Aquatic Mammals 2008, *34*(3), 471-513, DOI 10.1578/AM.34.3.2008.471

Historical Perspectives

Sam H. Ridgway

(born 26 June 1936)

Dr. Sam Ridgway is one of the founders of mammal medicine. He completed a large share of the seminal work in marine mammal medicine, and he continues to promote both applied and basic research in the field of marine mammalogy. He has published over 260 papers, book chapters, and books, including one of the most definitive works on marine mammals, *Mammals of the Sea* (1972). Much of his work has examined mammalian bioacoustics with a focus on dolphin auditory physiology and echolocation. Dr. Ridgway and the late Dr. Kenneth Norris share the high distinction of being viewed as the founders of dolphin physiology and medicine.

Dr. Ridgway earned his Bachelor of Science (1958) and Doctor of Veterinary Medicine degrees (1960) from Texas A&M University. Commissioned as a Veterinary Officer in the U.S. Air Force in 1960, he was sent from Texas to California. In California, he was soon involved in the initiation of the U.S. Navy Marine Mammal Program (NMMP) at Point Mugu. In the 1960s, Dr. Ridgway pioneered dolphin anesthesia, medical technology, and methods for studying trained dolphins swimming freely in the open sea. In 1965, his work on marine mammal diving transitioned for use in the Navy SEALAB II project. At the suggestion of Captain George Bond, Medical Director of SEALAB, in 1966, Sam began preliminary work at Point Mugu, California, on the dolphin's ability to detect human divers. This work transitioned to Hawaii for development by Navy trainers and engineers of animal/human underwater intruder defense teams, first used in Viet Nam starting in 1970. (Human diver/marine mammal teams continue to work for personnel safety today in harbor defense, mine hunting, and underwater object recovery; see www.spawar.navy.mil/sandiego/technology/mammals/index.html.)

In 1970, Dr. Ridgway received a Navy fellowship for study under Professor Richard Harrison, FRS at Cambridge University, England. He earned his Ph.D. and returned to NMMP, which had moved to San Diego while he was in Cambridge. Dr. Ridgway has served on over 20 Ph.D. committees and has personally trained over 30 veterinarians through two- to six-year tours of duty with NMMP. Professionals Dr. Ridgway has mentored are now in zoological institutions, on university faculty, in the military (one is a General Officer), in government employment, and one is an astronaut. Dr. Ridgway is an elected Fellow of the Acoustical Society of America for his studies on hearing of marine mammals and also is a Fellow of the American College of Zoological Medicine for his work on marine mammal medicine. In 2008, the Acoustical Society of America honored Dr. Ridgway at their 156th conference in Miami, Florida, with 24 special presentations on his work over the past 40 years. Other awards include the Distinguished Alumnus Award, Texas A&M University, College of Veterinary Medicine; the Lifetime and Clinical Medicine Awards from the International Association for Aquatic Animal Medicine; Lifetime Membership Award, Society for Marine Mammalogy; the ZooMarine Award of the European Association for Aquatic Mammals; and two Navy awards—the Gilbert H. Curl Award and the Lauritsen-Bennett Award.

Sam was founding president of the International Association for Aquatic Animal Medicine (IAAAM) (1969-1971). He served as a scientific advisor to the Marine Mammal Commission in the 1970s and served on four committees of the National Research Council, National Academy of Sciences. His discoveries are published in more than 260 papers in leading scientific journals such as *Science*, *Nature*, *Journal of the Acoustical Society of America*, *Marine Mammal Science*, and *Scientific American*. With Professor Harrison, he edited a six-volume descriptive series of books covering all species, *Handbook of Marine Mammals* (Academic Press, 1984-1999). With Kurt Benirschke, MD, Dr. Ridgway chaired and edited the proceedings of an international conference on breeding dolphins in 1975. This meeting, under the auspices of the Zoological Society of San Diego, set the course of a self-maintaining dolphin population in North American facilities. He has also served for five years on the Board of Trustees of the Zoological Society of San Diego, chairing their Animal Health Committee.

He is currently Adjunct Professor of Comparative Pathology for the Medical School at the University of California at San Diego (UCSD). The only remaining professional at the founding who is still working with NMMP, Dr. Ridgway serves as Senior Scientist for Animal Care and Research. Recently, he became president of the newly formed NMMP Foundation (nmmp foundation.org). He is licensed to practice veterinary medicine in California.

Dr. Ridgway and his wife Jeanette married in 1960. They have resided in Point Loma, San Diego for the past 35 years. Jeanette possesses a doctorate in English Literature from the University of California at Los Angeles (UCLA). She has taught at UCLA, UCSD, and San Diego State University.

Compiled by Emily M. Walter, Assistant to the Editor, *Aquatic Mammals*

History of Veterinary Medicine and Marine Mammals: A Personal Perspective

Sam H. Ridgway

U.S. Navy Marine Mammal Program, 53560 Hull Street, San Diego, CA 92152, USA, and Department of Pathology, School of Medicine, University of California at San Diego, La Jolla, CA 92093, USA

*"The best doctor in the world is the veterinarian.
He can't ask his patients what is the matter—he's got to just know." Will Rogers*

*"The greatness of a nation and its moral progress
can be judged by the way its animals are treated." Mahatma Gandhi*

Treatment of animal injuries and diseases is as old as medicine itself. Bodner (2007) mentions papyrus fragments from an Egyptian medical textbook circa 1850 BC. These contain descriptions of cattle, dog, bird, and fish diseases. Ancient Egyptians understood some veterinary anatomy. They recognized signs indicating certain diseases and practiced specific methods of treatment. Other ancient civilizations, such as those of the Hindus, Babylonians, Hebrews, Arabs, Greeks, and Romans, recognized animal diseases and tried treatments (Smithcors, 1963; Bodner, 2007).

The first veterinary school in the world started in Lyons, France, in 1761. Veterinary medicine became an organized discipline. Additional veterinary schools developed elsewhere in Europe. With the importance of cavalry during the 1800s, the army veterinary corps developed. Military veterinary officers cared for camels, horses, and mules as well as the livestock used for food. There were opportunities for research, especially in tropical diseases. In 1880, British Army veterinary officer Colonel Griffith Evans made a discovery that was the first step in recognizing a number of diseases in animals and humans that was spread by biting insects (Ware & Hunt, 1979; Durrant, 2003). Working on the Indian Subcontinent during 1880, Colonel Evans discovered the first pathological trypanosome, now known as *Trypanosoma evansi*. More than 20 years later, in 1902, science recognized that a mosquito bite caused human malaria. Also in 1880, Louis Pasteur, already a noted scientist and physicist by training, became a member of the Central Society of Veterinary Medicine in France. Among other diseases, Pasteur developed vaccines for rabies, anthrax, and swine erysipelas, benefiting human and animal medicine.

In the United States, the Veterinary College of Philadelphia was the first establishment of veterinary education. It operated only from 1852 to 1866. A veterinary school briefly operated at New York University, but the first sustained school of veterinary medicine began at the University of Pennsylvania in 1883. It is the oldest accredited veterinary school currently operating in the United States.

