# BISON
## *Brookfield Zoo*

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# Why All the Blubbering?

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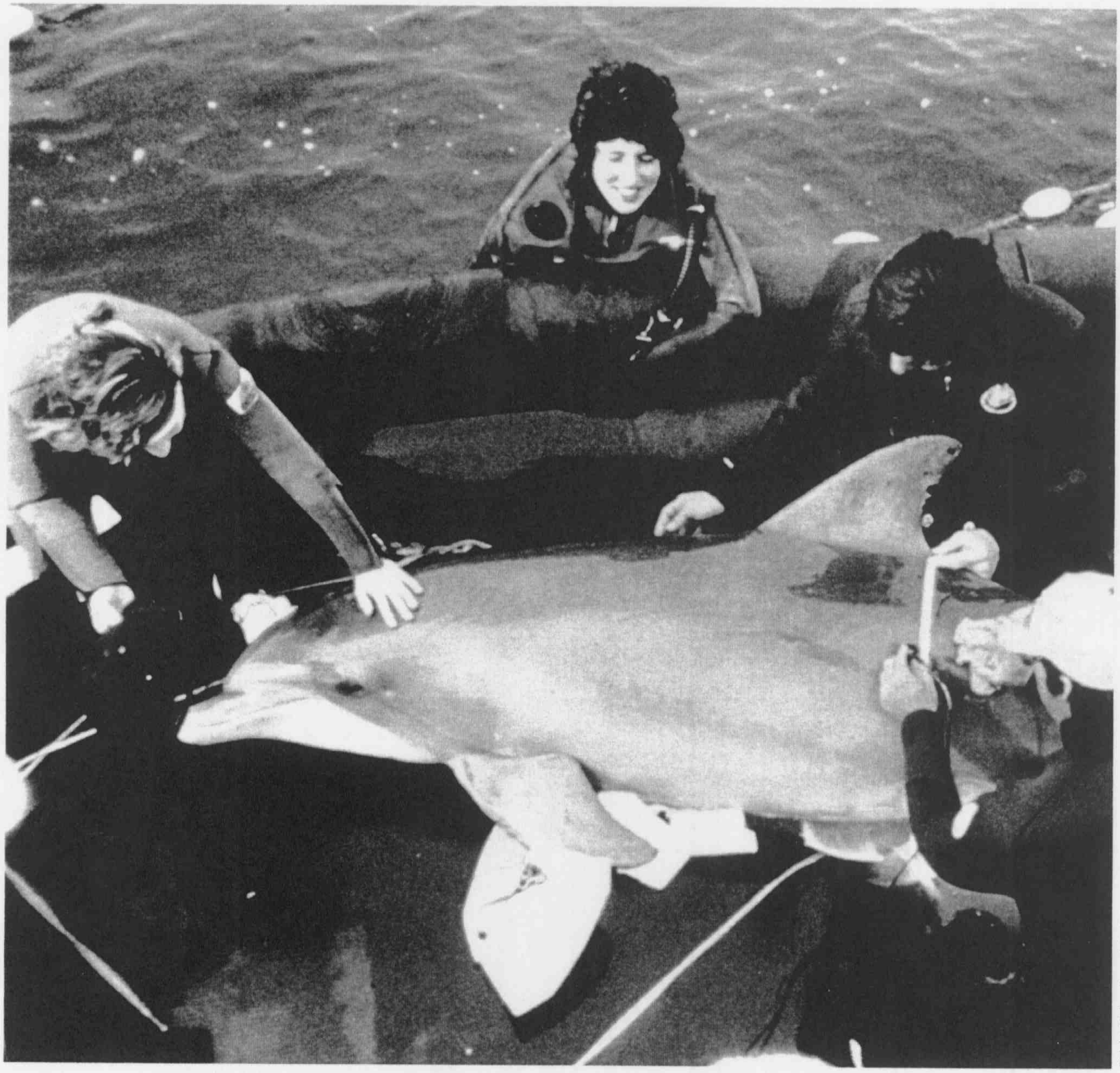


Dolphin Biology Research Institute

Volunteer research assistants help Dr. Randall Wells (foreground with cap) examine a wild bottlenosed dolphin in Florida.

