Historical Perspectives

Daryl P. Domning

(14 March 1947)

Daryl Domning's scientific work has been mostly devoted to fossil sirenians and their relatives, the extinct desmostylians, starting with his Berkeley dissertation on the evolution of Steller's sea cow. Following the two-year interlude with manatees in Brazil described here, he moved to Howard University in Washington, DC, where he remains a Professor of Anatomy in the medical school and a Research Associate at the Smithsonian's Museum of Natural History. From 1994 to 2004, he led a National Geographic-supported field project in Jamaica that unearthed the most complete skeletal remains of a four-legged, fully amphibious Eocene sirenian. Other paleontological fieldwork has taken him to Puerto Rico. Mexico. Venezuela. Austria, France, and Libya. While pursuing fossil sea cows across the globe, he has also remained involved with the conservation of the living sirenians, serving at various times as an advisor to the International Union for Conservation of Nature (IUCN), the U.S. Marine Mammal Commission, the State of Florida's Manatee Technical Advisory Council, the Save the Manatee Club, and Sirenian International, Inc. He founded the IUCN newsletter Sirenews and edited it for its first 21 years. He also created the bibliography of the Sirenia and Desmostylia now available online at http://sirenian.org/biblio. Daryl now lives near Washington, DC, with his wife, Kathy, and teenage daughter, Charlotte.



Daryl Domning (Photo courtesy of Jorge Velez-Juarbe)

The Early Years of the Amazonian Manatee Project at INPA, Manaus, Brazil

Daryl P. Domning

Department of Anatomy, Howard University, Washington, DC, USA E-mail: ddomning@howard.edu

Having been born in Biloxi on the Mississippi Gulf Coast (14 March 1947), I was exposed to aquatic life from the start. My interest in biology grew from picking up bones on the beaches, and later carcasses and roadkill in the countryside, which I collected in a private museum and assembled into mounted skeletons during my high school days. But my deeper interest (nourished by dinosaur books) was in paleontology, even though no significant fossil deposits were near at hand. This focus has remained with me throughout my career.

My undergraduate training was in geology and biology at Tulane University in nearby New Orleans. Here, I developed an interest in sirenians-again from reading, specifically A. S. Romer's (1945) textbook Vertebrate Paleontology, which depicted the skeleton of the extinct sirenian Halitherium. This was such an odd-looking creature that it piqued my curiosity, though in those days I'd never seen an actual sirenian except for "Snooty," the lone captive manatee at the South Florida Museum in Bradenton (who is still there and, at about a year younger than me, the oldest sirenian in captivity). Nor had I any sirenian fossils to work with, save some rib and other bone fragments picked up in Florida. So, with some spare time on my hands in the middle of my junior year of college in January 1967, I figured I could at least start my study of these animals by compiling an exhaustive bibliography of the Sirenia (and their extinct relatives the Desmostylia), hopefully before midterm exams(!). How naïve that notion was became clear only gradually: the product was not published for some 30 years (Domning, 1996)!

In 1968, I moved to the University of California at Berkeley to do a master's degree and Ph.D. in Paleontology (finishing in 1975). There I was finally able to study some decent sirenian fossils, many of which had already accumulated in the university's museum and constituted a perfect thesis project just waiting for someone like me. Those specimens, and ones that I and others subsequently collected, made possible a very satisfying study of North Pacific sirenian evolution and the origin of Steller's sea cow (*Hydrodamalis gigas*) (Domning, 1978a). And then it was time to find a job.

As far back as the fall of 1974, I had made the acquaintance of Diana Magor, a Canadian who had

begun a manatee research project in the Brazilian Amazon. Together with several leading sirenian researchers, we had both attended a workshop in La Jolla sponsored by the United Nations Food and Agriculture Organization (UN FAO) in December of that year. (I had gotten wind of this meeting; called up Bob Brownell, one of the organizers; and gotten myself invited at the last minute.) Diana and the other participants actively working with live manatees and dugongs reported on their doings and the conservation status of the species they studied. She returned to Brazil, but we met again in June, and in December at the First Annual Conference on Marine Mammals held at UC Santa Cruz. At that time, she was the world's only "authority" on the biology and status of the Amazonian manatee, and I missed no opportunity to pick her brain for information I could apply to problems of sirenian evolution.

That meeting in Santa Cruz produced one moment of enlightenment that I still vividly recall. I had gone one evening to the room that Diana shared with Sandra Peterson, who had written a literature-based master's thesis on manatees. We were all going to dinner, and before setting out, the talk had naturally turned to manatees. I happened to ask Diana what manatees in the Amazon ate, and I was thunderstruck by her simple answer: "Grass." At that time, our knowledge of sirenian natural history was still so faulty that even so basic a fact could not be found clearly stated in the published literature, at least the English-language literature. It was also news to me that the dominant aquatic vegetation in most of the Amazonian waterways consisted of thick meadows of floating grasses-true grasses that, like terrestrial grasses, contained hard silica phytoliths. Instantly, I saw that this source of heavy tooth abrasion in their diet explained why manatees had evolved their peculiar mode of tooth renewal, wherein the teeth are continually replaced from behind as they move forward and drop out at the front. This idea, which I subsequently developed at length in several papers, proved to be central to understanding manatee evolutionary history.

Equally exciting, I also learned from Diana in the course of our contacts that there was a possibility of employment on her manatee project. The situation there (as it eventually emerged) was this, though the full political ramifications did not become apparent until long after I had arrived in Brazil. Diana (Figure 1) had been an undergraduate and lab technician with Dr. Keith Ronald at the University of Guelph, where she got experience with captive seals and other marine mammals. Once, while on vacation in South America, she learned about Amazonian manatees and conceived the idea of studying them in the Amazonian wilds. Never lacking for initiative or resourcefulness, and assisted by her boyfriend Jim Lovisek, she subsequently acquired funds from the Canadian International Development Agency, returned to the Amazon, ransomed a manatee calf that had been harpooned by a hunter, and set about nursing it back to health in a hotel bathtub in Leticia, Colombia. That was in August 1973.



Figure 1. Diana Magor with assistants, nursing Amazonian manatee calf "Pretinha," Manaus, Brazil, 5 August 1976

Since proper research facilities were not available in Leticia, she soon began looking about for greener pastures and found them a few hundred miles downriver in Manaus, Brazil. There she talked her way into some space and modest support for a manatee research project at the National Institute of Amazonian Research (INPA), whose director was the noted bee geneticist Warwick E. Kerr (the same individual from whose laboratory in southern Brazil the infamous killer bees had escaped many years before). So Diana, Jim, and the manatee "Butterball" duly relocated to Manaus.

By July 1974, they had acquired another orphaned manatee calf, and then several others over the next couple of years. By dint of devoted labor and guesswork as to what care and feeding a baby manatee needed, they managed to save the first two of their wards (a notable and perhaps unprecedented feat for that time), though their subsequent attempts failed. Meanwhile, they traveled about the Amazon basin as opportunity permitted, interviewing fishermen and hunters and gathering odd bones and bits of manatee lore. Jim eventually moved on, but Diana obtained other assistants and persuaded a Canadian foreign aid agency to buy her some plastic swimming pools for the manatees. INPA was then in an expansion phase, so her attempts to scrounge material assistance of various sorts met with some success, and she even persuaded Kerr to add some salaried personnel to her project.

One obstacle, however, was harder to overcome. INPA insisted that the formal head of a research project hold a doctorate, and Diana had only a bachelor's degree. That was where I came in. As a newly minted Ph.D. with a strong research interest in sirenians, both fossil and living, I was a suitable candidate for the titular leadership of the manatee project; my degree would give the project the needed academic legitimacy in the eyes of the Brazilian government. And it was an undreamt-of chance for me to make the acquaintance of some of the creatures I'd been reading about for most of a decade.

Diana encouraged me to apply to Kerr for the job; in January 1976 came the offer of a two-year contract. Diana, of course, wanted to keep the real decisionmaking power in her own hands, and I was happy to agree since I had no interest in being an administrator anyway, even on a small project. For me, the scheme's entire appeal lay in the opportunity to work with the animals.

My contract with the Brazilian National Research Council or CNPq (of which INPA was a part) was to begin in June 1976, so I had plenty to do. In anticipation of this opportunity I had begun auditing Portuguese 1 at Berkeley the previous October, and I continued with the course for the entire year. The grounding it gave me in grammar and vocabulary later proved invaluable; unlike those who joined the project later and had to start learning the language from scratch in Brazil, I was able to speak (and write the necessary official memos) with something approaching grammatical and orthographic accuracy (though fluency, of course, developed only after some time in-country).

The spring was spent in preparations for the move. I also got an early start on work with live Amazonian manatees by running a series of feeding experiments with the one, also named "Butterball," in San Francisco's Steinhart Aquarium. This study exemplified my aim in most of the subsequent work I did with extant sirenians, which was to learn things that could be applied to interpreting their fossils. For example, while in graduate school, I had spent a summer at the Smithsonian in Washington, dissecting and describing the muscles of a dugong (*Dugong dugon*) to provide background information for identifying the muscle attachments on my fossil bones.