Early veterinarians sometimes treated marine mammals. Sea lions balancing balls on the tip of their noses have been a part of zoos and circuses for a long time. Treatment of these exotic animals' medical problems (*cf* Blair, 1912; Rigdon & Drager, 1955; Williamson et al., 1959) sometimes involved the efforts of local veterinarians. Such was the case with one of my own earliest mentors in veterinary medicine, Dr. Robert M. Miller. Dr. Miller would not "shy away" from helping any kind of animal. When we met in 1961, he had recently opened the Conejo Valley Veterinary Clinic in Thousand Oaks, California. At the time, Thousand Oaks was a very small community with few people and many animals. One of Miller's clients was a small zoo-animal training facility, Jungleland, that had elephants. One of the elephant trainers, Wally Ross, had taken on the training of sea lions, bottlenose dolphins, and pilot whales for Pacific Ocean Park, an amusement center adjacent to the pier in Santa Monica, California. Dr. Miller, who treated their animals, invited me along on some of his calls. We published a few of our cases (Miller & Ridgway, 1963), including the first X-ray of a live dolphin. Dr. Miller had the best medical equipment available; at the time, he owned the only good X-ray machine in Thousand Oaks—one so good that his physician friends used it in the care of their human patients. One local man liked to tell a story about when his mother-in-law came to Thousand Oaks for a visit. She injured her ankle stepping off the bus. "We had to take her to the vet," he chuckled!

These marine mammal experiences occurred while I was a veterinary officer in the U.S. Air Force on active duty from 1960 to 1962 (Figure 1). Coming from the dusty ranch country of southwestern Texas, I knew nothing about sea animals. After my graduation from veterinary school at Texas A&M, I worked briefly for the

Bellaire-Richmond Pet Hospital in a Houston suburb. Military service was required of male citizens my age, so I won a U.S. Air Force commission and orders to California. At Oxnard Air Force Base in Camarillo, I was the base veterinary officer. I also served two Navy bases. My duties included supervising food inspections of military facilities and caring for sentry dogs. I also helped maintain and care for some research animals at the large naval air base at nearby Point Mugu. During this time, I was fortunate to meet some Navy officers, especially Jim Berrian and Lee Hall, and some civilian Navy scientists, who wanted to study and use dolphins for Navy science. The Navy already worked with "Notty," a Pacific white-sided dolphin (*Lagenorhynchus obliquidens*) at the former Marineland of the Pacific on the Palos Verdes Peninsula in Los Angeles.

I began to study-up on dolphins. I visited experts: trainers at Pacific Ocean Park in Santa Monica, Dr. Robert M. Miller in Thousand Oaks, trainers at Marineland of the Pacific, new curator David Brown (Brown et al., 1960), and Marineland's former curator Dr. Kenneth Norris, a professor at the University of California at Los Angeles. About this time, I found an intriguing book, *Man and Dolphin* by Dr. John Lilly. I learned of Hilda Hempl Heller's work at the Hooper Foundation of the University of California Medical Center at San Francisco. She published information on clostridial and gangrenous infections of whales from the whaling industry, describing how whale septicemia related to livestock diseases such as blackleg and malignant edema (Heller, 1920). I also learned of several works on the pathology of whales aboard whaling ships (*cf* Case, 1948; Rewell & Willis, 1949; Stolk, 1950). W. Ross Cockrill, a veterinarian, did postmortem examinations of whales aboard whaling vessels (Cockrill, 1960a, 1960b). Dr. Charles Schroeder and Dr. H. W. Wegeforth published an interesting paper on the development and pathology of gastric ulcers in California sea lions (Schroeder & Wegeforth, 1935). Dr. Wegeforth, a physician, was the founder of the San Diego Zoo. Dr. Schroeder was the zoo's first full-time veterinarian and later became director of the zoo. He was largely responsible for the San Diego Zoo's rise in status—in its becoming, in the opinion of many, the world's foremost zoological park (Myers & Stephenson, 1999).

Figure 1. The author in 1961 at the start of his career with marine mammals as a U.S. Air Force veterinary officer

In September 1962, the U.S. Navy's dolphins arrived at Point Mugu after a flight from Gulfport, Mississippi (see a description in Ridgway, 1987). The Mugu dolphin facilities were not complete, so the dolphins went to a temporary home at Pacific Ocean Park in Santa Monica, California.

In October 1962, my active duty obligation to the U.S. Air Force complete, I was hired by the Naval Missile Center at Point Mugu to serve as the Animal Health Officer for the bottlenose dolphins. Although it did not occur to me at the time, I was the first veterinarian to begin a full-time career caring for marine mammals and the first full-time civilian professional employee of what eventually became the Navy Marine Mammal Program (NMMP). Two Navy petty officers, Bill Scronce and Marty Conboy, were serving at Point Mugu, and the three of us would drive to the Santa Monica Pacific Ocean Park to work with the dolphins. Bob Bailey arrived and introduced himself as our Director of Training. With this qualified staff for just the two bottlenose dolphins at Santa Monica, we were elated with a gift of three more bottlenose dolphins from Marineland of Florida, a historical marine mammal facility near St. Augustine. All of our staff traveled to St. Augustine in order to learn from the Marineland staff and to prepare ourselves for accompanying our three new dolphins back to Point Mugu in a Navy plane.

In St. Augustine, we met Forrest Glenn Wood ("Woody"), who had replaced Arthur McBride, the original curator. Woody educated us about dolphins and also about Florida Marineland's history. We hung on Woody's every word and made many mental notes as he toured us around the world's first oceanarium.

I also visited Marineland's veterinarian, Dr. Ronald F. Jackson, at his veterinary clinic south of St. Augustine. Dr. Jackson was recognized in the veterinary profession for his occasional work at Marineland and especially for his treatment and surgical correction of heartworm disease in dogs. He collaborated with veterinary cardiologist Dr. Robert Hamlin for the first good description of the dolphin's electrocardiogram with the vectors detailed (Hamlin et al., 1970).

Although bottlenose dolphins and other small whales such as belugas, *G. grampus*, and pilot whales had been kept for brief periods and at various locations (*cf* Townsend, 1914) in the U.S. and in Britain, the first sustained "oceanarium" was developed south of St. Augustine, Florida, in 1938 as an underwater film location. In my college days, I saw a movie, *Creature from the Black Lagoon* (1954), that had been filmed there. At the Marineland site, Marine Studios was on a beautiful Atlantic coastline with clear blue water and golden sand dunes extending down the coast as far as the eye could see. Four prominent men planned the oceanarium: W. D. Burden, C. V. Whitney, Sherman Pratt, and Ilya Tolstoy. Ilya, the grandson of Leo Tolstoy, the Russian author of *War and Peace* and *Anna Karenina*, gave the Studios a certain literary standing. Along with flocks of tourists who came to see the dolphins, notables, such as the writers Marjorie K. Rawlings (*The Yearling*), John Dos Passos (*Manhattan Transfer*), and Ernest Hemingway (*The Old Man and the Sea*), visited and could be found in Moby Dick's Bar near the dolphin tanks. Hemingway was deceased by the time I arrived at Moby Dick's; however, I met an equally erudite and entertaining man, Keller Breland, who also frequented the bar. Keller was an expert in animal behavior who had studied under the leading behavioral psychologist, B. F. Skinner (see Skinner, 1957). With his wife Marian, Keller set up a practical animal behavior consulting firm. In the early 1960s, he was bringing science directly to the animal training business (see Breland & Breland, 1966). F. G. Wood hired Keller Breland to instruct the dolphin trainers. I learned a great deal from Keller and Marian Breland as well as from their protégés Bill Scronce, Bob Bailey, and Kent Burgess. As a veterinarian, I remain convinced that some understanding of animal behavior is vital to the practice of veterinary medicine.

