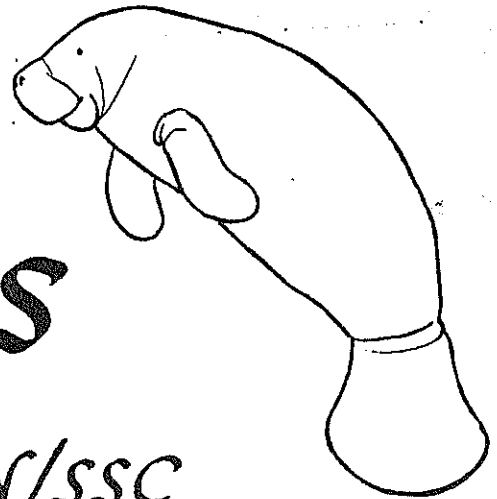


# Sirenews



## Newsletter of the IUCN/SSC Sirenia Specialist Group

NUMBER 25

APRIL 1996

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### EDITORIAL: BAD NEWS OR GOOD?

Several significant developments for Florida manatees have occurred since our last issue. One is the publication of the workshop volume on manatee population biology edited by Tom O'Shea, Bruce Ackerman, and Franklin Percival (see Recent Literature, below). The upshot of the two decades of painstaking work summarized in this impressive compilation is that Florida manatees actually seem to have increased in numbers since protective efforts were begun. At the end of the volume, O'Shea and Ackerman conclude that "the increases in numbers of manatees counted in aggregation areas in winter reflected an increase in the Florida population from the 1970's through the 1980's .... We are uncertain whether such a trend continued in the 1990's." Furthermore, "Reproduction parameters revealed by studies presented in these proceedings ... indicated the potential for more rapid growth than previously recognized": as high as 7% per year at Crystal River. "This higher potential for population growth makes the probability of true population growth in other areas during the 1970's and 1980's more plausible than previously thought...."

These conclusions were promptly underlined by the results of two statewide aerial surveys conducted by the Florida Department of Environmental Protection after cold fronts in January and February 1996: total counts of 2,274 and 2,639 manatees, respectively. These numbers are dramatically higher than the previous high count of 1,856, made in 1992; and as minimum estimates of actual manatee abundance, they show that the true population size is



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closer to 3,000 than to the figure of 2,000 routinely quoted in recent years. Although survey coordinator Bruce Ackerman noted in a press release that weather conditions nearly perfect for counting manatees accounted in part for this result, the evidence for a growing manatee population seems to be mounting.

What are we to make of this? Is the manatee population on the road to recovery and removal from the endangered species list? Have all the protective regulations had their desired effect, so that no further constraints on boaters or developers are needed? If manatee numbers have grown along with human numbers in Florida, does that not show that human population growth is harmless to wildlife, maybe even beneficial? Was the whole uproar over the supposed plight of the manatee in fact just an environmentalist hoax to begin with? Or (to put a more charitable face on it) is this a demonstration of the self-correcting nature of science in the light of new data?

Before jumping to any of these conclusions, we should read more of what O'Shea and Ackerman had to say: "Possible increases in manatee population size since the mid-1970's may be attributable to intensified conservation. However, the threats to manatee survival and habitat loss have accelerated and are expected to increase. A turning point may soon be reached, if it has not already. This contention is supported by the possibility that upward trends in counts at power plants in winter may have diminished in the late 1980's and early 1990's ...; by the lack of a notable increase of counts and a higher number of deaths in southwestern Florida ...; by the high number of recovered carcasses in 1994 [plus a still higher number in 1995 and a disastrous start to 1996 - see other news in this issue]; and by increased numbers of boats and the more complex technology of high-speed boating.... Because of the lack of accuracy and precision in estimates of population size, the size of the Florida manatee population could decrease even while counts may seem to increase or be stable.... Given that negative effects on manatee populations will continue to increase with burgeoning human populations in Florida and that decreases in adult mortality can result in growth and long-term persistence of Florida manatee populations ..., no prudent alternatives exist to maintaining proactive, vigorous management aimed at mortality reduction."

In short, the catch is that even if the manatee population has grown under the protection it has received, we are rapidly approaching the limits of the protective measures now envisioned. The legally-mandated Manatee Protection Plans are already in place in at least four of the 13 Florida counties considered critical for manatee protection, and further tightening of regulation beyond what is in these plans is likely to be strenuously opposed. Meanwhile, the numbers of humans, boats, and new developments continue to grow without limit. An aggressive manatee-protection campaign has bought the population valuable time, but the onslaught of demography will soon throw the manatee and its allies back on the defensive, facing ever-grimmer odds. The population recruitment suggested by the latest synoptic surveys may still prove to have been no more than reinforcements thrown into a losing battle.

The shape of this battle is already evident to those who read the published evidence more closely. O'Shea and Ackerman cite "data ... that suggest substantial population growth from internal recruitment at the Crystal River and at Blue Spring and slower growth or stability on the Atlantic Coast...." These preliminary results show, in other words, that manatees have increased in precisely those areas where they are most strictly protected, but may have been unable to do so where boating activity and boat-caused mortality are heaviest. What we see here, in fact, is an inadvertent experiment to determine what level of human harassment manatee populations can tolerate. The results neatly demonstrate both their ability to flourish, given reasonable protection, and (more realistically) their likely inability to survive much longer, as the worst that Florida is presently throwing at them worsens still further.

This was not, however, the message that was reaching the public in the wake of the 1996 synoptic surveys. As manatee researchers anticipated when the State of Florida began these surveys several years ago, they are two-edged weapons. While it is always useful to have minimum counts to plug into population models, the danger is that these minimum counts will be taken as actual estimates of population size, and growth in these numbers will be misinterpreted as actual growth in population. They are in fact being misinterpreted this way in the Florida press, by boating advocates and others, and some have even begun to call for

downlisting of the Florida manatee to a less endangered status.

The issue of downlisting should, in principle, be easy to dismiss. The revised Florida Manatee Recovery Plan (1996 version, due to be published in a few weeks) states that "downlisting should be considered when ... the population is growing or stable, when mortality factors are controlled at acceptable levels or are decreasing, and when critical habitats are secure and threats to them are controlled or decreasing." Of these three criteria, it is obvious that the latter two are not likely to be met in the foreseeable future: human-caused mortality continues to rise, and the threats of human population growth and development pressures are anything but "controlled or decreasing." In practice, however, only the first criterion readily registers in the public consciousness, where higher manatee counts necessarily mean a recovering population.

Sometimes, however, one problem is solved by another; and the misleading press coverage of the January and February surveys was fortuitously swept from the headlines by the disastrous manatee dieoff in March. For the moment, this antidote of well-founded alarm seems to have taken effect, but spells of complacency are bound to recur. When they do - and whenever any of us has occasion to communicate with the public or the mass media on these issues - we need to emphasize as strongly as possible the following points:

1. The statewide synoptic surveys provide only *minimum* counts, not estimates of the total population; they are extremely sensitive to weather conditions and *cannot* be compared statistically with each other or with estimates derived from other techniques.
2. While it is possible that the total manatee population in Florida has increased, it is more certain (and more significant) that increases have occurred in precisely those areas where manatees are best protected, while in areas of lesser protection there has been little or no increase (and none that is likely to be sustained).
3. We can take no comfort in any numerical increases that have been achieved, because the protective measures that made them possible are approaching the limits of political acceptability, while the threats to manatees only increase and can be expected to wipe out the recent gains. For this reason, no talk of downlisting the Florida manatee is even remotely justified.
4. The manatee population is still small in absolute terms, and always vulnerable to unexpected catastrophes like the March 1996 dieoff - especially when, as in this case, the victims are predominately adults in their prime, which are the animals most essential to survival of the population. When some 2% of that population can be wiped out in one such event - over and above all other sources of mortality - there is ample cause for concern about the species' future.

Not all these points are easy to make in sound bites, but this is the message we urgently need to get out. - DPD

**DEATH REPORTED**

**Jesse R. White, D.V.M.**

Dr. Jesse White, well-known marine mammal veterinarian, died on 23 January 1996 at his home in Dunnellon, Florida, at the age of 61 years. A native of Oklahoma, he received his D.V.M. degree from Texas A&M University at College Station in 1962. He served as Staff Veterinarian at the Miami Seaquarium, 1967-86, and Marine Mammal Veterinarian for the Florida Department of Natural Resources, Homosassa, Florida, 1986-87. In 1984, he founded the Florida Manatee Research and Education Foundation, an organization for which he always served as Director and President. He was an Adjunct Professor at the College of Veterinary Medicine, University of Florida, 1983-87, and Clinical Professor in the Department of Small Animal Medicine at the same institution from 1987 until his death. He received several lifetime achievement and conservation awards from professional associations, and was the first

veterinarian to serve on the U.S. Marine Mammal Commission's Committee of Scientific Advisors. His publications focused on manatees and marine mammal care and maintenance. He was particularly interested in captive breeding of manatees, and it was during his tenure at the Miami Seaquarium that the first successful and regular breeding of captive Florida manatees began. (John R. Twiss, Jr. and DPD)

### SHOULD THE SIRENIA SPECIALIST GROUP ESTABLISH A HOME PAGE ON THE WORLD WIDE WEB?

A couple of weeks ago, I attended a meeting of the IUCN Species Survival Commission (SSC) Steering Committee which was held in Australia. I was invited to attend the meeting as an observer along with other Specialist Group Chairs from the region. The Australians enjoyed being the only delegates not suffering from jet lag, a reverse of the usual situation.

The issue of communication among and within Specialist Groups was discussed. The SSC is planning to set up a home page on the World Wide Web which will concentrate on being a link among the home pages established and maintained by various Specialist Groups. This initiative raises questions for the Sirenia Specialist Group:

- How many members would have access to a Sirenia SSG home page on the World Wide Web if one were established?

- Is there anyone who is prepared to establish and maintain such a page?

The page would have many advantages. Here are a few:

- It would be a source of up-to-date information on manatees and dugongs.

- It would be an additional method of distributing this newsletter.

- It could enable Group members to access the gray literature and publications lists of other members, etc.

- It could be an effective method of distributing the Dugong and Manatee Action Plans when they are finalized.

I do not see a Sirenia Specialist Group home page duplicating the role of MARMAM.

Your reactions, please; and is there a volunteer who is willing to establish and maintain the page? - Helene Marsh

### NIRS BREAKS THROUGH SIRENIAN FOLIAGE

The conventional methods used for analyzing nutrient contents of seagrasses are laborious and expensive. This is essentially why most studies dealing with sirenian and/or seagrass nutritional ecology have limited numbers of replications. This may now be a thing of the past.

Near-infrared reflectance spectroscopy (NIRS) has been in use for the analysis of agricultural and food products since the late 1960's. This technique makes use of a small segment of the electromagnetic spectrum (just above the visible region, 700 nm to the edge of the infrared region, 2500 nm), called near-infrared (NIR). The NIR spectrum contains information on the major building blocks of the biological world (CH, OH, and NH groups).

I applied this technique in my research entitled "The ecology of seagrasses as food for dugongs and green turtles" at James Cook University. It allowed me to predict multiple constituents of seagrass relevant to a dugong's (and green turtle's) perspective, for a large number of samples (ca. 1,200, which would have been expensive and laborious using conventional methods). This technique allowed me to select the "best" (most typical) calibration set (15-20% of the total), based on the population's spectral variability, for which precise conventional nutritional/chemical analyses were performed. These calibration data were then used for the development of predictive equations for each constituent using a cross-validation technique. The predicted values have a good agreement with the laboratory values. The  $r^2$  values for the different constituents were: 0.99 for nitrogen, 0.96 for organic matter,

0.94 for neutral detergent fiber, 0.91 for acid detergent fiber, 0.90 for lignin, 0.91 for water-soluble carbohydrates, and 0.92 for *in vitro* dry matter digestibility.

NIRS analysis offers several advantages. It is rapid, nondestructive, and environmentally safe. One of its most important features is that it can analyze samples for multiple constituents. Even though this technique has existed for more than 20 years, it has never been employed in nutritional ecology of wildlife. This technique will certainly simplify the task of trying to understand why sirenians prefer certain species of foliage. - Lem V. Aragones

## COURSES ON ZOO ANIMAL BEHAVIOR AND WELFARE

Edinburgh Zoo, in conjunction with the University of Edinburgh, is again offering a two-week summer school course from 15 to 26 July 1996 on Zoo Animal Behaviour and Welfare. It is designed for all those involved in management and husbandry of captive animal populations, and will update participants on the latest scientific theory and its practical implementation. Registration deadline is 31 May 1996.

A new two-module short course on Assessment and Implementation of Animal Welfare Programmes will also be offered on 1-3 November and 6-8 December 1996. (The first weekend module will cover scientific assessment of animal welfare; the second, animal welfare in practice.) Covering aspects of the new Royal College of Veterinary Surgeons' Certificate in Animal Welfare, Ethics and Law, this course will introduce the current scientific methods that are used to assess and understand animal welfare and demonstrate how these can be practically implemented.

For information on either course, contact Hamish Macandrew, UnivEd Technologies Ltd., FREEPOST, 16 Buccleuch Place, Edinburgh EH8 0LL, UK; tel.: 0131-650-3475; fax: 0131-650-3474.

## LOCAL NEWS

### AUSTRALIA

Dugongs Take Years to Recover From Seagrass Loss. - Preen and Marsh (1995) report dugong deaths associated with the loss of some 1000 km<sup>2</sup> of seagrass in Hervey Bay, Queensland, Australia, following a flood and two cyclones in 1992. Aerial surveys have been used to track the resultant changes in dugong numbers in the region. The surveys suggest that the decline had ceased by 1993:

Date	Population Estimate
1988	2206 ± s.e. 420
1992	1109 ± s.e. 383
1993	579-629 ± s.e. 126
1994	807 ± s.e. 151

However, calf counts associated with the surveys suggest that the population may take even longer to recover than originally predicted.