In my dissertation, I had also developed the idea that the degree of downward deflection of a sirenian's snout indicated its degree of adaptation for bottom feeding, an idea consistent with the North Pacific paleontological and paleoecological data. But it seemed advisable to test my hypothesis that there was a selective (probably energetic) advantage to sirenians in keeping the body axis as horizontal as possible and in adjusting the deflection of the rostrum according to where in the water column their food was predominantly located. Manatees offered a chance for an experimental test since the Amazonian species (Trichechus inunguis) had a less-downturned snout than the West Indian manatee (T. manatus); and as the hypothesis predicted, the former's habitat provided mainly floating vegetation, while the latter (at least in Florida) had access to food items throughout the water column, from floating water hyacinth to submerged Hydrilla to benthic seagrasses. Would this apparent morphological adaptation also be reflected in a behavioral preference? I built a ladder-like frame to which heads of lettuce (or other food) were attached, lowered it into a manatee's tank, and recorded to which of the several possible feeding depths the animal first gravitated. This simple procedure was, I believe, the first quantitative behavioral experiment ever conducted on sirenians (Domning, 1980).

On my way to Brazil, I spent some days at home on the Gulf Coast, then stopped at the Miami Seaquarium for a few more days to continue these experiments on their Florida manatees. At last came the late-night flight to Manaus. I was met there by Nigel Smith whose acquaintance I had made not many months before when he was finishing his Ph.D. in Geography at Berkeley. He was already an old Amazon hand, having done his fieldwork along the infamous Transamazon Highway.

The drive to INPA, through the delightfully humid night air, was exhilarating. At about 0500 h on 1 July 1976, I was deposited in one of the guest apartments on campus. My first day featured tours of the facilities and introductions-to Dr. Kerr; to Barbara Robertson, who looked after the manatee project in Diana's absence; and others. I dined with Nigel and his wife, Lisa, who subsequently steered me through my acclimation to Brazil: learning to get to and from town, opening a bank account, and seeing some of the local sights. We observed the U.S. Bicentennial on 4 July with a swim in the flooded forest at Praia Dourada on the Rio Negro, a cold coconut from a roadside stand, and a visit to the Tarumá waterfalls that Louis Agassiz had described in the previous century. Such falls are sacred sites to practitioners of macumba (related to voodoo), who had left numerous burnt-out votive candles on the banks.

I soon settled into my work on the Projeto Peixe-Boi or Manatee Project (peixe-boi or "ox-fish" is the usual Portuguese term for manatee). I rearranged the collection of manatee bones and modified the drain on the largest manatee tank to better trap teeth shed by the animals (on which more later). The monograph I had written on dugong myology had been accepted by the Smithsonian Press (Domning, 1977), and I had galley proofs to read. I also took over from Barbara supervising the Brazilian assistants who fed the manatees and dealing with minor crises such as the accidental defrosting of a freezer full of manatee carcasses (a frequent occurrence, I was to learn). I continued my behavioral experiments on our two captive animals, "Butterball" and "Boo."

Diana Magor arrived in the wee hours of 15 July, and it was my turn to do the honors at the airport. (The once-weekly Varig flight from Miami was an overnighter to Rio de Janeiro with intermediate stops in Caracas and Manaus, and likewise for the northbound return flight; hence, all U.S. arrivals and departures occurred in the depths of the night.) Diana's arrival brought a quickening of the pace. But first, an overview of INPA is in order.

The institute occupied a beautiful and spacious campus on the edge of the city, with numerous modern buildings scattered through dense secondgrowth tropical forest. Monkeys, agoutis, storks, and other creatures roamed at will. Over a hundred researchers like myself, from Brazil and abroad, and many more Brazilian staff, manned laboratories devoted to botany, ecology, entomology, fish and fisheries, tropical medicine, and several other disciplines. Support facilities included a library with an excellent collection of rare Amazoniana, a modern herbarium, a motor pool, and a cantina; off-site facilities included a couple of forest reserves and a floating fuel dock on the river (the Rio Negro, a few miles above its confluence with the Amazon). Buses and taxis passing the front gate offered transport into town. Manaus at that time was a city of some 400,000 people, the urban center of the Amazon region.

Our manatee project was administratively a part of Fish and Fisheries, headed by Dr. Wolfgang Junk, a German limnologist and my immediate boss. He was one of a sizable contingent from the Max-Planck-Institut of limnology in Plön, Germany. Junk, in turn, reported to Kerr. Dr. Kerr was a tall, cherubic-looking fellow of considerable charm and admirable openness with Brazilians and foreigners alike (see Figure 9). He was respected by all for his reputed courage and honesty. He had been a wellknown university professor in São Paulo and had been imprisoned a couple of times by the military government for his vocal opposition to the torture of political prisoners. Eventually, General Geisel became President, and during his regime (which included my stay in Brazil), there was a bit of a thaw in the political climate. One sign of this, in the view of veteran observers, was the fact that a liberal like Kerr was given such a visible and prestigious job as the directorship of INPA. I came to have great respect for Kerr; he was a leader who sincerely looked out for the welfare of his employees and effectively fought our battles with CNPq. Although, of course, he could never please everyone or grant all requests, and there was no lack of griping in the ranks about working conditions of all sorts, every INPA veteran I have since spoken to has agreed that Kerr's administration was the golden age of INPA.

Reports up this chain of command from my level usually seemed to take the form of complaints about non-availability of water, electricity, powdered milk (for baby manatees), or other resources that had failed to materialize when needed. The long-suffering Dr. Kerr did his best to provide, and somehow we muddled through. Actually, for the first six months I was there, INPA was quite flush, with a budget in the neighborhood of US\$12 million. If we wanted a new refrigerator, dehumidifier, or outboard motor, we had only to write out a requisition and (lo!) it would shortly appear.

After six months, however, the bottom dropped out of the Brazilian economy and INPA's budget. The procedure then changed. Each year, I, as project director, would prepare an elaborate budget detailing how many million cruzeiros were needed for the manatee project in the coming year. This document was ritually sent up the line but served no further practical function. At some point, long after the start of the fiscal year, INPA would receive from CNPg an allocation of funds. Each division and project was in turn allocated its budget, but this was largely a fiction. In practice, when you were told your budget was overspent in some category, you went to the fiscal officer, a chap named Ricardo, and pounded on his desk. He then (provided you were sufficiently convincing) took the funds you so desperately needed from someone else's theoretical budget. Heaven knows how it all worked out.

Some things were in shorter supply than others. We had a large pool of vehicles, boats, outboard motors, and people to operate them, but the year's allocation of gasoline was typically used up in a few months. Clean water to refill the manatee tanks (we had no filtration systems for them) was also scarce at first, but this eventually improved to the point that we could depend on being able to change the water completely once or twice a week. After a day or so, the water was again an opaque brown, but the manatees didn't seem to mind the additional privacy.

The manatee project occupied an office and lab in a building called the Biotério, which also housed the experimental animals used by other departments. It surrounded a small courtyard populated by some tortoises and a tank of young caimans. Across the road and a few yards into the bushes were located our two large plastic swimming pools (the larger one being 6 m in diameter and 1.5 m deep), separated by a thatch-roofed working platform with a traveling chain hoist overhead (Figure 2). Later, another large pool and several smaller tanks were added. Several times a week our technicians would (gas permitting) take a jeep off into the boondocks and harvest a supply of grass and aquatic plants to feed the manatees. They also took care of draining and cleaning the tanks and routinely weighing and measuring the animals.



Figure 2. Manatee pools and tanks at INPA, Manaus, July 1978

The manatee tanks' accessibility to anyone wandering the grounds made them a magnet for visitors, ranging from INPA employees on their lunch breaks to foreign heads of state. This was something of a nuisance to us (and the tanks tended to accumulate pebbles thrown by the mischievous), but at least it gave our project high visibility, and we benefited from being one of Kerr's showpieces.

In August, I moved from the guest apartment on campus to an INPA-subsidized apartment a couple of miles closer to town. This was unfurnished but long on space, with four rooms, a kitchen, 1¹/₂ baths, and myself as sole occupant (though it often served as a flophouse for visitors working on our project). Thanks to INPA, it cost me less than \$50 a month, but it overlooked an extremely noisy street with barking dogs, screeching brakes of buses, and unlimited dust. The back rooms were relatively quiet, however, and its second-floor location and single entrance made it effectively burglar-proof, unlike the habitations of many of my friends.

Amazonian habitations generally didn't have water heaters; hot showers were provided by a plug-in attachment to the showerhead that heated the water right at the nozzle and looked like a first cousin to an electric chair. I was not sorry that my new lodgings lacked one of these monsters; the climate was warm enough that cold showers were preferable to the seeming threat of electrocution.

Manaus was the third city in the world to have electric street lighting, thanks to a wood-fired steam generator that reputedly functioned into the 1940s. The turn-of-the-century rubber boom was the source of its prosperity, and it left a legacy of elegant but run-down mansions and public buildings. When I arrived, a few yards of one downtown sidewalk were still paved with bricks of natural rubber, but even those were removed before I left, in the course of converting that street into a pedestrian mall full of electronics shops. The city's recent designation as a zona franca or duty-free zone had given it modest new life as a mecca for shoppers from the big southern cities, who otherwise disdained Manaus as the moldy and provincial place it was and viewed Amazonia in general as the Siberia of Brazil.