In addition to the tourists and notables who visited Marine Studios in the earliest days, a number of notable scientists came. The curator of the Marine Studios (Marine Studios later changed its name to Marineland of Florida) was Arthur F. McBride (see McBride & Hebb, 1948; McBride & Kritzler, 1951). McBride's invaluable efforts included bringing in a number of scientists to study the dolphins. These scientists published a wealth of entirely new information about the living dolphin. Among the early publications that were highly useful to me were those of DuBois et al. (1940), Fetcher & Fetcher (1942), Eichelberger et al. (1940a, 1940b, 1940c), and Geiling et al. (1940).

Interestingly, McBride was the first to discover dolphin echolocation or sonar. This discovery began with the first attempts to capture dolphins in the visually opaque waters of the St. John's River and estuaries near St. Augustine. In the same year that Marine Studios was founded, Donald Griffin, a student at Harvard University, working with a fellow student, Robert Galambos, used high-frequency microphones in the laboratory of physics professor G. W. Pierce to prove that insect-eating bats "see" in the dark by emitting sound frequencies above the human hearing range. This work confirmed that bats find insects and avoid objects by listening to echoes received by their ears from the sounds they themselves emit. An intellectually curious man, McBride may have been acquainted with the discovery of Griffin and Galambos. If so, McBride likely thought of these discoveries about bats as he marveled at how dolphins could catch fish and avoid his nets at night in the opaque waters of the St. John's River estuary and tributaries. McBride wrote in his notes, "[T]his behavior calls to mind the sonic sending and receiving apparatus which enables the bat to avoid obstacles in the dark." We have this information because William E. Schevill later published some of McBride's early notes to establish McBride's priority in the discovery of dolphin echolocation (McBride, 1956).

Other scientists used Marineland dolphins to conduct additional early studies on dolphin sonar after McBride's untimely death in 1949. These individuals included F. G. Wood (1953), Winthrop Kellogg (1961) from Florida State University, and the Bill Schevill and Barbara Lawrence team from Woods Hole (*cf* Lawrence & Schevill, 1954, 1956, 1965).

In the spring of 1963, the U.S. Navy had five bottlenose dolphins at Point Mugu, and Forrest G. Wood was hired. He left Marineland of Florida to become the manager of the Navy's Marine Bioscience Facility at Point Mugu. F. G. Wood, always "Woody" to those of us who worked with him over the years, was a brilliant thinker and manager who became my supervisor, mentor, and good friend. Only a few months after he arrived at Point Mugu, Woody offered me a learning opportunity. I accompanied him to attend an important conference, the first International Conference on Cetacean Research. Participants assembled at a hotel just across Key Bridge from Washington, DC, in Arlington, Virginia, in August of 1963. The American Institute of Biological Sciences and the Office of Naval Research supported the conference. Participants in the symposium represented a variety of scientific disciplines. These disciplines included cetacean taxonomy, fisheries, zoogeography, natural history, anatomy, physiology, hydrodynamics, acoustics, linguistics, and behavior.

At this 1963 Conference, I was the only veterinarian present. I was not a member of the symposium or a speaker. Instead, I was a guest observer. L. Harrison Matthews, Scientific Director of the Zoological Society of London, chaired the first session. He provided a fusillade against the organization that had paid for his ticket. To quote: "[S]ome people are proposing to prostitute their biological work on Cetacea and involve the animals in human international strife by training them as underwater watchdogs . . . " (Norris, 1966). I value the role of military sentry dogs and view watchdogs as noble creatures whether on land or under water. I thought it was a harshly critical remark for someone from Britain, considering the actions of the U.S. Navy on Britain's behalf only two decades before during World War II.

Many of the attendees (with some notable exceptions, i.e., F. G. Wood, William Evans, Carleton Ray, Ken Norris, William Schevill, John Kanwisher, David and Melba Caldwell, Carl Hubbs, and others) were seemingly befuddled by what I, a veterinarian, was doing there and wondered what possible use a veterinarian could be in cetacean research. This unwelcoming attitude was not universal. For example, an early contributor to our veterinary knowledge was Professor E. J. Slijper of the Institute of Veterinary Anatomy, Utrecht, Netherlands. Dr. Slijper did path-finding work on the anatomy of whales and porpoises from the 1930s to the 1960s. His book, *Whales* (1962), was very useful to me. I took the book along to the conference and asked Professor Slijper to sign my copy. *Whales* is still on my shelf and much worn. Also, on the anatomical side, Woody gave me a copy of R. H. Burne's *Handbook of Cetacean Dissections* published in 1952 by the British Museum (Natural History). This monograph contains drawings or photographs of beautiful and detailed anatomical dissections, many of them reproduced in color. For many years, the original specimens of this splendid anatomical work were on display at the British Museum. Alas, they were later taken off public display; however, when I visited the museum in the late 1980s, I saw them in a back room.

I learned a great deal at the First International Conference on Cetacean Research where scientists were required to defend their ideas. Like great battleships dueling with big guns at sea, the giants of cetacean research traded "broadsides," supporting first one theory then another. The sparks especially flew between Dr. John Lilly on the one hand, with his ideas on dolphin communication, and Drs. Schevill and Wood on the other. The great breadth of cetacean science and the huge gaps in knowledge were becoming apparent to me. During a session entitled "Roundtable, Practical Problems," it was very generous of Professor Ken Norris to recognize me at the meeting and to mention that I was collecting all data possible on cetacean medical care. I could put out a newsletter if people could send me observations and information that might have relevance to cetacean medicine (Norris, 1966, p. 665, fifth paragraph).

For Ken Norris's noble suggestion, there was immediate rejection and refusal to support a newsletter. The opinion of many was voiced by David Brown of Marineland of the Pacific, saying, "I don't want to put my hard-earned findings" into a "melting pot of anonymity." In those days, the details of dolphin care were sometimes guarded as proprietary company information. As it turned out, Brown and the others that demurred did me a great favor. Since the suggested newsletter never materialized, I was able to use time made available for other pursuits.

Within five years from this date, we had a small group of veterinarians who were involved, at least part time, in the field who eventually formed the International Association for Aquatic Animal Medicine (IAAAM). By 1968, there were over 20 of us with enough data related to marine mammal veterinary care to hold a conference. This symposium, held at Florida Atlantic University, had 15 presented papers and three demonstrations. Drs. David and Melba Caldwell edited the papers. They presented interesting and useful information on the social interactions of the various cetacean species that they observed at Marineland of Florida. Daniel F. Cowan, MD (1968), presented work on lung diseases of pilot whales. (It is important to note that Dr. Cowan had been one of our most prolific contributors at meetings of IAAAM and in the general scientific literature [*cf* Cowan et al., 1985; Turnbull & Cowan, 1998; Clark et al., 2006; Cowan & Curry, 2008].) Among other presenters at this conference were Drs. William Medway, Joseph Geraci, John Simpson, Richard Hubbard, James C. Woodard, David Sergeant, Thurman Grafton, and Donald Cooperrider. In the following year after this first conference, other interested veterinarians met for an organizational meeting at the Stanford Research Institute at the invitation of physicist Dr. Thomas Poulter and his veterinarian Dr. Richard Hubbard. There are only 18 of us in the picture shown in Figure 2; it is likely that the other two had volunteered to take the picture or that one had to leave early. The founding members of IAAAM were Drs. Lanny H. Cornell, Joseph R. Geraci, T. S. Grafton, Mark C. Keyes, Ted Hammond, Richard G. Hubbard, J. D. Hyman, Ronald F. Jackson, David W. Kenney, G. W. Klontz, William Medway, E. G. Ogorsolka, N. E. Palumbo, Sam H. Ridgway, John G. Simpson, D. H. Spechler, Al K. Takayama, David C. Taylor, Jesse R. White, and Ann C. Van Goethem. Our group had only one woman member at the start. Things have changed. More on that change later.