Date	% Calves
1988	22
1993	2.2
1994	1.5

These figures parallel changes in the pregnancy rate and proportion of reproductively active males in Torres Strait dugongs coincident with an extensive seagrass dieback in that region in the mid-1970's (Marsh 1995). Data from Australia suggest that large-scale diebacks of tropical seagrasses, often associated with extreme weather events such as floods or cyclones, are relatively common (Poiner and Peterken, 1995). In addition to any direct mortality of dugongs associated with such diebacks, their impacts on the life history of dugongs in the affected area is likely to be serious and long-lasting. The only data I know of concerning temporal changes in the pregnancy rates of manatees are from Marmontel (1995), who provides evidence that suggests an increase in Florida from 1976 to 1991.

Does anyone else have any data suggesting temporal changes in the life history parameters of sirenians?

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- Helene Marsh

## CARIBBEAN REGION

**Manatee Plans and Materials Being Developed.** - The regional management plan for the West Indian Manatee in the Wider Caribbean was approved at the Third Meeting of the Interim Scientific and Technical Advisory Committee to the Protocol Concerning Specially Protected Areas and Wildlife (SPAW) in the Wider Caribbean Region (Kingston, Jamaica, 11-13 October 1995). The plan will be published in English, French, and Spanish.

The Caribbean Environment Programme is also supporting the preparation of manatee recovery plans in Belize, Colombia,

Honduras, Mexico, Suriname, Trinidad and Tobago, and Venezuela, and the development of educational activities on manatee conservation in Belize, Jamaica, Mexico, and Suriname. It is also producing a number of educational materials for children in English, Spanish, and French on manatee conservation as part of a region-wide public awareness and education campaign. A number of these products (poster, coloring book, and bumper stickers) are available, as is a directory of manatee experts and institutions from the Wider Caribbean including Brazil. Address: Regional Coordination Unit for the Caribbean Environment Programme, 14-20 Port Royal Street, Kingston, Jamaica; tel.: 1-809-922-9267/9268/9269; fax: 1-809-922-9292. - (Source: *The Pilot* [UNEP], No. 13.)

## FLORIDA

**Major Manatee Dieoff in Southwest Florida.** - Beginning 5 March 1996, fresh manatee carcasses began turning up in southwest Florida between Englewood and Marco Island. The animals were large adults, and the only gross abnormality was a diffuse bilateral pneumonia. By 10 March, as many as four carcasses were being reported per day. By the 13th there were reports of 11 deaths in one day, and the Florida Department of Environmental Protection's (DEP) Marine Mammal Pathobiology Laboratory in St. Petersburg, which was handling the necropsies, moved its operation to a field station on Sanibel Island to process the carcasses more efficiently. As of 4 April, the total number of carcasses reported in the area since 5 March amounted to 110, with the total continuing to mount as this went to press. Even if a few of these turn out to have died from causes other than that of the majority, this will still easily rank as by far the largest single mass mortality of West Indian manatees in recorded history.

All of the carcasses so far necropsied were in good flesh; none had any indication of cold stress and all had pulmonary lesions characterized as diffuse, bilateral discoloration of purple and bright red on the serosal surface of the lungs. On a cut surface, the lungs were congested and bled. In the more severe cases, the primary airways were filled with a serosanguinous exudate that was adherent and occluded the secondary airways.

In the less severe cases, the airways were open, but the pulmonary parenchyma appeared the same in all cases and there was a conspicuous absence of inflammation. All other organs appeared grossly normal. Death was rapid and the result of pulmonary failure.

The vast majority of animals were large (275 cm or more); the smallest were 191 cm and there were no perinatal-sized animals involved. At least seven animals were pregnant. Tunicates were not observed in any of the GI tracts. Microbiological results indicated a diversity of bacteria that, in the absence of an inflammatory response and of consistency between cases, were considered secondary to the event.

Following the guidelines of the Marine Mammal Protection Act, the Florida DEP has requested technical advice from the Working Group for Unusual Marine Mammal Mortality Events. In addition to State biologists, Federal scientists from the U.S. Fish and Wildlife Service, National Biological Service, National Marine Fisheries Service, and Armed Forces Institute of Pathology are cooperating in the response to the dieoff, as well as scientists from the University of Florida, University of Miami, Miami Seaquarium, Sea World, and Erasmus University in The Netherlands.

In 1995, Florida reported a total of 201 manatee deaths. This year, 200 have died in Florida's waterways in little more than three months.

The same area of southwest Florida was the scene of another mass mortality in 1982 in which some 37 manatees died. These deaths were traced to ingestion of tunicates that contained red-tide organisms. That outbreak included cases of manatees behaving abnormally, and some animals recovered; but in this case there have been no reports of sick or strangely-acting manatees, only deaths. Although the 1996 incident has coincided with a red tide that has killed sea birds and other marine animals, preliminary screening of manatee blood for red-tide toxins has been negative. Neither have any of the other analyses so far produced any conclusive evidence of a cause.

On 1 April, researchers captured six manatees in the area of the dieoff and extracted blood from them in an attempt to obtain a control group of live animals with

which to compare analytical findings from the carcasses. For instance, if the live animals have been exposed to the disease, they might show unusual blood cell counts or perhaps antibodies. Alternatively, whatever is causing the disease may be present in the control group's blood but for some reason absent from the blood of the animals that have died. Passive Integrated Transponder (PIT) tags were also placed in the captured animals, so if any of them turn up dead in the near future, they could provide insight into the incubation period if an infectious disease is to blame, or possibly give other clues about the cause of death. At this time a viral infection is considered a likely culprit, but unusual bacteria and natural or man-made toxins have not been ruled out. (Source: Florida DEP)

#### **Award and New Job for Pat Rose.** -

Patrick M. Rose, who has headed the Florida Department of Environmental Protection's (DEP) manatee program for the past twelve years, was recently the recipient of a 1995 special edition National Conservation Achievement Award sponsored by the National Wildlife Federation (NWF).

This award recognizes contributions made by dedicated public servants in the cause of conservation. Recipients are selected by the Awards Committee of the NWF Board of Directors.

Pat has long been known for his aggressive championing of boat speed zones and other protective regulations on behalf of the Florida manatee, and has borne the brunt of many hard-fought intra-agency political battles, as well as much bitter public criticism incurred in the course of regulatory controversies. To him belongs much of the credit for the great success DEP has had to date in enacting manatee protection.

Pat instituted the Florida Audubon Society's manatee program, then became the U.S. Fish and Wildlife Service's first Manatee Coordinator, before starting DEP's manatee program. He is also a noted manatee photographer, and his still and motion pictures have appeared in many publications and films.

In recent weeks he has left DEP to become the new Director of Government Relations for the Save the Manatee Club, which has opened a new satellite office in

Tallahassee in order to become more involved in advocacy for stronger manatee protection. Pat's dedication and government experience will be major assets to this effort, and his many friends and colleagues are happy that his talents will not be lost to the cause of manatee conservation. (Sources: DEP, *Save the Manatee Club Newsletter*)

**Save the Manatee Club Goes Online.** - Visit the Save the Manatee Club's new web site! Facts about manatees, information about the Adopt-A-Manatee program (including an online adoption application), and materials for educators are all featured. Address: <http://objectlinks.com/manatee>.

## GERMANY

**More on Manatee Breeding in Nuremberg.** - A letter to the U.S. Marine Mammal Commission from Dr. Peter Mühlring, Director, Tiergarten Nürnberg, supplements the information reported in *Sirenews* No. 22. He reports that between 1981 and 1995, 14 manatees in two generations were born at his zoo, including two births of twins. The founding stock came from Guyana.

The manatee pool is 1.6 m deep with a surface area of some 50 m<sup>2</sup> (not including an island). The manatees often rest in the shallow areas, while ducks in the enclosure rest in turn on the manatees' exposed backs.

No behavioral problems have been observed, even with up to ten manatees in the pool at once. As of June 1995, only four animals were still held, the others having been transferred to the Arnheim Zoo, Tierpark Berlin, Singapore Zoo, and Seapalace in Japan. Plans are now underway to enlarge the manatee pool and make more room for continued breeding.

## INDONESIA

**Cultivation Grazing by Dugongs in the Moluccas.** - From 1990 to 1995 we studied the interactions between seagrasses and dugongs in the Moluccas, East Indonesia. This project was a collaboration between the Pattimura University at Ambon, LIPI Jakarta/Ambon and The Centre for Environmental Science of Leyden University, The Netherlands. We found convincing evidence that dugong practice "cultivation grazing."

Preen (1993) postulated that seasonal nutritional stress in subtropical areas, and a response to this stress by "cultivation grazing," would be major factors in the observed difference in dugong herd size between tropical and subtropical areas.

An impact of environmental stress on herd size has also been observed for terrestrial herbivores. Increased densities of African elephants caused by restriction in available habitat led to an increase in group size (Laws, 1975). According to Preen (1993, 1995), "cultivation" grazing occurs when herds of dugongs forage intensively in an area, effecting a high level of seagrass removal over a large area. "Cultivation" grazing allows dugongs to improve the quality of their diet by one or more of the following: (1) maintaining the meadow at a younger, actively growing stage, so the seagrasses contain less fiber; (2) converting the meadow to a lower seral stage composed of preferred and nutritionally superior seagrasses; and (3) concentrating the regrowth vegetation into areas that can be efficiently cropped. The nutritional benefits of these modifications to the seagrass meadows would maximize the fitness of individual dugongs." McNaughton (1979) postulated that the fitness benefits gained by individual animals through increased foraging efficiency could lead to the development of herding behavior in ungulates. According to Preen (1993, 1995), due to their mode of feeding, these benefits could only be achieved if the dugongs fed in large herds.

Preen (1993, 1995) also stated that in tropical areas, the benefits of cultivation grazing may not be necessary, or relevant, in which case there may be no pressure to feed in large herds.

The conclusions of Preen (1993, 1995) are contradicted by the findings of our study, since we observed concentrated feeding plots inside both intertidal and subtidal seagrass meadows in the Lease Islands, caused by cultivation grazing practice by small herds of dugongs (2-6 animals). These small herds could sufficiently disturb the seagrass bed, through a dense grazing pattern, to maintain monospecific meadows (*Halodule uninervis* and *Halophila ovalis*) of low standing crop.

The principal effect of cultivation grazing in an intertidal multispecies meadow



in our study area (Nang) was the creation of monospecific *Halodule uninervis* pioneer meadows surrounded by multispecies associations. This pattern of grazing, similar to patterns described for Moreton Bay by Preen (1993, 1995), leads to the spatial containment of less favored species, like (in our study) *Thalassia hemprichii* and *Cymodocea rotundata*.

The principal effect of cultivation grazing in a subtidal monospecific *Halodule* meadow in our study (Haruku) was a higher *in vitro* digestibility inside the grazing plots, compared with the undisturbed meadow. This phenomenon has not been described by Preen (1993, 1995) for Moreton Bay. Cultivation grazing in monospecific meadows results in patches with lower standing crop, but with a higher *in vitro* digestibility, indicating a feeding strategy along a productivity gradient as described by Van der Koppel et al. (1995).

During our study we have identified at least five permanent feeding plots with concentrated, regular patterns of recropping by dugongs. We concluded that dugongs in these plots grazed in facultative feeding assemblages with loose social interaction rather than in fixed herds with strong social bonds. Cultivation grazing benefits all individual dugongs through an increased rate of digestibility and energy intake, but lowers the amount per bite and overall biomass in the grazing plots.

With a computer model we calculated the maximum sustained population size for Haruku Strait as 11 dugongs. With a maximum sustained number of 90 dugongs and the estimated minimum population of 22-37 dugongs for the study area, the quantity of the available seagrass in combination with mortality from accidental capture by man may be major factors determining population size, but seagrass quality seems to determine herd size and dispersion.

A "cultivation" effect similar to that observed for small groups of dugongs in the present study has been observed for small herds of manatees in Florida (Lefebvre and Powell, 1990). Florida manatees, with muzzles less specialized for bottom feeding, do not produce feeding trails in the manner of dugongs. Instead, when they feed on seagrasses, they crop circular patches (mean 27 m<sup>2</sup>). Interestingly, there is some evidence that they return to the same patches in subse-

quent years.

Our study confirms that the practice of recropping permanent grazing plots through cultivation grazing is moreover part of a permanent evolutionary pattern of adaptations of the dugong as a species in response to its low-quality forage, rather than a temporary response to seasonal nutritional stress as postulated by Preen (1993, 1995).

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- Hans De Iongh (Centre for Environmental Science, Leiden University, The Netherlands)

[EDITOR'S NOTE: I strongly suspect that production of feeding trails is a function of seagrass and substrate type and density, not of degree of muzzle specialization. If seagrasses are sparse, delicate, and easy to uproot, a sirenian can maintain headway while removing most of the biomass, thereby producing a trail during a single dive. If the foliage is thicker and/or the rhizomes are harder to dig out, only a small patch can be cleared during a single feeding bout (dive), and there is no reason

for patches cleared on successive dives to be linearly aligned, so a large circular feeding scar results. If manatees were observed feeding on (e.g.) sparse *Halophila* beds, they might be found to make trails too!]

