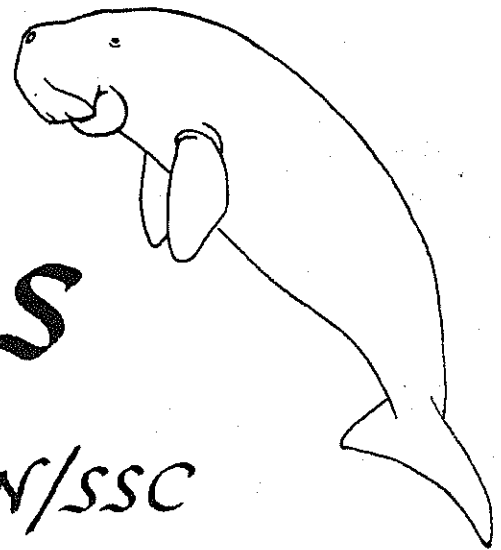


Sirenews



Newsletter of the IUCN/SSC Sirenia Specialist Group

NUMBER 34

OCTOBER 2000

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- DUGONG STUDIES IN THAILAND (p. 11)

GUEST EDITORIAL: MANATEES ARE STILL ENDANGERED

Recently, several news organizations reported that the Florida Fish and Wildlife Conservation Commission (FWC) said manatees were ready to be downlisted from endangered status to threatened. This news was reported in error, as the FWC did not suggest downlisting manatees but instead was discussing the *criteria* for downlisting at a recent meeting. Unfortunately, however, this story has escalated and now misinformation is circulating widely. Here's the real situation:

Many researchers agree that the manatee population has increased slightly in two areas that have had protection measures in place for a long time – namely Crystal River and Blue Spring. This increase is probably due to reproduction and recruitment (manatees moving there from other places). However, these two areas account for only about 16% of the entire manatee population.

Researchers don't know for sure what is happening with the East Coast manatee population. The general feeling is that the East Coast population may be stable at best and could very well be declining. There isn't enough information yet to be able to state what is happening with the southwest Florida manatee population. That population may also be declining.

UNION INTERNATIONALE POUR LA CONSERVATION DE LA NATURE ET DE SES RESSOURCES
INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES

Commission de la sauvegarde des espèces—Species Survival Commission



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What we can say is that manatee mortality from human activity – especially from boat collisions – is increasing, and threats to their habitat are also increasing. Preliminary figures from the FWC indicate record-setting manatee mortality this year. As of 13 October 2000, there have been 231 manatee deaths -- 70 of those deaths were attributed to watercraft collisions. These figures compare with 211 total mortalities and 65 watercraft deaths at this same time in 1999, which was a record year for manatee mortalities.

The *Florida Manatee Recovery Plan* was developed as a result of the Endangered Species Act of 1973 and is coordinated by the U.S. Fish and Wildlife Service (USFWS). According to the USFWS, downlisting should be considered when the best available scientific data indicate that the population is growing or stable, when mortality factors are controlled at acceptable levels or are stable or decreasing, and when critical habitats are secure and threats to them are controlled or decreasing.

At present, none of these criteria has been met. Increasing numbers of manatees killed by boats and tremendous increases in boat traffic are the most important problems presently faced by manatees in Florida. According to the *Recovery Plan*, intensive coastal development is also a threat to the Florida manatee. In a news release issued on 8 September 2000, FWC executive director Dr. Allan L. Egbert said, "There is no proposal to downlist Florida's manatees from their endangered status to threatened. We simply aren't there yet. The manatee population has not recovered to the point we could consider changing its endangered species status."

In fact, recognizing the severity of the situation, Florida Governor Jeb Bush recently announced there would be a manatee summit in October to bring interested parties together to address record-setting manatee mortality. The situation is so bad that we must do everything possible to reverse the upward trend in human-related manatee mortality and the loss and degradation of the manatee's habitat or, eventually, we will lose these unique animals. - **Judith Vallee** (Executive Director, Save the Manatee Club)

BUDDY POWELL WINS PEW FELLOWSHIP

Dr. James A. "Buddy" Powell, head of the State of Florida's sirenian research program at the Florida Marine Research Institute in St. Petersburg, is a recipient of a Pew Charitable Trusts Award Year 2000 Marine Conservation Fellowship. An initiative of The Pew Charitable Trusts in partnership with the New England Aquarium, the fellowships (worth \$150,000 each) are awarded annually to ten outstanding individuals to conduct interdisciplinary projects that apply sound science to urgent challenges in marine ecosystem conservation, fisheries management, marine pollution, and coastal conservation. With these awards, the Pew Fellows Program seeks to foster greater public understanding of the direct and crucial relationships between life in the sea and life on land.

The fellowships are highly competitive awards targeted primarily to mid-career professionals. Nominations are made through an international network of environmental experts. Evaluation and selection of Pew Fellows is conducted by a 12-member international advisory committee. Selection is based on the applied conservation merit of

the project, the individual's record of professional accomplishment, and the potential impact of the initiative.

The 2000 Pew Marine Conservation Fellows will tackle a variety of issues, from empowering Southeast Asian villagers to save wild seahorses and raising awareness to restore the Pacific northwest salmon runs, to educating Ecuadorian fishermen to collect data that protects the Galapagos Marine Reserve. The total of \$1.5 million presented annually by the Pew Fellows Program in Marine Conservation makes the fellowships the world's largest award for marine conservationists.

Powell's project is entitled "Improving coastal habitat protection in West Africa and the Caribbean through manatee conservation." He is the second member of the *Sirenia* Specialist Group to receive this prestigious award, following Helene Marsh (see *Sirenews* No. 30, Oct. 1998).

Congratulations, Buddy!

JOHN TWISS RETIRES

John R. Twiss, Jr., Executive Director of the U.S. Marine Mammal Commission since its inception in 1973, retired as of 2 September 2000. He has long been a friend to manatees, providing essential oversight at the federal level of manatee-related activities by federal, state, local, and private entities, and contributing mightily to the support of manatee conservation and research. On behalf of marine mammals and marine conservation, he fought and won many a vicious battle in bureaucratic Washington. Thanks to him, the Commission has also provided the bulk of the financial support for *Sirenews* from its beginning in 1984 to the present day. Among many less-public achievements, he organized and edited (together with Randy Reeves, John Reynolds, and Butch Rommel) the pair of impressive volumes on conservation, management, and biology of marine mammals which the Smithsonian Institution Press published in 1999. All marine mammal workers in the U.S. and abroad owe him a debt of gratitude for his tireless and forceful leadership.

Thanks, John, and enjoy your retirement!

Death Reported

Dr. Edgardo Mondolfi

7 November 1999, in Caracas, Venezuela

Dr. Edgardo Mondolfi (1918-1999) passed away very suddenly on 7 November 1999 after a severe attack of dengue fever. He was a well-known Venezuelan biologist with a long-standing interest in manatees. In 1974 he reported distribution records which indicated that only the West Indian manatee occurs in the lower Orinoco River. This laid

to rest the erroneous but universally-disseminated belief, dating back more than a century, that *Trichechus inunguis* inhabits the Orinoco as well as the Amazon basin. In later years, Dr. Mondolfi also served as Venezuela's ambassador to Kenya. - **DPD**

GLOBAL DUGONG ACTION PLAN

In addition to IUCN, UNEP has provided funding to complete the Dugong Action Plan. The document is currently divided into four sections which cover the dugong's complete range: Western, Central, Eastern and Western Pacific. The status of the Action Plan will be presented at the UNEP meeting in Monaco in November, and we hope to have a complete draft finished by the end of the year. We thank all those who have contributed their time and expertise to the Action Plan to date. Your contributions will be formally documented in the Plan. Please provide any additional updates on the status of the dugong in your region and any information/suggestions for potential reviewers to Carole Eros (<erosc@pac.dfo-mpo.gc.ca>). It is critical that we obtain as much local input as possible to ensure accuracy and to document the local conservation and management priorities. - **Helene Marsh** (James Cook University, Townsville, Qld., Australia; <helene.marsh@jcu.edu.au>).

SIRENIAN INTERNATIONAL IS INCORPORATED

Sirenian International (<<http://www.sirenian.org/>>) received its incorporation certificate from the Virginia State Corporation Commission on 21 June 2000. This is the first step in a grassroots effort to create a viable non-profit foundation that will support manatee and dugong research, education, and conservation projects around the world. As empowering tools, our goals emphasize career development of students, development of inter-cultural relationships, and collaboration with local communities in scientific, educational, and conservation projects. While Sirenian International is a "neonate" organization, we are lucky to have support from many experienced sirenian experts around the world. With your help, we hope to grow at about the same rate as manatees and dugongs! We offer three levels of membership:

1. **PARTICIPATING MEMBERS** are scientists, students, conservation managers, governmental agencies, NGOs, etc., who are directly involved in sirenian projects. Because we realize that Participating Members are trying to raise money for their own projects and have little to spare, there is **NO** membership fee for Participating Members. Remember, however, that there is a "cost" for Participating Membership: information about your research! We do of course welcome contributions from anyone who feels able to support the network and its projects (see below). Our primary goal is to award five US\$1000 grants during our first full year (2001). Participating Members are eligible to apply for these small grants. An announcement will be made regarding the application process in the April 2001 issue of *Sirennews*. Other benefits of Participating Membership include: a subscription to **SIRENIAN LISTSERV**, a private e-mail discussion list; participation in our network **DATABASE**; a subscription to *Sirenian Voice*, our

electronic newsletter; eligibility to serve on our Scientific Advisory Council, our Inter-Cultural Advisory Committee, our Board of Directors, and other committees.

2. **SUPPORTING MEMBERS** are concerned citizens who support projects endorsed by Sirenian International through small contributions. Supporting Members receive information about sirenian projects via outreach efforts such as Newsletters, Ambassador Kits, Private Websites (future), and networking among volunteers who have participated in educational tourism. Tax-deductible annual dues are affordable and on a sliding scale (e.g., \$10 for teachers/classrooms/students, up to \$50 for families), in the form of donations to Sirenian International.

3. **CONTRIBUTING MEMBERS** are donors who are in a position to provide larger contributions and other resources to support sirenian projects. In addition to the benefits of Supporting Members, Contributing Members are invited to meet with project participants and/or to observe field activities (at their own expense). Tax-deductible contributions of \$500 for individuals and \$1000 for corporations may be partially earmarked for specific projects. In-kind contributions are also encouraged. Charter Contributors are recognized for contributions made at the Contributing Membership level prior to 31 December 2000.

We invite you to visit our webpage at <http://www.sirenian.org> or write to us for more information c/o Caryn Self Sullivan, 200 Stonewall Drive, Fredericksburg, VA 22401 USA (phone 1-540-287-8207). If you are interested in becoming a more pro-active member of SI, please consider signing up for one of our organizing committees: Fund Raising (chair Caryn Self Sullivan, caryn@sirenian.org), Budget and Finance (chair Katie LaCommare, katie@sirenian.org), Strategic Planning (co-chairs Angie Sullivan, aksulliv@fls.infi.net and Tami Gilbertson, tami@sirenian.org). Special NOTE to USA citizens: our IRS 501(c)3 status is still pending, but once received, all contributions will be tax-deductible retroactive to the date of incorporation (i.e., 21 June 2000). - **Caryn Self Sullivan** (graduate student, Wildlife & Fisheries Sciences, Texas A&M University, Mail Stop 2258, College Station, TX 77843-2258; lab: 1-979-845-0495; fax: 1-979-845-3786; e-mail: caryns@tamu.edu)

NOTE: Caryn's Homepage, "Call of the Siren", has moved to: <http://www.sirenian.org/caryn.html>.