"I'm here to talk to you about fat. Blubber, if you will. Those oozing corpuscles of biomatter that are the bane of beautiful bodies. The arch enemies of wetsuits everywhere! Our culture spends billions to shed, conceal, firm up, and relocate blubber. Blubber is bad, right? WRONG! Blubber is critical to the lives of most marine mammals. Blubber is good." These words were uttered by Seven Seas keeper Raquel Luna at the 1992 International Marine Animal Trainers Association conference as she introduced the results of the Chicago Zoological Society's research on dolphin blubber. Through field studies and research at Brookfield Zoo and the dolphin facility in Florida, the Chicago Zoological Society has been working to try to understand the complex role blubber plays in the lives of dolphins. In the process of learning more about blubber, we have also been able to develop blubber monitoring as a husbandry tool to aid keepers in their care of the dolphins at Brookfield Zoo and elsewhere.

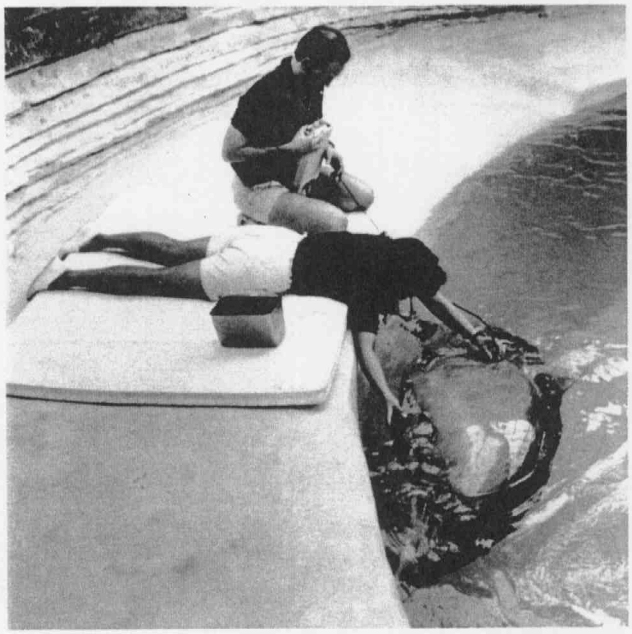
Blubber is found on all whales, dolphins, and porpoises. It consists of a layer of fat and connective tissue that lies just under the skin. Dr. Graham Worthy has found that blubber layers vary from species to species in thickness and quality. Blubber covers most of the animal's body, except for the extremities: the tail flukes, the pectoral flippers, and the dorsal fin. Within a species, blubber thickness varies from one part of the body to the next. The variable distribution of blubber on an individual may be related to one of the proposed functions of blubber: to aid in streamlining. The underlying blubber layer can provide shape and rigidity to the skin that may increase the efficiency of moving through water. Some of the other functions of blubber include providing insulation, serving as an energy reserve, and offering some degree of protection from predators. But in addition to its positive features, blubber has a down side. Many organic environmental pollutants, such as pesticide residues, bind with the kinds of lipid (fat) molecules found in blubber, so blubber also stores and accumulates these contaminants.

Historically, blubber research was limited to examining dead animals. Carcasses were dissected, and blubber was measured, weighed, and sampled for microscopic and biochemical analyses of composition. This provided useful information, but not from living animals. As part of our long-term study of a resident wild community of bottlenosed dolphins along the central west coast of Florida, I wanted to find a harmless technique that would allow me to measure blubber thickness as an indicator of body condition of living dolphins.

In 1986, elephant seal researchers at the University of California, Santa Cruz, introduced me to ultrasonography as a way of measuring blubber thickness. The ultrasound technique was originally developed to measure fat in pigs. A probe about the size and shape of a doctor's stethoscope is touched gently to the animal's skin. The instrument emits a very high-frequency pulse of sound and registers the echoes that are produced at each change in tissue density. The principle is much the same as that of the dolphin's own echolocation, or sonar system, but the sounds used by the machine are well above the capabilities of the dolphin's hearing. Because blubber and muscle are neighboring tissues of different densities, this difference is registered on the instrument, resulting in a measurement of the blubber thickness.