I, however, enjoyed it, at least when I wasn't trying to do anything that required first-world technology or efficiency. The famous opera house, the Teatro Amazonas, was newly and beautifully refurbished, and the waterfront featured such relics as a public market designed by Gustave Eiffel; a river-powered turbine generator (no longer working for lack of spare parts); and a huge floating dock built decades before by the British, where the seagoing ships tied up, 1,200 km from the ocean. With the 12-m annual rise and fall of the river, the canoes and other small river craft that plied the Amazonian interior shifted seasonally between beaching themselves on the fetid mudflats and mooring at the very edge of the riverfront street. The latter, which overlooked the dry-season mudflats from atop a massive retaining wall, was itself submerged in peak flood years. The scene was always lively and colorful.

Diana Magor's return on 15 July brought a flurry of administrative chores and policy meetings, including sketching out grandiose plans for a new building and manatee facility, but also my first excursions into manatee habitat.

One of these took us up the Rio Negro, guided by an old fisherman named Sidoca, an INPA employee and walking encyclopedia on Amazonian fish and fisheries. He knew of an even older fellow, an outstanding manatee hunter whom Diana wanted to interview. Crossing the mile-wide Rio Negro in our aluminum skiff, we cruised up the west bank, cutting across patches of flooded forest ($igap\delta$) and through beautiful little *paranás* or waterways edged by bromeliadclad, half-submerged trees and occasional thatchroofed houses. Late afternoon brought us to Paraná Ariaú—a magnificent vista of wilderness in which river dolphins, egrets, and hawks sported to the accompaniment of howler monkeys hidden in the forest depths.

Past sunset, we groped our way by flashlight to an airy house built on huge floating logs, the home of Cristovão Francisco Soares and his family. Cristovão, a sturdy and genial 76-year-old, welcomed us and regaled us until midnight (and the end of my recorder tape) with tales of the 1,939 manatees he claimed to have killed in a career of nearly 40 years (Figure 3). Next morning, he and Sidoca were again talking manatees before Diana and I even crawled out of our hammocks, and we went on pumping him for information until after noon. Such veteran hunters were a mine of natural history lore, and interviews of this sort were a major focus of our project at that time.



Figure 3. Diana Magor interviewing manatee hunter Cristovão Francisco Soares, Paraná Ariaú, Rio Negro, Brazil, 20 August 1976

I was also becoming acquainted with an established custom of well-to-do Amazonian citizens who assembled private collections of wildlife on their farms or even in their city backyards. These collections, whose value as status symbols was not diminished by their illegality, often included manatee calves purchased at considerable sums from fishermen, who accidentally netted them or caught them after harpooning their mothers. Rather than have such animals confiscated, we generally tried to keep open our lines of communication with the owners and persuade them that this was not an environmentally correct practice. We usually got possession of the manatees eventually, after they died of malnutrition or sometimes even before.

One guy had two of these calves languishing in a small concrete pool behind his house. The yard was a menagerie of caged birds, tortoises, and cutias roaming about as well as other luckless creatures. We managed to talk him into "loaning" us the smaller and weaker of the manatees, which we succeeded in rehabilitating, as recounted below, and kept for the remainder of its short life. He called one morning a few months later to report that the other one also looked sick (i.e., sicker than usual), and he wanted us to nurse it back to health for him, too. We kept it for about 10 days, but it finally died as was usually the fate of these young, unweaned calves. He wasn't happy over losing his two "pets," but he got little sympathy from us.

In late July, I'd been invited to attend a UN conference in Bergen, Norway. This gave me my first experience in attempting to escape from Brazil, which was no simple matter for a Brazilian citizen or a government employee like myself. An exit visa was required, and getting this treasured document from the Federal Police involved a veritable scavenger hunt for other official bits of paper and rubber stamps from other agencies-for example, an atestado de antecedentes or certificate that I wasn't wanted for any reason by the local police. (Among the expatriates, it was considered a good idea to always have a currently valid exit visa in case of emergencies since it took at least a couple of days to get one; but the visas were only good for six months, so this entailed a semiannual chore. I was conscientious about keeping mine current, and thereby became a resident expert on the procedure.) At least I, with my twoyear work visa, was better off than Brazilians or government-employed foreigners with indefinite contracts, who, in addition to the exit visa, needed to post a bond of 12,000 cruzeiros before leaving the country. This was supposed to be a currencydrain remedy, designed to discourage all but the wealthiest Brazilians from traveling and spending money abroad. (When I arrived, a U.S. dollar was worth about 10 cruzeiros and had climbed to 18 cruzeiros by the time I left.)

On this occasion, the getting of my own exit visa was the least of my problems for it coincided with the inauspicious August day of Diana's departure for the same meeting in Norway. This day (a vivid example of what life at the Projeto Peixe-Boi could be like) began for me when I relieved her on sick-manatee watch at 0230 h, after three hours of sleep. (Our patient was the second of the two calves that had been kept in the backyard pool mentioned above; his erstwhile owner had given him the name "Negão" or "Blackie.") I passed the remaining time until breakfast dissecting a frozen manatee, in search of a suitable vein for blood sampling (a procedure which up until then we had not mastered). Diana wanted blood samples to take north for analysis. After breakfast and a trip downtown for my visa, I sparked the day's first major excitement by noticing a stamp on Diana's plane ticket requiring her to have an exit visa. This proved to be a mistake by an airline clerk, but it was good for an hour and a half of scrambling on Diana's part to straighten it out, and it delayed the afternoon's scheduled feature (the blood sampling) until nearly dark. Meanwhile, there was a stream of supplies and visitors to be received and a sick animal to be nursed.

Dusk found us jabbing needles into struggling manatees by flashlight, with our usual lack of success at drawing useful amounts of blood. Next came the tornado of Diana's packing, while two assistants and I were kept busy taking bacteriological samples, drawing graphs, and extracting data from her notebooks. Twenty-five minutes before final check-in time at the airport (0110 h), we were at last ready to leave when she remembered a need for a fecal sample from the sick calf. We found him belly-up and himself apparently about to depart-doubly ominous since I had planned to try a fancy embalming job on him if he expired, and I didn't want to contemplate this task amid the present chaos and fatigue. Hoping for the best, we detailed an assistant (who had been on overtime since 1800 h) to keep watch while we dashed for the airport.

Not far from INPA, we passed a cluster of lighted macumba candles by the roadside, which moved Diana to comment that that might be the cause of our manatee's crisis. Soon we noticed that the jeep's headlights were also no longer working. Onward through the night we roared, with the driver flashing the turn signals to illuminate the road, arriving alive at the airport barely in time to get Diana checked in. Only then did she recall the manatee harpoon she had sworn to bring Sandra Peterson for an exhibit at the meeting! Fortunately, the plane from Rio had not yet arrived, so I roared back through the night to INPA and sent the harpoon and driver back to the airport (in another jeep, with lights).

Negão was still alive, so I bedded him down in blankets on the lab floor so he wouldn't have to struggle to the surface to breathe, and I prepared to bed myself down beside him. At this point (*ca.* 0300 h), the driver and harpoon returned, reporting that Diana had already boarded the plane but that takeoff was being delayed by fog. I fled this waking nightmare and crashed. The nightmare, however, would not end. I was awakened at 0630 h by Diana. The plane was still grounded until 1630 h. Negão, surprisingly, showed improvement, and some remission of his constipation, so after feeding him we both turned in; I until noon.

The afternoon was a replay of the day before, juggling the arrival of new equipment and building contractors who wanted to clear the forest prematurely for our not-yet-approved new building, more data collation for Diana's report, more fecal samples, and more visitors. At 1500 h, we at last tore off, with the harpoon, for another 100 km/h jeep ride to the airport and Diana's finally successful departure.

That night, little Negão was much improved, consuming milk and plants. Like most calves, especially sick or malnourished ones, he tended to float in a down-by-the-head posture and had a hard time breathing. As an experiment, I fastened a weight belt to his tail, which improved his trim and comfort tremendously. He weathered this crisis and was successfully weaned, eventually making significant contributions to our research program before his accidental death almost two years later.

After a few days, I was off to the airport again, having gotten clearance from the Brazilian authorities for my own trip to Bergen. My way was bureaucratically smoothed by INPA's not paying me a salary for the two weeks involved, though Dr. Kerr, with his usual solicitude for his people, promised to find a way (dar um jeito, in the ubiquitous Portuguese phrasing) to sneak me the money eventually. The trip was a delightful one, occasioned by a UN FAO conference on marine mammals, and embellished by a tour of the local fjords. The plenary sessions were conducted in genuine UN style, with headphones and simultaneous translations, and the Lord Mayor gave a reception in the 13th-century royal banquet hall for the 200 or so delegates. The final session featured an ethologist's enlightening analysis (patterned after analyses of behavior in seal rookeries) of the behavior of mammalogists at the convention: for example, vocalizations indicating mild submissiveness ("Yes, Mr. Chairman") or more profound submissiveness ("I fully concur with the excellent suggestion of the Chairman"), and a strongly skewed sex ratio with the more numerous males tending to cluster around the few females at certain kinds of aggregations ("receptions"), etc.