NEW NEWSLETTER ON STRUCTURE-CAUSED MANATEE DEATHS

The Florida-based Inter-Agency Task Force to Eliminate Structure-Caused Manatee Deaths has instituted a monthly e-mail newsletter, *The Billboard*, dealing with manatee deaths in canal locks and flood-control structures. To contribute or subscribe, send an e-mail note to: billy_brooks@fws.gov by the end of each month.

WORLD POPULATION AWARENESS WEEK

22-28 October 2000

FLORIDA POPULATION AWARENESS WEEK

29 October - 4 November 2000

For information, visit www.flsuspop.org

LOCAL NEWS

AUSTRALIA

Four Decades of Decline in Dugong Numbers off the Urban Coast of Queensland: Evidence from the Queensland Shark Control Program. -

We used the 38-year data set collected by a government program to provide information on the status of dugongs on the east coast of Queensland, Australia. The state government has conducted the "Queensland Shark Control Program" by progressively introducing anti-shark measures at popular coastal resorts from 1962. This program aims to protect swimmers at ten contract areas on the east coast of Queensland between Cairns (17°S) and the Gold Coast (28°S). Six of these contract areas are in the Great Barrier Reef World Heritage Area. Each contract area consists of a number of beaches where gear is deployed to reduce the number of large sharks in the local area. Since its inception, the program has deployed shark nets and baited drum lines in a "mixed gear strategy" that adapts the type of gear to the characteristics of each beach. In addition to sharks, these nets also catch a variety of non-target species including marine mammals and sea turtles. Contractors employed by the program have to record this by-catch.

We analyzed the dugong by-catch data with two objectives: (1) to investigate factors affecting dugong mortality in nets, and (2) to use the change in catch per unit effort of dugongs in shark nets as an index of the change in the status of the dugong population in the region between 1962 and 1999.

The analysis indicated that the numbers of dugongs caught in shark nets

set adjacent to the urban coast of Queensland at eight shark contract areas between latitudes 17° and 28° S declined from the inception of the Queensland Shark Control Program in the 1960s. The estimated rate of decline for a balanced data set from six contract areas averaged 8.7% per year [95% CI = (7.1, 10.6)]. This represents a decline to 3.1% (1.4, 6.1) of initial catch rates over the 38-year sampling period (1962-99). For the full data set from eight areas, the overall capture rates were 8.2% per year (6.8, 9.7), only marginally lower than for the reduced data set. The rate of decline also increased over time, starting at about 6% in 1962, and increasing to 14% in 1999. This analysis is conservative, especially with respect to dugong mortality in the early years of the Queensland Shark Control Program. It is likely that the actual decline in the number of dugongs caught is greater than that reported here.

The catch rates varied strongly between contract areas, and to a lesser degree between beaches within areas. Four of the six contract areas in the reduced data set showed severe declines, with two areas showing a modal distribution of catches, with higher catches centered around 1980-1982.

If the catch of dugongs in shark nets is proportional to dugong population density, and if dugongs have not changed their behavior so that they are less likely to encounter nets, the estimated decline in catches in shark nets can be taken as an estimate of decline in the dugong populations **from all causes** averaged over the areas where nets were deployed. This suggests that by 1999 dugong numbers in the local regions of the shark nets had declined to about 3%

of their 1960 value, reinforcing concern for the status of the dugong along the urban coast of Queensland. It is possible that the pattern of decline in net captures has been exacerbated by dugongs avoiding inshore areas because of increased human use over the netting period. However, there is no firm evidence to accept or reject this hypothesis. We conclude that the netting data suggest a substantial depletion in dugong numbers along the urban coast of Queensland since the early 1960s.

The likely reasons for this decline are complex and include habitat loss, traditional hunting, and incidental drowning in commercial gill and mesh nets, as well as the Shark Control Program *per se*. The most salient questions to be determined by management agencies and stakeholders is the target level of recovery for dugong populations in this region and the time frame to achieve this target. - **Helene Marsh**

Improving Aerial Survey Population Estimates Using Model Dugongs. - Methods of assessing dugong populations via aerial survey rely on the ability to account for dugong diving behavior to derive accurate estimates. This is because at any one time some of the dugongs will be below the surface of the water and potentially not visible to observers flying overhead in an aircraft.

To develop suitable correction factors to account for this source of error requires two types of information: knowledge of the diving patterns of dugongs in different depths of water, and data on the depths at which dugongs become identifiable as dugongs to aerial survey observers. With this information

it can then be estimated what proportion of the time dugongs spend at depths where they are visible, and hence correction can be made for the remainder of the time when they are not. We conducted experiments using artificial dugongs to determine the depths at which dugongs become visible under various survey conditions. Data have been collected on the diving patterns of dugongs using time-depth recorders.

Three artificial dugongs were constructed from marine plywood and fiberglass to resemble the view of a dugong as seen from above by aerial survey observers. They were made in three sizes, ranging from the size of a calf (1.5 m long) to that of an adult dugong (2.5 m long). The models were positively buoyant. A rope and pulley system enabled the position of each model in the water column to be manipulated by operators on an anchored boat.

Two observers hovered in a helicopter above the models at the height and approximate relative position of a survey aircraft. When the helicopter and models were in position, each model in turn was allowed to rise slowly to the surface. Each observer then recorded the exact time at which the model became recognizable as a dugong. Data on the depth at which this occurred were calculated by matching these times to the time and depth recorded by a Wildlife Computers time-depth recorder attached to each model. The time-depth recorders are accurate to 0.25 m and record depth every second.

Trials were carried out for each model under a range of water turbidity and depth conditions to encompass those encountered during aerial surveys. Where possible the conditions were repeated at two levels of sea state;

smooth water and Beaufort Sea State 3 (the upper limit considered acceptable for aerial surveys).

Visibility was greatest in clear, deep water at approximately 4-5 m for the larger models. Under all other conditions visibility was substantially less. Even in clear water at intermediate depth the models were only identifiable at slightly over 2 m below the surface. In shallow, clear water where bottom detail was clearly visible, all models were identifiable at the bottom. In turbid water the depth at which models became identifiable was reduced to 1-2 m.

Model size was important. In all cases the largest model was visible at greater depth. The smallest model was usually, but not always, identifiable at the shallowest depth. This may have some implications for underestimating calf counts. Beaufort Sea State had a substantial effect on visibility. In all cases examined at Beaufort 3, the models were only identifiable at depths ranging from 0.5 m to 1.85 m. In general, in clear water visibility was reduced to approximately 1 m, while in turbid water the models were recognizable at only half a meter below the surface at Beaufort 3.

The data collected in this series of experiments will be valuable in allowing us to better correct for submerged dugongs in future estimates of dugong population size. They will allow us to estimate and apply correction factors that are appropriate to the particular conditions under which each sighting is made. We will be able to use the data collected here in conjunction with the data on the diving behavior of dugongs in different depths of water to allow us to estimate the proportion of time that dugongs spend at depths visible to observers. This will enable us for the

first time to estimate the absolute population size of dugongs via aerial survey. - Helene Marsh and Ivan Lawler

FLORIDA

Traveling Exhibit on Manatees Opens. - A new museum exhibit entitled "Manatees: The Edge of Extinction" opened to the public at the Florida Museum of Natural History in Gainesville on 23 September 2000. It includes displays on sirenian evolution, anatomy and physiology, behavior, habitat, and conservation, with actual fossils, modern skeletons, and replicas; video and audio tapes of wild manatees; and a new reconstruction of Steller's sea cow by sculptor William Monteleone.

Specially featured are the first skeletal and fleshed-out reconstructions of the world's most primitive sirenian, a 50-million-year-old, four-legged, pig-sized beast discovered in Jamaica by Daryl Domning and his coworkers.

The exhibit was created by the Potomac Museum Group of Minneapolis, Minnesota. It will remain in Gainesville until 14 January 2001, after which it is tentatively scheduled to travel to the Charleston Museum in South Carolina. Institutions interested in booking the exhibit for subsequent venues should contact Jon Kramer (phone 1-612-521-0421; fax 1-612-588-4912; e-mail <jk2surf@aol.com>; website <www.natural-history.com>).

Another View of Manatee Conservation. - Let it never be said that *Sirenews* suppresses dissenting opinions. James L. "Jamie" Adams, Jr., a member of Florida's Fish and Wildlife Conservation Commission (FWC), which oversees Florida's manatee

research and management programs, published a column on manatees entitled "Politically Incorrect and Proud of It" in the hunting and fishing magazine *Woods 'n Water* (April 2000, p. 60). The column was occasioned by lawsuits brought against the state by several environmental organizations seeking increased protection for manatees, including additional boat speed zones. Some excerpts are worth sharing:

"... Friends, there is not anyone I know of anywhere that does not want to see manatees protected to the fullest, most especially the members I serve with on the FWC. Manatees are loved by everyone, and they surely must be protected. On the other hand, it is very politically incorrect to ever raise a negative question in regards to manatees. Frankly, I do have some unanswered questions concerning them. Just where are all the manatees coming from? Have they always been here in the numbers they are today? ...

"I was raised near the gulf coast, and I can honestly say that the first manatee I ever saw was at Crystal River in 1963.... I have talked to a lot of old-timers who claim that the manatees have only appeared over the last 30 years.

"I'm sure that the warm, spring-fed rivers did attract some over the centuries, but I don't believe they were ever here in the numbers that they are today. Some non-experts believe that manatees have been drawn to the warm water created by the power plants all around our coasts....

"I hope we are not attracting a multitude of manatees from central America, or wherever they might be coming from. I know this may not set well with some animal rights groups, but I must ask the question: Are there not more manatees in our waters than the

good Lord originally intended for there to be[?] Are we, in fact, attracting nonnative manatees to our shores?

"Are we, in some unnatural way, enticing manatees to our waters which might someday, in the distant future, severely impact the sea grasses and other aquatic vegetation that is necessary for native species[?] These are some of the many questions that research is going to have to take a long, hard look at....

"... I am tired of sitting on my hands and keeping quiet just because it is not the right place or time to voice an honest opinion, just because a few people can't face the real world and some of the facts of nature...."

For the record, some of the "facts of nature": Sirenians have been in Florida for about as long as they have been anywhere, nearly 50 million years. Manatees (*Trichechus manatus*) have been in Florida for over one million years (probably with intermittent absences during the Ice Ages); i.e., a lot longer than people have lived there. The present Florida manatee (*T. m. latirostris*) is a subspecies endemic to Florida. Genetic studies to date indicate that it is not derived from the populations in Mexico or Central America, but more likely colonized Florida from the Greater Antilles thousands of years ago, after the last Ice Age. However, there is no evidence that manatees are now entering Florida from Central America, the Caribbean, or anywhere else. The manatees in Florida today have every right to be considered Florida natives -- more so, indeed, than recently-introduced aquatic weeds like *Hydrilla* and water hyacinth, which they eat.

Manatee numbers have increased in areas of Florida where they are well protected (partly, no doubt, by animals

fleeing boat traffic and development in other parts of the state), and therefore may well be greater than in the distant past. But what conservationists are concerned about is the future. As long as human numbers continue to grow (and they are growing far faster than the number of manatees), the manatees cannot be considered safe, and probably cannot continue to increase or even maintain their numbers. As of 13 October, the unofficial statewide manatee death toll for 2000 stood at a record 231, of which 70 (30%) were due to watercraft collisions. Also looming as threats are power deregulation and shutdown of inefficient power plants, together with increased tapping of aquifers, which together jeopardize both artificial and natural warm-water refuges.