Since 1986, measuring blubber thickness has become a regular part of our semi-annual dolphin capture, sample, mark, and release program in Sarasota. In this program, we briefly handle a few selected members of the local dolphin community. We do this to conduct veterinary examinations and take samples for health monitoring, to collect behavioral and biological data, and to determine the gender, age, and genetic relationships of the individuals. We have learned that blubber thickness varies somewhat from individual to individual within a season—which suggests, perhaps, that dolphins have the equivalents of "couch potatoes" and "triathletes." More significantly, blubber depth varies for an individual from season to season. During the winter, the blubber at our indicator point may reach about one inch in depth. In summer, the blubber at the same spot may only be half of the winter reading.

Why do we see seasonal variations in the blubber thickness of wild dolphins? Is it because the animals build up and draw upon energy reserves to get them through periods when food may not be plentiful? Or is it an insulating response to seasonal changes in water temperature, essentially like putting on and taking off a blubber overcoat as necessary? The Seven Seas Panorama at Brookfield Zoo offered the ideal setting to test these hypotheses. In Sarasota, water temperatures range between 55°F and 95°F each year. At Seven Seas, the water temperature is maintained at a constant 70°F throughout the year, and the animals are provided with all the food they need. Thus, under such controlled circumstances, we might expect the zoo animals to maintain a maximal blubber layer if the energy reserve function is most important, or an intermediate blubber thickness if the insulation function is most important.



M. Greer

The dolphins at Seven Seas have been trained to hold still for regular blubber monitoring. Trainer Raquel Luna holds the probe while trainer Tim Sullivan reads the results.

To test our hypotheses, we began measuring the blubber depths of the dolphins at Seven Seas in 1990. As is so often the case in biology, the answer that is evolving is not simple and clear-cut. With constant water temperature and diet, there was no seasonal variation in the blubber depth of the Seven Seas dolphins. For most of the zoo animals, however, the blubber was somewhat thicker than would be expected for wild Sarasota dolphins in water of the same temperature. These facts suggest, not unreasonably, a combination of both insulation and energy reserve functions for blubber. We might speculate on the basis of these results that the Seven Seas dolphins have met their basic needs for insulation, and they receive sufficient food to be able to maintain additional blubber as an energy store.

Mammals cope with the temperature constraints of their environments through a combination of anatomical, physiological, and behavioral adaptations. As mammals, dolphins maintain a constant body temperature approximately that of humans. They spend their lives in an environment that tends to be cooler than their body temperature. Water conducts heat away from the dolphins' bodies more than 20 times faster than air would. In much the same way, a person in a 50°F swimming pool will feel the cold much more quickly and intensely than the same person standing in 50°F air. However, a dolphin's options for maintaining a constant body temperature in its heat-draining environment are limited. A high activity level (leading to an increased metabolic rate) is an energetically costly option, requiring extra effort to secure enough food to maintain its metabolism. A layer of insulation would help hold in the dolphin's metabolic heat, while minimizing its food requirements.

An indication of the relative importance of maintaining this minimum insulating layer comes from observations of sick and stranded dolphins. These animals may start to use up other tissues, such as muscle, for energy before they will reduce their blubber depth below the appropriate thickness for their water temperature. We speculate that once the critical insulation layer is compromised, a downward spiral begins from which the animal may not be able to recover. A sick animal with a thin blubber layer may not be capable of meeting its energy needs for normal metabolic activity, fighting the illness, healing, and maintaining a constant body temperature, especially if its ability to feed is impaired by its illness. The more energy that is drawn from the blubber, the thinner the layer, and the more the problem is exacerbated.