Most of the world's active sirenian researchers were present, and I valued the opportunity to meet those individuals, such as George Heinsohn, whom I had not met previously. One evening, the Greenpeace folks showed a film of one of their attempts to disrupt the Soviet whaling operations. The Soviet delegation attended, and I heard later that one of them, Alexei Yablokov, joined Greenpeace and bought one of their buttons! Yablokov was a fine fellow and a leading Russian scientist and environmentalist, who many years later served in the Congress of Peoples' Deputies under Gorbachev's government and was an environmental advisor to Yeltsin. He was certainly no proponent of commercial whaling; I once heard him confide, in conspiratorial tones, that there was a population of gray whales in the Sea of Okhotsk that the whalers didn't know about!

Another of the Soviet delegates was A.A. Berzin, an expert on sperm whales who in 1963 had reported a sighting of what he thought were live Steller's sea cows in the Bering Sea. This report was later ridiculed by another prominent Soviet biologist as a misidentification of some female narwhals; it was not generally believed, although it did raise people's curiosity as to the possibility of the species' survival after 200 years of supposed extinction. All the same, the word was out that Berzin was touchy on the subject, and it wasn't a good idea to mention Steller's sea cows to him! Though I placed no stock in his report either, when the time came to say something about it in the conference documents, I argued for a statement to the effect that the question could easily be settled once and for all by a simple aerial survey (if the Soviet military would ever permit such a thing!) since Steller's sea cows should be highly conspicuous from the air. Some of my colleagues were irked that I wanted to give even this much recognition to the Soviet report.

Some of the Bergen restaurants served whale meat (listed on the menu under "Fish"), and quite a few of the conference delegates ordered it. For some days, I righteously avoided doing so, but toward the end of the conference, I was running short of cash. And, at about US\$5, it was the cheapest dinner on the menu (and very good by the way).

At last I had to return to Brazil, by way of Miami, where I stayed with Dan Odell, met his then-graduate student John Reynolds, and saw John's manatee study area at Blue Lagoon next to the airport. We lured some of his animals to our canoe by playing some manatee noises at them, and we observed the carcass of one of their hapless comrades floating below the floodgate that generally kept them confined in the lagoon. At that time, the South Florida flood-control structures were still a major source of manatee mortality, a problem later partly solved by modifications to the operating procedures for the floodgates.

Mid-September 1976 found me back at INPA, followed a few days later by Diana. Her arrival coincided with another manatee crisis, this time the death of a tiny female calf called "Pretinha" (another Brazilian rendition of "Blackie") that was being kept in a fenced-off corner of a pond on someone's ranch near the INPA campus (Figure 4). We obtained her mortal remains, which helped to fill our third freezer-full of dead manatees. Pretinha eventually gained posthumous fame of sorts as the star, in serially sectioned form, of my study of manatee hydrostasis and ballast distribution (Domning & de Buffrénil, 1991).



Figure 4. Daryl Domning with manatee calf "Pretinha," Manaus, Brazil, 5 August 1976

In mid-October, the manatee project reached a major turning point with the arrival of another Canadian participant, Robin C. Best, whom Diana had recruited from Guelph. Robin was a tall, good-looking rugby player and intercollegiate rowing champion. He'd just finished his M.A. on polar bear nutrition, had experience in the capture and transport of beluga whales, and possessed much animal-care experience gained at the Vancouver Zoo where his father was director. He brought to INPA some much-needed knowledge of animal nutrition and physiology, and he quickly turned around the project's long losing streak in its struggle to rehabilitate orphaned manatee calves. Robin also brought boundless energy and an intensely competitive spirit to his research.

He quickly became, and remained throughout my time at INPA, the manatee project's real driving force.

The following weeks kept Robin and me busy with cleaning tanks and other chores, while Diana made river trips to collect manatee-ecology data. Friction soon developed, however, over her methods and her somewhat disorganized ways. She also had developed problems with the INPA administration by failing to make any formal report on her activities during the two years she worked there. Diana collected masses of undigested data, but organizing them on paper didn't suit her temperament, and report writing took a back seat to any other chore whatsoever. INPA had begun badgering her with ultimata; the latest threat was no more field trips until the report appeared. (The scramble to assemble a report for the Bergen conference was an earlier phase of this continuing saga.)

I hadn't anticipated any opportunities for paleontological work in Brazil, but not long after my arrival, Dr. Kerr asked me to undertake a collecting trip to the State of Acre in far western Amazonia. Vertebrate fossils had been collected there since the turn of the century, most notably by a 1956 expedition that included the noted paleontologist George Gaylord Simpson. On that ill-starred trip, while a campsite was being cleared, a tree fell on Simpson's leg and fractured it. During the time it took to evacuate him in those pre-jet days, he had to be given so much morphine for the pain that he developed an addiction and took years to recover.

More recent reports of giant fossil tortoises and other bones, seen somewhere up the rivers of the interior, had reached the rector of the university in Rio Branco, the capital of Acre. He had asked his friend Kerr for a paleontologist to come and collect some of these marvelous things for his institution. By chance, Kerr had just acquired a paleontologist, me. But preparations dragged, and I didn't arrive in Rio Branco until well into November, which put us into the start of the rainy season.

Nevertheless, I flew on to Cruzeiro do Sul on the Rio Juruá and arranged a reconnaissance by boat to the fossil-producing area farther up the river. On our way upriver, we often passed *boutos* and *tucuxís* (*Inia* and *Sotalia*). Manatees, however, were never common, the narrow Juruá having little in the way of aquatic vegetation to feed them this far upstream (the last one seen, in fact, had gotten trapped in a deep spot by receding waters and starved to death).

The river itself, though, was delightful, winding through dense forest broken frequently by farms, with thatched houses of farmers, fishermen, and rubber tappers at every turn. They lived a simple life, without electricity or plumbing, and they hunted deer, peccary, tapir, armadillo, and other game to supplement their basic diet of sawdustlike *farinha* (manioc flour). Modernity intruded, however, in the form of ubiquitous battery-powered radios, tape recorders, and stereos.

We passed an uninhabited place called Grajauzinho, reputedly the spot where Simpson broke his leg in 1956. Even 20 years later, it was a long way from any medical help. There were still a number of people in the region who remembered that expedition, and someone commented to me that their field party would have been better off staying with people along the river as we were doing rather than pitching camp in the forest. Almost any guide one might hire would have friends or relatives in nearly every riverside settlement (as did my guide and our motorista). One can always count on the hospitality of folks in the interior.

Due to the rising river, our six-day voyage yielded few fossils, but I got a sense of what would be needed for a return trip the following year. Back in Cruzeiro do Sul, awaiting the weekly plane out, I busied myself collecting samples of manatee food plants, interviewing people about manatee distribution and hunting, and laying plans for the next year's fieldwork. I also exercised my Portuguese in composing a report on the expedition and a set of recommendations for future work. Here, I pulled no punches: I stated very bluntly that the notion (expressed to me by the university rector) of a museum in Rio Branco would have to be backed by a serious commitment of funds to ongoing fieldwork, curation of collections, and research. I pointed out that in the U.S., as well as in Brazil, it was common for local pride to spawn so-called "museums" for display of hometown fossils, which eventually languished for want of support. If the proper commitment from the university was not forthcoming, it was preferable that all specimens collected should go to one of the established natural history museums elsewhere in Brazil.

When I returned to Manaus, Diana was still away on a trip up the Rio Negro, but her expedition had reportedly been more exciting than mine. The boat's cook got drunk and went after the captain with a knife; he was flown back to Manaus in handcuffs—hardly the sort of publicity the manatee project needed. Our five manatees, however, were waxing fat and happy under Robin's care.

Diana returned from the field in early December 1976 amid a cloud of recriminations about who did what on the Rio Negro trip; but in Manaus, she found herself in an even worse pickle. By this time, she was provisionally enrolled as a Master's student at UC Santa Cruz and had committed herself to spending six months of each year there. However, Diana's credit had about run out at both INPA and UC Santa Cruz: if she didn't produce an acceptable progress report on her past two years' work within the next six months, she stood every chance of being dumped by both institutions. Robin and I tried to give her constructive suggestions but to no avail. On 15 December, she returned to Santa Cruz.

Robin and I lost no time in returning to our manatee work. The Scripps oceanographic R/V Alpha Helix was in the area with a shipload of hematologists studying blood chemistry of whatever Amazonian animals they could lay hands on. We still had not mastered the technique of bleeding our manatees and keeping the blood in liquid form for sufficient time to analyze it. So, in his typical hard-charging fashion, Robin arranged to carry two of our manatee calves by boat out to where the Alpha Helix was anchored on the Amazon, tens of miles from Manaus, to do the sampling right there on deck. Thus, the samples would be fresh. This frontal assault on the problem actually succeeded; and in the fullness of time, it bore fruit in a jointly authored paper on manatee hemoglobin (Farmer et al., 1979).

