterinary facilities would include the following: laboratory space for autopsy, clinical pathology, X ray, anaesthesia and surgery. Quarantine tanks would also be needed to treat sick animals and for the initial isolation of animals that come to the Centre for research.

Nutrition

Research on manatee nutrition is needed to provide a better understanding of various aspects of digestive physiology and biochemistry, such as (1) the nutritive value of the natural vegetation; (2) carbohydrate digestion, protein utilization, milk production and composition; and, (3) feed intake of adults and calves on natural and unproved diets. The data collected could lead to an improvement of the animal's breeding potential in captivity and permit early weaning of the calves, thus shortening the calving interval and speeding growth of the animals.

The optimal age for weaning should be the object of immediate investigation.

Ecology and Behaviour

A complex of experimental studies is prerequisite to a full understanding of the biology of the animal and its behaviour under natural conditions, e.g., studies on nutritional requirements, energy-transfer mechanisms, thermal requirements, the reproductive cycle, the mediation of the manatee's behaviour through its senses – as well as on aquatic-weed productivity. Varying soil and water conditions in a water body may affect the production, availability, and nutritive value of aquatic weeds and vary their manatee-carrying capacity and the manatee's preference for such areas. Factors that can enhance a habitat to support the largest number of animals should be investigated. Most are studies to be conducted primarily in the animals' natural environment.

Basic studies on the relations between manatees and their environment should include:

Chemical, physical, and topographical conditions of the water environment in which manatees occur, with particular reference to breeding and calving localities

Quality of the water in which manatees live, e.g., pH, oxygen content, salinity, temperature.

Food plants, feeding patterns, and environmental conditions that contribute to the abundance of the animal in river environments, and the carrying capacity of various environments; and

Population structure, density, and sex ratios of manatees in the wild.

An important requisite for ecological and behavioural studies is to locate, mark, and identify manatees, since the animals are normally invisible in discoloured tropical waters. Radio tracking will also be important.

Based on observations in Florida, the following aspects of wild manatee behaviour are likely to be most significant:

- Migration and local movements
- Daily and seasonal activities of significance to husbandry and survival
- Maintenance behaviour (feed preference and availability in relation to nutritive requirements)
- Social aggregations, mother-offspring interactions from birth to weaning, and copulatory behaviour
- Sensory responses and learning behaviour
- Man-manatee relations

Much more needs to be known about the distribution, abundance, social structure, migrations, and population dynamics of existing natural populations. Such studies may be facilitated through sophisticated new study techniques developed for observing wildlife, particularly the marine mammals. Once elucidated, the behaviour patterns of manatees should provide vital information on their choice of habitat.

Aquatic Weed-Control Research

Initially, certain basic studies must be made:

Quantitative measurement of the effectiveness of manatees as weed-control agents in different aquatic environments, e.g., quantifying the composition and productivity of aquatic weeds, the amount and composition consumed daily, the amount of nutrients returned to the waterways as faeces, and changes in the plant species present

- Parameters for steady-state cropping, and manatee spacing
- Design of kokers (a small floodgate used in Guyana), sluices, culverts, etc., that are safe for manatees and fences that can contain them

Conservation Research

The Centre should produce and collate manatee census data for all the regions where the animal is found. It should endeavour to alert the forty or so governments in whose territories the animal occurs to its importance and its endangered status.

Some of this educational programme may be accomplished by encouraging local zoos and botanical gardens to include manatees in their displays, and by promoting collaborative manatee research and weed-control experiments in universities and research organizations.

The Centre could initiate many collaborative efforts by providing guidelines for the care and preservation of manatees and by short-term work-study programmes for nationals of the countries involved. Communication could be maintained by a newsletter that contains information on the latest findings from each of the collaborating institutions and, for trainees, by periodic return visits to the Centre.

Every effort should be made to enforce existing protective legislation in each country where manatees exist; this is fundamental. Once manatee breeding and husbandry have been achieved at the Centre, pilot introductions to repopulate depleted herds should be conducted.

The immediate goal should be the establishment of a manatee reserve within Guyana.

APPENDIX A

MANATEE WORKSHOP

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APPENDIX B

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The generosity of the Guyana Sugar Producers Association in providing an aeroplane flight to Berbice and a boat trip to the East Demerara Water Conservancy, and of the Ministry of Works and Communications in organising a demonstration of manatees feeding on aquatic weeds in a canal and a boat trip to a natural manatee habitat in the Abary River is gratefully acknowledged.