On the other hand, excessive insulation may also cause a problem due to overheating. Dolphins "doff their overcoats" in the summer. As in the case of a human with a fever, too much heat can lead to tissue damage. Dolphins have a system for regulating temperature that involves controlling blood flow to their "radiators"—their fins. When the water is cold, blood flow to the extremities is reduced and warm blood is kept closer to the body core where it can be used to keep the animal warm. As the animal's body temperature increases, blood flow to the extremities increases, so that excess heat can be dumped from the warmer tissue to the cooler water through the animal's skin. When the water is very warm, as is the case in Florida in the summer, the difference between the body temperature and the temperature of the environment is so small that heat is drawn from the dolphin's body very slowly. Under extreme conditions, the dolphin's metabolic rate increases with the additional effort required to speed delivery of heated blood to the fins. This activity produces additional heat, creating additional problems.

Given the potential problems associated with either not enough or too much blubber, it seems reasonable that there should be a range of optimal blubber thicknesses, depending on the temperature of the water in which a dolphin lives. The optimal thickness will keep a dolphin within its "comfort zone"—not too cold and not too warm. We have been able to apply this knowledge to aid in the care of dolphins. The keepers at Seven Seas weigh each dolphin and measure its blubber once each week to ensure that it is eating enough. The dolphins have been trained to cooperate for both procedures. Dr. Susan Crissey of Brookfield Zoo's Commissary determines the caloric and nutritional composition of the fish fed to the dolphins. In this way, the dolphins' calorie intake can be adjusted accurately to maintain weight and blubber depth. Trends in blubber thickness over time can provide a subtle indication of a potential health problem, which can then be examined more closely through a blood sample analysis or a full veterinary examination. The measurement of blubber thickness is also important for evaluating whether a dolphin can be moved between two facilities, for example between Brookfield Zoo and the Chicago Zoological Society's dolphin facility in Florida. Keepers are able to determine if the current blubber layer is appropriate for the water temperatures that will be encountered at the other facility.

While we all understand how sitting in front of the television munching copious amounts of potato chips and ice cream results in the enhancement of our own fat layer, the process of blubber development for dolphins is less clear. The Florida facility provides new opportunities to understand some of the details of seasonal blubber deposition and loss. The dolphins there live in natural seawater pens, and thus face the full range of seasonal variation in water temperature. We have begun monitoring blubber depths for these dolphins, and we have found that the blubber changes relative to the water temperature throughout the year—blubber increases in the fall and decreases in the spring. Along with these changes come changes in the dolphins' food consumption. The adult dolphins at the Florida facility eat about 10% to 20% more calories in fall (when the water cools and they are depositing additional blubber) than they do during spring (as the water warms and they are presumably losing the blubber they gained in the fall). These data provide additional support for the relative importance of blubber as an insulator (rather than an energy source) because the dolphins there are provided with all of the food they need throughout the year, and their diets are re-evaluated weekly by the Florida staff.

The studies of dolphins at Brookfield Zoo and in Florida provide us with important perspectives for addressing ecological questions for wild dolphin communities. For example, how much fish is required to support a resident community of 100 dolphins for one year? From the study

## The Dolphin Connection

The Chicago Zoological Society has long supported collective animal management programs. Such partnerships are in the best interest of individual species and are an excellent way to maximize resources. However, cooperative breeding programs have traditionally focused on endangered species. Two and a half years ago, in an attempt to help a species before it was in serious trouble, the Chicago Zoological Society expanded its dolphin program to a Florida facility.

Although bottlenosed dolphins are not endangered, their marine environment is increasingly threatened by human activities. Our goals at the Florida facility are to manage a healthy breeding population of Atlantic bottlenosed dolphins, to educate visitors about marine environments, and to study the dolphins to expand our basic knowledge of their needs.

Chicago Zoological Society employees are now responsible for the daily care of the fourteen dolphins living in outdoor ocean enclosures in the Florida Keys. Three dolphins have been born there since 1991.

at the Florida facility, we now know that food consumption, in terms of calories, varies from season to season with changes in water temperature. Therefore, any study of food consumption must take seasonal variation into account. In a National Science Foundation-sponsored study, Dr. Dan Costa of the University of California, Santa Cruz, Dr. Graham Worthy of Texas A&M University, and I are examining the energy requirements of the Sarasota dolphins by studying their metabolic rates—the first time this has been done for any free-ranging cetacean. We use a harmless technique developed for work with human infants. We orally administer labelled water to selected dolphins during winter and summer. The labelled water consists of non-radioactive hydrogen and oxygen isotopes. After the water has equilibrated with the body water pool, a blood sample is drawn, a one-quarter-ounce radio transmitter is attached to the dorsal fin, and the animal is released.