My other efforts at that time included marking manatees' bones and teeth with tetracycline antibiotics in order to measure growth rates and develop a means of age determination. This too eventually paid off in a short paper, the first to report successful application of this technique to sirenians (Domning & Myrick, 1981). I was also at work on a draft chapter I'd been asked to write for a book on fossil mammals of Africa—a request that caught me off-guard in the Amazon, far from much of the relevant literature. Nevertheless, I eventually managed to put together an acceptable summary of the African sirenian record (Domning, 1978c).

Since Robin arrived, he and I had adopted the strategy of looking for short, simple research projects we could conduct and publish quickly to give the project some much-needed credibility and a track record that we could parlay into external funding. A key element of this strategy was enthusiastic opportunism: we eagerly latched on to any visiting foreign researchers who wandered near the INPA campus with fancy equipment, and we persuaded them to try it out on our long-suffering manatees. The hemoglobin venture with the Alpha Helix was a good example of this technique. Another such chance appeared one night while I was waiting for a friend to clear customs at the Manaus airport. I noticed another American, a bearded, middle-aged chap, who was having some difficulty with a large amount of excess baggage. I offered my assistance and learned that he was Ted Bullock, a neurophysiologist from La Jolla who was bound for a stint at INPA to study electric fish. His crates of electronic gear immediately set me

scheming. I gave him a sirenian sales pitch along with a ride to his destination. Soon Robin had him ready to go to work with us, and poor little Negão was lying on a lab table with his head stuck full of electrodes, repaying us for his months of care and feeding. This quickie study of auditory-evoked potentials resulted in yet another short paper (Bullock et al., 1980). This project indirectly led Ted to follow up with a similar paper some years later on Florida manatees, in collaboration with workers there (Bullock et al., 1982).

I next went to work dissecting manatees, having planned a detailed study of manatee muscles as a sequel to my Smithsonian monograph on the muscular system of the dugong. In comparison with all the INPA researchers trying to do fieldwork, I was lucky to have a stay-at-home project to keep me busy now that the fiscal bubble had burst and gasoline rationing had been instituted. My dissections would also help clean out our freezers and reduce the number of half-thawed carcasses that would have to be hastily moved the next time one broke down! In the end, this study not only described the manatee's entire myology but also revealed that manatees have a unique jaw apparatus dominated (unlike dugongs and most other herbivores) by the temporalis muscle, with an extra jaw joint between the pterygoid process and the mandible (Domning, 1978b).

The series of manatee feeding experiments I began in San Francisco were still in progress. Again, these were designed to test my idea that the degree of downturning of a sirenian's snout was an adaptation to where in the water column it fed. In contrast to the sharply deflected snout of the bottom-feeding dugong, the rostrum of the Amazonian manatee's skull was downturned only slightly. I thought this might be reflected in a preference for feeding near the surface. From the first moments of my first trial with the Steinhart Aquarium's Butterball, however, I knew there was a flaw in that argument; he showed the strongest possible preference for dining at the bottom of his tank. Replicate trials with other animals at INPA, and Florida manatees in Miami, confirmed this pattern, and I eventually had to conclude that preference had nothing to do with it-all sirenians seemed to like bottom-feeding if given a choice. In my publication of these results (Domning, 1980), I suggested instead that, druthers aside, rostral deflection was adapted to where in the water column the animals were forced to feed in their natural habitats. In the Amazon, for example, there were few if any submerged plants, and most of the aquatic vegetation—those floating grasses—rode on the surface of the seasonally rising and falling waters; hence, the relatively straight snouts of the manatees.

One of our more comical research efforts was an attempt to determine whether Amazonian manatees echolocate. Some German bat-sonar experts, including Dr. Ule Schnitzler, were in town doing their thing, and we enlisted them and their equipment to record manatee vocalizations. We then devised a set of plywood obstacles painted black, hung them in a pool on a dark night, and prodded an unwilling manatee into trying to navigate the obstacle course without bumping into them. From its inability to do this, we surmised that echolocation was not part of its bag of tricks.

Much longer running and in the end far more successful, though even less high-tech, was my study of tooth shedding. Manatees continue to produce new teeth as long as they live, and these are continuously shed from the fronts of the convevor-like tooth rows. Diana had been, before my arrival, the first person ever to find teeth shed by a captive manatee, a discovery made during regular cleaning of the tanks. I saw to it that the search for teeth became intensive rather than casual. For this purpose, the necessity of draining and cleaning the tanks by hand every week proved providential; and whenever possible, I personally waded into the muck and searched the tank bottom for the centimeter-long teeth. No doubt I was quite a spectacle, ankle-deep in manatee manure (Figure 5); our Brazilian assistants were not accustomed to seeing Ph.D. researchers getting their hands and feet dirty to that degree. During and after my stay in Manaus, the project managed to collect dozens of teeth from several manatees. With the help of Smithsonian statistician Lee-Ann Hayek, I was able to correlate the rate of tooth replacement with dietary intake; we published a paper that I consider one of my best and most original-and certainly the hardest for anyone else to ever duplicate (Domning & Hayek, 1984).



Figure 5. Daryl Domning searching for shed manatee teeth in partly drained pool at INPA, Manaus, 1977

Among our other pioneering studies was Robin's attempt to determine the passage rate of manatee gut contents. He fed some dye to one of our young calves, and we set up an hour-by-hour watch to see when it emerged at the other end. After a couple of days without result, Robin had to leave on a field trip, so I took over the round-theclock surveillance. When he returned one morning about a week later, he found me still camped out on the laboratory floor—and still nothing to report. Years later, other investigators confirmed that our technique was not at fault: manatee passage rates are indeed that long.

Another visiting researcher was Dr. David Piggins, an optometrist from Canada invited down by Robin to do a study of our manatees' eyesight (Piggins et al., 1983). There was also Dr. John Sprent, an Australian parasitologist whom I invited to sample nematodes from our collection of manatee gut contents. Later, he thanked me by naming a new species from the West African manatee, *Heterocheilus domningi* Sprent, 1983. He first took the precaution of asking my permission since he'd learned that not everyone feels honored to be the namesake of a parasite. I assured him that this name was highly appropriate since the worm and I had something important in common: a strong attachment to manatees.

A major event in early July 1977 was the arrival of Jim Gallivan, a former fellow student of Robin's from Guelph whom he'd invited down to help him study manatee respiration and metabolism. Jim was a compactly built, red-bearded fellow, and a talented physiologist. During the several months he worked with us, he was instrumental in the design and execution of some of the manatee project's most sophisticated and successful studies (Gallivan et al., 1983, 1986; Gallivan & Best, 1986; and earlier papers) (Figure 6). Yet one more physiology study attests to the amount and diversity of data our project collected in those early years, the potential of which has even today not been exhausted. Robin rigged up a canvas sling with a hole in the bottom, in which a manatee could be suspended over a graduated cylinder to collect urine for analysis (Figure 7). Unfortunately, Robin never lived to publish the results; however, they were dug from the project's files and used in a paper as recently as 2010 (Pantoja et al., 2010).

The end of August approached and plans for the second Acre expedition were revived. Although I had found the results of the first excursion disappointing, the university rector in Rio Branco had been sufficiently impressed that he was enthusiastic to continue the project. So, off I went again to Acre. Better equipped and provisioned this year, we finally shoved off from Cruzeiro do Sul on 27 September, hopeful of beating the rainy season. On our way up the Juruá, we managed to find a fair number of fossils, though the river was beginning to rise in fits and starts. We went to the Peruvian border, the limit of our planned travels, and then turned back downriver, collecting more bones as we went. Although many of the outcrops were still accessible, others were now submerged, and it was clear that, as in the year before, delays in starting the trip had once again cut measurably into the results produced.

Cruising downstream one afternoon, we spotted the fresh carcass of a *bouto*, or pink river dolphin (*Inia*), caught on a snag mid-river. I instantly ordered the boat run on shore, and, taking the end of a line with me, I swam out to the still-airtight carcass, secured it, and maneuvered it to the beach. After taking measurements and photos, I severed the head and wrapped it well in several plastic bags, placing it atop our boat's cabin for the four-day ride home. Thus sporting an increasingly aromatic dolphin head on our superstructure, we returned to Cruzeiro on 11 October. We crated our loot for shipment to Rio Branco—10 boxes



Figure 6. Jim Gallivan conducting respiratory measurements on an Amazonian manatee calf (inside covered tank at left), Manatee Project Laboratory, INPA, Manaus, 20 February 1978; the large plexiglass spirometer was custom-fabricated at INPA for this study.



Figure 7. Robin Best collecting urine from Amazonian manatee, INPA, Manaus, January 1978

of bones weighing 235 kg—and awaited air transport. After a couple of days, a plane came along that was headed for Manaus, so my discreetly packaged *bouto* head and I seized that opportunity for a shortcut home.