We formally initiated IAAAM in 1969. Since formative meetings in 1968 and 1969, the IAAAM has met annually. I was founding president and presided for the first two years. Starting with 20 attendees at the organizational meeting in 1969, IAAAM has grown into the primary veterinary medical organization for those working with aquaria and zoos that keep aquatic animals. There were 350 attendees at the 2007 IAAAM Conference in Orlando, Florida, and the total membership is just under 500 (www.IAAAM.org). Even small aquaria now have veterinary consultants, and they care for fish, especially sharks (Figure 3), turtles, other marine reptiles, all marine mammals, and even corals. Many veterinarians also work with stranding networks that attempt to help mammals that become beached or entrapped in fishing gear. I will review a few accomplishments of some of the founding members of the IAAAM. Later, I will point out some of the achievements made at different times by others. I apologize in advance for overlooking some other important contributions.

Only one non-U.S. citizen, Dr. David Taylor from England, was present at the formative meeting. However, soon, many European colleagues joined. Early work, especially in Russia, Ukraine, Japan, South Africa, Australia, and Europe, added to marine veterinary knowledge. Dr. Taylor practiced zoo animal and marine mammal medicine all over the world from his base in England. He has written a number of popular books about his experiences as a "zoo vet." Notably, Dr. Taylor was the first to suggest the possibility for brucellosis in a marine mammal. When I was at Cambridge doing my Ph.D. with Professor Richard Harrison, I met a young veterinary student, Andrew Greenwood (*cf* Greenwood et al., 1971). Upon graduation, Dr. Greenwood joined Dr. Taylor and, upon Dr. Taylor's recent retirement, is the senior veterinarian in the practice with long marine mammal experience. Soviet scientist Dr. S. L. Delyamure (1955) provided valuable information on parasitology in his 1955 monograph translated to English in 1968. Around that time, another colleague, Murray

Figure 2. IAAAM founders meeting at Stanford Research Institute, Palo Alto, California, 1969: *First Row (L to R)*: Drs. Lanny H. Cornell, David W. Kenney, William Medway, Al K. Takayama, Ted Hammond, E. G. Ogorsolka; *Second Row (L to R)*: Jesse White, Ronald F. Jackson, John G. Simpson, G. W. Klontz, N. E. Palumbo, Ann C. Van Gothem; *Back Row (L to R)*: Joseph R. Geraci, David C. Taylor, T. S. Grafton, Sam H. Ridgway, Mark C. Keyes, Richard G. Hubbard.

Figure 3. Dr. Diedrich O. Beusse treating a shark; Dr. Beusse worked with Sea World of Orlando, Florida, as a contract veterinarian for 30 years and mentored many veterinarians in marine mammal and aquarium animal care. He was the recipient of the Excellence in Aquatic Animal Medicine Award of the IAAAM in 2000. He was professor and first director of the Marine Mammal Medicine Program at the University of Florida from 2001 to 2004, as well as contract veterinarian for the U.S. Navy Marine Mammal Program.

Dailey, Ph.D. (Figure 4), took an important interest in marine mammal parasitology. Joining us at Point Mugu, Dr. Dailey worked for some summers defining the life cycle of the sea lion lungworm (*Parafilaroides decorus*) among many other contributions (Dailey, 1970). Dr. Dailey continues to be a major resource in the diagnosis of parasitic disease (*cf* Geraci et al., 1978; Dailey et al., 1990).

Dr. Lanny Cornell served as veterinarian for Marineland of the Pacific and was a primary contributor in the earliest dolphin and killer whale breeding efforts at that park with Brad Andrews and Tom Otten. Later, Dr. Cornell, as head veterinarian and then Zoological Director for the Sea World Parks, promoted the breeding of Commerson's dolphins (*Cephalorhynchus commersonii*) (Joseph et al., 1987), bottlenose dolphins (*Tursiops truncatus*), and killer whales (*Orcinus orca*), among many other achievements. Following Dr. Cornell as Sea World Zoological Director was Mr. Edward Asper, who especially contributed information on the care of walrus (*Odobenus rosmarus*) calves and the assessment of wild dolphin populations as well as the birth and development of killer whale calves (Asper et al., 1988). Brad Andrews replaced Edward Asper as Sea World Zoological Director, overseeing progress, including the hiring of veterinarian and reproductive physiologist Dr. Todd Robeck and the appointment of Dr. James McBain as overall Corporate Veterinarian. Today, Dr. McBain is sought the world over for his diagnostic and clinical advice (see McBain, 2001).

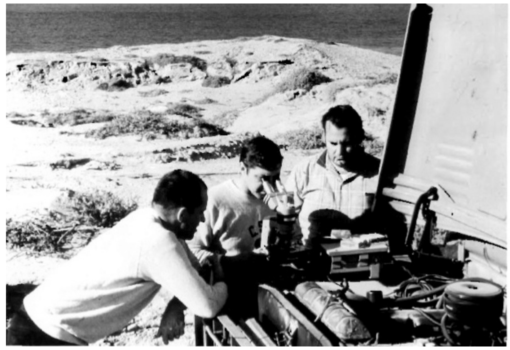


Figure 4. W. G. Gilmartin, Murray Dailey, and the author on San Nicholas, Island, California; we could not fix the engine, so Dr. Dailey looked for signs of parasites in sea lion scat.

Dr. Joseph Geraci had a major impact on aquatic animal medicine as an aquarium veterinarian, veterinary school professor, aquarium research director, and scientist at The University of Guelph, The New England Aquarium, and The National Aquarium at Baltimore. As a student of Dr. William Medway at the University of Pennsylvania, School of Veterinary Medicine, Dr. Geraci first worked with dolphins from the nearby Aquarama in Philadelphia. Hired after graduation at the request of curator Dr. Carleton Ray, Dr. Geraci became the first full-time veterinarian at the New York Aquarium. He made early discoveries in marine mammal nutrition and improved husbandry. For example, he established the relationship between the deterioration product histamine and gastric ulcers (Geraci & Gerstmann, 1966). Dr. Geraci later did his Ph.D. work at McGill University in Montreal. His research and diagnostic interests have been of broad scope. An interest in the causes of marine mammal strandings led Dr. Geraci to many investigations of these events, numerous publications, and important guides regarding marine mammal strandings (*cf* Geraci & St. Aubin, 1979; Geraci, 1989; Geraci et al., 1989; Geraci & Lounsbery, 1993, 2005). Dr. Geraci discovered that toxins from dinoflagellates that accumulate on marine plants (blooms of algae) could concentrate in the marine food chain and result in cetacean deaths (Geraci et al., 1989). Although the 1987-1988 die-off of bottlenose dolphins on the eastern U.S. coast (Geraci, 1989) was later determined to be more likely associated with dolphin morbillivirus (a disease unrecognized at the time of Geraci's work; Lipscomb et al., 1994; Schulman et al., 1997), Geraci's investigations and reports served as a sentinel. In recent years, at least four different marine toxins have been shown to cause disease and strandings among marine mammals (*cf* Gulland et al., 2002; Van Dolah et al., 2003). Geraci's findings and the findings of early investigators of disease in stranded marine mammals have resulted in the federal National Oceanic and Atmospheric Administration Fisheries Service establishing a contingency fund for unusual mortality events. This fund has enabled stranding networks that developed around the country to investigate mortality events, which has resulted in the identification of many marine mammal diseases (*cf* Dierauf & Gulland, 2001). In recent years, Dr. Teri Rowles of the NOAA Fisheries Service led the effort to get veterinarians involved in strandings to enhance knowledge of marine mammal diseases. Dr. Geraci also was involved in the rehabilitation of a number of stranded marine mammals.