The labelled hydrogen and oxygen mix with the body water of the animal over the next four to six days and are diluted through the metabolic process. We track the animal during this period and record its activities. The dolphin is then recaptured, a blood sample is drawn to measure the amount of dilution of the isotopes, the radio transmitter is removed, and the dolphin is released. Through a series of calculations, the amount of dilution can be translated into a metabolic rate for the dolphin. The metabolic rate can, in turn, be converted into a value for the number of calories consumed by the dolphin during the period.

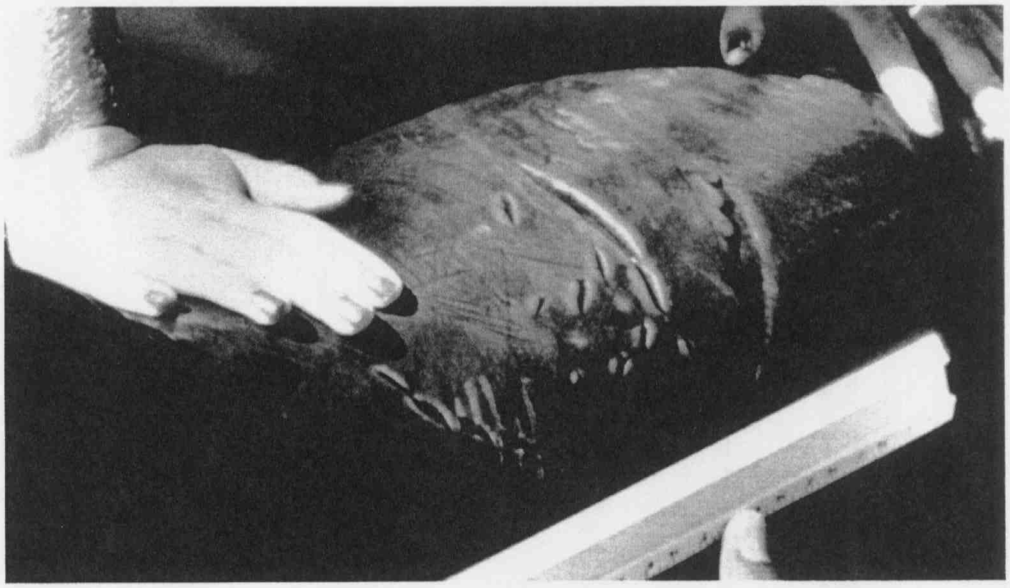
While it is too early to present final data on the quantities of fish needed for this wild dolphin community, we can describe the directions the analyses will take as the data become available. One step in the process has been determination of the species of fish consumed by the Sarasota dolphins. Dr. Nelio Barros of the Hubbs Sea World Research Institute has examined the stomach contents of stranded Sarasota dolphins and has identified the three most important local prey species as pinfish, pigfish, and mullet. Knowing the average seasonal caloric content of these fish and the relative proportion of each species in the dolphins' diets, we can estimate the dolphins' daily food consumption during winter and summer. We can then compare the annual food consumption of the resident dolphin community to trends in commercial fish catches, and evaluate the prospects for food remaining available for the dolphins. For example, over the last 40 years, commercial catches of mullet have declined by 50% within the home range of the Sarasota dolphin community. How long can this kind of trend continue before the fish are no longer able to maintain a population, as well as meet the needs of dolphins and humans?

Preliminary findings from the metabolic studies indicate that the animals have a higher metabolic rate in summer than in winter. There are several possible interpretations. The animals may be more active in summer than in winter. Summer is the primary breeding and calving season for the Sarasota dolphins. Perhaps less effort is required for feeding in winter than in summer. In fall and winter, some of the prey fish, such as mullet, are heavy with roe as they prepare to spawn. This greatly increases the caloric content of each fish. Thus, the dolphins can catch fewer fish to obtain the same calories.