This modestly successful and very enjoyable two-week excursion proved to have far-reaching effects. The university rector was most impressed with the bones delivered to Rio Branco, which formed the nucleus of their new museum. They took my recommendations of the previous year more seriously than I ever expected and actually established a permanent paleontological research facility with an ongoing field program. On my recommendation, two of my Brazilian field companions received training down south in Porto Alegre under the leading Brazilian vertebrate paleontologist: one, Arito Rosas, Jr., as a fossil preparator, and the other, Alceu Rancy, who earned a master's degree (and subsequently a Ph.D. at the University of Florida). Both returned to work at the museum in Rio Branco. I am proud to have had a hand in their careers and in stimulating the growth of this indigenous center of vertebrate paleontological research.

I returned without mishap to Manaus—though the porter at the airport couldn't refrain from pointing out that something in my luggage was spoiled—and quickly set the dolphin head to macerating in a bucket of water out in the woods near the manatee tanks. (Pellets later recovered from the bottom of the bucket showed that the cause of death was acute lead poisoning, doubtless inflicted by some fisherman resentful of cetacean competition.)

The lab routine resumed—maintaining manatee tanks, looking for teeth, embalming and dissecting dead manatees, and experimenting with freeze-branding of live ones. Robin and Jim were running a variety of physiological experiments. I was busy doing drawings for my monograph on manatee myology.

I also undertook some applied research in biochemical warfare. Some months before, the fellow in the apartment downstairs from mine had acquired a stray puppy, which he installed in the courtyard below my bedroom window. It was very cute but in the habit of making noise at unpredictable hours. As it grew, so did its output of waste, which its owner was not prompt in removing. It also learned the trick of endlessly slamming the patio door against its frame to attract the attention of its none-too-attentive master—though this rarely worked. Complaints to the dog's owner did no good, so the door kept slamming, the food dish kept rattling, the smells kept worsening, and I began seeking ways to retaliate.

There then intervened my trip to Acre, whence I returned with that exceedingly ripe *bouto* head. Now, as many readers of this journal know, nothing in Christendom smells worse than a decomposing dolphin, and this gave me an idea. I filled a jar with the contents of the bouto bucket. Early one Sunday morning, after several days' accumulation of dog excreta and uneaten food (and a laterunning party downstairs the previous evening), I seasoned the courtyard's contents with a few ccs of the secret formula and left for the day. When I returned 12 hours later, the patio was clean and smelled only of pine oil. Over the ensuing week, as the dog odors repeatedly built up to noticeable levels, I judiciously enhanced them several more times, whereupon the dog permanently disappeared-his uncongenial owner never suspecting that the poor beast had not been the sole culprit.

Dr. Junk, the head of Fish and Fisheries, finally wrote to Diana in December 1977, informing her that her association with the *peixe-boi* project was officially terminated, but still she made no reply. An absurd rumor even circulated that the Federal Police wanted her for allegedly killing some unconscionable number of manatees and skipping the country! It was also reported (and this may have been the origin of the rumor) that fishermen up the Rio Negro were brandishing her business card as a license for hunting manatees and claiming falsely that they were collecting specimens at her bidding.

The first months of 1978 passed less eventfully, though one morning in January stands out in my memory. Two fellows approached us offering to sell yet another baby manatee. I set out with them downriver to inspect it. The exhilaration of the canoe ride down the broad Amazon, with a 40-hp motor driving us into a glorious sunrise, more than made up for the early hour of our departure. Five hours out we came to Costa da Conceição, a homestead on the north bank above Itacoatiara. Directly opposite lay Ilha da Trinidade and our quarry.

The luckless little creature's story was typical of its genre. He had been netted nearby the previous May; his mother had escaped. A smaller calf, a female, had been caught under similar circumstances a few days later but had died after a couple of months, doubtless being too young to survive without milk. Since then, the male had been kept in one or another pond left on the island by the receding river waters, which he shared with the usual piranhas. These, however, had done no more than relieve the manatee of part of a digit of one flipper, long since healed. Of greater concern was his nutritional status. Forcibly weaned from his mother well before he should have been, and fed by his captors on nothing but a few water hyacinths every couple of weeks, he measured less than 1.2 m in length (not the 1.4 m advertised) and weighed less than 20 kg. On account of his small size and thinness, I offered them 1,400 cruzeiros in place of the 2,000 or so they wanted, and the deal was made. (Since they caught him illegally in the first place, I wasn't inclined to be generous.) At least the poor beast gained a chance at survival; cushioned and wetted, he lay quietly throughout the boat ride back to INPA. Sadly, he did not prosper under our care and died within two months.

By the end of February, I'd finished my manuscript on manatee muscles—only to be told that INPA was willing to publish it only in Portuguese. This was a major nuisance because it entailed seeking another outlet for English-language publication, not to mention the hassles involved in overseeing and editing a Portuguese translation of this highly technical manuscript, for which there was little foreseeable demand in any case (for either the translation or the monograph itself!). This was all due to a spasm of nationalism on the part of some government bureaucrat.

The Ides of March found all INPA, and especially the British expat community, aflutter over a state visit by Charles, Prince of Wales. This occasion had its uses in that it finally brought action on our long-ignored request for renovation of the boardwalks around our manatee pools. The event came off smoothly. After the official reception in Kerr's office, HRH paid a quick call on our newly spotless manatee facility and watched Butterball being measured. Robin introduced our visitor to a three-toed sloth and offered to let him hold it; but Charles, in his cream-colored suit, hastily declined, saying "No! It'll cling to me!" He and his entourage then proceeded down the road to the ichthyology section's fish tanks, where he stayed considerably longer, being reputedly keen on fishing. All told, I don't think he was at INPA an hour. I believe I got to talk to him longer (in my role as peixe-boi master of ceremonies) than anyone else save Dr. Kerr. Seemed like a nice chap.

A few days later, I was off to the States on a multipurpose trip—mainly to interview for a job in Washington, DC, and attend a manatee conference in Florida. The itinerary was complicated and the reservations had been hard to get (and not all were confirmed). I had to stop in Panama City, Panama, and did not know until the moment of reboarding whether I would escape from that Bermuda Triangle of air travel without getting bumped like so many other passengers who'd been stranded. Fortunately, the flight had room to spare for me and my worms. (I was carrying a styrofoam box full of giant Amazonian earthworms, entrusted to me by Robin for delivery to an American researcher who would meet the plane in Miami. I breezed through customs as soon as the lady inspector was told what the box contained.)

After safely delivering the worms, I went on to Washington for my job interview in the Department of Anatomy at Howard University. This was encouraging, and I spent some time at the Smithsonian with my longtime colleague and mentor Clayton Ray. One particularly gratifying piece of information I collected concerned the discovery of fossil seagrasses in the Eocene of Florida. This tidbit confirmed a prediction I had made a couple of years before: namely, that the existence of sirenians in Florida at that time indicated the presence of seagrasses, even though the evidence from foraminifers suggested otherwise.

The array of sirenian fossils waiting to be studied and the many stimulating people to be found in Washington made the thought of leaving Brazil more and more attractive. My two-year stay at INPA was beginning to seem just about right. Although I had the option of renewing my contract, I'd done most of what I'd planned to do there (and more) and could foresee the beginnings of stagnation if I stayed longer.

After my visit to DC, it was on to Orlando, Florida, where I attended a three-day manatee workshop and moderated the session on research needs. After visiting with Dan Odell in Miami, I returned to Manaus, where wildlife biologist Gene Montgomery had joined Robin in preparing to radio-tag and release one of our manatees. Soon, they were out on the river following the beast's signal through the floating meadows. This was the first successful radio-tracking of any sirenian in the wild, I believe. This pilot project was a notable first for our laboratory (Montgomery et al., 1981). Also that spring, John Kanwisher came from Woods Hole to work with Robin and Jim Gallivan on manatee heart-rate telemetry.

On 12 April, there came a job offer from Howard—an assistant professorship at \$20,000 a year, starting in July. Given the difficulty of finding academic jobs in those days, especially for someone living abroad, this was an offer not to be sneezed at. I accepted with alacrity and began planning my final three months in Brazil. Simultaneously, there came another piece of welcome news: the Brazilian Army (!) had agreed to allow INPA to publish my manatee muscle monograph in English rather than Portuguese (Domning, 1978b). This I owed to Dr. Kerr, who had convinced the military authorities running the government that my research was of so little significance to national security that it could safely be permitted to appear in a foreign language!

I had one more major goal in Brazil—to conduct an interview survey of the region around the mouth of the Amazon in order to determine whether the Amazonian and West Indian species of manatees had overlapping ranges. This was of theoretical interest because this was the only possible place on the planet where any two species of sirenian might coexist in one habitat, providing an opportunity to study how such species might ecologically interact. With the countdown to my departure now running, I decided to devote the month of May to a field trip to Belém and its environs.