Finally, a theological thought: What if there are now (or someday will be) fewer manatees in our waters than the good Lord intended? Who will answer for that? - DPD

INDONESIA

Captive Dugongs in Indonesia. -

I. On 7 October 1999 a young male dugong was reported by a local fisherman on Bojonegara, Serang, about 120 km west of Jakarta. A team from SeaWorld Indonesia (SWI) and the Government Wildlife and Forestry Bureau went to check the animal's condition. The dugong showed some scars on his dorsal skin, and bruises in the right pelvic area of the ventral body surface. The approximately 150-cm dugong looked weak, presumably as a result of heat stroke from being previously placed in shallow water and exposed to direct sunlight for hours.

We decided neither to release him right away nor to transport him to

Jakarta since he wasn't in a favorable condition for transport. To release him right away would risk his recapture and slaughter by local residents, who would happily pay 30,000 rupiahs (about US\$12 before our country was hit by the monetary crisis, but presently worth less than US\$4) for each kilogram of meat. On the other hand, we were not sure that transporting him to our facility in such a condition would be of benefit to the dugong. Hence, an attempt was made to settle him in a pool owned by the Installation of Agricultural Technology Development, a government institution situated on Bojonegara, Serang.

The dugong was placed in an 8 m-diameter and 2 m-deep cement pool. A local fisherman was hired to collect sea grass and feed the dugong twice a day. The dugong started to eat on the second day. The diet primarily consisted of *Syringodium isoetifolium*, the major species growing in the area.

At the second visit a couple of weeks later, we found a perforated skin injury at the previous bruise site. Ischemia followed by dermal necrosis was suspected to be the etiology of the perforation. Three repetitions of oxytetracycline 20% long-acting injections at 4-day intervals, using the dosage recommended for cows, were given intramuscularly to eliminate bacteria, which possibly entered the body through the perforation. Topical rinses with 3% perhydrol followed by applications of levertran + 1% povidone iodine ointment were conducted twice a week. This treatment at first seemed ineffective, but showed results after several repetitions. Dermal reformation took place in the tenth week, while the deformation of the lower body wall remains un-rehabilitated.

SiDul, the dugong, was transferred to the SWI exhibit on 10 May 2000. On the departing day he weighed 78 kg, with 94 cm pectoral girth, 114 cm abdominal girth and 163 cm length. We provided him with 20 kg of sea grass daily, divided into four mealtimes. The sea grass was collected three times a week and stored in a 16°C cool room. Preventive medicine was conducted by administering multivitamins plus iron preparation twice a week and an oral anthelmintic on a six-weekly basis. Fecal samples that were taken every month following the preventive action were found to be negative for gastro-intestinal nematode eggs.

Eruption of two pairs of molar teeth in the mandible, with no such accompanying indication in the maxilla, was found in oral cavity exploration in August 2000. Besides some mild gastro-intestinal problems initially, the dugong then showed quite good physical condition. Some interesting behaviors were observed: backstroke swimming on the water surface when eating, and preferring his keeper rather than others to feed him. Advice on how to determine the dugong's age is needed and would be highly appreciated.

II. A tragically-ending story of a female baby dugong started when she was found stranded at Ujung Beach Coast, Campalagian, in South Sulawesi on 13 July 2000. The local people, who were excited and impressed by this cute little creature, insisted on keeping her in a shrimp pond, which was less than 50 cm deep. A local newspaper reported that she was fed with 5 bottles (about 1500 cc) of milk and bananas (!) a day.

SeaWorld Indonesia was informed about two weeks after she was found (actually after she had turned lethargic). Staff from SWI then arrived on 30 July

2000 to see how she was doing, but at just that time she was found dead. A necropsy protocol could not be performed because the keeper insisted on keeping the dugong's body (!).

We hope that someday there will be people or institutions who take a serious interest in rescuing dugongs in the Indonesian region, as WWF Philippines has been doing in their country. - **Linda Tjhin** (curatorial staff/associate veterinarian, SeaWorld Indonesia, Jl. Lodan Timur No.7, Ancol, Jakarta 14430, Indonesia; phone 62-21-6410080; fax 62-21-6410079; e-mail <tjhai_hui@hotmail.com>)

JAPAN

New Book on Dugongs of Okinawa. - The Dugong Network of Okinawa, a group seeking the protection of dugongs, has produced a book on the status of dugongs and seagrass in Okinawa. The contents are listed at <<http://www.okinawa-u.ac.jp/~tsuchida/Save-Dugong/love/contents.E.html>>. - **Kana Aketa** (Aquatic Ecology Laboratory, Faculty of Bioresources, Mie University, 1515 Kamihama, Tsu, Mie 514-8507, Japan)

THAILAND

Dugong Movements in the Seagrass Ecosystem. - From 1991 to 1998, the Royal Forest Department of Thailand has been monitoring and investigating movements of dugongs related to the seagrass ecosystem in Had Chao Mai National Park and Mu Koh Libong Nonhunting Area in Trang Province. The data were obtained from extensive aerial surveys by helicopter, observations from small anchored or drifting boats, observations from a cliff

close to one feeding ground of a dugong, and investigations from feeding tracks left in the seagrass. The data show movement of dugongs between the seagrass ecosystem and deep channels nearby during daytime. Dugongs come into the seagrass beds twice a day, start moving into the seagrass beds during high tide, and move back to the favored nearby deep channels during low tide. The movement of dugongs is related to seawater movement in the seagrass ecosystem. Dugongs use the current for traveling between seagrass beds and the deep channels which they use for resting. - Suwan Pitaksintorn¹, Komon Pragtong², and Surachai Wongsiri³ (1, 2. Forest Research Office, Royal Forest Department; 3. Natural Resource Conservation Office, Royal Forest Department, Jatujak, Bangkok, Thailand)

Behavior of Dugongs (Dugong dugon) in a Seagrass Ecosystem. - From 1991 to 1998, the behavior of dugongs was observed in a seagrass ecosystem in Had Chao Mai National Park and Mu Koh Libong Non-Hunting Area, Trang Province, southern Thailand. Data were obtained from helicopter surveys, observations from boats and from a cliff in close proximity to a dugong feeding ground. Dugong

feeding tracks within the seagrass ecosystem and observation of the dugongs' reaction to human disturbance were investigated. Data showed that their movement is dependent upon both tide and current, with the animals following tidal patterns. Feeding was undertaken diurnally and nocturnally. Areas were grazed on a rotational basis. A dive of two minutes was recorded during feeding. Both solitary and herd social behavior was observed. Calves were always observed in close contact with their mothers, who looked after the calf and taught it about the environment. The dugongs reacted to all human disturbance but showed less reaction to swimmers. Boats were particularly avoided. Swimming was the main method for escaping from danger, but they also used camouflage by creating a sediment cloud by disturbing the seabed. The dugongs were seen to tolerate a small amount of disturbance; however, the huge amount of disturbance in the area may have a detrimental effect on the dugong population. - Suwan Pitaksintorn¹, Tippawan Sethapun², Komon Pragtong¹ (1. Forest Research Office, Royal Forest Department.; 2. Natural Resource Conservation Office, Royal Forest Department, Jatujak, Bangkok, Thailand)

ABSTRACTS

The following abstracts are of papers and posters presented at the 13th Biennial Conference on the Biology of Marine Mammals, Wailea, Maui, Hawaii, 28 November-3 December 1999.

Seasonal Variation in the Digestibility of the Dugong *Dugong dugon* in Captivity (Kana Aketa, Akito Kawamura, Teruo Kataoka, Masami Furuta, Shiro Asano, and Wakai). - The digestibility of the Philippine dugongs were examined. They have been kept for 11 and 19 years at Toba Aquarium in Mie, Japan; one female (244 cm in BL and 345 kg in BW) and one male (240 cm, 296 kg). The experiment was carried out from October 1997 through September 1998 with a total of 19 time series observations. The digestibility was measured by the ratio techniques collecting all fecal materials within 144 to 166 hours after food intake. The constituent of feed, Korean eelgrass *Zostera marina* L. as

neutral detergent fiber, lignin and calorific value, was also measured together with keeping environments as water temperature and salinity. The averaged digestibility in female was 78.5% ± 14.8%. Between December 1997 and May 1998 the digestibility became lower than the mean. The constituent of feed eelgrass and keeping environments in terms of calorific value and water temperature were reflected to the female digestibility. The digestibility increased at every 2 months, and this was coincided with an expansion of the external reproductive organs with 10 days lag. As the ovulation cycle in mature dugongs has been presumed about every 2 months, it was suggested that the female digestibility sharply changes nearly every 2 months along with the internal physiological changes. The averaged digestibility in male was 81.8% ± 12.9% and the value was always higher than 70.0% as the case in female. The digestibility of male, however, was not steady and varied frequently without clear seasonal trend. Despite of the same feed constituent and keeping environments as female, male showed different digestibility from the female. No seasonal cycles were found too. Generally, the digestibility in this study roughly agreed to the past record. The digestibility in female was not only influenced by the feed constituent and water temperature but also the internal physiological change such as ovulation. On the other hand, the digestibility in male was considered less affected by the internal physiological condition.

Lipid Chemistry of the Florida Manatee, *Trichechus manatus latirostris* (Audra Ames and Edward Van Vleet) - An initial step to determining fatty acid signatures of tissues from the Florida manatee, *Trichechus manatus latirostris*, was to determine the lipid composition of a variety of tissues (liver, kidney, lung, heart, brain, rib, stomach, cecum, distal colon and their contents, abdominal fat, cardiac fat and skin, blubber and muscle from the dorsal side at the umbilical, anal and peduncular girths). An Introscan MK-5 TLC-FID Analyser was used to separate each of the lipid classes present in the tissue extracts. The lipid content of most tissues was less than 15%. Several colon extracts showed a high lipid content (>50%) with the rest of the extracts having a lipid content less than 6%. On average, blubber and fat extracts had a lipid content of about 50%. Most tissues were composed of free fatty acids, triacylglycerols, sterols, monoacylglycerols, phospholipids and small amounts of diacylglycerols and wax esters. Brain extracts were composed of large quantities of sterols and phospholipids. The major phospholipids were phosphatidylcholine, phosphatidylethanolamine, sphingomyelin and small amounts of phosphatidylserine. Further analysis will focus on fatty acid composition of tissue extracts and its relationship to diet and metabolic reserves.

Captive Observations of a Stranded Manatee Calf in Belize, Central America (Nicole E. Auil, Barbara A. Bilgre, and E. M. Eastwood Bronwen) - On April 26, 1999, the Belize Marine Mammal Stranding Network (BMMSN) rescued a 129-cm-long male manatee (*Trichechus manatus manatus*) calf from a canal north of Belize City, Belize. He was not accompanied by an adult for at least 2.5 days prior to the BMMSN intervention, therefore, presumed orphaned. He was transferred to an in-door concrete tank and monitored for seven days. Clinical examinations were performed including blood work, penicillin inoculations, and weighings. The manatee was bottle-fed a soy milk and dextrose formula every three hours, and from day four, alternated with a soy milk and pedalyte formula. He was offered a mean of 2,391 ml of formula per day (less day 7) and drank a mean of 47% each day (range 39-58%). Of the four feeding methods exercised, i) out of tank bottle feed, ii) restrained in water bottle feed, iii) restrained in water using finger as nipple, and iv) unrestrained bottle feed in the water, his steady feeding rate was greatest during unrestrained feeding (305.08 ml/hr). Respiration rates were recorded throughout the week. Breathing was faster when he was out of the water (0.97 breaths/min) than when he was in the water (0.89 breaths/min). However, it was lower during feeding outside the tank (0.95 breaths/min) than feeding in the tank (1.44 breaths/min). Rates were 0.69 breaths/min during undisturbed activity, 1.33 breaths/min during feeding, and 1.59 breaths/min during medical exams. There was no difference in respiration rates based upon time of day (Diurnal = 0.71 breaths/min, Nocturnal = 0.65 breaths/min, Crepuscular = 0.73 breaths/min). The calf floated primarily on his stomach (67.65%), but showed signs of abnormal buoyancy by floating on either lateral region (13.47%) [later diagnosed with infectious enterocolitis]. Since Belize houses a significant population of manatees, these observations will serve as a baseline for comparison with future strandings.