Dr. J. D. Hyman had established veterinary hospitals in New York and followed Dr. Geraci at the New York Aquarium. Dr. Hyman also consulted on marine mammal care at various other locations. One of the active founders of IAAAM and one of its early presidents, Dr. Hyman, an avid pilot, went through a terrible airplane crash. Injuries limited his professional activities in later years. Dr. George W. Klontz served as consultant veterinarian for the Seattle Marine Aquarium during the Puget Sound killer whale collections by marine parks of the 1960s (Klontz, 1970). Later, he went to Texas A&M University to found an aquatic animal medicine program. Dr. Klontz was followed in that effort by Dr. Raymond Sis, a former president of IAAAM, who was also a professor in the Texas A&M School of Veterinary Medicine. Dr. Raymond J. Tarpley (Figure 5), also from Texas A&M, during a post-doctoral fellowship with me (Tarpley & Ridgway, 1991, 1994; Tarpley et al., 1994; Ridgway et al., 1995), did exacting and accurate anatomical studies. Dr. Tarpley worked on bowhead whale (*Balaena mysticetus*) anatomy with Dr. Tom Albert by accessing the native whale hunt in Alaska. More recently, he formed a series of one- to two-week courses, MARVET, drawing students each year who want to learn about marine animal anatomy and veterinary care.

Dr. Richard Hubbard worked at the Stanford Research Institute, Coyote Hills Facility, where various pinnipeds were studied (Hubbard & Poulter, 1968). Notably, he cared for pinnipeds involved in the beginning of Dr. Ronald Schusterman's long and distinguished career in marine mammal behavior. Dr. Hubbard developed formulae for raising orphaned harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) and treated their diseases. He worked with University of California professor N. A. Vedros, Dr. Alvin Smith, Dr. George Migaki, and others to identify the first epizootic of *leptospirosis* in California sea lions on the Pacific coast (Vedros et al., 1971).

Figure 5. Dr. Raymond J. Tarpley, cetacean anatomist and teacher

Dr. William Medway, now deceased, taught clinical laboratory pathology and zoological medicine at the University of Pennsylvania, School of Veterinary Medicine, for 30 years (1958-1988). A founding member of IAAAM, Dr. Medway was the leading professor of veterinary students who went into marine mammal medicine. One of his earliest students was Dr. Joseph Geraci. They collaborated on numerous studies, advancing marine mammal medicine. Another of Medway's students, Dr. Jay C. Sweeney, has been very productive for our field (*cf* Sweeney & Ridgway, 1975; Geraci & Sweeney, 1986; Sweeney et al., 1999). Other distinguished Medway students include Dr. Greg Bossart, Research Professor and Chief Marine Mammal Veterinarian and Head of Pathology, Harbor Branch Oceanographic Institute at Florida Atlantic University; Dr. Lawrence Dunn, for many years the consulting veterinarian for Mystic Aquarium (Dunn, 1990); Dr. Greg Lewbart of North Carolina State University; and many others. A colleague of Dr. Medway at the university of Pennsylvania, Dr. Don Abt, was a president of IAAAM who retired from the University and taught an AQUAVET program for a number of years. The AQUAVET program continues at the Marine Biological Laboratory at Woods Hole. Today, each of his students proudly supports the IAAAM Education Award established in honor of Dr. Medway's brilliant teaching and leadership.

One of the early founders of IAAAM, Dr. Mark C. Keyes, now deceased, became a full-time veterinarian for the National Marine Fisheries Service's Marine Mammal Laboratory in Seattle in the early 1960s. His primary responsibility was to assess the health of the North Pacific fur seals (*Callorhinus ursinus*) to aid in their conservation (*cf* Keyes, 1965; Geraci & Keyes, 1970). This work led to the discovery of the deadly seal hookworm's unusual life cycle. The seal hookworm (*Uncinaria lucasi*) is uniquely adapted to survive the frigid Arctic winter in seal mothers' milk, being transmitted to the newborn pup when it nurses. Today, the conservation award of the IAAAM is named in honor of Dr. Keyes.

Another veterinarian whose contributions improved conditions for marine medicine, Dr. Ted Hammond, worked at Scripps Institution of Oceanography for a time and then, for many years, at Ocean Park, Hong Kong. Today, he is a consultant marine mammal veterinarian, especially for marine parks in Asia. Another important contributor to marine mammal science is Dr. Al K. Takayama from Hawaii. He was Sea Life Park's first veterinary consultant and worked with Dr. A. C. Pier and others to provide the first thorough investigation of cetacean nocardiosis in the late 1960s (Pier et al., 1970).

Honored as a Life Member of IAAAM, Dr. Jesse White, now deceased, worked at the Miami Seaquarium. There, Dr. White made numerous contributions to general marine mammal care, especially in dolphin nutrition and in manatee (*Trichechus manatus*) medicine, husbandry, reproduction, and conservation (White, 1970; White et al., 1990). He also made significant contributions to legal standards for the protection of marine mammals.

Dr. John Simpson worked with me at Point Mugu from the mid-1960s until 1970 when the Marine Bioscience Laboratory transferred to San Diego. He was an outstanding clinical veterinarian and pathologist. Dr. Simpson brought in W. G. Gilmartin (Figure 6) as a microbiologist. Gilmartin, in turn, made significant contributions to the basic science underpinning veterinary care of marine mammals. (Gilmartin later spent a dedicated life in protection of monk seals and other species in Hawaii.) Dr. Simpson did postmortem examinations critical to determining disease states and causes of death among stranded animals as well as those in the laboratory or at marine exhibits. Together, we worked out effective and safe means of restraint and anesthesia for major surgery (Figure 6 & 7B) in sea lions (Ridgway & Simpson, 1969). Dr. Simpson was instrumental in designing the pinniped "squeeze cage." This device is employed for handling larger sea lions and seals for treatment in marine mammal facilities even today. Before our paper on anesthesia and restraint for the California sea lion was even published (Ridgway & Simpson, 1969), the system was put to work in the field for evaluating its use during an ecological disaster.

On 29 January 1969, a Union Oil Company platform about six miles off the coast of Santa Barbara, California, "blew out." Oil workers struggled to cap the hole. However, pressure build-up caused breaks in an ocean floor fault releasing oil and gas. Around 200,000 gallons of crude oil formed a slick on the water surface that covered some 800 square miles and involved the offshore islands that were breeding areas for five species of pinnipeds.

Figure 6. Bill Gilmartin and Dr. John Simpson anesthetize a California sea lion circa 1967.

As concern mounted, our facility at Point Mugu was asked to help. Woody accompanied U.S. Senator George Murphy (R. California) to San Miguel Island to see what we might do (Figure 8). I stayed behind to care for our Navy animals. Dr. Simpson and Bill Gilmartin flew to the island. Using our equipment, they were able to examine numerous California sea lions, elephant seals (*Mirounga angustirostris*), and other pinnipeds, treating them when necessary and collecting valuable specimens essential for determining the impact of the oil spill. The Santa Barbara oil spill killed thousands of sea birds and other marine fauna. However, pinniped damage by oil was minimal to nonexistent (Simpson & Gilmartin, 1970). Still, their investigation did not end with oil. Teaming with Dr. Robert De Long, their investigations determined that premature birthing and resulting deaths of California sea lion pups was the consequence of a more insidious form of pollution, that of organochlorine contamination of the ocean food chain (DeLong et al., 1973). Dr. Simpson made major progress in describing the histology and pathology of many marine mammal organ systems. He enlisted the expert help of Dr. Murray Gardner. After 36 years, their work (Simpson & Gardner, 1972) is still frequently cited.