I flew to Belém at the end of April and established my base of operations at the venerable Museu Goeldi, a natural history museum then under INPA's administration. Their collection of skulls provided useful data on the distribution of manatees in the region, as well as an enlarged sample for an eventual in-depth review of manatee taxonomy (Domning & Hayek, 1986). While enjoying an apartment on museum grounds, I was also able to do some needed library work for a historical analysis of manatee exploitation (Domning, 1982a). The Museu Goeldi occupies a charming island of tropical forest in the midst of urban Belém, which also houses a zoo (including a manatee) and is a thoroughly delightful place for researchers of all sorts to stay. Bill Overal, an entomologist, was most helpful in acquainting me

with the city and museum, and he also helped me arrange a boat trip into the vast Amazon delta.

After a week in the city, Bill deposited me on the dock late one night, and I boarded the *Diplomata do Marajó*, a sturdy cargo sloop that made regular runs over to Ilha de Marajó, the Switzerland-sized island that plugs the mouth of the Amazon. She was 12 or 15 m long and 60 years old; boasted a gaff mainsail and a 37-hp engine; and on this voyage carried some 16 men, women, and children besides me. I slung my hammock below and turned in. We shoved off right on schedule at midnight; by 0700 h, we were on Marajó, headed up the Rio Ararí.

Marajó is cattle country. We passed through miles of flat alluvial pasture, and more miles of marsh with nothing human in sight. We stopped at one ranch, Fazenda São Joaquim, where the owner had a captive manatee in a large pond. I laid plans to return again in a week or two and made arrangements for the manatee to be recaptured at that time so I could find out what species it represented. We anchored for the night in Lago Ararí and were underway again well before dawn. Turning eastward through a long canal leading to the Rio Tartaruga, we came at length to the Atlantic coast and headed northward under sail and power. With nothing but Africa to starboard, we were still in fresh water, thanks to the Amazon's enormous discharge.

In the course of the voyage, I was able to interview several of the passengers and crew, as well as residents of settlements where we put in, concerning manatees. Our skipper, Sr. Pedro Dantas da Silva, also supplied some information and advice on who had killed manatees recently and where I might be able to find some bones. In general, though, my informants were more enthusiastic over the idea of going out and killing one themselves so I could get the bones I wanted (and they, incidentally of course, the meat)—an idea I did not encourage!

The following afternoon we entered *Canal Perigoso* (Dangerous Channel), where fittingly enough the starboard tiller rope soon parted; but this hardly provided a diversion, much less a danger. At about 1400 h, we crossed the Equator under canvas, northbound, in roughly 49° 50' west longitude—my first crossing of the Line by sea and a few minutes later we landed at the settlement on Ilha Caviana.

This beautiful fazenda boasted a well-kept airstrip, ponds of fish and turtles, and a sizable collection of skulls of game animals (though no manatees). A few minutes farther up the coast was Pedro's handsome two-story house, where I stayed for several days with him and his wife. This was a good chance to interview several of his neighbors (some of whom had hunted manatees) and to collect manatee food plants. I also got to see a platform used by harpooners and a type of fence-like trap or *cambua* that accounted for most of the manatee captures in this region. At length, we met the owner of the *cambua*, who still had the skulls of two recently killed manatees. Finally, I was able to collect some definitive data on which species occurred hereabouts: these were Amazonian manatees, not West Indian ones. Even here on the Atlantic coast, we were zoologically, as well as botanically and hydrologically, still in the Amazon basin.

These sparsely populated coasts and islands were unspoiled and beautiful—covered in places with dense forest growing down into the water; and elsewhere bordered by enormous meadows, and fringed with aquatic plants that were submerged and fed on by manatees at high tide. Veining the shorelines were small *igarapés* or tidal creeks full of mudskippers, amusing little fish that skimmed across the water like animated hydrofoils when frightened. Birds and monkeys enlivened the trees, and occasional hogs and cattle added a domesticated note to this peaceable kingdom.

This was as far as Pedro and his Diplomata would take me; but his brother-in-law had a smaller cargo boat, the Correio, that was northbound for Macapá, the chief city on the north side of the Amazon's mouths. We soon took our departure from Caviana, laden with pigs, people, and the frame of an ancient treadle-powered sewing machine (one of the most ubiquitous items in Amazonian river trade). By the next afternoon, our 10-hp main propulsion system was nudging us across the Amazon's northern mouth at four or five knots as we rolled in the troughs of one- to two-foot seas-much to the discomfort of the passengers sharing the hold with the pigs. The latter were theoretically confined to the rear of the hold by a couple of loose boards; but as these shifted with each roll, the human-pig frontier remained somewhat fluid for most of the voyage. I preferred the fresh air of the deck. Soon we arrived off Macapá and anchored under the guns of the 18th-century French fort.

After lunch, I tracked down a captive manatee, which we had tried to acquire for INPA the previous year, in the hope that it might represent the West Indian species. She lived in a small, muddy, weed-choked pond in a vacant suburban lot, where she had been for most of a decade, calmly munching the grass her keeper brought her daily. She seemed healthy except for two wicked, partly healed gashes on her head, which had almost obliterated one eye. These were the result of a recent attempt on her life by a machete-wielding neighbor. The poor beast was now officially government property, and plans were to move her someday to a park with better security. Meanwhile, I secured permission to capture and examine her.

After a couple of days of negotiating and arranging, I rounded up two fishermen and a net, and we set about stalking our quarry. The manatee was quite tame and would stick her head well out of the water to be fed by hand. While her keeper distracted her in this fashion, my men tried to slip the net into the water behind her. Alas, she took instant umbrage at this violation of fair play, and she immediately retreated into her opaque element. The pond, we then realized, was larger than we thought, and so full of old tires, logs, and sticks that the net could not be handled effectively. After three hours of playing the Three Stooges to the stealthy beast, we left the field in ignominious defeat.

The next day, I took the local air taxi up the coast to the fishing village of Amapá to continue my interviews. The townsfolk were friendly, and I managed to get information from several residents. But no bones were to be had, nor did it seem possible to arrange transport down to the coast or offshore islands where such might be obtained. After two nights, I flew back to Macapá.

Seven the next morning found me once more at the manatee pool, ready for one last attempt. This time I dispensed with fishermen and nets, having resolved to regain my honor in single, handto-flipper combat. For an hour or so, the keeper tempted the now-suspicious beast to the edge with offerings of fresh grass. Finally, she was in range. Sneaking up on her blind side, I tackled her and blocked her path of retreat. Each grabbing a flipper, the keeper and I landed her after a brief struggle, and she lay calmly on the ground, accepting our conquest philosophically. She too proved to be of the Amazonian species as far as I could tell from the outside in those pre-DNA days; and after the usual measurements, we restored her to her pond with what little remained of her trust in humans.

I returned to Belém and was soon outbound again to Marajó, this time aboard a cargo vessel of landing-craft configuration. A day's voyage retracing my previous route brought us once more to Fazenda São Joaquim, where I had a rendezvous with the owner's pet manatee. Sr. Liberato Castro, owner of the manatee, ranch, and cargo boat, was just returning from an all-day horseback tour of his 28,000-hectare spread, and I was made welcome in his spacious and comfortable centuryold house.

The next morning I laid siege to the manatee with the aid of four men and a net—and no greater success than in the first Amapá campaign. The lake was an elongated, shallow borrow pit alongside Sr. Liberato's private airstrip. Though simple in shape and unencumbered by brush, it covered two or three hectares and was wider and deeper than our net, and a day's worth (less six hours' respite from the midday heat) of desultory net-sweeps up and down its length yielded not so much as a glimpse of the alleged manatee. There was also a *bouto* in the lake, and even it was hard to spot.

On the second day, the search continued, this time with two fewer men and equally disappointing results. The third day dawned under a heavy overcast. I was gaining a new appreciation of the problems involved in finding the Loch Ness monster. This time, we were reinforced with additional helpers and an extra net, which we joined to the first one so that it reached across the entire lake. This did the trick, and soon we had the manatee entangled and beached—together with about half of a buffalo skeleton and assorted other junk from the bottom. This one, too, turned out to be a female Amazonian manatee (Figure 8), rather thin and underfed, but furnishing one more data point for my survey.



Figure 8. Amazonian manatee kept captive at Fazenda São Joaquim, Ilha Marajó, Brazil, 26 May 1978; the ranch owner, Sr. Liberato Castro, is at right.

Back in Belém, I began another excursion, this time with Bill Overal by road to the coastal zone south of the Amazon's mouth. Over a couple of days, we did some *peixe-boi* interviews and collected a few fossils, but I was unable to determine which manatee species lived in the region. Thus, I set off once more by bus to the Rio Mearím, a day's drive south of Belém, to see if I could at least make that determination for Maranhão, the next state to the south.

In the village of Vitória do Mearím, I was assured that manatees were hunted a few hours upriver, so I chartered a launch for a three-day trip. There was certainly ample aquatic vegetation for manatees to eat, and we had to fight our way through most of it to get upstream through weed-choked channels and oxbow lakes. *Peixeboi* data were sparse and inconclusive, but at last I met a fellow who told of a manatee he helped kill some years before. Without prompting, he then volunteered the information that manatees have five digits on their flippers, "just like a Christian," with a nail on each digit. The latter feature is characteristic of the West Indian manatee, so at last I had, if not a specimen, at least some credible testimony to indicate that species' presence on the Amazonian coast.