Danielle Waples, a marine sciences Master's student at the University of California, Santa Cruz, is conducting focal animal behavioral observations of the Sarasota dolphins to compare their activities from season to season (her techniques are adapted from those pioneered by Brookfield Zoo's baboon researcher, Dr. Jeanne Altmann). These results might also indicate the effectiveness of blubber as an insulator, successfully meeting the animals' needs in winter so that a high metabolic rate is not needed. In the summer, the increased metabolic rate may be due in part to the increased energy demands for dumping body heat.

While blubber may serve primarily to protect dolphins from cold, it may provide secondary protective benefits as well. More than 22% of the juvenile and adult dolphins examined during our capture/release program bear healed shark bite scars. The fact that most of the dolphins in the Sarasota area survive the shark attacks may be attributable in part to blubber. In order to reach more vital organs, sharks must first penetrate a half- to one-inch-thick layer of blubber. We speculate that under most circumstances a healthy dolphin can wriggle free from the grip of a shark before it can bite through the blubber.

Blubber also serves as an energy reserve. The fats in blubber can be mobilized as necessary to meet an animal's energy needs. As a result of increasing human activities near coastal waters, environmental contaminants find their way into dolphins through their food and are accumulated in the blubber. Over time, as they reach high enough concentrations, these contaminants can become toxic. When blubber is converted to energy, as it is seasonally in Florida, the contaminants are released into the bloodstream. From there, they either find their way back into the blubber or they are bound into some other form of fat, such as that found in milk.




Researchers measure a healed shark scar on a live dolphin in Florida. The dolphin's blubber layer may have saved it from a more serious injury.

Studies by Dr. Vic Cockcroft and colleagues in South Africa indicate that a mother dolphin transfers about 80% of her accumulated pesticide residues to her first-born calf through the lipid-rich milk she provides. This provides the females with a mechanism for dumping contaminants from their bodies, presumably before they reach toxic levels. Unfortunately, this may occur at the expense of their offspring, which may be receiving toxic levels of contaminants through their milk. We hypothesize that this may be one explanation for why young females demonstrate such poor reproductive success, typically losing their first, second, and sometimes even third calves before raising one to the normal age of separation of three to six years. Perhaps this is also the reason for the different life expectancy of males and females. The oldest females in Sarasota are more than 50 years old, whereas most of the males are lost by age 40. Males lack the lactation mechanism for dumping contaminants, and therefore accumulate contaminants throughout their lives.

With scientists from Sarasota's Mote Marine Laboratory, we are examining carcasses of stranded Sarasota resident dolphins to determine patterns of contaminant accumulation in blubber and other tissues. Because we have monitored many of these animals throughout their lives, we can determine their histories of exposure to various contaminants in the Sarasota Bay environment. In time, we hope to be able to identify the mechanisms and rates of accumulation and to use this information to identify sources of contaminants and the means for reducing their impacts.

In parallel research, we are working with ecotoxicologist Dr. Wally Jarman and marine sciences Master's student Jocelyn Vedder of the University of California, Santa Cruz, to develop a harmless technique for assessing concentrations of environmental contaminants in living dolphins during our veterinary examinations. With the support of the Chicago Zoological Society's conservation and research committee, we are developing ways of using blood samples to indicate total body concentrations of organic contaminants. In this way, we hope to be able to identify potential health problems from environmental contaminants before they become life-threatening.

Humans are mostly concerned with the visual impact of their own fat. For dolphins, there is more to fat than meets the eye. As we continue to learn more about the functions and implications of blubber, we will be in a better position to understand and meet the needs of wild dolphin populations. The Chicago Zoological Society's dolphins will also benefit from this knowledge as new tools are developed that will lead to continuing improvements in their care.

*Based at Mote Marine Laboratory in Sarasota, Florida, Randall Wells has studied dolphins for 23 years. He currently supervises several studies of the wild dolphins in the Sarasota Bay area and works with researchers around the country. Wells and colleagues Blair Irvine and Michael Scott were the first to prove that wild bottlenosed dolphins have discrete home ranges, and were first to define the social structure of a wild bottlenosed dolphin community.*