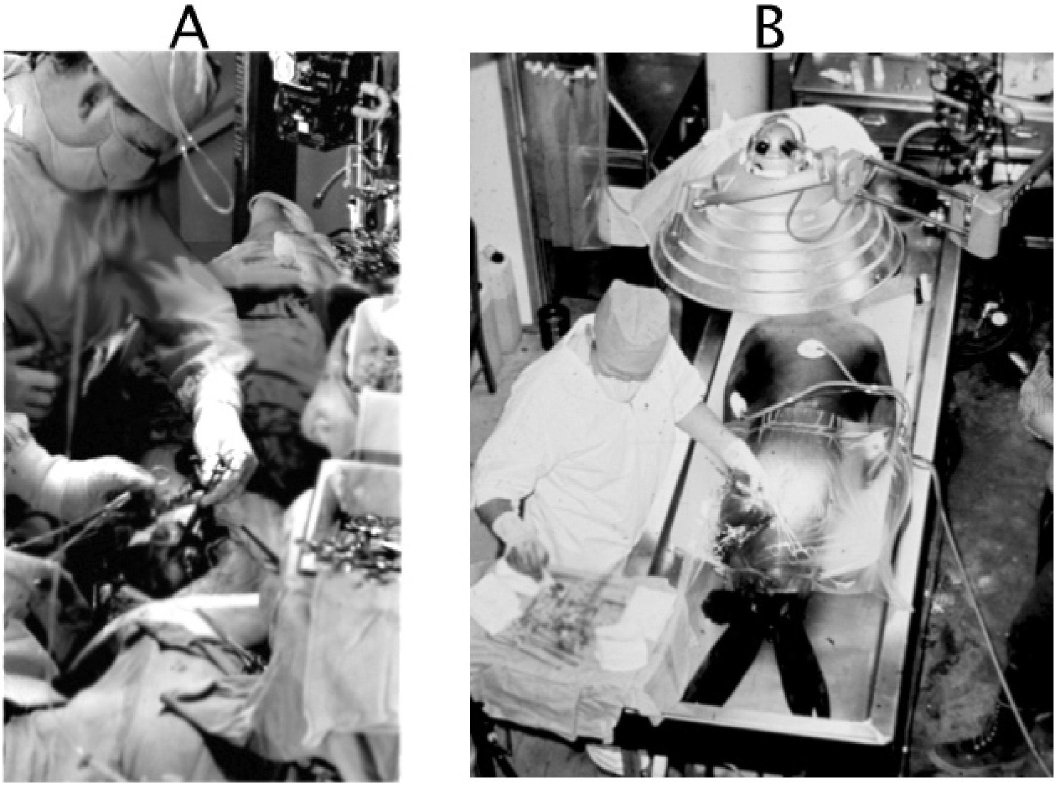


Figure 7. (A) The author with the first major dolphin abdominal surgery in 1966; the dolphin patient, an adult female, recovered and lived a healthy life until 1987; (B) Dr. John Simpson with a surgical procedure on a sea lion circa 1967.

My years at Point Mugu with Dr. Simpson were memorable not only for our scientific and veterinary accomplishments. I fondly recall his indomitable spirit and determination. We had a basketball hoop on the sand next to Mugu Lagoon where, at noontime, we played aggressive, sometimes even violent, dirt basketball games. Dr. Simpson always insisted that the "little guys" (represented by Simpson, Steven Leatherwood, Murray Dailey, Dan Pearson et al.) could beat the "big guys" (including Bill Gilmartin, Blair Irvine, his brother Rock, and me). These intense, 30-minute games, sometimes more like rugby football with a round ball and basket, left our faces red, our hearts pounding, and our minds ready to tackle problems more cerebral than physical.

Figure 8. F. G. Wood (left) with U.S. Senator George Murphy (R. California) and their Navy pilot (right) at San Miguel Island, California, to inspect results of the 1969 Santa Barbara oil spill.

In the late 1960s, we had an idea that dolphins might be susceptible to human influenza during the flu season. It was just a suspicion. Dr. Michael Sigel of Miami, Florida, an expert on flu and influenza vaccines, came out to Point Mugu with some test virus. This was a pilot project to see if we could immunize the dolphins. While Dr. Simpson placed a tube through the test dolphin's larynx into the bronchi, I was at the animal's tail fluke taking a blood sample. Dr. Simpson injected the virus, and the dolphin gave a great cough and snort. I was okay, the immune Dr. Sigel was okay, the dolphin never showed any ill effects, but Dr. Simpson soon went home to bed with the flu! This ended our influenza research. More recently, however, different types of human influenza have been found in harbor seals (Webster et al., 1981; Osterhaus et al., 2000).

Dr. David W. Kenney was Sea World of San Diego's first full-time veterinarian. Among notable achievements was his care of a baby gray whale (*Eschrichtius robustus*), "Gigi," for a year at the oceanarium in 1971 and releasing it in 1972 (*cf* Evans, 1974; Wolman, 1985). The animal was kept for a year at Sea World during which its nutrition, treatment, and growth were monitored. Released during the spring northward migration, the animal was thought to have survived and join its conspecifics. As a notable coincidence (or not?) the "friendly whale phenomenon" (Gilmore, 1976) began to be noticed soon after this whale's release. According to Balcomb (1994),

> this return of a large whale to its native waters was probably successful insofar as the whale surviving, in spite of the fact that the baby whale was released approximately 400 miles from where it was captured a year earlier. That the baby whale had never been near the release location was not an impediment to its release, nor was its prolonged captivity over a very formative period of its life. Natural instinct or the presence of migrating congeners may have provided her the clues necessary for survival.
>
> It is also interesting to note that the "friendly whale" phenomenon began to be experienced by gray whale watchers not too many years after Gigi's release. It is interesting to speculate if her release and the phenomenon had any correlation.
>
> Presumably, after spending virtually all of her life in captivity, Gigi was able to migrate several thousand miles to the feeding areas of her natural population.

Gigi was not the only gray whale to spend a year or more at Sea World in San Diego. In January 1997, a gray whale calf stranded on a California beach. This whale, named "JJ," was orphaned and very ill. The baby whale nursed (Figure 9) with a special formula (McBain & Reidarson, 1997) until weaning (Figure 10) in August of 1997 (for other formulae for nursing marine mammals, see Townsend & Gage, 2001). After weaning at seven months of age, the length of this little gray whale had increased from 735 cm to 915 cm. Daily weight gain averaged 16.6 kg per day on a diet of 30 kcal/kg of body weight (McBain & Reidarson, 1998). The rehabilitation of this baby whale (Figures 11 & 12) yielded a wealth of information. After 14 months at Sea World, JJ was back in the Pacific Ocean (Figure 13) with the northward migration of the species in 1998.