Underwater visual acuity of the Florida manatee, *Trichechus manatus latirostris* (Gordon B. Bauer, Deborah Colbert, and Wendi Fellner) - Two male Florida manatees, 13 and 15 years of age, were tested with black and white grating stimuli (ronchi rulings) in a simultaneous discrimination procedure using a modified staircase method. Two 32 mm, square targets were presented on each trial. One target with 1 mm stripes served as a standard on all trials. The other, variable target, the "to-be selected target," had broader stripes. If the subjects achieved criterion discrimination of 75% correct over a block of 20 trials, the width of the gratings of the variable target was reduced. If criterion was not reached over a trial block, broader gratings were presented. Subjects swam toward the targets until they reached a divider extending 1 m from the targets, where they had to make a left or right choice based on binocular discrimination of the grating stimuli. Placement of targets was counterbalanced using Gellerman scales. One subject has demonstrated a minimum visual resolution at 1 m of 42' of visual arc, the other is further behind in training. Subjects have not reached threshold at this point in testing.

A Comparison of Techniques Used in Determining Ages of the Florida Manatee (*Trichechus manatus latirostris*) (M. E. Bolen, S. A. Rommel, T. J. Evans, D. M. Fagone, T. D. Pitchford, and Szemer) - Age estimation is crucial to understanding population biology and determining life-history parameters of a species. Methods that have been developed for determining ages of Florida manatees include examining 1) growth-layer-groups (GLGs), 2) ankyloses

of cranial and vertebral sutures, 3) forelimb bone ossifications, and 4) pelvic bone morphometrics. Evaluating the utility and the limitations of each technique can assist researchers in establishing useful and cost-effective alternative aging methods. GLGs in the dome portion of the periotic bone were used to determine the chronological ages of salvaged carcasses (n = 1673). Ages of these wild Florida manatees ranged from 0 to 59yr, 56% were younger than 5yr (n = 942), and only 7% were older than 20yr (n = 116). This technique provides accurate, absolute ages and is useful for formulating demographic models. This GLG technique also allows us to gather life-history data, based on trends observed in GLG spacing intervals. This information increases our understanding of manatee biology and of the effects of anthropogenic and natural changes on manatee health. However, using GLGs to determine ages and analyze life history is labor intensive and is possible only on dead manatees. Other successful techniques used in estimating manatee ages include analyses of cranial suture ankylosis (n = 165), of forelimb ossifications (n = 162), and of changes in pelvic bones (n = 129). In addition to determining relative age, analyses of cranial suture ankylosis allow us to recognize the onset of sexual maturity because it coincides with the fusion of the basioccipital-basisphenoid cranial suture. With radiographs, forelimb ossifications and cranial suture fusion could be assessed in living manatees. A variety of techniques – some time-intensive and costly, others easy and inexpensive – can provide various levels of resolution to questions about chronological age, relative age, and life-history attributes of manatees.

Post-Release Monitoring: An Important Aspect of the Captive Manatee Release Program (Robert K. Bonde, Lynn W. Lefebvre, Leslie I. Ward, I. Elizabeth Wright, and James A. Valade). - The number of manatee (*Trichechus manatus latirostris*) rescues in Florida has increased gradually over the last 10 years. Last year alone 20 manatees were rescued in the southeastern United States and taken into captivity for rehabilitation. Many of the rescued manatees are orphaned calves, which present both a challenge and an incentive for development of effective captive release strategies. Captive manatees are evaluated and selected for release using criteria intended to predict their readiness to adapt or readapt to natural environments. The success of this program has hinged on researchers' abilities to use satellite and conventional radio tracking techniques to locate, track, and monitor the released manatees. Between 1988 and 1998, 50 captive manatees were released with radio tags as part of an extensive multi-agency post-release monitoring program in Florida. Of these, 16 were orphaned calves and 8 were born in captivity. Twelve of the 50 manatees are known to have died during the study period; 8 died from human-related causes, and 4 from natural causes. Twenty-four manatees were periodically captured for biomedical assessment in order to monitor their adjustment to the wild. Body condition was evaluated using ultrasound to determine blubber thickness. Blood parameters, morphometrics, weight, general gross appearance, and behavioral activity were also examined. Four captured manatees were returned to captivity. Two manatees were tracked for more than 3 years and 8 were tracked for more than 2 years. Two long-term captive females mated and successfully gave birth to healthy calves following their release. Four expert panels reviewed the progress of the captive release program at a workshop held in St. Petersburg, Florida, in May 1998. Strategies and protocols were recommended to improve captive rearing, pre-release conditioning, release procedures, post-release monitoring, biomedical assessment, and overall management of the program to enhance the long-term success of captive manatees returned to wild.

Evidence For a Resident Dugong Population in the Johor Straits, Between Malaysia and Singapore (Catherine Brassaud, Chitramala Nadarajah, Isa Bin Mat Mansor, Thomas Jefferson, and Elizabeth Taylor). - Before 1990, dugongs (*Dugong dugon* (Muller)) were rarely reported in the Johor Straits, in Malaysian waters or in Singapore. From 1924 to 1990 there were only 11 known sightings and strandings of dugongs in this area. In contrast, between 1994 and March 1999 reports of 12 strandings, 6 live individuals caught in fishing nets (2 were mother and calf pairs), and 22 aerial survey sightings suggested that dugongs inhabit the area. In fact, dugongs were considered only as transitory in the Johor Straits area until the observations made in 1999 strongly supported the hypothesis that all stranded and sighted individuals might belong to a resident population. The results of genetic studies conducted on 2 stranded juveniles are consistent with the hypothesis of a resident population. They showed that the 2 individuals, washed ashore 2 months apart, were closely related, most likely siblings. As the only social unit identified for dugongs is the cow-calf pair, it is unlikely that siblings would have traveled there from separate home ranges. Furthermore, past research on seagrass distribution combined with the 2 aerial surveys conducted by the Department of Fisheries Malaysia on the 25th of March 1999 and again with the assistance of Professor Helene Marsh on the 11th of May 1999 identified several seagrass beds in the area, some with feeding trails in *Halophila ovalis*, which is a species preferred by dugongs. Based on the hypothesis of a resident dugong population, long-term research studies have been launched. An integrated study of endangered marine species in the Exclusive Economic Zone waters of Malaysia, with special emphasis on the dugong and its habitat, has been recently proposed by the Department of Fisheries, Malaysia, and the Singapore Wild Marine Mammal Survey project (SWiMMS) also includes dugong distribution and abundance assessments among its main goals.

Manatees, Monofilament, Crab Traps and Management (William Brooks, Jr.) - The number of West Indian manatees (*Trichechus manatus*) in the Florida population that become entangled in monofilament and crab trap lines continues to rise. During the past ten years (1989-98), distressed manatee rescues have increased five fold, 10 to 50. Historically, abandoned calves and manatees seriously injured by collisions with boats were the predominant reason for initiating a rescue. Entanglement rescues have increased to an equal level and will most likely become the leading cause in 1999.

During the past ten years, 2,180 manatee carcasses were documented. Mortalities specifically attributed to crab trap lines and monofilament was 3 (0.14%) and 1 (0.05%) respectively. The relatively low number of mortalities attributed to entanglement injuries highlights the heightened level of public awareness and also the success of the manatee rescue/rehabilitation program. If a manatee is rescued shortly after its entanglement, the animal is usually disentangled and released with only minor injuries. However, the longer an entanglement goes undetected or the manatee eludes capture, the prognosis deteriorates and in several cases entanglements have resulted in loss of a flipper and death. The significant increase in entanglement related manatee rescues highlights the need to develop strategies to stop the increasing trend in documented entanglement "takes." A continued high level of public awareness will allow for injured and distressed manatees to be reported and subsequently rescued at an increasing rate. The rehabilitation program continues to experience an increased success in treating and releasing injured manatees. Therefore, the strategies need to be aimed at stopping the entanglement. For monofilament, these efforts need to focus on educating the fishing community on properly discarding monofilament and provide an avenue for the recycling of monofilament and encourage underwater clean up of monofilament in popular fishing areas. Novel object studies focusing on entanglements associated with crab trap lines should be pursued in an effort to make recommendations on fishing methodology and technology that may decrease such entanglements.

Habitat Usage and Feeding Behavior of the Florida Manatee (*Trichechus manatus latirostris*) in Sarasota Bay, Florida (Heather Chichester, Jessica Koelsch, and William Ambrose). - The Florida manatee (*Trichechus manatus latirostris*) is an endangered marine mammal found in the coastal waters of the Southeastern United States. Lack of knowledge regarding the critical habitat of the Florida manatee has contributed to the risk of extinction of the species. This study examined the relationships between specific habitats and behaviors, as well as food and feeding location preferences of a summering population of manatees in Sarasota Bay, Florida in order to identify critical habitats in this area. Behavioral and feeding observations, including observations of habitat, behavior, feeding location and environmental variables, were made between 1 May and 31 August 1996. Of the available habitats in Sarasota Bay, grassbeds were identified as the most important habitat to this population of manatees, with over 30% of the observed behaviors occurring within this habitat type. Manatees in Sarasota Bay do not seek out locations specifically to feed, instead, they are selective in how long feeding sessions last among feeding locations. Manatee abundance and minutes spent feeding were found to be significantly different, $p < 0.01$ and $p < 0.0001$, respectively, among feeding locations within Sarasota Bay. Percent *Syringodium filiforme* coverage and salinity were found to be major factors influencing these differences. Four specific locations within Sarasota Bay were identified as critical feeding areas. The results of this study suggest that the single location presently protected within Sarasota Bay is not adequate for extending protection to the manatee population in the Bay, and further protection must be extended to the locations identified in this study as critical habitat areas.

Dugong Diving: The Effect of Depth and Behavior on the Allocation of Time (C. A. Churchward and P. K. Anderson). - Dugong diving behavior is unique among fully marine mammals due to their herbivorous habits, shallow water foraging, and low metabolism, yet studies to date are limited and without behavioral and/or environmental context. This study examined the diving activity of dugongs in Shark Bay, Australia, in terms of behavior and habitat to determine the influence of water depth on the allocation of time during the dive cycle. Three hundred thirty-three dugongs were observed over a depth range of 0.7 to 12.5m. Data were collected by direct observation so behavior could be noted. Of the 3947 dive cycles recorded, 58.3% occurred while foraging, 11.9% while travelling, and 9.9% while resting. Foraging dives showed the greatest overall mean submerged time (149.60 sec), followed by resting (79.58 sec), then travelling (57.80 sec). Mean surface time and mean number of breaths were also greatest while foraging (26.83 sec, 2.8 breaths), followed by resting (1.23 sec, 1 breath), and then travelling (1.20 sec, 1 breath). Travelling and resting dives were unaffected by depth, while foraging dives showed increases in each stage of the dive cycle. Submerged time showed a non-linear increase with depth, suggesting a maximum optimal submerged time of approximately 300 sec while foraging. Surface time also increased non-linearly with depth while foraging, although the ratio of submerged to surface time was relatively constant beyond 3m. These trends were qualitatively similar to predictions from optimal diving models by Carbone and Houston (1992). No evidence of anaerobic dives was found at the observed depths. Investigation of the relationship between dugongs and deep-water habitats in Shark Bay is crucial due to their seasonal variation in foraging depth. In addition, the relationship between water depth and the proportion of surface to submerged time is important to the development of accurate correction factors for aerial surveys.