**PREEN RESPONDS:** It is very pleasing that cultivation grazing has been documented from a tropical area, and that the process seems identical to that in subtropical Moreton Bay, where I did my study. The only substantive differences appear to be the size of the dugong herds and the size of the cultivation patches. In Moreton Bay the median herd size was 140, and cultivated areas were up to 75 ha within 11,054 ha of seagrass. In Hans De Iongh's study, the herds were 2-6 dugongs and the study area (Nang Bay) was 6 ha.

Hans has misunderstood the nature of cultivation grazing in Moreton Bay. It is not "a temporary response to seasonal nutritional stress." Rather, I speculated that seasonal stress may necessitate cultivation grazing (and omnivory; Preen, 1995, *Jour. Mamm.* 76:163-171) by dugongs when they live at the extremities of their range. However, this is not to suggest that cultivation grazing (or omnivory) are seasonal in Moreton Bay, as they are not, or to imply that cultivation grazing could not occur in more tropical areas. Indeed, in the Gulf of Carpentaria, in northern Australia (15.5° S), I have subsequently found that large herds of dugongs persistently feed in the same locations for extended periods, and that they appear to return to these areas, perhaps on an annual cycle.

Interestingly, in this area that is overwhelmingly dominated by an abundance of dense *Syringodium isoetifolium*, the dugongs feed more in the manner described for manatees. Rather than forming feeding trails, they tend to form small oval feeding patches (ca. 30 x 50 cm) from which they remove only the leaves. These patches grow and coalesce, and eventually very large areas are substantially denuded. It is only after most of the shoots have been removed that they start removing substantial amounts of rhizomes. The extent to which this grazing favors species like *Halophila ovalis* and *Halodule uninervis* depends on the extent to which the rhizomes of *Syringodium* are removed. Mere cropping of the leaves results

in a rapid and vigorous shooting by the *Syringodium*. - Tony Preen

## JAMAICA

**The World's Most Primitive Seacow.** - With support from the National Geographic Society, I have been working in Jamaica for the last three years, collecting fossils of *Prorastomus*, the oldest and most primitive sirenian known. A site in the hills south of Montego Bay, originally discovered by Roger Portell of the Florida Museum of Natural History, is yielding abundant post-cranial bones of this Early to Middle Eocene animal, which was previously known almost entirely from a single skull found at another Jamaican site in the 1850's. Assisting Portell and myself in the field are Steve Donovan of the University of the West Indies, Kingston, Jamaica, and Kevin Schindler of the Lowell Observatory, Flagstaff, Arizona. The new material may represent a new species distinct from the type species *P. sirenooides*.

In addition to numerous ribs (which are typically sirenian in their bulk and density) and vertebrae, we have found a scapula, two humeri, an ulna, several pelvic bones, three femora, a tibia, a metapodial, a phalanx, and several skull elements and teeth. Much of the material collected remains to be prepared, and probably includes still other parts of the skeleton.

The appendicular bones of these pig-sized, 50-million-year-old seacows resemble those of land mammals far more than do bones of *Protosiren*, the next most primitive seacow known. Since even *Protosiren* retained well-developed hind limbs and was obviously amphibious, it seems that prorastomids were even more capable of terrestrial locomotion, although their aquatic adaptations (retracted nasal opening, dense ribs) indicate that most of their time was spent in the water. They still possessed two or more sacral vertebrae that were connected to the pelvis, but these vertebrae were not fused to each other, indicating a degree of spinal flexibility comparable to that of early whales like *Rodhocetus*. Prorastomids also seem to lack an enlarged tail like that of later sirenians, so they may have used the hind limbs to swim, like the primitive whale *Ambulocetus*.

Further fieldwork is planned, and as collecting and preparation proceed, we expect

to rapidly learn more about the anatomy and lifestyle of this true "missing link" between land mammals and sirenians. - DPD

## MEXICO

**Manatee Rescue in Chiapas.** - One of the most important areas for manatees in Mexico is the Usumacinta River and its basin, with streams and many lakes, in the states of Chiapas and Tabasco. The number of manatees in this area has not been estimated, but it appears they are fairly common.

During the first months of 1995, the southeastern states of Mexico suffered an extensive drought; the water levels of many streams and lakes decreased to critical levels. On 29 May we received news of a group of manatees isolated in an almost dry lake named San Juan (17° 46'44" N, 91° 55'45" W), located in the municipality of Catazajá in Chiapas. Manatees have been sighted in this lake for more than 10 years.

In March and April, the people from villages nearby took grass to the water to feed the manatees, because they realized that the water level in the lake was dropping fast, and the manatees had nothing to eat. By late May, authorities of Chiapas decided to rescue the manatees.

The rescue work lasted from 31 May to 4 June. Seventeen manatees were captured and moved. From the second day of capture we collected data on morphology and sex, and also took five samples of blood and eight of skin for genetic analysis.

The animals were corralled with a 100-m-long fishing net and then caught by hand by slipping a rope around their peduncles while the net was contracted slowly. They showed an extraordinary ability to escape from the net by lifting the lower edge with their noses. During transport, which lasted about 30 min, all animals showed passive behavior until they were successfully released.

The authorities decided to free the rescued manatees in the Catazajá Lake, which has a maximum area of 16,000 ha in the rainy season, and where the local fishermen estimate a population of 50-80 manatees.

Of the 17 captured manatees, five were adults and the rest were juveniles, including at least one calf. The sexed animals were seven females and four males.

The Chiapas state authorities are now planning to initiate an educational and research program in the region with the aid of the Quintana Roo Research Center, where a research program on the Antillean manatee was started in 1987.

A video of this rescue is available (8 minutes long, VHS). For information, fax: 983-20447 in Chetumal, Mexico. - **Benjamín Morales Vela** and **David Olivera Gómez** (El Colegio de la Frontera Sur [ECOSUR], Apdo. Postal 424, C.P. 77000, Chetumal, Q. Roo, Mexico)

## NEW CALEDONIA

**New Dugong Studies.** - **Jean-Philippe Das** has been conducting studies of dugongs in New Caledonia, and in October 1995 he produced a wide-ranging 97-page privately-printed report entitled *Etude des dugongs en Province-Nord: Compte-rendu*. It covers the distribution, ecology, and status of dugongs in the province, giving data from aerial and interview surveys, catch data, and ethnobiological information. In 1994 he produced another report, *Etude des dugongs en Province-Sud*. He can be contacted at: 18 Rue Rameau, 91160 Longjumeau, France (tel./fax: 33-90-49-55-28) or at CEMMEN - Conservation et Etude des Mammifères Marins en Nouvelle-Calédonie, BP 13098, 98800 Nouméa, New Caledonia (tel./fax: 687-44-22-34).

## PHILIPPINES

**Symposium on Cetaceans and Dugongs.** - A Symposium and Workshop on the Biology and Conservation of Small Cetaceans and Dugongs of Southeast Asia was held in Dumaguete, Negros Oriental, on 26-30 June 1995 and hosted by the Silliman University Marine Laboratory. The one-day Symposium was attended by over 120 participants from 10 countries.

The group agreed that its work should include the dugong, since it faces many of the same threats as small cetaceans and because in several nations dugongs and small cetaceans are studied by many of the same researchers.

The Workshop agreed to establish a small cetacean interest group in Southeast Asia, with a regional newsletter appearing at

least three times a year (to be published by the Ocean Park Conservation Foundation). The proceedings of the Workshop are being edited by Dr. W. F. Perrin and will be published as a UNEP East Asian Technical Series Report. - (source: *The Pilot* [UNEP], No. 13.)

WASHINGTON, D.C.

**U.S. Postage Stamp to Feature Manatee.** - For the first time, a manatee is to appear on a United States postage stamp. Part of a sheet of 15 multicolored stamps featuring 15 different endangered species, the 32-cent stamp depicting a Florida manatee is scheduled for its first day of issue on 2 October 1996 in San Diego, California.

The U.S. is late in joining the club of nations that have put sirenians on their stamps: at least 31 other countries have already done so. The first were apparently Niger and Cameroon in 1962. Still conspicuously absent from the list is Australia. How about it down there?? It's a cheap and easy way for a government to help raise consciousness about sirenians among children and other collectors the world over. - DPD

**Publication of Sirenian Bibliography Still Approaching!** - After further delays caused by the past winter's government furloughs and shutdowns (what else can go wrong?), Domning's *Bibliography and Index of the Sirenia and Desmostylia* is now expected to appear this summer as Number 80 in the series *Smithsonian Contributions to Paleobiology*. It will consist of a single sewn, paperbound volume (about 8" x 10" format) of over 610 pages. It is an exhaustive, annotated and indexed compilation of 500 years of scientific and popular literature on the biology, paleobiology, and ethnobiology of sirenians and desmostylians. Since the Smithsonian does not retail its series publications to the general public, arrangements have been made for the Save the Manatee Club to obtain a limited supply of copies for sale to individuals. The retail price has been tentatively set at around US\$25.00 per copy. If you wish to acquire a copy for personal use, please contact the Save the Manatee Club, 500 N. Maitland Ave., Maitland, Florida 32751, USA (phone: 1-800-432-5646), as soon as possible to reserve a copy and obtain up-to-date information on price and handling costs. To repeat, copies are not available for shipment at this time, but will be ready sometime in the next months. - DPD

## ABSTRACTS

The following abstracts are of papers and posters presented at the Eleventh Biennial Conference on the Biology of Marine Mammals, held at Orlando, Florida, 14-18 December 1995.

### RECYCLED BY-PRODUCT BASED DIET FOR CAPTIVE MANATEES

A.G. Abend<sup>1</sup>, F.M. Byers<sup>2</sup>, and G.A.J. Northy<sup>3</sup>  
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2: Dept. of Animal Science, Texas A&M, College Station,  
3: Dept. of Marine Biology, Texas A&M, Galveston

Although manatees *Trichechus manatus* have been maintained in captivity for more than 45 years, there is a paucity of knowledge about their nutrition and diet formulation has been largely by convenience vs. science. In addition, upkeep of captive manatees on lettuce is so costly that some parks are now rethinking about further displaying them. To address these issues, we investigated development of new diets for captive manatees through linear programming techniques that were more nutritionally sound than their general diet of lettuce and carrots, which would also reduce the cost of their feeding.

We investigated the use by-products from food and beverage processors to create this product. Proximate compositions were derived based on desired specifications of 2.5, 5.0, 7.5% fat, and 15, 20, 25% of crude protein (CP) and acid detergent fiber (ADF) using brewers grains, citrus pulp, carrots, lettuce, soybean meal, and alfalfa. For a desired diet specification of 5.0% fat, 20% CP, and 25% ADF the derived makeup consisted of 47% brewers grain, 23% citrus pulp, and 23% alfalfa at an approximate cost of \$88/ton vs. an approximate cost of \$32,000 for a lettuce diet. A 25% CP, 20% ADF, and 5% fat composition yields a makeup of 47% brewers grain, 34% citrus pulp, and 18% soybean meal at \$98/ton. With feeding costs and nutritional concerns on the rise, this provides an excellent way to recycle our agricultural resources and also reduce the costs of zoo/aquarium animal husbandry.

### AGE-STRUCTURED POPULATION MODELS FOR FLORIDA MANATEES

Ackerman, B.B. Wright, S.D., Florida Department of Environmental Protection, 100 Eighth Avenue S.E., St. Petersburg, FL 33701

Population models were developed for 5 regional subpopulations of the endangered Florida manatee (*Trichechus manatus latirostris*). Population dynamics have been uncertain, and it is unclear whether the populations have been increasing or decreasing. Two simple models were developed using: 1) age-specific survival and reproduction from long-term radio-telemetry and photo-identification studies, and 2) regional trends in carcass recoveries and aerial estimates of population sizes. Intensive efforts yielded 2454 carcasses 1974-94, with 1161 carcass ages (maximum age 59 years). The number of carcasses through time in 3 age classes was used to validate the models. No previous manatee models have: 1) used actual trends in carcass numbers and sex-age structure, or 2) covered southwest Florida where manatee mortality is highest. Mortality varies among regions because of differing densities of manatees, humans, and watercraft, degree of crowding in constricted waterways, and other factors. Regional population projections 1975-94 were compared to long-term aerial studies which previously suggested increases of 1 to 10 %/year in some areas. Other scenarios tested included higher mortality, lower reproduction, reduced watercraft-related mortality, and interchange between populations. Model projections indicate a range of feasible population outcomes which are validated with independent data sets. Models are being used to assess current population dynamics, predict future trends, and improve conservation strategies in critical areas. Additional modelling will assess changing human impacts into the future.

PRELIMINARY RESULTS ON THE USE OF STABLE CARBON ISOTOPE ANALYSIS FOR DETERMINING THE DIETARY HABITS OF THE FLORIDA MANATEE, *TRICHECHUS MANATUS LATIROSTRIS* Ames, A.L., Van Vleet, E.S. and Sackett, W.M. University of South Florida, Department of Marine Science, 140 7th Avenue South, St. Petersburg, Florida 33701

The sloughed skin from three captive manatees at Lowry Park Zoological Garden (Tampa, Florida) was examined over a period of one year to determine its stable carbon isotopic composition ( $\delta^{13}\text{C}$ ). The food consumed by these manatees was also sampled and their  $\delta^{13}\text{C}$  values determined. The sloughed skin  $\delta^{13}\text{C}$  values from the captive manatees were enriched by an average of +4.1 % relative to lettuce the animals consumed, while the average enrichment relative to carrots was +1.6 %.  $\delta^{13}\text{C}$  values of the skin were shown to be related to changes in the manatees' diet.

The stable carbon isotopic composition of internal tissues (liver, kidney and blubber) and skin from dead, stranded manatees was also determined. These values were compared to values of vegetation that manatees are known to eat in the wild. The  $\delta^{13}\text{C}$  values of the internal tissues and skin of wild manatees was consistent with the range of  $\delta^{13}\text{C}$  values of their expected diet.