Having secured all the usable data I could in the time available—it was now well into June—I returned to Belém. There, I examined another Amazonian manatee in a city park, as well as one more in private hands, which the owner hoped to sell to the Museu Goeldi.

This last one set an unenviable record for occupying the worst marine-mammal holding facility I ever hope to see. In a waterfront favela (slum), near a bar and just behind a blacksmith shop, stood a huge rectangular concrete tank at least 4 m deep. It was roofed over with lumber, iron girders, and other junk; two large valves at the bottom could let in water at high tide. Fortunately, it was low tide. The owner ordered the tank drained at once so I could inspect his prize, which had been netted by a fisherman a couple of months before. I climbed down into the tank by an iron ladder, and to my horror, found myself in calf-deep mud filled with jagged rocks and scrap iron. Miraculously, the manatee had not eviscerated himself while thrashing about in the receding water. Also luckily, he was small and thin enough for me to handle unaided, and I was able to get some measurements on him in addition to identifying him as Amazonian. I recommended better feed and housing for the poor creature, but never heard more of his fate. At least he provided one more data point for my survey of manatee distribution (Domning, 1981), which pointed to parapatry of the two species near the Amazon's mouths.

Back at INPA, I was quickly absorbed in chores. Soon, INPA was again descended upon by royalty, in this case Crown Prince (subsequently Emperor) Akihito of Japan (Figure 9). Since marine biology runs in his family, we knew we could count on seeing him at the *peixe-boi* project, but he spent even less time manatee-viewing than had Prince Charles. Like the latter, he hastened down the road to the ichthyology department. Royals (N = 2) seem to prefer fish for some reason.

Finally, my days in Brazil were ended. While those days brought their share of aggravations and frustrations, they were also exciting and very



Figure 9. Daryl Domning showing manatees to Crown Prince Akihito, INPA, Manaus, 25 June 1978; INPA Director Dr. Warwick Kerr is at right.

productive. Although I was content to be leaving, I wouldn't have missed the experience for the world. It served me in place of a postdoctoral appointment, and it provided data that took me years to digest: the last major piece of it was not published for 13 years (Domning & de Buffrénil, 1991). Most importantly for my purposes, I had acquired knowledge of South American manatees that was critical to an interpretation of their evolutionary history (Domning, 1982b, 1997).

The Projeto Peixe-Boi's future obviously lay in the direction of neobiology and conservation, and that was a task for others. I left the project in the capable hands of Robin Best, who expanded both its physical facilities and its research agenda to include river dolphins and giant otters. After his untimely death from leukemia in 1986, I was gratified to see it (now as INPA's Laboratory of Aquatic Mammals) taken over and continued by Brazilian scientists, including Dr. Fernando Rosas and Robin's widow, Dr. Vera da Silva. Long may it prosper!

Literature Cited

- Bullock, T. H., Domning, D. P., & Best, R. C. (1980). Evoked brain potentials demonstrate hearing in a manatee (*Trichechus inunguis*). Journal of Mammalogy, 61(1), 130-133. http://dx.doi.org/10.2307/1379969
- Bullock, T. H., O'Shea, T. J., & McClune, M. C. (1982). Auditory evoked potentials in the West Indian manatee (Sirenia: *Trichechus manatus*). *Journal of Comparative Physiology*, 148A(4),547-554. http://dx.doi.org/10.1007/ BF00619792
- Domning, D. P. (1977). Observations on the myology of Dugong dugon (Müller). Smithsonian Contributions to Zoology, 226, 1-57. http://dx.doi.org/10.5479/si. 00810282.226
- Domning, D. P. (1978a). Sirenian evolution in the North Pacific Ocean. University of California Publications in Geological Sciences, 118, xi + 176.

- Domning, D. P. (1978b). The myology of the Amazonian manatee, *Trichechus inunguis* (Natterer) (Mammalia: Sirenia). Acta Amazônica, 8(2), Supplement 1, 1-81.
- Domning, D. P. (1978c). Sirenia. In V. J. Maglio & H. B. S. Cooke (Eds.), *Evolution of African mammals* (pp. 573-581). Cambridge, MA: Harvard University Press.
- Domning, D. P. (1980). Feeding position preference in manatees (*Trichechus*). Journal of Mammalogy, 61(3), 544-547. http://dx.doi.org/10.2307/1379851
- Domning, D. P. (1981). Distribution and status of manatees *Trichechus* spp. near the mouth of the Amazon River, Brazil. *Biological Conservation*, 19(2), 85-97. http:// dx.doi.org/10.1016/0006-3207(81)90044-6
- Domning, D. P. (1982a). Commercial exploitation of manatees *Trichechus* in Brazil c. 1785-1973. *Biological Conservation*, 22(2), 101-126. http://dx.doi. org/10.1016/0006-3207(82)90009-X
- Domning, D. P. (1982b). Evolution of manatees: A speculative history. *Journal of Paleontology*, 56(3), 599-619.
- Domning, D. P. (1996). Bibliography and index of the Sirenia and Desmostylia. *Smithsonian Contributions* to Paleobiology, 80, iii + 611. Updated online version: http://sirenian.org/biblio.
- Domning, D. P. (1997). Sirenia. In R. F. Kay, R. H. Madden, R. L. Cifelli, & J. J. Flynn (Eds.), Vertebrate paleontology in the neotropics: The Miocene fauna of La Venta, Colombia (pp. 383-391). Washington, DC, & London: Smithsonian Institution Press.
- Domning, D. P., & de Buffrénil, V. (1991). Hydrostasis in the Sirenia: Quantitative data and functional interpretations. *Marine Mammal Science*, 7(4), 331-368. http:// dx.doi.org/10.1111/j.1748-7692.1991.tb00111.x
- Domning, D. P., & Hayek, L. C. (1984). Horizontal tooth replacement in the Amazonian manatee (*Trichechus inunguis*). *Mammalia*, 48(1), 105-127. http://dx.doi.org/ 10.1515/mamm.1984.48.1.105
- Domning, D. P., & Hayek. L. C. (1986). Interspecific and intraspecific morphological variation in manatees (Sirenia: *Trichechus). Marine Mammal Science*, 2(2), 87-144. http:// dx.doi.org/10.1111/j.1748-7692.1986.tb00034.x
- Domning, D. P., & Myrick, A. C., Jr. (1980). Tetracycline marking and the possible layering rate of bone in a manatee (*Trichechus inunguis*). In W. F. Perrin & A. C. Myrick, Jr. (Eds.), Age determination of toothed whales and sirenians. Report of the International Whaling Commission, (Special Issue No. 3), 203-207.
- Farmer, M., Weber, R., Bonaventura, J., Best, R. C., & Domning, D. P. (1979). Functional properties of hemoglobin and whole blood in an aquatic mammal, the Amazonian manatee (*Trichechus inunguis*). *Comparative Biochemistry & Physiology*, 62A, 231-238.
- Gallivan, G. J., & Best, R. C. (1986). The influence of feeding and fasting on the metabolic rate and ventilation of the Amazonian manatee (*Trichechus inunguis*). *Physiological Zoology*, 59(5), 552-557. http://dx.doi. org/10.1007/BF01101104
- Gallivan, G. J., Best, R. C., & Kanwisher, J. W. (1983). Temperature regulation in the Amazonian manatee

Trichechus inunguis. Physiological Zoology, 56(2), 255-262.

- Gallivan, G. J., Kanwisher, J. W., & Best, R. C. (1986). Heart rates and gas exchange in the Amazonian manatee (*Trichechus inunguis*) in relation to diving. *Journal of Comparative Physiology B*, 156(3), 415-423.
- Montgomery, G. G., Best, R. C., & Yamakoshi, M. (1981). A radio-tracking study of the Amazonian manatee *Trichechus inunguis* (Mammalia: Sirenia). *Biotropica*, 13(2), 81-85. http://dx.doi.org/10.2307/2387708
- Pantoja, T. M. A., Rosas, F. C. W., da Silva, V. M. F., & dos Santos, A. M. F. (2010). Urinary parameters of *Trichechus inunguis* (Mammalia, Sirenia): Reference values for the Amazonian manatee. *Brazilian Journal* of Biology, 70(3), 607-615. http://dx.doi.org/10.1590/ S1519-69842010000300018
- Piggins, D., Muntz, W. R. A., & Best, R. C. (1983). Physical and morphological aspects of the eye of the manatee *Trichechus inunguis* Natterer 1883: (Sirenia: mammalia [sic]). *Marine Behavior and Physiology*, 9(2), 111-129. http://dx.doi.org/10.1080/10236248309378588
- Romer, A. S. (1945). *Vertebrate paleontology* (2nd ed.). Chicago: University of Chicago Press.
- Sprent, J. F. A. (1983). Ascaridoid nematodes of sirenians— A new species in the Senegal manatee. *Journal of Helminthology*, 57(1), 69-76. http://dx.doi.org/10.1017/ S0022149X00007902



Daryl Domning (Photo courtesy of the Natural History Museum of Los Angeles County)