Barnacles Associated with Caribbean Marine Mammals (Jamillette Cintron-De Jesus, Ernest H. Williams, Lucy Bunkley-Williams, and Antonio A. Mignucci-Giannoni). - No systematic study of the presence of cirripeds associated with marine mammals has been carried out for the Caribbean. We collected barnacles from stranded whales, dolphins and manatees in Puerto Rico and Florida to assess species richness associated to marine mammals. Barnacles were extracted using forceps and a blade or by hand, and were preserved in 70% ethanol. They were dissected with forceps, blade and pliers or in large specimens by using a specialized geology saw. Three species of barnacles were found in hosts studied. In humpback whales (*Megaptera novaeangliae*), all barnacles found were *Coronula diadema*. In odontocetes, including sperm whales (*Physeter macrocephalus*), goosebeak whales (*Ziphius cavirostris*), Gervais' beaked whales (*Mesoplodon europaeus*), and pygmy killer whales (*Feresa attenuata*), we found *Chonchoderma*

auritum, in most cases attached to one or more of the animal's teeth. West Indian manatees (*Trichechus manatus*) were found to host *Chelonibia manati lobatosis* in different stages of development. Few research mention the species identification of barnacles present in marine mammals. This situation clearly establishes the need of a better description of barnacles associated to whales, dolphins and manatees.

Mechanical Properties of Manatee Bone in Compression (Kari B. Clifton, Thomas J. Koob, and Roger L. Reep). - Florida manatee (*Trichechus manatus latirostris*) mortality has been documented since 1974. Watercraft-related mortality, caused by propeller wounds or impact, accounts for approximately 23% of all deaths from 1976-1998, and comprises 78% of anthropogenic-related deaths. Sixty-six percent of animals killed by impact suffered broken or luxated ribs. This study represents the first attempt to quantify the biomechanical effects of boat strikes on manatees. The number of watercraft-related deaths increased at an annual rate of 10% from 1992-1998; the last three years have been the highest on record. Reducing watercraft-related mortality is a high priority in state and federal manatee recovery efforts, which focus primarily on regulating boating activities. However, the increasing population along the Florida coastline has resulted in more boats utilizing the waterways. The potential threat posed by watercraft continues to increase, and regulatory efforts have not been successful in reducing the number of watercraft-related deaths. In contrast to most marine mammals, manatees exhibit pachyostosis, characterized by thickening of bone tissue, replacement of cancellous with compact bone, and absence of free medullary cavities. The goals of this project were to calculate stress, strain, and Young's modulus for rib bone in compression. Test pieces were broken in compression for ten adult manatees (five males, five females) in three orthogonal planes. Compressive strength was greatest parallel to the long axis of the rib (119 MPa \pm 20SD), and significantly weaker in the cranio-caudal (109 MPa \pm 20SD) and medio-lateral planes (104MPa \pm 18SD). Females (99 MPa \pm 18SD) were significantly weaker ($p=0.02$) than males (109 MPa \pm 17SD) in the medio-lateral plane. Manatee bone appears to be weaker in compression than other types of bone, including human. This would be consistent with its high density, high degree of compactness, and high mineral content. Results indicate that boat impacts may inflict fatal injuries even at low speeds.

Assessing the Population Trend of the Florida Manatee via a Stochastic Model and Aerial Surveys: 1982 - Present (Bruce A. Craig and John E. Reynolds, III). - In many animal population studies, the construction of a stochastic model provides an effective way to capture underlying biological characteristics which contribute to the overall variation in the data. In this paper, we develop a stochastic model to assess the population trend of the Florida manatee, *Trichechus manatus latirostris*, along the east (Atlantic) coast of that state using aerial survey data collected at winter aggregation sites between 1982 and 1998. This model accounts for the method by which the manatees were counted, their movements between surveys, and the behavior of the total population over time. Unlike the previous version of this model (Craig et al., *Biometrics*, 1997), we incorporate a Markov chain process to describe the population trend (at most a 10% increase or 20% decrease in annual growth), thereby reducing the trend's dependency on the selected trend model (previously a log-quadratic model). Based on our results, the data show an overall increase in the population from 1982-1989 of around 6-8% a year and a leveling off (0-4% annual growth) or even a decrease in this population in the 1990's.

Winter Movements among Thermal Refugia by West Indian Manatees (*Trichechus manatus*) along the U.S. Atlantic Coast (C.J. Deutsch, J.P. Reid, R.K. Bonde, D.E. Easton, H.I. Kochman, and T.J. O'Shea). - The West Indian manatee's metabolic physiology constrains it to subtropical and tropical waters. At the northern limit of the species' year-round range in Florida, the ability to find reliable warm-water refugia during winter cold periods is critical to survival. We studied how radio-tagged manatees used a network of 13 industrial warm-water effluents and at least 3 "natural" sites (unheated but thermally buffered waterways) along the Atlantic coast of Florida and Georgia during winter. Most sites were power plant discharges but also included pulp mill effluents. A total of 73 manatees were tracked over 12 winter seasons (1986-1998) using field-based VHF radio-telemetry and Argos satellite-based telemetry. Thirty-one animals were located on at least 100 days between November and March, some for multiple years. With the exception of three manatees in the Florida Keys, all manatees tracked between December and February used at least one industrial warm-water effluent in every year. The mean number of thermal refugia visited by individuals within a winter season was 3.7 (SD = 1.7, maximum = 9), of which about 80% were industrial effluents. Upon the onset of cold winter weather, most tagged manatees migrated south to a more favorable thermal regime; some moved to local warm-water sites, however. Most individuals exhibited interannual site fidelity to overwintering sites in a particular region and used other warm-water refugia as "stepping stones" during migrations. One adult female, for example, visited a total of 10 warm-water sites between central and south Florida over 6 consecutive years, but she regularly attended only two of those sites in her core winter range in every year. The network of thermal refugia that individual manatees are familiar with varies in extent from quite localized to widespread (>500 km), and this is likely to affect their ability to cope with interruptions or shutdowns in industrial thermal output.

Conception and birth of the first Amazonian manatee *Trichechus inunguis* in captivity (V.M.F. da Silva, J.A.R. D'Afonseca Neto, R.M.C. Faraco, Z.E. Rodriguez, and G. Mattos). - This paper presents the record of the first Amazonian manatee conceived and born in captivity as a part of a program to study the life history and to promote conservation and public awareness of this species in the region. Since 1974, when this program was created, orphan

manatees have been kept successfully in captivity. On April 8, 1998, a female raised on artificial milk diet and kept in captivity during 24 yrs. gave birth to a male calf manatee. Immediately after the birth, the baby was observed swimming beside his mother, keeping a constant physical contact, spending most of his time on top of her back or tail. Only the next day the pool was drained and the baby was weighed (10.5 kg), measured (85 cm TL/SL), and examined. The placenta was expelled 40-47 hrs. after birth. During the first week after birth, continuous observations of the behavior, lactation, and respiratory frequency were made. Four hours after birth, the calf was observed lactating. He sucked twice per hour for about 2 min (s.d. = ± 36 sec.) each time and most of the times suckling with his body in a 45-degree angle in relation to his mother's body, or in a vertical position, motionless at middle water or while swimming around the pool. After two weeks of direct observation and feces exam, it was noted that the calf was already biting and ingesting plants (*Cabomba* sp. and lettuce). During the first week respiratory frequency was 01:09 min ± 56 sec, reaching a respiratory pattern of about 2 min only after the 15th week. During this period, the maximum dive time recorded was 6 min. During the first year the calf was nursed by his mother and was measured and weighed once a week, showing a linear growth rate of 1.7 mm per day and an increase of 1kg of body mass per week. Detailed information on the growth, respiratory frequency, and husbandry of the first year will be presented.

Manatee Vocalizations: Acoustic Evidence for Distinct "Voices" (Katherine Frisch). - Florida manatees (*Trichechus manatus latirostris*) are known to produce sounds. Some attempts have been made to characterize their vocal repertoire. However, little has been documented about intermanatee differences in these vocalizations. This pilot study examines the acoustic differences in vocalizations of two captive born manatees at Mote Marine Laboratory in Sarasota, FL. The manatees are of comparable size and age, and are the same gender, so any individual differences that are found are likely to have behavioral, rather than physiological, origins. The manatees were recorded at random intervals while engaged in typical activities. Vocalizations were isolated from the recordings and were analyzed along a number of acoustic dimensions. In contrast to previous studies of manatee vocalization (Steel 1982), the majority of vocalizations recorded were aperiodic and had very little evidence of complex harmonic structure (formants). Despite a great deal of overall variability in amplitude, bandwidth, and duration, there was a clear bimodal distribution of central frequency characteristics, particularly near the end of the vocalization. There are a number of potential sources for this bimodal distribution. However, the simplest conclusion is that manatee vocalizations have an individually determined natural frequency range. The difference in frequency modes is greater than 50%, while the larger of the manatees is only 25% greater in weight, suggesting that this difference may not be entirely physiological. At present, little is known of the vocal source in manatees, so speculation on physiological factors is speculative. If distinct acoustic cues like central tendency in frequency can be linked to individuals, acoustic analysis may provide additional means of identifying and distinguishing individuals from each other in the wild. Recently, automatic speech processing techniques have been applied to bioacoustic data, and such techniques might be useful to researchers involved in cataloging individuals or tracking populations in the wild.

A Serologic Survey of Manatees in Florida (Joseph R. Geraci, Jill Arnold, Beverly J. Schmitt, Michael T. Walsh, Scott D. Wright, Gregory D. Bossart, and Valerie Lounsbury). - The Florida manatee, *Trichechus manatus latirostris*, inhabits an environment under intense pressure. Human activities, mostly vessel strikes, account for 25 to 40% of annual mortality. Natural mortality factors include cold stress and poisoning associated with outbreaks of the red tide organism *Gymnodinium breve*. The role of infectious agents, if any, is undetermined, in part because carcasses decompose rapidly in warm water, leaving little evidence of disease. However, manatees inhabit coastal and freshwater systems that receive urban and agricultural runoff, a setting potentially rich in pathogens. In September 1996, the National Aquarium in Baltimore initiated serologic studies on manatee serum samples collected over the previous 20 years and archived at Sea World of Florida and the Florida Marine Research Institute (Florida Department of Environmental Protection) (FMR/FDEP). Over 1900 analyses were performed by the National Veterinary Services Laboratories (NVSL) on samples from 71 manatees for viral and bacterial agents of significance to humans and domestic animals. Analyses were positive for antibodies to 17 of the 28 selected agents, including: pseudorabies (3/71), bovine herpes mammillitis (1/71), bovine coronavirus (4/71), San Miguel sea lion virus type 1 (15/71), bovine adenovirus type 1 (19/71) and type 5 (27/71), *Brucella* sp. (5/71), avian influenza (1/71), eastern equine encephalitis (64/71), Venezuelan equine encephalitis (57/71), western equine encephalitis (55/71), and six serovars of *Leptospira interrogans* (*australis* [1/71], *autumnalis* [3/71], *bratislava* [6/71], *canicola* [1/71], *pyrogenes* [2/71], and *sejroe* [2/71]). In cooperation with the University of Maryland, NVSL, FMR/FDEP, Sirenia Project (USGS), and the University of Miami, studies are underway to expand the database, further characterize the encephalitis viruses and examine the degree of cross-reactivity, and associate test results with life history and pathology data. Results will increase our understanding of potential risks to the Florida manatee population and of the ecology of pathogens in coastal ecosystems.