#### ARE FEMALE MANATEES MORE VULNERABLE TO ENTANGLEMENT IN CRAB TRAP LINES?

Beck, C. A. and Lefebvre, L. W.  
National Biological Service, Southeastern Biological Science Center, Sirenia Project, 412 NE 16th Avenue, Gainesville, FL 32601.

Each year, an increasing number of manatees are reported entangled in crab trap lines, monofilament line, or unspecified lines. Nearly all of the documented entanglements involve one or both flippers. Records of scarred or mutilated flippers on known free-ranging cataloged manatees, and records of manatees rescued due to entanglement were tabulated. Thirty free-ranging manatees were identified by healed flipper wounds and, for most, the material that resulted in the loss or constriction of a flipper was not identified. Thirty-five manatee rescues to remove lines on flippers have been documented since 1976. Lines, typically 1/2" nylon and reported as crab trap lines, often with buoys still attached, were the primary source of entanglement for 24 (68.6%) of the rescued manatees; monofilament line, or monofilament with other nylon lines or ropes of unknown origin, was entangled on eight (22.8%) manatees; three (8.6%) manatees were entangled in lines of unspecified origin. Of the 30 free-ranging affected manatees, 22 (73.3%) were females, four were males (13.3%), and the sex was unknown for four (13.3%). Of the 35 rescued manatees, 23 (66%) were females, 8 (23%) were males, and the sex was unknown for four (11%). We propose that female manatees may be especially vulnerable to entanglement, possibly due to a propensity to rub their teats on lines suspended in the water. Beck and Barros (1991) documented manatee entanglement in lines and other debris. Flippers were the primary site of entanglement. Efforts should be made to collect materials involved in documented entanglements and to investigate the origin of these materials. Research on captive manatees may elucidate the behaviors that promote entanglement and assist managers in developing ways to prevent further entanglement incidents.

#### WINTER MOVEMENTS OF RADIO-TAGGED MANATEES BETWEEN WARM WATER SOURCES ON THE WEST COAST OF FLORIDA

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The Florida Department of Environmental Protection has radio-tagged and monitored the movements of 48 West Indian manatees along the west coast of Florida since February 1991. Three warm water sources in Tampa Bay used by manatees during the winter (Dec.-Feb.) include: Tampa Electric Company's Big Bend and Port Sutton power plants and Florida Power Corporation's Bartow power plant. Analyses of movement data for 28 animals shows a yearly variation in the use of these plants. Two groups of manatees were studied: those that used only Big Bend and those that traveled between power plants. Animals that utilized all the power plants, were generally larger than 295 cm. Those that used only Big Bend were smaller or females with calves.

Movements between warm water sources in Tampa Bay and other west coast aggregation sites during a winter season and between seasons were rare but have been documented. A 280 cm female manatee, without a calf, spent 7 days at warm water sources in Tampa Bay after initial tagging at Big Bend during January 1995. She then traveled 180 km south to the Fort Myers power plant. A 242 cm female tagged at Big Bend in 1994 utilized all three power plants in Tampa Bay throughout the winter. She then traveled south and spent the next winter at the Fort Myers power plant. Movements of non-tagged animals between west coast power plants have also been documented by the use of the scar catalog.

CAPTIVE MANATEE RELEASES AND MONITORING ALONG FLORIDA'S EAST COAST  
Bonde, R.K., Reid, J.P., Tyson, S.L. and Easton, D.E.  
National Biological Service, Southeastern Biological Science Center, Sirenia Project, 412 NE 16th Avenue, Gainesville, FL 32601.

In June 1988, the Sirenia Project incorporated the radio tracking of rehabilitated, previously captive manatees (*Trichechus manatus latirostris*) into an ongoing study of manatee movements along the east coast of Florida. Through June 1994 we have radio tagged and monitored the release of 18 manatees (10 ♀, 8 ♂). Length of captivity for these individuals ranged from 6 days to more than 85 months, and has included animals from different age classes. Two cow/calf pairs were tagged and released together. Tracking was accomplished with the use of conventional VHF transmitters as well as satellite-monitored platform transmitter terminals. Fifteen manatees have been documented to have survived their first independent winter, and 13 individuals were observed utilizing a reliable warm-water source during cold winter weather. Two manatees lost their tags prior to the first winter season. General movements and habitat utilization appears to be similar to patterns established by wild manatees. Two manatees travelled into north Florida and Georgia during the warm season. One animal died when it became trapped in a storm water drainage pipe. Data gathered from this study have helped to establish guidelines for future releases of long-term captives, as well as captive born manatees.

#### FUNCTIONAL ANATOMY OF PERIORAL BRISTLE USE IN MANATEES

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Manatee feeding behavior involves the use of modified perioral vibrissae (bristles, primarily the U2 and L1 fields) to manipulate vegetation. The facial musculature of the Florida manatee, *Trichechus manatus*, was examined in order to develop a functional model of manatee feeding behavior. Manatee heads were dissected grossly and sectioned coronally in order to identify the underlying myology. Muscles identified include the *M. levator nasolabialis*, *M. buccinatorius*, *M. maxillonasolabialis*, *M. centralis nasi*, *M. lateralis nasi*, *M. sphincter colli profundus pars oris (SCPO)*, *M. orbicularis oris*, and *M. mentalis*. We hypothesize that U2 bristle protrusion is the result of contraction of the *M. buccinatorius*, along with the contraction of the *M. levator nasolabialis*. Midline sweeping of the U2 bristle fields occurs by the relaxation of the SCPO, with concurrent contraction of the *M. centralis nasi*. Lateral movements of the U2 bristles are due to contractions of SCPO and *M. levator nasolabialis*. Protrusion of the L1 bristles anterior to the lower horny pad is due to contraction of the *M. mentalis* rolling down the lower lip exposing the bristles. Retraction of both the L1 and U2 bristles is the result of a relaxation of the surrounding musculature.

Supported by NSF grant BNS-912045 to R.L.R. and Florida Department of Environmental Protection.

#### RELIABILITY OF TOXICOLOGICAL ASSAYS CONDUCTED ON DECOMPOSED MANATEE TISSUES

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Marine mammal science depends heavily on stranded carcasses for biological information. For some species, nearly all that is known about them was derived from stranded carcasses and most of these were not fresh. Tissue concentrations of various toxins are becoming more frequently reported and appear to have a greater role in marine mammal epizootics than previously thought. However, the reliability of results of assays conducted on decomposed tissues is in question.

Carcasses are recovered from throughout Florida year-round and are classified as fresh, moderately decomposed, or badly decomposed at time of necropsy. As part of the Manatee Recovery Plan, we have conducted assays using standard EPA test protocols to test for the presence of 34 organic compounds and 28 heavy metals in liver tissue collected from manatee carcasses. Only fresh or moderately decomposed tissues were used.

No organic compounds were detected above the standard minimum detectable levels in any tissues. Of the metals tested, copper, aluminum, and cadmium were detected in both fresh and moderately decomposed tissues. Of these, mean concentrations of copper and aluminum were significantly higher in fresh tissues (Wilcoxon rank-sum,  $p < 0.05$ ). These results suggest that decomposed carcasses may have limited value as accurate indicators of toxin concentration in tissues.

MANATEE (*TRICHECHUS MANATUS*) MOVEMENTS AND SPATIAL USE PATTERNS ALONG THE EAST COAST OF FLORIDA  
Deutch, C. J., J. P. Reid, R. K. Bonda, and H. I. Kochman.  
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Home range and movement patterns of the endangered Florida manatee were studied along the east coast of Florida from 1986 to 1994. Sixty-nine manatees were tracked using VHF field-monitored radio-transmitters (n=24) or a combination of VHF tags and UHF satellite-monitored transmitters (n=45), resulting in over 45,000 locations. Annual movement patterns varied among individuals in terms of distance between summer and winter ranges, geographic region, timing of movements, and degree of site fidelity. About 90% of wild-caught manatees made seasonal migrations, typically between south FL in winter and central or north FL during the warm season (median one-way distance = 250 km), while the remainder were resident year-round in a given region. Migratory distance did not vary significantly with age class or adult body size. Warm-water refuges, typically power plant effluents, were utilized during cold winter periods. Travel between high-use areas was usually direct and rapid (up to 50 km/day). Most individuals exhibited strong site fidelity to summer ranges across years. Manatees rescued and rehabilitated as adults (n=8) exhibited migratory patterns similar to those of wild-caught animals, but those rehabilitated as orphaned calves (n=3) showed restricted annual movements. Three animals tagged as dependent calves used their natal summer and winter ranges after weaning. These two findings suggest that annual movement patterns and preferred areas are learned from the mother during the calf dependency period. Information on spatial use and movements is necessary to protect manatee habitat and to reduce human-caused mortality.

MOVEMENT PATTERNS OF RADIO-TAGGED FEMALE MANATEES  
Fitzgerald, M.R., Flamm, R.O., Weigle, B.L.  
Florida Department of Environmental Protection, St. Petersburg,  
FL 33701

The Florida Department of Environmental Protection radiotelemetry project tagged 23 female Florida manatees (*Trichechus manatus latirostris*) between February 1991 and March 1995. Movement patterns for 13 female manatees both with calves (FNC) and with no calves (FNC) were compared to determine differences in ranges and distances traveled. Point locations were retrieved from ARGOS satellite receptions and from visual sightings. The data were entered into the ARC/INFO Geographic Information System. ARC macro programs were written to connect sequential point locations and produce a shortest travel route between points while maintaining the travel path in water. Mean daily travel distances were calculated for each month and shoreline ranges were totaled from estimated travel routes. Differences between mean daily travel distances for FNC and FNC on a monthly basis were minimal. However, shoreline ranges for FNC were substantially smaller than ranges for FNC. Results suggest that FNC selected habitat close to their preferred winter aggregation sites while FNC selected habitat over a wide geographic range along the west coast of Florida. A comparison of movement patterns to evaluate habitat use by FNC and FNC will help managers identify and protect areas preferred during different reproductive stages.

HABITAT INFLUENCES ON THE DISTRIBUTION AND ABUNDANCE OF FLORIDA MANATEE IN THE INDIAN RIVER LAGOON, FLORIDA  
Flamm, R.O., Ward, L., and Weigle, B.L. Florida Department of Environmental Protection, St. Petersburg, FL 33701, USA.

The influence of habitat on the seasonal distribution and abundance of manatees in a portion of Florida's Indian River Lagoon was investigated. Manatee densities for winter and summer were estimated from point locations collected during 63 aerial surveys flown in 1986 and 1987 between Grant and Fort Pierce. A new GIS spatial filtering algorithm called a fixed-area spatial filter was applied to the points to create a manatee density surface. Filter size was based on a circle with a radius equal to the median of the movement rate distribution, 325 meters/hr, as derived from an analysis of satellite telemetry data. The filter polygon always contained the same amount of habitat adjacent to the point location, varying its shape when encountering land to satisfy its size requirement. Manatee density maps were compared to spatial data layers of bathymetry, distance to seagrass, and distance to water discharge sites. The spatial arrangement of manatee densities were similar in winter and summer and the correlation between shallow depths and high manatee densities was statistically significant for both seasons ( $T > 3.03$ ,  $P = .05$ , Dunn's non-parametric multicomparison test). Distributions appeared to be more strongly influenced by the proximity to fresh water rather than distance to seagrass beds.

POPULATION GENETIC STRUCTURE OF THE WEST INDIAN MANATEE  
Garcia-Rodriguez, A.I., Rudin, M., Bowen, B., Mignucci-Giannoni, A.A., and McGuire, P.M.  
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Red Caribeña de Varamientos, San Juan, PR 00937

The mtDNA D-loop region in 54 samples from five locations was analyzed to study the genetic structure among populations of the West Indian manatee (*Trichechus manatus*). Twenty-four samples were collected from Florida, eleven from Puerto Rico, fourteen from Colombia, four from Venezuela, and one from the Dominican Republic. Twenty-two distinct haplotypes were observed. One haplotype was found in Florida samples, eight in Puerto Rican, eight in Colombian, four in Venezuelan, and one in the Dominican Republic. No haplotypes were shared among sample sets, except for three individuals in Puerto Rico which shared the Florida haplotype. Haplotypes in the Florida, Puerto Rican, and Dominican Republic samples constitute a cluster of closely related mtDNA lineages. Venezuelan and Colombian samples comprise a second cluster. A deep genetic partition was found between these two clusters. These results indicate strong structuring among West Indian manatee populations and two phylogeographic units within the species. [This work was supported by the Caribbean Stranding Network, the Sirenia Project of the National Biological Service, and the State of Florida Department of Environmental Protection.]

UNDERWATER HEARING ABILITIES OF THE WEST INDIAN MANATEE  
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^ Navy Undersea Warfare Center, Division Newport, Underwater Sound Reference Detachment, P.O. 568337, Orlando, FL 32856

A comprehensive series of psychophysical tests have been conducted to measure the hearing abilities of two captive-born manatees. Results from 3 tests: (1) the pure-tone threshold, (2) the acoustic masked threshold, and (3) the underwater directional hearing test, provide the first empirical sensory data and definitive audiogram for any Sirenian species. The pure-tone and masked threshold tests used an up-down staircase procedure in a two-choice forced alternative paradigm. The underwater localization test used a direct stimulus-response technique with 4 transducers rotated and electronically pulsed to negate speaker-specific artifacts. The resultant audiogram from both subjects is U-shaped with peak frequency sensitivity at 12-18 kHz,  $50 \pm 3$  dB re:  $1 \mu Pa$ . The masked thresholds have consistent critical masking ratios ranging from  $29-14 \pm 4$  dB for the respective frequencies tested. Underwater localization performance was poor for signals below 3 kHz and improved as a function of frequency and pulse repetition. High frequency sensitivity may be an adaptation for living in shallow-water environments where lower frequencies do not propagate as well because of physical boundary effects. The collective hearing data suggests manatees can not detect and localize the sounds of approaching boats against an ambient background  $> 70$  dB (relevant wild levels are  $> 80$  dB). An "environmentally friendly" acoustic warning device, designed to optimize manatee hearing abilities, could help wild manatees detect and locate boats in enough time to avoid repeated collisions.