When the IAAAM formed in 1969, only one woman was involved (Figure 2). Today, like the veterinary profession in general, there are many

Figure 9. Young gray whale, JJ, nurses on a special formula (McBain & Reidarson, 1998) at Sea World of San Diego. (Sea World Photo, Courtesy of Dr. Jim McBain)

Figure 10. After weaning at seven months, gray whale JJ would come to the side of the pool to be fed. (Sea World Photo, Courtesy of Dr. Jim McBain)

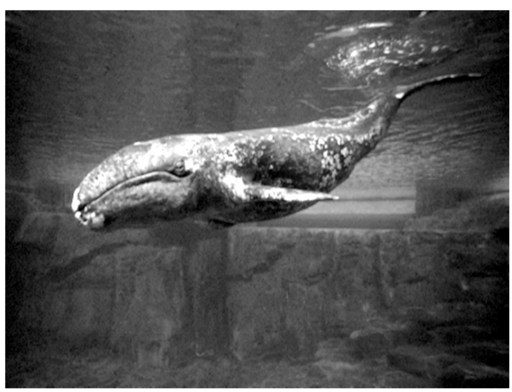


Figure 11. JJ, the gray whale rescued by Sea World of San Diego (Sea World Photo, Courtesy of Dr. Jim McBain)

women veterinarians who care for marine mammals. Currently, veterinary students are about 70% women, and a high percentage of IAAAM members are women. Many of my close associates for the past 20 years have been women (*cf* Figures 14 to 18). Their current contributions to marine mammal care and research is now at least equal to their male counterparts. (The temptation to curry favor with such competent females by suggesting that women are outpacing us males is strong!)

When I started work with dolphins, one of the major problems in providing comprehensive veterinary care was sedation and anesthesia for animals requiring handling for physical examinations or for minor or major surgery. To solve this problem was one of my early tasks. No matter how original the research or how specialized the field of science, the researcher soon becomes aware of predecessors who had previously thought the same thoughts and planned similar schemes. Earlier in this century, Dr. Orthello Langworthy tried to use ether to anesthetize a dolphin lying on the blowing beach sand of North Carolina, not far from where the Wright brothers first achieved motorized flight. Langworthy wrote about his experiences with dolphins in several papers. He recognized the challenge of studying their physiology and their great brain. He knew that anesthesia was essential for pursuing such studies in a humane manner. Unfortunately, however, Langworthy's dolphin died under the ether.

Where Langworthy had failed, I hoped to succeed. Although aviation had made great strides after Kitty Hawk, a half-century had passed and dolphin anesthesia was still not practical. Like Langworthy, I knew that anesthesia would be essential for experiments needed for understanding the cetacean's physiology and mysterious brain.

Figure 12. Continuing with the rehabilitation process, gray whale JJ sucks up fish from the pool bottom. (Sea World Photo, Courtesy of Dr. Jim McBain)

Figure 13. At the end of the rehabilitation, gray whale JJ is placed back into the Pacific Ocean during the northward migration of the species. (Sea World Photo, Courtesy of Dr. Jim McBain)

Figure 14A. Drs. Daniel Cowan and Gabriela Hernandez-Mora with the author, 2007; Hernandez-Mora et al. (2008) have found neurobrucellosis in a group of 10 stranded striped dolphins (*Stenella*) in Costa Rica. Dr. Cowan and the author have, for many years, been concerned about how many diagnoses are missed when the brain is not examined.

Figure 14B. Drs. Jim and Judy McBain and Dr. Joseph Geraci

Figure 15. Dr. Cynthia Smith with dolphin in scanner

Characteristically, Woody cautioned me that the task of devising a safe anesthetic procedure for dolphins would not be easy. He reminded me that he had been curator of Marineland of Florida in 1955 at the time of the so-called "Johns Hopkins Expedition." Three distinguished neuroscientists from Johns Hopkins University and two from the University of Wisconsin (Lilly, 1962) went to Marineland to map the dolphin's cerebral cortex in order to determine which parts of the brain surface responded to sounds, light flashes, and pressure on the skin. Studies of these and other such sensory stimuli would reveal a great deal about the workings of the dolphin's large brain. However, to expose the surface of the brain required major surgery and the scientists failed to foresee the difficulty of anesthetizing dolphins.

The problem, Woody explained, was that bottlenose dolphins, and apparently all whales, do not breathe as land mammals do. Instead of inhaling and exhaling every few seconds in a rhythmic fashion, dolphins have adjusted their breathing pattern to life in the water; they inhale in a fraction of a second, hold the air in their lungs for 15 to 60 seconds, and exhale to begin the next respiratory cycle. Before surgically examining the first dolphin's brain, the Johns Hopkins' group anesthetized the dolphin with an injection of barbiturate in the abdomen. This was standard practice with laboratory animals such as rats and guinea pigs at the time. Some time after the injection, the animal relaxed, lost the air in its lungs, and never breathed again. In their subsequent attempts to map the brain, the neurosurgeons used a simple respirator to keep the animal breathing during anesthesia, but the machine proved inadequate. After several more dolphins died, the experimenters abandoned the surgical approach as a means of studying the dolphin brain.

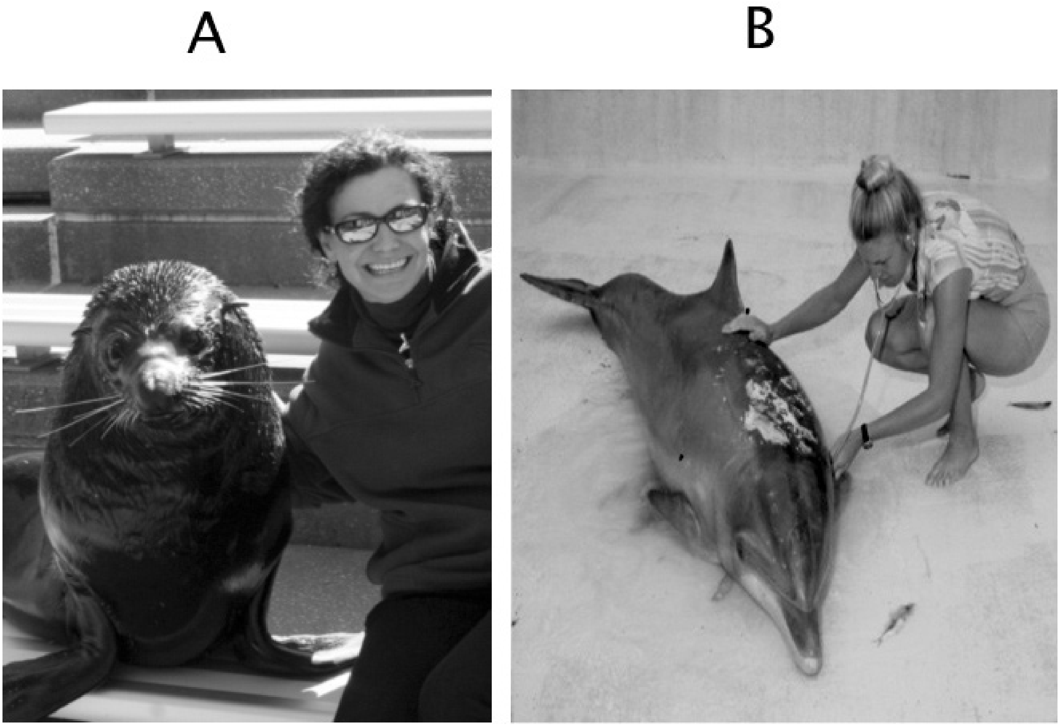


Figure 16. (A) Dr. Judy St. Leger, pathologist of Sea World, with a fur seal; (B) Dr. Candace Jacobs, first female military veterinarian in the NMMP, checks a beached dolphin in our San Diego Laboratory in 1978.