Do Manatees Grow on Trees? An Education/conservation Campaign in the Colombian Amazon (Sarita Kendall, Magda Perez, Engelbert Chavez, M. Alejandra Galindo, and Nataly Castelblanco). - Amazonian manatees (*Trichechus inunguis*) have been hunted for centuries, primarily for their meat. Between January 1998 and May 1999 at least 8 manatees were killed in the River Amazon border area of Colombia/Peru and two orphaned calves received at local holding facilities. The Omacha Foundation, responsible for one of the calves, launched an education/conservation

campaign for manatees in 1998, emphasizing traditional knowledge and story. Airuwe, the calf at the Omacha field station, was a focus for the campaign, with children, teachers, the military, fishermen, local leaders and tourists visiting for talks and viewing at feeding time. Two drawing/writing competitions on manatees and other aquatic fauna were held and activities were carried out in 20 local schools, as well as in urban schools in Colombia. Educational materials were also developed. Structured interviews were conducted with 24 fishermen (23 of them Ticuna Indians) living in the Puerto Narino area and known to be familiar with manatees. In addition to collecting data on locations, feeding and hunting, the interviews covered conservation and cultural aspects. Between them the fishermen had hunted some 40 manatees, all but 3 with harpoons. 66% of respondents said controls on hunting should be enforced. Perceptions of the status of manatees varied, with some saying they are dying out and others claiming large numbers, on the grounds that few people know how to hunt them any more. Respondents quoted a Ticuna story about certain trees where grubs develop enormous cocoons and eventually transform into manatees. At a workshop with the respondents, this cultural perception of abundance was explored and fishermen agreed that such trees are very rare nowadays so manatees must be in need of protection. Some fishermen offered support for conservation efforts, including the possible reintroduction of Airuwe to the wild.

Observations of Identifiable Manatees Along the Central and Southwest Coast of Florida (Jessica Koelsch, Suzanne Tarr, and Sheri Barton). - Year-round observations of identifiable manatees (*Trichechus manatus latirostris*) along Florida's West Coast are providing information on site use and fidelity as well as seasonal and long-distance movements, suggesting current concepts of subpopulations and associated management strategies might benefit from reexamination. We used photographic identification of distinct individuals to identify manatees at numerous sites within three regions (Tampa Bay, Sarasota Bay, and southwest Florida including the Ft. Myers area and Charlotte Harbor). Distinct manatees were documented in Tampa Bay (n = 147, winters 1982/83-1997/98), Sarasota Bay (n = 201, non-winters 1993-1998), Ft. Myers (n = 151, winters 1982/83-1997/98; n = 44 non-winters 1983-1998), and Charlotte Harbor (n = 96, winters 193/94-1997/98; n = 96 non-winters 1985-1998). Effort was unequal among regions and years. Regional site use and manatee movements were variable and individualistic. Some manatees used multiple winter sites within a region (i.e., southwest Florida), however a limited number traveled between regions within a single winter. Manatees in Tampa Bay were resighted over 200 km north and 220 km south of Tampa Bay whereas manatees in Sarasota Bay also used sites 220 km to the north and over 180 km to the south in southwest Florida. These movements occurred both within and between seasons or years. Manatees observed wintering together often used different non-winter sites, and many of those observed together at non-winter sites used different winter refugia. Many individuals displayed site fidelity over one or more years to both winter and non-winter sites; others used numerous sites within and between regions. Year-round movements along the coast are fluid and continuous, indicating a high potential for genetic mixing and suggesting management may require multiple or complex strategies.

Reproductive Endocrinology of the Florida Manatee (Iske V. Larkin, Roger L. Reep, and Timothy S. Gross). - Sexually mature manatees often form mating or escort herds when a female is receptive to breeding, consisting of a focal female and several males. This may last 2-4 weeks and occur at any time of the year, however, reproductive activity appears reduced during winter months. The female is promiscuous in her breeding habits and will mate with several males, however, there is typically only one calf born. Gestation is 12-14 months. Calves will remain with their mother for 1.5-2 yr. and mothers have a calf approximately every 3-5 years. The objectives of this study were to utilize non-invasive fecal radioimmunoassays to: 1) Document the hormonal parameters of the female manatee estrus cycle, concentrations of estradiol and progesterone throughout the cycle, the cycle's length and frequency, and what factors may influence the cycle. 2) Determine if seasonal variations exist in the estrus cycle of females and the testosterone concentrations in males. 3) Examine possible correlations between physiological hormone concentrations and observed behaviors of female manatees in captivity. 4) Determine whether light cycle dynamics or water temperature influence seasonal changes in captive manatee hormonal concentrations. Results to date suggest there are seasonal decreases in male and female hormone concentrations during the winter. Female behavioral activity levels also decrease in winter and this may parallel the hormonal data. Differences in fecal hormone concentrations can distinguish adult male versus female manatees. Information gathered from fecal radioimmunoassays will help supplement our basic understanding of manatee biology, thereby suggesting management policies that better protect this endangered species. Supported by College of Vet. Med., Univ. of Fl. grant, Save the Manatee Club grant and U.S. Fish and Wildlife grant to I.V.L.; and The Living Seas Epcot, Sea World, Miami Seaquarium, Homosassa Springs State Park, National Biological Service and the Florida Department of Environmental Protection.

Observations on the Lingual Structure of the West Indian Manatee (*Trichechus manatus latirostris*) (Milton Levin and Carl Pfeiffer). - The West Indian manatee tongue was examined macroscopically, light microscopically, and electron microscopically (scanning and transmission). The tongue was slender, muscular, and firmly fixed in the oral cavity. Only the cranial free tip was free and mobile. Numerous filiform papillae were present over the dorsal surface of the rostral lingual region. Caudal to the filiform papillae, multiple raised, round papillae were distributed over the majority of the dorsum. Fungiform-like papillae were also restricted to the lateral margins of the tongue. Caudally, the dorsal and lateral regions showed numerous open fossae and pits. Microscopic examination showed the majority of the dorsum to be covered with a thick stratified squamous epithelium. The caudal dorsal and lateral open pits led to

salivary glands, most of which were mucous but some of which were mixed serous and mucous glands. Foliate-like papillae, located on the caudal region of the tongue, contained taste buds embedded in the epidermis. Throughout the tongue, striated muscle was abundant below the epidermis. Blood vessels, lymph channels, and nerve fibers were freely distributed throughout the intermuscular stroma.

Experimentally-induced Serum and Urinary Creatinine Elevations in Captive West Indian Manatees, *Trichechus manatus* (Charles A. Manire, Howard L. Rhinehart, Deborah E. Colbert, and David R. Smith). - In most species of mammals, a rise in serum creatinine concentrations signals renal failure. This study was initiated to determine the cause of elevations in serum creatinine concentrations that have been observed in rehabilitated West Indian manatees following their return to the wild. During the study, routine serum chemistries, blood cell counts, and urinalyses as well as serum creatine kinase and urinary creatinine were monitored. Two captive manatees were utilized to determine the effects of partial fasting, short-term total fasting, simulated transport, diet change from a captive diet to a wild diet, and salinity changes. The most dramatic changes in both serum and urinary creatinine occurred during the partial fasting and short-term total fasting experiments. A diet reduced by 80% for two weeks led to an almost immediate increase in both serum and urinary creatinine concentrations that both returned to normal after one week back on their usual diets. Four days of total fasting also led to an immediate increase that remained elevated for only three days following return to their usual diets. Simulated-transport for six hours did not affect either serum or urinary creatinine in one animal but the other showed a minor increase in serum creatinine that lasted for only a day. Serum lactate dehydrogenase and creatine kinase concentrations were elevated for both manatees, probably as a result of muscle cell damage from being out of the water. Initial results indicate that creatinine elevations are unlikely with both diet change and salinity change. It is suggested that the serum and urinary creatinine elevations are probably due to either protein or fat metabolism that takes place during limited food intake and the manatee kidney is incapable of clearing it as rapidly as it is produced.

Feeding Behavior Of The West African Manatee (*Trichechus senegalensis*) (Christopher Marshall, Shiro Asano, and Masami Furuta). - The use of perioral bristles for feeding has been examined in three of the four extant sirenian species (*Trichechus manatus*, *T. inunguis*, and *Dugong dugon*). Lack of captive West African manatees precluded a complete comparison of perioral bristle use among living sirenians. However, in May 1996, the Toba Aquarium (Toba City, Mie Prefecture, Japan) acquired two West African manatees from Guinea-Bissau for captive study and display. West African manatees were videotaped while feeding; behavioral data were analyzed in real time, slow motion, and frame-by-frame to determine the component movements of perioral bristle fields during feeding. Like other trichechids, West Indian manatees possess a bilateral pair of robust bristle fields located on the upper lips (U2) and a single large bristle field located on the lower lip (L1). West African manatees used perioral bristles in a rhythmic cycle which alternated between grasping and pulling vegetation into the buccal cavity at the midline (U2 bristle fields), and a sweeping action which pushed vegetation into the buccal cavity (L1 field). This feeding behavior is consistent with all other trichechids; however, this mode is divergent from dugongs despite the similarities in morphology and distribution of perioral bristles. Tooth morphology, tooth replacement, and rostrum deflection among modern sirenians are evolutionary derivations from ancestral conditions which have been correlated with feeding behavior (benthic, mid-water column, surface foraging, and specialists vs. generalists). Natural selection has also acted on oro-facial musculature and other soft tissues of the sirenian feeding apparatus to produce a dexterous vibrissal-muscular complex that increased aquatic foraging efficiency. Furthermore, the behavioral divergence in the use of this vibrissal-muscular complex between specialist foragers (dugongs) and generalist foragers (manatees) may have resulted in an increase in foraging efficiency for both groups, but in ecomorphologically different directions.

Radiotracking Manatees off the West Coast of Puerto Rico (Antonio A. Mignucci-Giannoni, Nilda M. Jimenez-Marrero, Maritza Vargas-Gomez, Jorge E. Saliva, James P. Reid, and Robert K. Bonde). - While radiotracking studies of West Indian manatees (*Trichechus manatus*) are common in Florida, tracking Antillean manatee movements in the Caribbean has only been done in a few localized studies. These include Mexico, Belize, Brazil and the east coast of Puerto Rico. To enhance our understanding of manatee movements and habitat use, we captured 8 and tagged 4 manatees (2 females and 2 males) off the west coast of Puerto Rico in 1997 and 1998. Each animal was fitted with a belt, tether and a floating radio tag which combined UHF and VHF transmitters. Service Argos provided locations remotely while land-base radiotracking documented animal behavior and specific habitat use patterns. Tracking bouts for individual animals ranged from a few days to 148 days. Although all bouts terminated when floating tags detached, two belted manatees tagged in 1997 were found and retagged in 1998. Location data showed high use of the southwest coast (Mayaguez to Boqueron) where shallow seagrass beds extend several kilometers offshore. Feeding areas were documented in both nearshore and offshore seagrass beds. All four animals returned frequently to drink fresh water at the mouth of Rio Guanajibo (capture location), near Mayaguez. A nursing mother and her calf showed the most restrictive use pattern by remaining in this region. Soon after tagging, a subadult male made a long-distance move from Mayaguez to San Juan and Luquillo (Puerto Rico's northeast coast), a distance of 210 km. He returned to Cabo Rojo 45 days later and remained in the southwest area. Movement and habitat use data obtained from this study will be used to address conflicts between manatee areas and coastal boating activities.