DEVELOPMENTAL SEQUENCE OF OSSIFICATION CENTERS IN MANUS OF MANATEE (*TRICHECHUS MANATUS LATIROSTRIS*)  
Goodyear, D.M.S. and Watson, A.G.  
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Management and conservation of endangered Florida manatees (*Trichechus manatus latirostris*) requires life-history data based on accurate age estimation. In mammals the sequence of limb ossification is often used to estimate age. Radiographs from a developmental series of 161 flippers from 151 salvaged manatees (1.0 - 3.5 m TL) were analyzed for the first appearance of 43 carpal and epiphyseal ossification centers in the manus. At birth (1.2 m) the diaphyses of radius, ulna, metacarpals 1-5 and all phalanges (I-1, II-3, III-3, IV-3, V-3) are ossified. In weaned immatures (2.0 m), 6 of the 7 carpal bones, the epiphyses of the distal radius and ulna and all proximal metacarpals and distal metacarpals 3-5 begin to ossify. At 2.3 m the radial carpal bone appears and at 2.1 - 2.3 m the distal epiphyses of metacarpals 1-2 ossify. Proximal and distal phalangeal epiphyses appear later and continue to ossify after sexual maturity (2.7 - 3.5 m). Correlation with sequences from known-aged manatees will form the basis for age estimation. Supported by National Biological Survey P.O. #83023-4-0213.

THE ABUNDANCE AND DISTRIBUTION OF THE WEST INDIAN MANATEE, *TRICHECHUS MANATUS LATIROSTRIS*, AT SELECTED SITES IN THE BANANA RIVER AND AT THE FPL AND OUC POWER PLANTS IN BREVARD COUNTY, FLORIDA

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The abundance and distribution of the West Indian Manatee, *Trichechus manatus latirostris* (Linnaeus), along Florida's east coast exhibits seasonal variation. Several sites within the Banana and Indian Rivers were surveyed to further document such seasonality of manatee abundance and distribution within Brevard County, Florida. According to the ANOVA ( $\alpha=0.05$ ), there was a significant difference in manatee abundance between sites and between the interaction of seasons and sites. Land and boat surveys were utilized to monitor daily movement of manatees within and between sites. During this study 121 distinctively scarred individuals were identified through photo-identification. There were 179 animals that had unclear photos and/or sketches, of which there were possibly 54 additional identifiable individuals. Site fidelity was documented and movement between survey sites was observed on a few occasions.

Although previously documented, no correlations ( $p>0.05$ ) between manatee abundance and salinity, air temperature or water temperature were observed during this study. The relationship between manatee abundance and boat traffic was also examined. The only significant relationship occurred at OUC in which there was a positive correlation (0.05) between boat traffic and manatee abundance.

This study provides information about manatee abundance and distribution that could prove beneficial for the development and implementation of useful management strategies.

FIRST SUCCESSFUL RELEASE OF A CAPTIVE-RAISED ORPHANED ANTILLEAN MANATEE IN THE CARIBBEAN

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Recovery plans for the West Indian manatee mandate the release of captive-raised orphan manatees, including those rescued in Puerto Rico. The first candidate for release in Puerto Rico was a male Antillean manatee (*Trichechus manatus manatus*) rescued in 1991. A detailed protocol for a conservative, progressive release was slated cooperatively by the Caribbean Stranding Network, Commonwealth, Federal and U.S. Naval officials. On 22 March 1994, the manatee was transported to Roosevelt Roads Naval Station where he was placed into a fenced natural pen for acclimatization prior to his release. After 5 months, the manatee was released into the adjacent bay and monitored with a radio transmitter. Soon after release, it was observed socializing with wild manatees, and although it returned to the pen frequently, he traveled to and utilized areas where manatees were known to feed. After 1.5 years, the manatee remains healthy, active and well-acclimated. This is the first successful release of an orphaned captive-raised Antillean manatee to the marine environment in the Caribbean.

TRENDS IN ABUNDANCE AND DISTRIBUTION OF FLORIDA MANATEES (*TRICHECHUS MANATUS LATIROSTRIS*) NEAR SARASOTA, FLORIDA: 1985-1994

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For the past decade, Mote Marine Laboratory observers conducted once or twice monthly aerial surveys to assess manatee abundance and distribution in the inshore and coastal waters of Sarasota Bay. These surveys have identified a seasonal occurrence of manatees within the region and have helped identify several sites of regular and recurring manatee use. I analyzed this ten-year database to obtain long-term, year-round information on manatees along the west central coast of Florida. Counts per survey ranged from 0 to 41 within the 90 km<sup>2</sup> area. Relative abundances showed a significant positive trend over the ten years ( $p=0.01$ ). Greater abundances were recorded during Apr/May through Nov/Dec although mid-summer counts were occasionally lower. Division of the study region into five smaller areas did not reveal annual shifts in distribution however significant seasonal variations were observed. Average calf percentage was 5.1% and ranged between 1.3% and 7.9% annually; significantly more calves were observed in the summer (Jul-Sep) and fall (Oct-Dec) ( $p=0.046$ ). Average herd size was 1.98 and traveling was the most frequently recorded behavior. Several different observers participated in this project which may have contributed to variations over time. However, it is more likely that the observed trends are the result of a difference in the level of use of the study area due to changes in regional distribution and/or the population size.

THE EPIGLOTTIS OF AQUATIC MAMMALS: IT'S NOT ONLY SIZE THAT COUNTS, BUT HOW IT'S POSITIONED  
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In most terrestrial mammals, the epiglottis is a leaf-shaped cartilage of the larynx that overlaps the soft palate, creating essentially separate respiratory and digestive pathways. Our studies have shown that this condition has been extensively modified in odontocetes. Their epiglottis is greatly enlarged, elongated, and is placed in a permanently intranarial position. This arrangement allows the air and food pathways to be totally separated, and may allow these animals the ability to feed while communicating. Whether this is the baseline configuration for other aquatic mammals, however, remains unclear. To address this issue, we examined the larynges of 39 specimens obtained post mortem from eight genera of non-cetacean aquatic mammals (*Zalophus californianus*, California sea lion; *Callorhinus ursinus*, northern fur seal; *Phoca vitulina*, harbor seal; *Enhydra lutris*, sea otter; *Lutra canadensis*, river otter; *Castor canadensis*, beaver; *Ondatra zibethica*, muskrat; and *Trichechus manatus*, Florida manatee). Results show that their epiglottis more closely resembles those of terrestrial mammals than it does those of odontocetes. In particular, the epiglottis is relatively small, as compared to the huge structure typical of odontocetes. While some groups exhibit epiglottic modifications (e.g., bifurcation in *Zalophus* or posterior orientation of the tip in *Trichechus*) none exhibit a morphology as extensively derived as that of any odontocete species. Similar to most terrestrial forms, the epiglottis of non-cetacean aquatic mammals is positioned to overlap the posterior surface of the soft palate. This flexible epiglottis may unlock from this position in certain situations (e.g., swallowing a large bolus of food), in contrast to the permanently intranarial position in odontocetes. Thus, while all inhabit a water-based environment, the retention of a terrestrial pattern among some species suggests that a single aerodigestive tract configuration for all aquatic mammals does not exist.

MARK-RESIGHTING ESTIMATES OF ADULT SURVIVAL RATES IN FLORIDA MANATEES (*Trichechus manatus latirostris*).  
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We used open population mark-recapture models to estimate annual adult survival probabilities ( $\hat{\phi}$ ) for manatees wintering in three areas: Blue Spring, Crystal River, and the Atlantic coast. Natural and boat-inflicted scars uniquely "marked" individuals cataloged in a computerized photographic system; photo-documented resightings "recaptured" individuals. We used goodness-of-fit tests in Program RELEASE to search for violations of assumptions. We used Program SURGE to model survival and capture probabilities, and to statistically choose between competing models. There were no differences in  $\hat{\phi}$  between sexes. At Blue Spring and Crystal River  $\hat{\phi}$  was best estimated as constant from 1982 to 1991 at 0.96. Survival is high enough at these protected sites to maintain a growing population if reproductive rates and juvenile survival also are sufficiently high. On the Atlantic coast  $\hat{\phi}$  was lower and varied from 1985 to 1991. Mean  $\hat{\phi}$  was estimated at 0.90. Management practices that increase survival rates (such as boat speed restrictions) should be improved along the Atlantic coast to promote faster progress towards population recovery.

MANATEE GRAZING EFFECTS ON SEAGRASS BIOMASS AND SPECIES DIVERSITY.  
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Domínguez proposed that sea cows and seagrasses have co-evolved over millions of years. Seagrasses are an important part of the West Indian manatee's (*Trichechus manatus*) diet, and are the principal food of the dugong (*Dugong dugon*). Manatee and dugong feeding reduces seagrass shoot and root biomass, and possibly influences species succession and composition. We examined the short-term and long-term effects of manatee grazing on seagrass biomass and species composition in a mixed-species seagrass bed in the northern Banana River, Brevard County, FL. This is an important feeding area for a large number of manatees, particularly in late winter and spring. In October 1990, two 12.8 x 12.8 m manatee enclosures were built and a paired open area of the same size was established near each enclosure. Species composition was mapped and random biomass cores were taken of the co-dominant species, *S. filiforme* and *H. wrightii*, in all 4 areas in October, February, and July of 2 consecutive years (through July 1992). Species composition mapping was continued seasonally through October 1994. A multivariate ANOVA on log-transformed biomass indicated that manatee grazing reduced biomass in the open study areas, but that differences occurred in the impact to the two species. The relative frequency of *S. filiforme* and *H. wrightii* changed over time in both open and enclosed areas, with open areas tending toward dominance by *H. wrightii*, the pioneering, early successional species, and enclosed areas tending toward dominance by *S. filiforme*. We postulate that, in the absence of manatee grazing, *H. wrightii* is shaded out by the taller, more robust *S. filiforme*. Manatee grazing may help to maintain mixed-species seagrass beds.



A RECENT LIST OF SIRENIANS AND CETACEANS IN VENEZUELAN MUSEUMS. Linares, O. J. (1) and Bolaños, J. (2) (1) Universidad Simón Bolívar, Departamento de Estudios Ambientales, Valle de Sartenejas, Caracas, (2) Servicio Autónomo PROFAUNA (MARNR), A.P. 3985, Caracas 1010A, Venezuela. Fax +58 43 838264

Here we present the inventory of the aquatic mammals deposited in Venezuelan museums. Data were obtained from 11 collections. At the moment, there are 19 Sirenian and 85 Cetacean specimens. The only Sirenian is the west Indian manatee (*Trichechus manatus*). Cetacean species are represented as described below. **CORYPHÆNÆ:** 15 *Sotalia fluviatilis*, 13 *Delphinus delphis*, 12 *Inia geoffrensis*, 11 *Stenella frontalis*, 4 *S. longirostris* (previously identified as *S. attenuata*), 1 *S. attenuata* (previously identified as *S. frontalis*), 1 *Stenella sp.*, 9 *Tursiops truncatus*, 4 *Globicephala macrorhynchus*, 1 *Pseudorca crassidens*, 1 *Orcinus orca*, 1 *Grampus griseus*, 1 *Physeter macrocephalus*, 1 Ziphid (*Ziphius cavirostris?*); **MYSTICÆ:** 5 *Balaenoptera edeni*, 1 *B. physalus* and 4 unidentified whales. Though it cannot be used as a relative density index, the most representative species were *Sotalia fluviatilis*, *Delphinus delphis*, *Inia geoffrensis* and the baleen whale *Balaenoptera edeni*. According to the present work, at least 15 Cetacean species have been registered in Venezuela. Out of Balaenopteridae, there are no more baleen whale families represented in Venezuelan collections. More field research is required to evaluate the current status of Venezuelan cetaceans.

MINERAL CONTENT OF SERUM IN CAPTIVE AND WILD AMAZONIAN MANATEES Marmontel, M.<sup>1</sup>, F.C.W. Rosas<sup>2</sup>, and Kesa K. Lehti<sup>2</sup>  
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Blood was sampled from 5 wild and up to 10 captive Amazonian manatees. Wild animals were captured at Estaca Ecologica Mamiarau in mid-1994 as part of a radio-tagging program. Captives are maintained at INPA, on a diet consisting mainly of *Brachiaria mutica*, cabbage and lettuce, and were sampled 3 times between 1992 and 1993. Approximately 10 ml of blood were obtained from the palmar side of the pectoral flipper, centrifuged at 3000 rpm for 10-15 minutes and treated either with TCA or diluted with de-ionized water. Serum samples were analysed for zinc, magnesium, manganese, iron, sodium, calcium, copper and potassium. Zinc, copper, manganese and sodium levels were similar between captive and wild manatees, but magnesium, iron, potassium and calcium in wilds were considerably higher than those of captives. The results suggest that the diet of the captive animals needs improvement in magnesium, iron, potassium and calcium. A deficiency of calcium may cause fertility problems in herbivores; the lack of success in reproducing Amazonian manatees in captivity may be due to this mineral deficiency. We believe this information can contribute towards the knowledge of the nutritional status of manatees and lead to a detection of nutritional deficiencies of captive animals, if blood tests are carried out periodically.