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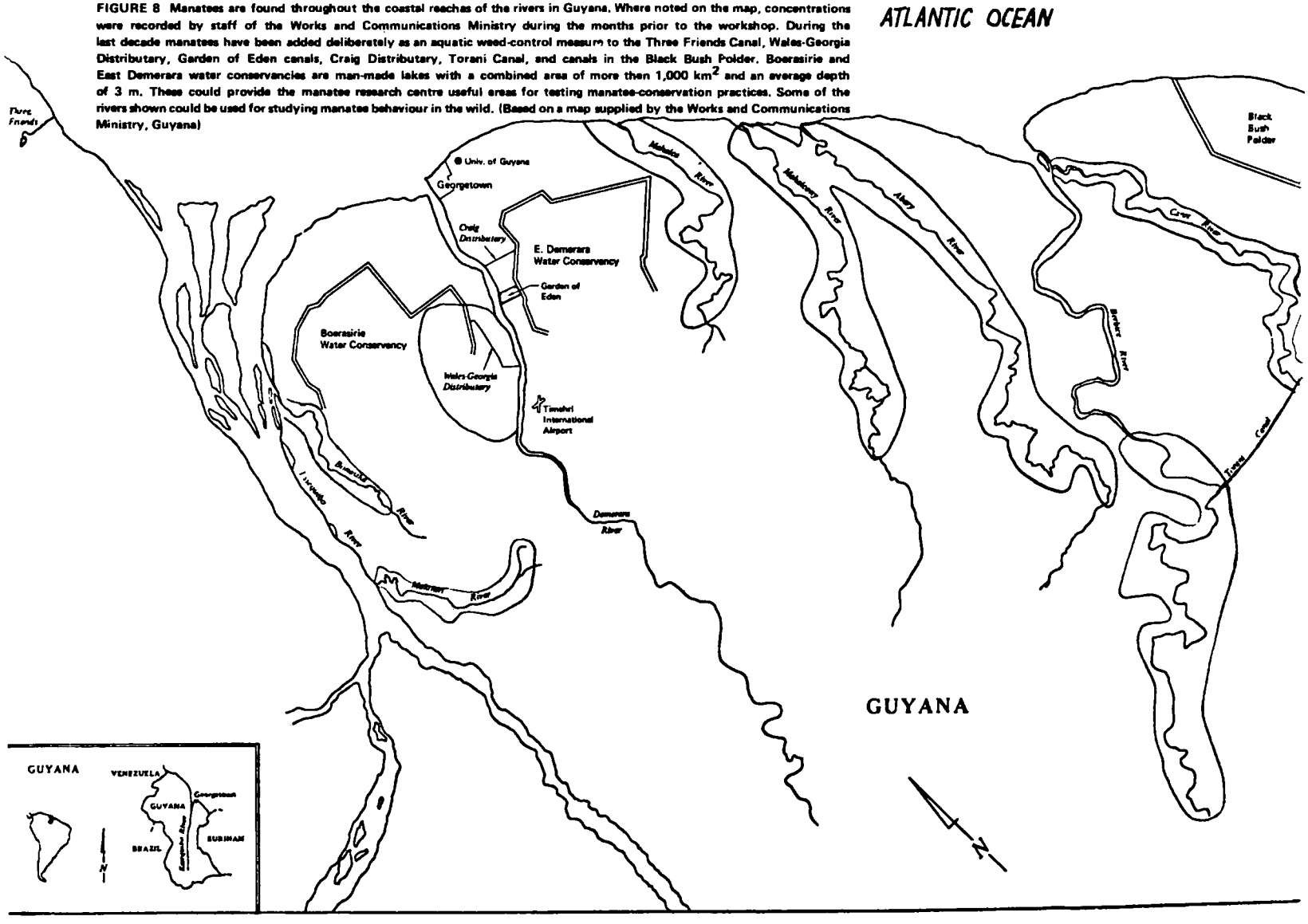
International Union for the Conservation of Nature (Switzerland)

FIGURE 8 Manatees are found throughout the coastal reaches of the rivers in Guyana. Where noted on the map, concentrations were recorded by staff of the Works and Communications Ministry during the months prior to the workshop. During the last decade manatees have been added deliberately as an aquatic weed-control measure to the Three Friends Canal, Wales-Georgia Distributary, Garden of Eden canals, Craig Distributary, Torani Canal, and canals in the Black Bush Polder. Boerasirie and East Demerara water conservancies are man-made lakes with a combined area of more than 1,000 km^2 and an average depth of 3 m. These could provide the manatee research centre useful areas for testing manatee-conservation practices. Some of the rivers shown could be used for studying manatee behaviour in the wild. (Based on a map supplied by the Works and Communications Ministry, Guyana)



APPENDIX C

GUYANA

Guyana (formerly British Guiana) lies along the northeast shoulder of South America between Venezuela and Surinam and borders Brazil to the south (See map, FIGURE 8). It is the only English-speaking country on the continent. Guyana has close ties with the Caribbean community, particularly the English-speaking territories with which it shares membership in the British Commonwealth. Most of its 215,000 km^2 (roughly the size of the United Kingdom) is tropical rain forests.

Three distinct geographical areas in Guyana are the coastal, the savannah, and the mountain regions.

The coastal region is about 440 km long and varies in width from 16 to 65 km – traversing the country from the northwest to the Corentyne River. The region includes most of the population and is intensively cultivated, despite the fact that it is only about 4 percent of the total area.

The country is broken up by rivers and streams. The main rivers – the Essequibo, Demerara, and Berbice – are navigable for approximately 80, 105, and 160 km respectively.