The Analysis of Distribution and Behavioral Trends of Dolphins and Manatees in the Northern Banana River, Florida Using GIS (Mario Mota and Jane Provancha). - Since 1977, systematic helicopter-based surveys of dolphins (*Tursiops truncatus*) and manatees (*Trichechus manatus*) have been conducted in the northern Banana River, Kennedy Space Center (KSC). Data included location, number, size, and behavior (travel, resting, milling, feeding, and mating). These data, along with bathymetry, ship-channels, boat-ramps, fresh-water sources, seagrass beds, and fishing areas, were converted into GIS coverages. Analyses were performed to identify the distribution and behavioral trends of these two marine mammals. Due to consistency of data collection protocols during 1978-81 and 1987-89, dolphin data were grouped and compared for these two periods. Seasonal analyses (winter vs. summer) showed higher numbers of dolphins in winter. Numbers were also higher in deeper waters, and at the channel locks connecting to the Ocean. The 78-81 period had an average of 13.2 dolphins/survey while the 87-89 period had 8.5 dolphins/survey (not stat. sig.). Mean pod size was not different (2.45 and 2.83, respectively). Spatial analysis indicated that larger pods ($n > 5$) and calves were more abundant north of the NASA Causeway Bridge and in the northeast terminus of the Banana River, known as Pepper Flats (PF). Bathymetric differences are likely to account for this distribution. Seagrass bed density was not correlated with dolphin density or distribution. Because the northern Banana River is restricted to boat traffic, and seagrass beds are extensive, manatees are widely distributed and specific behaviors were not associated with particular locations. However, manatee data continued to show greater concentrations of individuals near the AF boat dock, the ocean locks, and at Pepper Flats.

Does the Thick Skin of the Florida Manatee (*Trichechus manatus latirostris*) Provide Ballast? (E.K. Nill, D.A. Pabst, S.A. Rommel, and W.A. McLellan). - Unlike the skins of most other marine mammals, which contain a thick, lipid-rich hypodermal layer (i.e., blubber), manatee skin is nearly devoid of lipid. We determined that the skin of the Florida manatee (*Trichechus manatus latirostris*), though, is 2.5 times thicker than would be predicted for a mammal of its body mass. This thickness is due to their dermis, which is reinforced by a dense, three-dimensional weave of collagen fibers. The lipid-rich integument of cetaceans may provide a mechanism for positive buoyancy because lipids (900-920 kg/m³) are less dense than fresh water (1000 kg/m³) and salt water (1024 kg/m³). Contrarily, manatee dermis is constructed primarily of collagen (1120-1250 kg/m³), which is more dense than water. Unlike the function proposed for the skins of many other fully aquatic marine mammals, we hypothesized that the thick, collagen-dense dermis of the manatee may contribute to negative buoyancy, effectively adding ballast. The densities of the skin of manatees, bottlenose dolphins (*Tursiops truncatus*) and harbor porpoises (*Phocoena phocoena*) were determined volumetrically. Preliminary results show that the mean density of manatee skin (1151 kg/m³) is greater than that of both bottlenose dolphins (979 kg/m³) and harbor porpoises (978 kg/m³). In addition, manatee skin is denser than both fresh and salt water. Thus, it appears that the skin of the manatee, along with their dense skeleton (especially ribs), adds ballast to counteract their buoyant lungs and voluminous intestinal tract. This research supported by the Florida Department of Environmental Protection and the Center for Marine Science Research.

Distribution of Manatee Stocks in West Africa (Leslee Parr, Deborah Duffield, Steven Fain, and Monica Almeida e Silva). - Before 1995, no specimens of West African manatee, *Trichechus senegalensis*, tissues were legally available for genetic analysis in the United States. Due to the political, social, and economic state of the West African nations, it is extremely difficult to obtain *T. senegalensis* tissues. Over the past five years, we have obtained a small but meaningful sample set of tissues from Cameroon ($n=1$), Chad ($n=11$), Ghana ($n=1$), Guinea-Bissau ($n=5$), and Senegal ($n=1$). The analysis of these tissues provides the first insight into the genetic makeup of West African manatee stocks. Most of the tissue samples analyzed were bones ($n=17$) donated to field researchers by village fishermen. Bone has traditionally been a difficult medium from which to extract DNA. We have developed a highly successful extraction protocol, utilizing an extended mineral matrix dissolution prior to a modified GuSCN-silica-diatom extraction. Using this method, we were able to sequence a 438-base-pair (bp) sequence of the mitochondrial genome, including 112 bps of the 3' end of the cytochrome b gene, tRNAs Threonine and Proline (total, 137 bps) and 226 bps of the 5' end of the highly variable displacement loop (D-loop) region. Total sequence divergence among *T. senegalensis* is 5.0%, with the Guinea-Bissau stock contributing the full range of divergence (5.0%). Interestingly, this represents more divergence than we have reported in previous studies between the West Indian and West African species (4.4% divergence) and between the Amazonian and West African species (4.4% divergence). Domning and Hayek (1986) found no morphological distinction between the nominal coastal and inland subspecies of West African tradition. Our results indicate that samples from inland, possibly isolated populations in Chad are nearly as different genetically from coastal animals taken from Ghana and Senegal (2.5% divergence) as animals from the accepted subspecies of the West Indian manatee (3.6% divergence).

Trichechid Dentition: Tooth Structure and Wear Patterns in Florida (Tracy E. Popowics and Christopher D. Marshall). - This study examines the relationships of tooth morphology, enamel, and wear in Florida manatees (*Trichechus manatus latirostris*). In general, the dentitions of herbivorous mammals are structured to increase longevity using high-crowned teeth, open-rooted teeth, or modified enamel structure. Trichechids use an alternative strategy by employing supernumerary molars that erupt in the back of the tooth row, migrate forward as they wear, and are shed anteriorly when non-functional. New molars erupt in the posterior tooth row to replace those shed anteriorly. Each cheek tooth resembles its predecessors with little variation in cusp organization. An apparently unlimited number of

molars are available to replace lost teeth. We characterize the extent and direction of wear, and changes in tooth morphology within a tooth row by examining patterns of loph wear, cusp height, tooth position, enamel and dentin thickness. Additionally, we characterize the structure of the enamel and its potential to resist wear. Each tooth is comprised of an anterior and posterior loph with a posterior cingulum or accessory loph. The majority of loph wear occurs posteriorly in the tooth row. During forward migration, the anterior loph exhibits a faster rate of wear than the posterior loph, and lingual cusps wear faster than buccal cusps. Transverse scratches in dentin, in addition to behavioral data, suggest that manatee feeding mechanics primarily utilizes translational movement of the mandible during feeding, which is typical of most mammalian herbivores. Preliminary analysis of enamel suggests that it is weak in structure. During their evolutionary history, trichechids may have been faced with circumstances which selected for a system in which disposable teeth were more advantageous than investing energy in stronger, wear-resistant enamel.

The Sirenian Lateral Line: Postcranial Tactile Hairs in Manatees (R.L. Reep, C.D. Marshall, and M.L. Stoll). - Hair in sirenians is exclusively sinus type tactile hairs, distributed over the entire body. The facial portion of this system is known to be involved in tactile exploration and feeding, but postcranial hairs are too sparse to serve in thermoregulation. We hypothesize that the postcranial hairs function as an array encoding the intensity and direction of water currents, pressure gradients and low frequency vibrations impinging on the body, and generated by the presence of other animals, large features of the underwater environment, and tidal flows. This would aid in navigation and the detection of significant underwater stimuli. Here we sought to map the distribution and microanatomical attributes of the postcranial hairs. For 2 postmortem manatees the right side of the postcranial body was demarcated into 20 regions, their areas measured and follicles counted. Total postcranial follicles were 1332 and 1499 per side, for a mean density of 0.32 hairs/4cm² in each case. Hair is twice as dense dorsally as ventrally. Tail hair density (0.30/4cm²) is comparable to that on the body, but density on the flipper (0.15/4cm²) is half that of the body. Hair length on the flipper is about half that of the remainder of the body (2-3 mm vs. 5-10 mm). The modified vibrissae of the perioral region and face all possess a ring sinus and upper and lower cavernous sinuses. Several deep vibrissal nerves enter basally and their axons ascend along the inner margin of the sinus, terminating at the level of the ring sinus. Postcranial follicles exhibit a range of attributes. Some have small ring sinuses and others have only trabeculated cavernous sinuses, but all have extensive innervation. This system may have evolved as an adaptation of large, slow moving marine herbivores living in turbid waters and lacking echolocation. Supported by University of Florida College of Veterinary Medicine.

A Data-logging GPS Tag for Sirenians (Jim Reid, Dean Easton, Russ Tucker, and David White). - Human activity in the coastal zone threatens the existence of the West Indian manatee (*Trichechus manatus*), an herbivorous aquatic mammal that inhabits the coastal waters, estuaries and freshwater rivers of the Caribbean and tropical Americas. Radio-tracking studies, using field-monitored VHF radio-transmitters and Argos satellite-monitored platform transmitter terminals, have addressed questions on seasonal movements, site fidelity, and identification of high-use areas. However, managers often require precise information on habitat use for site specific management policies. The application of the NAVSTAR Global Positioning System (GPS) shows promise for obtaining frequent and detailed location positions (< 10 m after differential correction) from tagged manatees. Findings can then be correlated with seagrass habitat maps, bathymetry, and other detailed map coverages for fine-grained analyses of habitat use. The Sirenia Project collaborated with Lotek Marine, Inc. in the development of a prototype GPS tag for manatees. An 8-channel GPS receiver, independent VHF tracking beacon, sensors and a computer/memory module were enclosed in a floating housing which attaches to a manatee using a belt and flexible tether. Schedules for GPS position fixes (as frequently as every five minutes) and duty cycling of the VHF beacon are programmed by the user. Although brief surface times can limit the use of GPS tags on marine mammals, location fixes can be obtained as quickly as 18 to 22 seconds. In tests on manatees, up to 95% of attempted location fixes were successful during one 24-hour deployment period. Four thousand position fixes, with pseudoranges for differential post-processing, can be acquired per deployment. The attachment method must allow for tag recovery in order to obtain data. This tag, best suited for brief, intensive tracking bouts, may be applicable for use on dugongs, the only other marine mammal routinely tracked using tethered floating tags.

Heat Conservation and its Vascular Circumvention at the Testes -- Convergence in Dolphins, Seals, and Manatees (Sentiel Rommel, Ann Pabst, and William McLellan). - Aquatic mammals must conserve thermal energy in order to maintain high core temperatures in a highly heat-conducting environment. Dolphins and seals have gross morphological adaptations that facilitate conservation of body heat (e.g., large size, modification of appendages, and blubber). Additionally, in their extremities they possess vascular plexuses that "trap" heat. Most mammalian tissues tolerate limited temperature fluctuations; sperm production and maturation are particularly susceptible to hyperthermic insult. As one consequence of their streamlined morphologies, dolphins and seals have testes that are ascrotal and may be subject to elevated temperatures. Dolphins and seals possess specialized vascular designs to cool these thermally sensitive tissues. Like dolphins and seals, Florida manatees are large and have modified appendages, blubber, and testes that are ascrotal. Manatees are extremely sensitive to hypothermic insult and tend to seek warm-water refugia when water temperatures approach 20°C. In their extremities, they possess vascular plexuses that have hundreds to thousands of juxtaposed arteries and veins. These arterio-venous plexuses function as "heat traps" that maximize

thermal energy conservation. However, in warm tropical waters, these plexuses could theoretically cause the testes and epididymides of actively swimming manatees to become overheated. In our study, we found vascular structures in the manatee that are functionally similar to those that prevent reproductive hyperthermic insult in dolphins and seals. Manatee epididymides, positioned in thin-walled hypogastric fossae of the caudo-lateral abdominal wall, are juxtaposed to plexuses that carry cooled venous blood from the skin. Our observations demonstrate that these phylogenetically diverse marine mammals all possess similar connections between superficial vascular beds and deep vascular plexuses associated with the testes and epididymides. That is, vascular shunts in parallel with heat traps are "mandatory" safety devices, preventing hyperthermic insult to reproductive tissues. These thermo-vascular "circumventions" are convergent morphological adaptations in three diving mammals.