#### CAN COASTAL MARINE MAMMALS SURVIVE IN TROPICAL WATERS? DUGONGS IN AUSTRALIA AS A CASE STUDY.

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Most tropical coastlines are bordered by less developed countries and are suffering from the impacts of rapid population growth, habitat degradation and high fishing effort. In contrast, Australia is a developed country with a relatively undeveloped tropical coastline some of which is protected by marine parks and world heritage areas and with a relatively low human population. However, aerial surveys conducted since the mid 1980's indicate that dugong-numbers are declining in parts of their Australian range. In the southern half of the Great Barrier Reef region, dugong population estimates have declined from 3847 ± s.e. 459 in 1986 to 1750 ± 257 in 1994. In one bay adjacent to a military training area where gill-netting was the only anthropogenic impact, dugong numbers declined from 765 ± 161 in 1986 to 301 ± 87 in 1994. In Hervey Bay, dugong numbers declined from 1466 ± 326 in 1988 to 92 ± 53 in 1992. This loss was associated with the dieback of 1000 km<sup>2</sup> of seagrasses apparently due to sedimentation from the synergistic impacts of a cyclone, a flood and inappropriate farming practices. A total of 82 carcasses were recovered, many animals left the area. This failure to maintain dugong numbers in parts of Australia suggests that prospects for the survival of coastal marine mammals in other parts of the tropics was bleak.

SIRENIAN FEEDING BEHAVIOR: A COMPARISON OF MANATEE AND DUGONG FEEDING MECHANICS  
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Sirenians possess an unusual oral anatomy and associated behavior that is related to their aquatic herbivory. A systematic study of sirenian feeding behavior, focusing on the use of perioral bristles, was conducted on 11 Florida manatees, two dugongs, one Antillean manatee and one Amazonian manatee. Feeding trials involved a piece of plexiglass with holes drilled at 10 cm intervals to secure aquatic vegetation on which the animals fed. The cyclic movement of the lips, jaws and vibrissae during feeding of all sirenians in the study was compared. In general, all manatee species showed similar feeding behavior in that the two large bristle fields on the upper lip act in a prehensile grasping motion in a lateral to medial direction in conjunction with the large bristle field on the lower lip. The dugong feeding cycle is opposite to that found in manatees; the entire upper lip (including homologous bristle fields) undulates in a medial to lateral direction with relatively less prehensile action. Also, captive manatees at Lowry Park Zoo in Tampa, FL and Homosassa Springs State Park in Homosassa, FL and Sea World of Florida were fed a variety of freshwater vegetation and seagrass over a ten week period to test our hypothesis that Florida manatees manipulate vegetation differently depending on morphology of plants. Preliminary analysis shows that manatees manipulate *Hydrilla*, *Vallisneria*, and *Syringodium* in declining cyclic rates. Supported by NSF grant BNS-912045 to R.L.R.

CLONING AND EXPRESSION OF MANATEE IMMUNE CELL MARKERS  
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The endangered status of the Florida manatee has focused a great deal of interest on its biology and medical management. One goal is to develop reagents to assess the health of individuals. In this regard, an ELISA is being developed to quantify manatee immunoglobulins. In addition, flow cytometry has been used to screen hundreds of monoclonal antibodies for orthologous molecules on manatee lymphocytes. Although a number of positives have been found, to date none have identified T helper (CD4+) or T cytotoxic (CD8+) cells. One option is to produce manatee-specific monoclonal antibodies to these markers. As an alternative to this labor-intensive and stochastic process, genomic and cDNA sequence data for the CD8 gene were retrieved, aligned, and examined for regions of homology. PCR primers within the second exon were used to clone manatee sequences and express a CD8 polypeptide. Antibodies to a manatee-specific product can be tested for binding to lymphocytes. Positive results will allow quantification and isolation of manatee immune system components. This approach may prove generally useful in providing species-specific reagents. [This work was supported by the State of Florida Department of Environmental Protection.]

CHARACTERIZATION AND EXPRESSION OF THE INTERLEUKIN 2 GENE FROM THE FLORIDA MANATEE, *TRICHECHUS MANATUS LATIROSTRIS*  
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Pollution of various types, other forms of habitat destruction, and injuries from watercraft are among the possible stresses to Florida manatees, *Trichechus manatus latirostris*. Such stresses can impair immune system function in a number of ways. Since the cytokine, interleukin 2 (IL-2), plays a key role in an organism's cell-mediated immune response by stimulating proliferation of helper T cells and activating cytotoxic T cells, our research focussed on characterization and expression of the IL-2 gene of the manatee. Employing techniques of genetic engineering, the IL-2 gene was amplified, cloned, and sequenced from complementary DNA (cDNA). The cDNA was then transfected into an African green monkey cell line (COS-1) to produce large amounts of the IL-2 protein. A bioassay confirmed the presence of bioactive IL-2 in the COS cell media. We are attempting to develop assays from the recombinant manatee IL-2 to help monitor the immunocompetence of manatees and contribute to their conservation. We also are working to sequence and express other manatee cytokine genes as well as the genes from other marine mammals.



**METABOLIC CAPABILITIES AND THE LIMITS TO THERMONEUTRALITY IN JUVENILE AND ADULT WEST INDIAN MANATEES (*Trichechus manatus*)**

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Available data suggest that the West Indian manatee has a low metabolic rate.

Because these data are few in number and are based upon a narrow mass range, we have undertaken a multi-year investigation to examine the metabolic capabilities of a broader range of animal sizes. Manatees often show an inability to withstand decreased water temperatures during winter months, frequently resulting in mortalities. Smaller animals would be expected to be most affected by these cold stress situations.

Three animals, (A: 247 kg, B: 410 kg, C: 831 kg), housed at Lowry Park Zoo in Tampa, Florida were studied during the month of March, 1994. Standard metabolic rate (SMR) measurements were collected in a flow through respirometer while holding an animal in a temperature-controlled channel, with water initially set within the presumed thermoneutral zone. Oxygen consumption was analyzed via a subsample of air leaving the dome. Direct heat flow measurements were also collected from six points on the animals body.

The results thus far show that animal A, the smallest and youngest, consistently ran at a higher metabolic rate than the two larger ones. Mass specific metabolic rates were 0.74 Wkg<sup>-1</sup> (A); 0.28 Wkg<sup>-1</sup> (B); and 0.32 Wkg<sup>-1</sup> (C). These values are 88%, 35% and 47%, respectively, of Kleiber's prediction for an adult mammal of similar size. Consistent with other young mammals, manatee A has a metabolic rate approximately twice that of the older animals. Manatee B showed no increase in metabolic rate in water temperatures ranging from 19° to 29°C. Heat flux measurements indicate a low rate of heat transfer regardless of water temperature. Collectively, the values for adult animals are consistent with previously published data for this species. However, in order to ensure future success in husbandry, rehabilitation and reintroduction, we must gain a better understanding of the relationship between metabolic limits and body size, especially for neonates and juveniles.

**DWARFISM IN TWO ANTILLEAN MANATEES FROM COLOMBIA**

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In March 1991, two Antillean manatees (*Trichechus manatus manatus*), a 163 cm female and a 210 cm male, were accidentally captured by fishermen in the town of Magangué, Colombia. The animals were rescued and placed in a man-made reservoir in the town of Pincho. Examined in 1992 and 1993, both animals were unusually short and stout for their age and morphologically appeared to be dwarfed. They had hepatic problems indicated by abnormal blood serum levels and possibly hypothyroidism and/or hyperparathyroidism and secondary renal problem. In 1995, the total body length for the female was 176 cm and 211 cm for the male, a growth of 13 cm and 1 cm in length, respectively in four years. Manatees in similar semicaptive conditions in Colombia normally averaged higher growth rates. Serum chemistry analysis and thyroid profiles were normal. However blood cell counts indicated they had microcytic hypochromic anemia. Both animals were placed under veterinary treatment on July 1995. Possible reasons for this unusual slow growth rate include (1) nutritional deprivation or disorders, (2) hormonal inhibition due to casual exposure to a herbicide used in farms around the semicaptive lake, and (3) a genetic condition.

**A ENVIRONMENTAL EVALUATION OF PAREDES SWAMP (COLOMBIA, SOUTH AMERICA) AS A POTENTIAL HABITAT FOR WILDLIFE WITH EMPHASIS ON WEST INDIAN MANATEE (*Trichechus manatus*).**

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This work compiles the results obtained from information since November, 1993 to February, 1995, to define the potential of Paredes swamp, as a West Indian Manatee (*Trichechus manatus*) habitat, through the evaluation of physical, ecological and cultural parameters. This study is based on limnological analysis, identification of aquatic vegetation, carrying capacity of swamp, evaluation of human activities around the swamp, cultural and environmental history and evaluation of general status of manatee population in the area. A population close to 25 individuals was estimated, including mothers and calves. The carrying capacity of Paredes swamp is sufficient for estimated population. The principal problem is the deterioration of swamp surroundings that increases the sedimentation rates and produces the migration of fauna population to search deeper areas with more food availability. As a contribution, this work proposes a Regional Plan for Manatee Conservation, based in ecological and cultural parameters, identified during this study. It is important the environmental consciousness of local settlers, with special emphasis on manatee conservation.

**STATUS OF THE ANTILLEAN MANATEE (*TRICHECHUS MANATUS MANATUS*) IN COLOMBIA: A PRELIMINARY REPORT**

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Systematic distribution surveys of the manatee (*Trichechus manatus manatus*) in Colombia have only recently been started by Colombia's Ministry of the Environment. However, the presence of manatees has been confirmed by captures and sightings in the Caribbean basin and the Orinoco Basin. The data available since 1986 shows a total of 43 manatees were captured by fishermen, although more captures probably went unnoticed. From these, 20 animals died, 1 was released and 22 were rescued, including two orphans, all currently under medical and husbandry care by the Caribbean Stranding Network. Informal interviews revealed that hunting is reduced to specific regions, and is apparently accidental. Large animals are killed and the meat is shared among locals or is sold in the town's market at low prices. The more easily handled calves are kept alive as pets under extremely poor husbandry conditions. Although illegal hunting continues to represent a threat to manatees in Colombia, habitat destruction due to land-filling for agricultural and cattle-raising purposes, increased human settlement near river areas, and pollution, represent more complex threats to the survival of the species.

**ADRENAL CIRCULATION IN THE FLORIDA MANATEE, *TRICHECHUS MANATUS LATIROSTRIS*.**

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This is the first study on the anatomy of the circulatory system of the adrenal gland in the Florida manatee, *Trichechus manatus latirostris*. Adrenals are vital to maintain physiological levels of mineralocorticoids that control blood pressure and electrolytes; glucocorticoids that have an anti-inflammatory potency, and regulate carbohydrate, protein and lipid metabolism; and catecholamines that are involved in emergency responses. Because endocrine glands are dependent on blood to deliver their secretory products to target tissues, blood flow has the potential to directly alter adrenal secretion. Adrenals were collected from six fresh manatee carcasses, by the Florida Department of Environmental Protection (PRT773494). Glands were injected with a dye that permitted separate visualization of the cortical and medullary circulation, sectioned, and stained with hematoxylin and eosin or Gomori's trichrome. Using light microscopy, serial sections were examined to follow the origin, course and distribution of specific vessels to develop the description of the adrenal circulatory system. Adrenal arteries enter the capsule and form a plexus which supplies blood to the capsule and to the cortex. Blood drains through the cortical sinuses and at the cortico-medullary junction, a large spider capillary drains blood directly into the medulla. From the capsule, medullary arteries branch and transverse the cortex undisturbed to the medulla, where they flow into its sinuses. Thus, the medulla receives blood directly via medullary arteries and from the cortical sinuses. A portal system was not seen between the cortex and medulla. The venous system consists of the cortical effluents that drain into the medulla via venules. These venules agglomerate into larger vessels which combine and exit as the adrenal vein. Manatee adrenal circulatory anatomy is characteristically mammalian. The gland is supplied by arteries which divide into separate cortical and medullary circulatory systems. Abundant blood flow serves to speed entry of secretory products into the systemic circulation. The description of the adrenal vasculature serves as a foundation for future research investigating the unique mechanisms used by the adrenal cortex and medulla to regulate blood flow and secretory activities.

**Osmoregulatory Endocrinology Of Free Ranging And Captive West Indian Manatees (*Trichechus manatus*)**

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The ability of West Indian manatees (*Trichechus manatus latirostris* and *T. m. manatus*) to inhabit both fresh water (fw) and marine habitats presents an interesting model to study the question of osmoregulation in sirenians. Plasma and urine samples were obtained from captive and free-ranging manatees in both fresh and salt water (sw) and analyzed for electrolyte, osmolality and osmoregulatory hormone levels. Hormonal responses to changes in salinity were evaluated by switching four animals between fw and sw. In order to determine the tolerance of manatees to an osmotic challenge, five animals were maintained in a strictly marine habitat with limited access to fw. Data for wild, sw manatees suggests that incidentally ingested or dietary salt loads may have been sufficient to alter plasma osmolalities and electrolytes. Captive and free-ranging animals exhibited endocrine adjustments in vasopressin and aldosterone which served to conserve water in sw and Na<sup>+</sup> in fw. A significant correlation between aldosterone and plasma renin activity levels suggests that the renin-angiotensin-aldosterone axis is a functional mechanism of Na<sup>+</sup> regulation in these animals. Cortisol levels remained unchanged for animals maintained in a strictly marine habitat. The apparent lack of dehydration in wild animals exposed to a marine habitat suggests these manatees can maintain proper water balance.