Guyana's multiethnic population reflects its immigrant history. In July 1972 the population was said to be 714,233. Georgetown, the capital, and its environs has a population of 167,078.

The climate is equable throughout the year; mean temperature is about 27 C, with an average rainfall of 200 cm in the coastal belt, mostly confined to two rainy seasons, November - January and June - July.

In the high interior savannah, the climate is cooler because of higher elevation and lower humidity and rainfall. In the mountainous forested areas, the climate is hot and rainfall is high. Unlike some nearby Caribbean countries, Guyana is not afflicted with hurricanes.

Before 1814 the English, Dutch, and French fought for outright possession of Guyana. In that year Essequibo, Demerara, and Berbice were ceded to Britain; in 1831, these three colonies merged to become British Guiana.

Slaves from West Africa undergirded the plantation economy of the territory. After the abolition of slavery they left the plantations, and immigrants were brought from Portugal, China, and finally in great numbers from India to provide the necessary labour.

The population today includes people of African, East Indian, Chinese, Portuguese, European, and Amerindian origin.

Guyana achieved independence on May 26, 1966, and became a cooperative republic on February 23, 1970.

Guyana has a high literacy rate, considered to be about 85 percent. The University of Guyana, established in 1963, has five Faculties: Arts, Natural Science, Social Science, Education, and Technology. The first three offer first degree as well as diploma courses. Education offers a postgraduate in-service diploma, while Technology offers a general technical diploma, as well as higher diplomas in engineering and architecture.

Since 1969 the university has occupied its permanent site at Turkeyen (FIGURES 8, 14), some 4 - 5 miles from the centre of Georgetown. The 140-acre site was a gift of the Booker Group of Companies; the original nine buildings, erected at a cost of nearly G$5.0 million, were made possible

FIGURE 14 Part of the modern campus of the University of Guyana. (University of Guyana)

by capital grants from the governments of Britain, Canada, and Guyana.

Roughly 40 percent of the original capital grant was for the needs of the Faculties of Natural Science and Technology; subsequent grants-in-aid from the original donor countries have succeeded in improving facilities to the point where scientific research of a high quality can be pursued. Several of the staff are engaged in research relevant to the problems of Guyana.

Currently, the only graduate studies programme is in the department of history, but graduate studies in all departments are to be phased in over the next few years. There is as yet no faculty of agriculture, although it is planned, and no medical faculty. However, the university offers a certificate course in medical technology, a diploma in pharmacy, and a diploma course for the training of medical auxiliaries. A centre for paramedical studies is to be built shortly.

The university library has at present about 80,000 volumes of which about 7,000 are in the sciences. It receives 122 scientific periodicals. It is hoped to expand the physical facilities of the library within the next 5 - 10 years, and to increase its holdings to some 300,000 volumes, with greater emphasis on science.

Guyana is a member of the United Nations and several of its specialized agencies, the General Agreement on Tariffs and Trade (GATT), and the Commonwealth of Nations. It also participates in the Organization of American States (OAS) as a permanent observer.

Since 1969 Guyana has increasingly identified itself with the nonaligned nations of the world, and is now expanding its diplomatic contacts, especially with the African countries of Ethiopia, Guinea, Kenya, Nigeria, Tanzania, Uganda, and Zambia.

Guyana's economy is basically agrarian and, historically, has depended on sugar, which in 1970 accounted for 29 percent of the country's exports. Rice, 6 percent of 1970 exports, has become a major crop in recent years. Bauxite mining and aluminium production are Guyana's principal industries, together accounting for 52 percent of 1970 exports.

The Agriculture Division is carrying on research to facilitate opening up the interior in line with the government's 1966 - 1972 Development Programme. In addition to its central research laboratories, which have a library, the division has livestock stations at Ebini and Rupununi and an agricultural station in the Northwest.

The Ebini station is a modern, well equipped livestock nutrition research facility. A veterinary diagnostic laboratory is under construction in the East Demerara Area close to the Mon Repos Agricultural Research Station.

Most of the coastal area is below sea level and is protected from the Atlantic Ocean on the north by a system of dikes and sea defences, and in the higher land to the south by earthworks enclosing large, shallow catchment areas called conservancies. The conservancies are hugh man-made lakes and, when full, cover some 1050 sq km of water, averaging 3 m in depth.

The drainage and irrigation system of Guyana's coastal plain is extensive and costly. Many areas have had to be abandoned, and new areas have proved expensive to open because of the poor drainage of the plain. Gravity drainage is possible

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only at low tides and is supplemented by large pumping stations that push the unwanted water, including used irrigation water, into the sea. All new coastal settlement projects require extensive drainage control before they are suitable for agricultural use.

Sugar estates in Guyana have two extensive and separate canal systems: the low-level "sidelines" (with their field drains) for drainage and the high-level "middle-walks" and "cross-canals", about 2 m higher, for transport and irrigation. For each 250 ha of cultivated cane there are an estimated 26 km of high-level canals, 6 - 8 km of low-level canals, and 72 km of small field drains. In both high- and low-level canals, control of aquatic weeds has always been difficult.

APPENDIX D

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