Speed Kills...Efforts to Reduce Watercraft-related Manatee Mortality Through Enhanced Law Enforcement (Cameron Shaw). - Collisions with watercraft are the leading cause of human-related mortality to the West Indian manatee (*Trichechus manatus latirostris*) within the coastal waters of the southeastern United States (Wright et al. 1995). This mortality category has been increasing steadily and accounts for approximately 25 % of all known manatee mortality from 1974-1998. Recovery efforts of the West Indian manatee hinges largely on this important component of mortality. Zoning of manatee-occupied waters for reductions in boating activities and speed is essential to safeguard the manatee population. If boating regulations being implemented by the state of Florida in each of the 13 key coastal counties are completed, enforced, and effective, manatees and human recreation could coexist indefinitely. If regulation is unsuccessful, the Florida manatee population is likely to decline slowly toward extinction (Marmontel et al. 1997). The U.S. Fish & Wildlife Service has initiated an approach to this problem through coordination of law enforcement efforts focusing on manatee protection on a state-wide basis. This program involves all aspects of manatee/watercraft interaction; including outreach, interagency training and coordination, research and enforcement of manatee protection regulations. Since the inception of this program in 1997, a number of interesting patterns have evolved. Examples include the facts that approximately 66 % of the watercraft operators apprehended for violations of manatee speed zone violations were local residents, approximately 33 % of the violations involved personal watercraft and the average age of the operator in violation was 41 years of age.

Individually Distinct Vocalizations in West Indian Manatees. *Trichechus manatus manatus* (Renata S. de Sousa Lima, Adriano P. Paglia, and Gustavo A. B. da Fonseca). - Acoustics signals are assumed to form the basis of manatee communication, and some empirical evidence of individual vocal recognition has already been reported. Therefore, if manatees can recognize each other by acoustical means, it should be possible to identify individual vocal patterns. Vocalizations were recorded of 15 captive West Indian manatees, temporarily and individually housed. The vocalizations were digitally recorded and several variables measured. Five of these were subjected to multivariate statistical treatment. Principal Components Analysis (PCA) grouped the data indicating that some individuals could be distinguished on the basis of the variables related to the fundamental frequency of vocalizations (axis 1 of the PCA). We have also observed no significant difference in axis 1 between sexes, although a marginally significant difference between age classes was found when testing the pitch of the vocalizations (frequency of emission) and first axis of the PCA. An inverse relationship between body size (total body length) and the frequency of emission was verified. An inverse relation was also verified between body size and the range of the fundamental frequency, suggesting that the fundamental frequency is better defined as the animal grows old. This study reinforces the possibility of identifying individual manatees by their vocal patterns, hence making bioacoustics an useful tool for behavioral and social studies.

Manatee Entanglements in Fishing Gear and Plastic Debris (Ann C. Spellman). - Native to Florida's rivers, estuaries, and coastal waters, manatees share their habitat with a steadily increasing human population. Because manatees and both commercial and recreational fishermen use the same waterways, human pressures have likewise increased on an already stressed species. Entanglements in various types of fishing gear and other plastics are rapidly becoming one of the top reasons for manatee rescues. Rescue records from 1983 through April 1999 were examined for entanglements involving crab-pot lines, monofilament fishing line, or other plastic debris. Seventy-one entanglement rescues were documented during this period. Forty-six (64.8%) manatees were entangled in crab-pot lines, 13 (18.3%) in monofilament line, 5 (7.0%) in various types of nets, 3 in packing straps (4.2%), and 4 (5.6%) had ingested or been pierced by hooks. Two (2.8%) of the seventy-one manatees died from their wounds, and 9 (12.7%) lost a flipper either before being rescued, during the rescue, or afterwards by surgical amputation. Thirty-five (49.3%) were adult females, 12 (16.9%) were males, and 24 (33.8%) were of undetermined sex. Most of the manatees became entangled at the pectoral flipper area, supporting the theory that pregnant or nursing females may become entangled while rubbing against the lines to relieve their irritated teats (Beck and Lefebvre, 1995). Several animals showed evidence of previous entanglements (e.g. healed wounds). Although most reported entanglements involve crab-pots, the actual number of manatees that become entangled in monofilament may be larger than the data indicates. Crab-pot entanglements are highly visible, while monofilament is almost transparent in the water. Entanglement injuries may irritate the skin causing manatees to seek relief by rubbing against other lines, leading to possible further entanglement. Irritation from scar tissue may be similar to the sensation experienced by nursing or pregnant females, putting rehabilitated animals at risk, once released. This problem is being investigated.

Spring Distribution and Behavior of Antillean Manatees (*Trichechus manatus manatus*) in the Drowned Cayes, Belize (Caryn Self Sullivan, Jane M. Packard, and William E. Evans). - How do Antillean manatees (*Trichechus manatus manatus*) use offshore mangrove islands surrounded by seagrass beds along the Belize coast? Boat surveys (n = 71) were conducted in the Drowned Cayes between 1 February and 7 April 1999. Manatees were sighted in 82% of the surveys; 75 hours of effort resulted in 106 encounters and 209 sightings. Sighting probability varied among 9 survey zones (Kruskal-Wallis H = 25.299, P = 0.0014). Sites attractive to manatees included seagrass beds at the entrance to mangrove channels and secluded areas within the channels. Behavioral state was significantly related to substrate type (G squared = 100.61, P = 0.001). Manatees were more likely to feed in seagrass (z = 5.93) and to rest in muddy substrate (z = 4.77). No manatees were sighted in the coral reef zone, although previous researchers report sightings on the reef during the summer. During this ongoing study supported by a NSF Graduate Fellowship and the Oceanic Society, seasonal changes in distribution, activity, and vocalizations will be further examined.

The Manatee Rescue, Rehabilitation, and Release Program: An Overview (James A. Valade, Gregory Bossart, Kipp Frohlich, Lynn Lefebvre, Antonio A. Mignucci-Giannoni, Murphy, Pearson, Powell). - The U.S. Fish and Wildlife Service (Service) coordinates a manatee rescue, rehabilitation, and release program for Florida and Antillean manatees in the southeastern United States and Puerto Rico. After 1973, when the Endangered Species Act was passed, the Service began to coordinate the efforts of private institutions and government agencies involved in the rescue and treatment of this endangered species. Presently, the Service permits 18 private organizations and coordinates various Federal, state, and local government agencies to care for manatees in need of assistance. These participants verify the authenticity of reports of manatees in distress, rescue, treat, transport, provide follow up treatments, and eventually release manatees back into the wild, as appropriate. At present, there are 55 manatees in captivity. Included in this number are four "pre-Act" manatees whose captivity pre-dates the Endangered Species Act and are the property of their respective institutions. The captive population also includes 15 captive-born manatees, conceived in captivity prior to the adoption of Service guidelines that preclude captive breeding. The remaining animals include wild-born individuals brought into captivity as a result of illness or injury or because they were abandoned as calves. Manatees are brought into captivity when stressed by cold weather, when struck and injured by watercraft, when injured as a result of entanglement in crab traps and monofilament fishing line, when orphaned, and when compromised by other natural and manmade factors. Program veterinarians and animal keepers have developed treatments and protocols and have been remarkably successful in their efforts to rehabilitate these compromised individuals. Successfully treated individuals are returned to the wild in the vicinity of their rescue site. The successful treatment and return of healthy manatees to the wild and the attendant publicity that the program generates are pivotal to our efforts to recover the manatee.

The following abstract is of a poster presented at the 80th Annual Meeting of the American Society of Mammalogists, Durham, New Hampshire, 17-21 June 2000.

Underwater Communication Sounds of Florida Manatees (Thomas J. O'Shea, Michael S. Blouin, and Lynn B. Poché, Jr.). - We summarize findings from our studies of Florida manatee vocalizations. We recorded over 11,000 calls in the field on 94 days from 1980-1988, as well as 2,500 calls of captive manatees. Most recordings were made from the population of individually recognizable manatees that overwinter at Blue Spring. Simultaneous visual observations were attempted from shore and overhanging trees above the clear water of Blue Spring, and while following individuals by radiotelemetry in the surrounding black waters of the St. Johns River. Equipment included individually calibrated reel-to-reel tape recorders and U.S. Navy H-56 hydrophones with flat sensitivities through the range of frequencies emitted by manatees (frequency ranges of manatees were verified by simultaneous recordings with real-time recording oscilloscopes). Typical manatee vocalizations are faint, single syllable calls with complex harmonics and overtones. Frequency ranges vary from < 1 kHz to < 20 kHz, with most energy in the lower ranges (fundamental frequencies typically ranged 1.5 to 5 kHz). Calls vary in a number of features, and these are described and quantified based on time-frequency properties. Manatee sounds are graded communication signals used for maintaining contact and denoting basic motivational states (e.g., fear, alarm). Vocalizations are sometimes produced antiphonally, usually between females and nursing calves. Females and calves typically respond only to each other's calls, suggesting individual recognition by vocal cues. We performed statistical tests of hypotheses related to individual distinctiveness on a number of variables from the small subset of calls where context, source and individual identity were unambiguous. Some variables suggest distinctiveness among individuals, whereas other variables clearly vary by context. Our study did not reveal as complex an underwater sound communication system as is known for dugongs.

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SIRENIAN WEBSITE DIRECTORY

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Belize Coastal Zone Management Authority & Institute's Manatee Research Program:
<http://www.coastalzonebelize.org/pr_manatee.html>

The Call of the Siren (Caryn Self Sullivan): <<http://www.sirenian.org/caryn.html>>

Caribbean Environment Programme, Regional Management Plan for the West Indian Manatee: <<http://www.cep.unep.org/pubs/techreports/tr35/ct35indx.htm>>

Caribbean Stranding Network: <<http://netdial.caribe.net/~mignucci/>>

Columbus (Ohio) Zoo manatee exhibit, live camera: <<http://www.discovery.com/cams/manatee/manatee.html>>

Dugongs: <<http://home.t-online.de/home/rothauscher/dugong.htm>>

Florida Fish and Wildlife Conservation Commission, Bureau of Protected Species Management: <<http://www.state.fl.us/fwc/psm/>>

Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute (Florida manatee mortality data): <<http://www.fmri.usf.edu>>

Jacksonville University (Florida) Manatee Research Center Online:
<www.ju.edu/juconnect/research/marco>

Manatee neuroanatomy: <<http://www.neurophys.wisc.edu/Manatee/>>

"Manatee Watchers" Internet discussion list: <<http://www.listbot.com/archive/MANATEE>>

News clippings on Florida manatees: <<http://www.n-jcenter.com/menus/enmanate.htm>>

Philippines Dugong Research and Conservation Project: <<http://www.wwf-phil.com.ph>>

Save the Manatee Club: <<http://www.savethemanatee.org>>

Sea World of Florida: <<http://www.seaworld.org>>

Sirenews (texts of current and recent issues): <<http://pegasus.cc.ucf.edu/~smm/>>

Sirenia Project, U.S. Geological Survey: <<http://www.fcsc.usgs.gov/sirenia>> or <<http://www.nfrcg.gov/sirenia>>

Sirenian International, Inc.: <<http://www.sirenian.org/>>

Smithsonian Institution sirenian bibliography: <<http://www.si.edu/resource/faq/nmnh/sirenia.htm>> [This is a relatively short bibliography, compiled by Joy Gold, that provides a very good introduction to both the technical and the popular literature.]

Steller's sea cow: <<http://www.online.de/home/Rothauscher/steller.htm>>; also the website [in Finnish] of Dr. Ari Lampinen, University of Jyvaskyla, Finland: <<http://www.jyu.fi/~ala/ilmasto/steller.htm>>

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