A COMPUTERIZED PHOTOCOD-BASED IDENTIFICATION SYSTEM FOR MANATEES.  
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The documentation of individual Florida manatees (*Trichechus manatus latirostris*) based on unique features has been a major tool of manatee researchers for nearly 40 years. To help manage a growing catalog of over 14,000 sighting records for over 1,000 individual manatees, an updated computerized Photocod-based system was developed using Multimedia Toolbook for Windows. The Manatee Individual Photo-identification System (MIPS) accesses separate database tables containing each individual's unique identity information, feature codes, sighting data, and images. Images consist of photographs, taken from enhanced, high-resolution Photocods and compressed as JPEG files, and hand-drawn composite feature sketches, scanned as bitmap files. By entering one or more feature codes, locations, or specific identification numbers, or names, the system provides a list of known individuals that possibly match a newly photographed manatee. For each possible match the name, sex, complete feature list, and sighting history are displayed, while the composite sketch and images are rapidly perused. Any candidate manatees may be retained while additional individuals are selected by other feature codes or location qualifiers. Photocod offers the flexibility to inexpensively update images as features change, while JPEG compression provides quick access and display of any image in the catalog on a 486/66 personal computer. The MIPS is providing valuable, long-term data on habitat use, site fidelity, movements, and reproduction traits, and is the basis for current research on estimation of survival rates. The MIPS database framework and software is easily adaptable and may be used in other studies where rapid identification of many individual animals is needed.

INTERSPECIFIC GENETIC DIFFERENTIATION IN SIRENIANS  
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Interspecific patterns of mitochondrial DNA sequence variation were examined among the four living Sirenian species (the manatees, *Trichechus manatus latirostris*, *T. manatus manatus*, *T. senegalensis*, and *T. inunguis*; and the dugong, *Dugong dugon*). No variation in 300 base pairs (bp) of cytochrome b sequence was found among the manatees sequenced. Analysis of 200 bp of the hypervariable control region revealed a low level sequence variation (average 2.5% bp) between the subspecies *T. manatus manatus* (the Antillean manatee) and *T. manatus latirostris* (the Florida manatee). The Amazon manatee (*T. inunguis*) appears to be the most derived of the three manatee species, and *T. senegalensis* (the West African manatee) and *T. manatus*, phenotypically the most similar, also show the least sequence divergence. The dugong and manatee show a 50% sequence divergence in the hypervariable region, indicating, as expected, a long period of evolutionary isolation.

AERIAL CENSUS OF MANATEES IN NORTHEAST FLORIDA, 1991-1995  
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Distribution of the West Indian manatee (*Trichechus manatus*) in Northeast Florida is influenced largely by water temperature. Three aerial survey projects were designed to census portions of the waterways of northeast Florida to determine manatee distribution, minimum population size, and preferred habitat. Year-round distribution has not been adequately documented in this region in recent years. The twice monthly surveys were flown in a Cessna 172 high-wing airplane or a Robinson Beta 22 helicopter, and concentrated on the shoreline and shallow water habitats.

Study 1 (n=45 flights) covered the Intra-coastal Waterway, its tributaries and the nearshore ocean waters in St. Johns, Flagler and Volusia Counties between March 1991 and November 1993. A total of 775 manatees (8.0% calves) were sighted, with counts from 0 to 53 manatees. Study 2 (n=23 flights) covered the St. Johns River and its tributaries in Duval and portions of Clay and St. Johns Counties between May 1993 and May 1994. A total of 919 manatees (8.1% calves) were sighted, with counts from 0 to 102 manatees. Study 3 (n=25 flights) covered the St. Johns River in Clay, St. Johns, and portions of Duval and Putnam Counties between June 1994 and June 1995. A total of 1105 manatees (4.4% calves) were sighted, with counts from 0 to 124 manatees. No manatees were seen on the majority of the December-February flights in all 3 studies.

These 3 studies present a comprehensive picture of the seasonal migration of manatees in this region of Florida and indicate that water temperature limits winter use and plays a major role in the seasonal distribution of manatees in Northeast Florida. The high percentage of mother/calf pairs in the tributaries indicates the importance of these habitats. The tributary confluences are also high use areas. Based on the high number of manatees documented during the warm months, the 20 km stretch of the St. Johns River from Mulberry Cove and Goodby's Creek south to Black and Julington Creeks is one of the most important manatee areas in northeast Florida and warrants significant protection.

FIRST REPORT OF WINTER AGGREGATIONS OF MANATEES AT WARM  
MINERAL SPRINGS, FLORIDA  
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Florida DEP, Florida Marine Research Institute  
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Ground counts of manatees, *Trichechus manatus*, aggregating in the runoff from Warm Mineral Springs, Florida were conducted from December 1993 through April 1995. Highest single-day counts were recorded in January, 1994 (n=25) and February, 1995 (n=21). No manatees were detected during the months of April through November of any year. Photographs of individually recognizable manatees aggregating in the spring run were assembled into a catalog and analyzed to determine resightings within and between winter seasons. Thirty-three recognizable individuals were cataloged. Ten manatees photographed during the winter of 1993-94 were resighted in the spring run during the winter of 1994-95. Resightings of recognizable manatees throughout a single winter season suggest that many of these animals overwinter in the spring run. These data offer important insights into alternate wintering locations for manatees in southwest Florida and should be considered in the development of management strategies.

ABUNDANCE, DISTRIBUTION AND CONSERVATION OF MANATEES IN THE  
BANANA RIVER, FLORIDA, 1977-1995.  
Provanca, J.A., Provanca M.J., Reddick R.A.  
NASA, Dynamac Corporation, DYN-2, Kennedy Space Center, FL 32899.

The northern Banana River, remains the primary aggregation site for manatees (*Trichechus manatus*) along Florida's east coast. Long term monitoring of manatee distribution and abundance in these federal waters has continued for nearly two decades.

Systematic aerial surveys over the 75 km<sup>2</sup> study area are conducted on a biweekly basis and indicate that the animals consistently use specific sections of the river while other sections experience high densities intermittently. The general upward trend reported in the 1980's continued into the 1990's, with the maximum number per survey of 366 animals.

A section of the area has been closed to boating for 30 years. A second section was recently (1990) closed to motorized watercraft (boats are responsible for a considerable proportion of manatee mortalities in Florida). A small portion of the remaining area is open to all boats. An evaluation of the data using ArcView software was performed to determine if manatee abundance increased after the implementation of this management practice. Data for the summer season only were analyzed for trends over a 5 year period. A significant increase ( $r^2=0.94$ ) in manatee abundance in the newly non-motorized zone was found with the mean density per flight increasing steadily each year. A significant increase ( $r^2=0.74$ ) was seen in the section that has been closed for 30 years, and a slight, but insignificant ( $r^2=0.05$ ), increase occurred in the motorized zone.

CHANGE DETECTION TECHNIQUES USED TO ASSESS MANATEE FORAGING  
EFFECTS.

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Seagrasses and algae (SAV) provide the dominant forage for manatees along the east coast of Florida. The standard methods for mapping SAV include labor intensive interpretation, classification and digitization of aerial images. A pilot project to reintroduce previously captive manatees by a step-down process, including acclimation to enclosed seagrass meadows, has begun. The project affords opportunities to evaluate several questions. This report focuses on the frequent mapping required for each of the enclosures to assist in determining changes caused by feeding activity. The study site consisted of three, 0.6 ha enclosures, two considered treatments (manatees) and one a control (no manatees). Large scale, 1:1000, true color, aerial imagery was obtained for pre and post release of manatees into the enclosures. Images were both manually interpreted and scanned to perform image analysis for delineation of SAV distribution and cover categories. Field data included the pre and post sampling in each enclosure along 4 permanent transects for SAV species composition and percent cover. Additional groundtruthing was required after photos were manually interpreted. The combined data were used to assess the accuracy of the manually interpreted imagery and evaluate those classifications performed via computer image processing techniques. Results suggest that computer processing techniques efficiently provide a reasonable description of SAV changes in these shallow water foraging sites.

PERIORAL BRISTLES AND HAIRS IN THE FLORIDA MANATEE  
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We have identified six fields of perioral bristles (modified vibrissae) in the Florida manatee, four on each side of the upper lips and oral cavity (U1-U4), and two (L1-L2) on each side of the lower jaw, inside the oral cavity and rostral to the horny pad. The U2 group is of particular interest due to its use in a prehensile grasping fashion during feeding behavior. The bristles number 112 per side on average, with an average of 25 per side for the U2 group. Branches of the infraorbital nerve terminate at the bases of the largest bristles (U2 group) on the upper lip, while the inferior alveolar nerve supplies the bristles of the lower lip pad. Branches of the facial nerve were found to innervate the associated musculature which is likely to be involved in bristle eversion.

Manatees have a relatively high density of hair in the facial region, much of which is bristle-like, intermediate in thickness between normal body hair and the perioral bristles. It is concentrated in the oral disk, which is involved in the flare response seen during phase 1 of the feeding cycle, and these bristle-like hairs appear to be used in tactile exploration. We have examined 12 postmortem manatee heads in order to quantify the distribution of hairs and bristle-like hairs in the face area. The face rostral and caudal to the coronal ridge was marked in a grid of 2x2 cm squares and all hairs counted. There was an average of 1102 hairs per face, with no difference between the upper/lower (normal hair/bristle-like) or right/left halves. Although there is a large range of values for total hair number (829-1465), hair density decreases as a function of facial area (body size), following a 2nd degree polynomial curve ( $R^2=.84$ ).

Supported by NSF grant BNS-9120450 to R.L.R., the UF College of Veterinary Medicine, and the Florida Department of Environmental Protection.

DISTRIBUTION OF RADIO-TAGGED MANATEES IN RELATION TO NEAR-SHORE HABITATS AT ROOSEVELT ROADS NAVAL STATION, PUERTO RICO  
Reid, J.P., C. Krueger, L.W. Lefebvre, H.I. Kochman, W. Martinez,  
Nat. Biological Service, 412 NE 16th Ave., Room 250, Gainesville, FL 32601; Caribbean Fisheries Consultants Inc., P.O. Box 420334, Summerland Key, FL 33042; U.S. Naval Station Roosevelt Roads, Environmental Engineering/PHD, Box 3021, Ceiba, PR 00735

Since 1992, eight West Indian Manatees (*Trichechus manatus manatus*) have been radio tracked in eastern Puerto Rico. As of June 1995, satellite-monitored transmitters have provided over eight manatee/years of location data for these individuals. Locations determined by satellite and VHF radio tracking have identified high-use areas, mostly centered around the Roosevelt Roads Naval Station (RRNS). Visual observations of tagged manatees have documented sites used for feeding on seagrasses and drinking of fresh water. Recent color aerial photographs (1:9,600) of RRNS provided by the U.S. Navy were interpreted to produce digitized maps of benthic communities that were ground-truthed to verify habitat type (e.g. dense seagrass, patchy or discontinuous seagrass, sparse seagrass, macroalgae, bare substrate, and hard bottom/reef habitat). Also digitized were shorelines, dredged channels, and bathymetry (6, 12, and 18 foot depth contours). Overlays of manatee locations (highest precision satellite-determined locations) depict manatee use areas and corresponding habitat type. Locations of tagged manatees observed feeding are associated with shallow-water seagrass beds at RRNS. These maps will be added to existing digital habitat maps of RRNS to be used for habitat assessment, land-use planning, and resource management. Future research will examine the relationship between manatee location data and the extensive seagrass beds around Vieques Island, 10 km to the east of Puerto Rico. This study is supported by funds from the National Biological Service and the U.S. Navy.

EXTRACTION OF DNA FROM ARCHIVED MANATEE SAMPLES  
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Studies of population genetic structure by DNA fingerprinting and/or sequencing require reproducible methods for template extraction. Many protocols are available for DNA isolation from traditionally archived samples such as necropsy material or blood following capture. In the case of the manatee, a less invasive method for sampling freeranging animals is by tail biopsy. In addition, geographic regions without current populations often have archived bone samples. Both of these nontraditional samples require modification of existing extraction protocols. Five DNA extraction methods have been examined. In addition to determining the yield of DNA and estimating its purity spectroscopically, each sample was examined for template efficiency with either mitochondrial and/or nuclear PCR primers. Results demonstrate which method gave the most consistent results, yielding PCR products for both nuclear and mitochondrial DNA appropriate for sequencing. Thus, these nontraditional samples can be used to delineate haplotypes in D-loop sequences and for microsatellite analyses. [Acknowledgments: the Caribbean Stranding Network, the National Biological Service, and the State of Florida Department of Environmental Protection.]

A COMPARISON OF GROWTH RATES AMONG WEST INDIAN MANATEE CALVES,  
*TRICHECHUS MANATUS LATIROSTRIS* (Linnaeus)  
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Growth rates of West Indian manatee calves, *Trichechus manatus*, either born at or brought to the Mican Secuarium from 1990-present were determined by measuring change in weight over time. Twenty animals were divided into three categories: nursing only, bottle-fed only and nursing + bottle-fed. Animals presently residing at the Secuarium were weighed monthly from April-December, 1995. Weights from all other manatees were compiled from their records. Nursing only animals gained an average of .46 kg/day, while nursing + bottle-fed manatees gained an average of .53 kg/day. In sharp contrast, bottle-fed only calves gained an average of .20 kg/day. The bottle-fed only animals were weighed much more frequently and their average daily weight-gain reflects daily weight fluctuations. Nursing only calves, on the other hand, were weighed as infrequently as once per 3.5 years.

The regression equations calculated for each category were all highly significant ( $p<.001$ ). Through analysis of covariance, it was discovered that the separate regression lines for nursing only, bottle-fed only and nursing + bottle-fed did not differ significantly in slope ( $p<.001$ ). However, when age was held constant, there were significant differences ( $p<.001$ ) in weight among the three categories.

Data collected as of this writing indicate that the growth rate of nursing only West Indian manatees (measured by weight) begins to decrease at approximately 550 days. However, the growth rate of bottle-fed only calves appears to increase at approximately 300 days, perhaps to compensate for a significantly slower growth rate ( $p<.01$ ) in the first 300 days of life.

THE CHARACTERIZATION OF MANATEE KIDNEY EPITHELIAL CELLS  
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Florida Department of Environmental Protection, St. Petersburg FL 33711, and University of South Florida, Tampa FL 33620

The Florida Manatee *Trichechus manatus latirostris* is a herbivorous marine mammal which inhabits the coastal waters of Florida. To better understand disease pathogenesis in manatees, *in vitro* studies utilizing kidney cells were initiated. Kidney tissue was collected from a calf (MSE9504) during necropsy less than 12 hours post mortem. Characterization of manatee kidney epithelial cells (MKE) has included morphology, lineage determination, growth rate, seeding efficiency, and serum dependency assays.

MKE cells have a polygonal shape and clearly defined edges demarcating an advancing monolayer. A mouse IgG, anti-Pan cytokeratin as a primary antibody and a goat, anti-mouse IgG (Fab specific) secondary antibody, conjugated to fluorescein isothiocyanate (FITC), was used to demonstrate cytokeratin expression. A growth curve seeded at  $1 \times 10^4$  cells/ml, revealed a lag time of 3 days, a logarithmic growth period of 5 days, a population doubling time (PDT) of 48 hours, and plateau at day 8 with  $1.68 \times 10^4$  cells/cm<sup>2</sup>. A seeding efficiency assay revealed 95 to 97% at the fifth passage. With reduced or no serum supplementation, cells did not grow well and the cytosol was vacuolated and tenuous.

RESIGHTINGS OF PHOTOGRAPHICALLY DISTINCT MANATEES (*TRICHECHUS MANATUS LATIROSTRIS*) IN SOUTHWEST FLORIDA  
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Many Florida manatees (*Trichechus manatus latirostris*) are photographically distinct, bearing scars and mutilations caused by boat propellers and entanglements. Over time, resightings of recognizable individuals provide information on manatee movement patterns and habitat use. Scar photos contribute to data on radio-tagged manatees by providing a sighting history for animals newly tagged and movement updates for manatees no longer tagged. The Manatee Individual Photoidentification System (MIPS), an image equipped computer database, allows operators to compare features of manatees to distinct animals in the database and recommends possible matches. At least two qualified observers must confirm a match.

For this study, we compared photographically distinct individuals observed wintering (December-March) in the Tampa Bay area from 1983 to 1995 to animals seen in other areas of southwest Florida from 1977 to 1995. Most individuals exhibited winter site fidelity, although movement between aggregation sites during both a single season and over multiple seasons was documented. Some animals also exhibited summer (April-November) site fidelity. Additionally, some manatees wintering in Tampa Bay shared summer sites with animals wintering at other west coast aggregation sites.

CREATION OF THE FIRST MARINE MAMMAL OSTEOLOGICAL COLLECTION FOR PUERTO RICO AND THE VIRGIN ISLANDS  
Toyo-González, G. M.<sup>1</sup>, Mignucci-Giannoni, A. A.<sup>1</sup>, Pérez-Padilla, J.<sup>1</sup>, Montoya-Ospina, R. A.<sup>1</sup> and Williams, E. H.<sup>2</sup>  
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The collection of osteological remains of marine mammals provide a source of valuable information for researchers and is often used for academic teaching and education. In order to create a collection to be used for these purposes as part of the University of Puerto Rico Biology Museum, marine mammal skeletal remains were collected from stranded animals in waters of Puerto Rico and the U. S. Virgin Islands between 1989 and 1995 by the Caribbean Stranding Network. A total of 53 specimens from Puerto Rico and the Virgin Islands are at present catalogued in the collection, including 25 Antillean manatees (*Trichechus manatus manatus*), 27 cetaceans and 1 phocid. Of these, 30 are complete skeletons, 12 are partial skeletons, and 11 are skulls only. Additional osteological material was obtained from other localities in the United States and the Caribbean to augment the collection, including 10 odontocetes, 4 mysticetes (baleen), 2 Florida manatees, 2 phocids, 3 otterids, and 3 sea otters.

#### PESTICIDE RESIDUES IN THE FLORIDA MANATEE, *TRICHECHUS MANATUS LATIROSTRIS*

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Forty-five tissue samples, consisting of fifteen liver samples, nineteen kidney samples and eleven blubber samples from the Florida Manatee, *Trichechus manatus latirostris*, were analyzed using gas chromatography and combined gas chromatography/mass spectrometry for a variety of chlorinated hydrocarbons. The tissues were also examined for petroleum hydrocarbons, but none were found. Pesticides (o,p-DDT, o,p-DDD, hexachlorobenzene and lindane) were detected in all three tissues, but they were found most frequently in the liver and kidney. However, due to the low frequency of observed pesticides, their concentrations could not be related to age, sex, length or the geographic location where the manatee carcasses were recovered. One female perinatal manatee from Sea World had elevated concentrations of lindane in the liver and o,p-DDD in the kidney, suggesting that the pesticides found in this animal were transferred from the mother prior to birth.

MANATEE FECAL REPRODUCTIVE HORMONE CONCENTRATIONS  
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Little is known of the Florida manatee's reproductive physiology and hormonal cycles. Our long-term objective of the current study is to track reproductive hormonal concentrations (estrogens, progesterone and testosterone) of individual manatees over time. Some questions of interest are: how do males detect females in estrus; do manatees have a non-reproductive season during the winter; and are there other related hormones, such as chorionic gonadotropin, that may be used to detect pregnancy. Current efforts to validate fecal hormone analyses for these hormones are underway. Physiological differences between adult males and other Florida manatees have been detected for fecal testosterone. The average testosterone immuno reactivity for adult males is 76.4 ng/g, juvenile males 7.67 ng/g and females 4.83 ng/g. Currently the fecal progesterone assay does not show differences between pregnant and non-pregnant animals. Enzymes will be employed to enable measurement of progesterone conjugates and an antisera for pregnanediol glucuronide will be utilized. Further collections are underway to aid in the refinement of the fecal estrogen assay to detect periods of estrus.

The results of this study will enhance our understanding manatee mating behavior and reproduction.

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#### DEVELOPMENT OF NON-INVASIVE BODY CONDITION INDICES FOR THE FLORIDA MANATEE (*Trichechus manatus latirostris*)

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Total length, girths, and dorsal blubber thickness (measured with ultrasound) were used to assess body condition of Florida manatees. Measurements were made on captives held at oceanaria, free-ranging animals (restrained briefly during tagging operations) and carcasses of recently deceased manatees. Captive animals and carcasses were weighed. Girth/length relationships were not strongly predictive of reproductive status. However, blubber thickness varied with reproductive status and sex in free-ranging animals longer than 235 cm, and was greatest in pregnant females, followed by lactating females, and then males. Blubber thickness was generally greater for long-term rehabilitated captives than for free-ranging manatees. Body condition of rescued emaciated manatees was significantly poorer than that of apparently healthy animals of similar lengths. Predictive models were developed to use easily collected morphometric data to predict weight and to interpret body condition of free-ranging healthy manatees. The data are less clear than is the case for pinnipeds which have temporally and spatially distinct feeding and breeding. Nonetheless, the manatee models would be useful to help assess whether free-ranging individuals are undernourished and may require care, and to suggest whether rehabilitated captives have adjusted properly following reintroduction to the wild.

#### GIS ANALYSES FOR ESTIMATION OF MANATEE HABITAT UTILIZATION AND MIGRATORY CORRIDORS

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A five-year manatee telemetry project was initiated by FDEP in 1991 on Florida's west-central coast. Through July 1995, 48 manatees were tagged and tracked. We evaluated location data to estimate habitat utilization and migratory corridors. Location data were primarily acquired from transmitters monitored by Service Argos receivers on NOAA TIROS satellites. Biologists also used satellite locations and each tag's VHF signals to locate manatees and make visual observations of habitat use and behavior while acquiring additional environmental data. ARC/INFO GIS software was used to map location coordinates. ARC macro programs were developed to connect sequential location points while keeping the movement track in water using GRID cost-path surfaces weighted for bathymetric preferences. Time between locations was apportioned equally among cells along the cost-path and grids were built for total time spent in each cell, number of visitations to each cell, maximum single visitation time, and sum of squares of visitation times. Focal filters were applied to the grids to smooth the surfaces. The resulting grids permitted high-resolution estimation of preferred habitats and migratory corridors for individuals, sexes, and reproductive classes. Maps that depict habitat use in three dimensions, with accumulated time as the z-axis and habitat characteristics draped over the model, can be used by managers as another tool to protect components of the marine ecosystem essential to the recovery of the endangered Florida manatee.

#### AERIAL SURVEYS OF MANATEES IN TAMPA BAY, FLORIDA

Wright, I.E.<sup>1</sup>, Reynolds, J.E., IIF, Ward, L.I.<sup>1</sup>, Weigle, B.L.<sup>1</sup>, Ackerman, B.B.<sup>1</sup>, and Szelistowski, W.A.<sup>2</sup>  
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Fixed-wing aerial surveys of manatees were conducted monthly in Tampa Bay, from November 1987 through October 1992 and from April 1993 through May 1994. The purpose of the surveys was to establish a long-term database for assessing trends in abundance, reproductive performance, and habitat use. Data was incorporated into a Geographic Information System to analyze and map seasonal density estimates and spatial distribution patterns. Tampa Bay is the largest estuary in Florida. The human population of the three counties bordering the bay has grown by nearly 24%, making it the nation's third fastest growing metropolitan area. Despite this urbanization, the past decade has seen improvements in Tampa Bay's water quality and bottom coverage by submerged aquatic vegetation, a primary food source for manatees.

A total of 5,358 manatee sightings was recorded during 88 surveys. Counts were significantly higher in the "cold" season (Dec.-Feb.) (F-test, p<0.0001) than in the "warm" (Mar.-Nov.) season. There has been an 8% annual increase in the number of manatees at winter aggregation sites in Tampa Bay; the maximum single day count was 190. Warm season counts have remained relatively constant, at a mean of 51, but habitat use patterns have shifted somewhat between years, likely due to changes in the density and distribution of seagrass beds. Regulatory measures for manatee protection need to protect habitats used consistently or predictably by manatees, but should also be flexible enough to accommodate seasonal or annual changes in manatee habitat use.

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downlisting of the Florida manatee to a less endangered status.

The issue of downlisting should, in principle, be easy to dismiss. The revised Florida Manatee Recovery Plan (1996 version, due to be published in a few weeks) states that "downlisting should be considered when ... the population is growing or stable, when mortality factors are controlled at acceptable levels or are decreasing, and when critical habitats are secure and threats to them are controlled or decreasing." Of these three criteria, it is obvious that the latter two are not likely to be met in the foreseeable future: human-caused mortality continues to rise, and the threats of human population growth and development pressures are anything but "controlled or decreasing." In practice, however, only the first criterion readily registers in the public consciousness, where higher manatee counts necessarily mean a recovering population.

Sometimes, however, one problem is solved by another; and the misleading press coverage of the January and February surveys was fortuitously swept from the headlines by the disastrous manatee dieoff in March. For the moment, this antidote of well-founded alarm seems to have taken effect, but spells of complacency are bound to recur. When they do - and whenever any of us has occasion to communicate with the public or the mass media on these issues - we need to emphasize as strongly as possible the following points:

1. The statewide synoptic surveys provide only *minimum* counts, not estimates of the total population; they are extremely sensitive to weather conditions and *cannot* be compared statistically with each other or with estimates derived from other techniques.
2. While it is possible that the total manatee population in Florida has increased, it is more certain (and more significant) that increases have occurred in precisely those areas where manatees are best protected, while in areas of lesser protection there has been little or no increase (and none that is likely to be sustained).
3. We can take no comfort in any numerical increases that have been achieved, because the protective measures that made them possible are approaching the limits of political acceptability, while the threats to manatees only increase and can be expected to wipe out the recent gains. For this reason, no talk of downlisting the Florida manatee is even remotely justified.
4. The manatee population is still small in absolute terms, and always vulnerable to unexpected catastrophes like the March 1996 dieoff - especially when, as in this case, the victims are predominately adults in their prime, which are the animals most essential to survival of the population. When some 2% of that population can be wiped out in one such event - over and above all other sources of mortality - there is ample cause for concern about the species' future.

Not all these points are easy to make in sound bites, but this is the message we urgently need to get out. - DPD

**DEATH REPORTED**

**Jesse R. White, D.V.M.**

Dr. Jesse White, well-known marine mammal veterinarian, died on 23 January 1996 at his home in Dunnellon, Florida, at the age of 61 years. A native of Oklahoma, he received his D.V.M. degree from Texas A&M University at College Station in 1962. He served as Staff Veterinarian at the Miami Seaquarium, 1967-86, and Marine Mammal Veterinarian for the Florida Department of Natural Resources, Homosassa, Florida, 1986-87. In 1984, he founded the Florida Manatee Research and Education Foundation, an organization for which he always served as Director and President. He was an Adjunct Professor at the College of Veterinary Medicine, University of Florida, 1983-87, and Clinical Professor in the Department of Small Animal Medicine at the same institution from 1987 until his death. He received several lifetime achievement and conservation awards from professional associations, and was the first

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