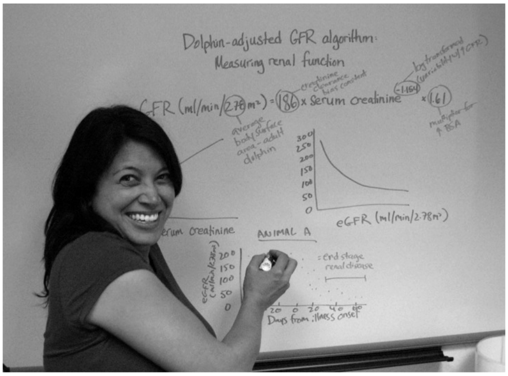


Figure 17. Dr. Stephanie Venn-Watson, our veterinary epidemiologist, explains the MDRD equation as it applies to dolphin glomerular filtration rate.

Figure 18. NMMP Army veterinary group in early 2008: *Front Row (L to R)*: CPT Elizabeth Hoffman, MAJ Stephen Cassle, CPT Katharine Frank; *Back Row (L to R)*: SGT Holly Cook, SSG (P) David Smith, Brig. Gen. Michael Cates, SGT Greg Beam, SFC Atwell Cersley. BG Cates was on a visit to our facility. In the early 1980s, Dr. Cates was an Army Veterinary Corps officer serving as a clinical veterinarian in the NMMP Hawaii Laboratory.

A breakthrough permitted me to devise an anesthesia method. This breakthrough came with the development of a control device made by Dr. Forrest Bird, inventor of the Bird respirator. A group in Miami led by Drs. Eugene Nagel and Peter Morgane showed that the control device allowed the respirator to mimic the normal dolphin respiratory pattern: inflating the lungs, holding them inflated for 20 or 30 seconds, then rapidly deflating and inflating the lungs again (Nagel et al., 1964).

We were able to get this new Bird respirator and other necessary equipment. Woody agreed that I should test my own ideas for surgical anesthesia on dolphins. As a first step in our project, Ensign Frank Harvey and I went to Palm Springs, California, where Dr. Bird and his associates instructed us in the operation of the new machine.

The Miami group had reported successful use of nitrous oxide, sometimes called "laughing gas," in anesthetizing dolphins. Back at Point Mugu, we tried to anesthetize dolphins with nitrous oxide. The equipment worked well. We were able to keep the dolphins on the respirator for an hour or more. However, our tests of their muscle reflexes, such as eyelid closure and flipper movements, showed that the dolphins were not sufficiently anesthetized. Dental work might be OK but not major surgery.

We did not want to keep testing the same dolphins because successive exposure to the anesthetic agents interrupted their training and, at this early stage of our understanding, could damage their health. Five bottlenose dolphins had been caught for our experiments in Gulfport, Mississippi; accordingly, trainers Wally Ross and Marty Conboy with Ensign Harvey and I flew there to experiment with anesthesia. Working night and day for a week at Gulfport, with the help of their manager, Don Jacobs, we anesthetized all the dolphins, thoroughly checking each anesthetized dolphin's reflexes to be sure they were insensitive to pain. We found that halothane, the anesthetic gas most commonly used in human surgery, also was effective for dolphins. We knew that we still had a great deal to learn about dolphin anesthesia—in fact, it would take two more years of careful work before Dr. James G. McCormick (then of Princeton University, Figure 19) and I finally perfected and documented the technique (Ridgway & McCormick, 1967, 1971). I felt confident that with the procedures we had developed at Gulfport, if one of our dolphins had a threatening illness, we could perform surgery. We have in fact used our procedures a number of times when surgery was necessary (Figure 7A).

News of our medical success traveled rapidly in the small international community of dolphin keepers. I presented the findings at the American Veterinary Medical Association's (AVMA) annual meeting in Portland, Oregon, in July 1965, and, when I returned home at 10:00 PM from Portland, my wife Jeanette greeted me with an urgent message: Hawaii was calling. Dr. Bill Evans, our dolphin sound expert, was spending the summer doing sonar research with the dolphins at Sea Life Park near Honolulu. Earlier, the park's star performer, a bottlenose dolphin named "Kiki," had swallowed a net float. They gave the dolphin special medication to vomit up the float. It did not come up, and Kiki would not eat. All feared that

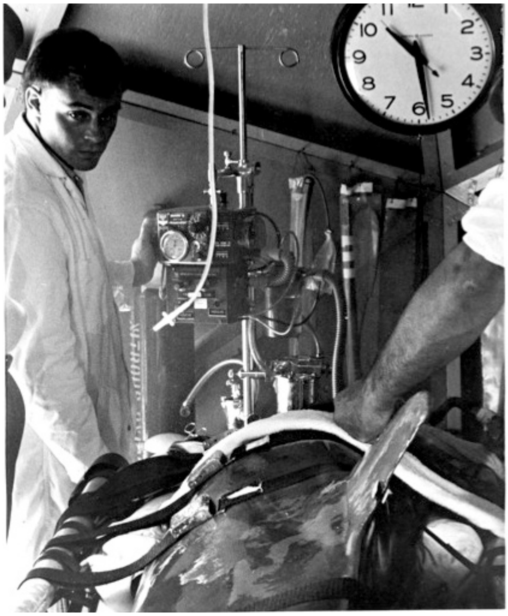


Figure 19. Dr. James McCormick with the Bird respirator maintaining a dolphin under anesthesia

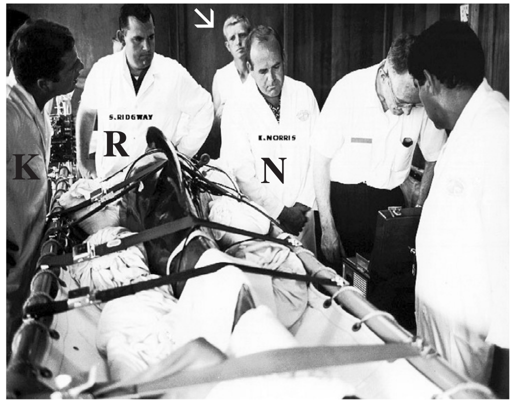


Figure 20. A dolphin is secured to a padded sling as Tap Pryor (arrow) prepares to use the "long, slim, greased arm method" to remove a foreign body from the animal's stomach; K = Dr. Ken Bloome, R= the author, and N = Dr. Ken Norris.

he was failing rapidly. Would I come and operate? Tickets would be waiting at the Los Angeles Airport.

We took all of our anesthesia and surgery equipment to Hawaii but, in the end, we did not need to do surgery on Kiki. This *Tursiops* was not a large dolphin. We decided to use the "long, slim, greased arm method" first. Tap Pryor, the director of Sea Life Park, was tall and lean with long arms (Figure 20). After Tap practiced manipulating and extracting an identical net float from a container of mineral oil, we secured the dolphin on our surgery table, held his jaws open with soft towels, and Tap thrust his highly lubricated arm down into the dolphin's forestomach. Success was ours! Tap was able to pull the float out of the forestomach. The dolphin's heart skipped a few beats during the procedure, but within minutes, Kiki splashed around his pool, taking fish, vocalizing, and appearing quite happy.

Why some dolphins swallow inanimate objects from time to time is still a bit of a mystery. Whalers have reported finding all sorts of objects in forestomachs. A dolphin in Japan swallowed a large rugby football (Amemiya, 1962). The animal probably took it down where sea pressure compressed the air-filled ball, making it possible for the dolphin to swallow the large ball. To pull out a rugby football, surgery or endoscopy would be required. However, the "long, slim, greased arm method" became a standard for removing objects from dolphins of a certain size. Repeat offenders have, on occasion, been trained to volunteer to accept the long arm into the stomach. Some oceanaria have even recruited professional basketball players for the "long, slim, greased arm method." Due to the history of such problems, various theories had been put forth as to why wild seals and sea lions swallow stones (see Schroeder & Wegeforth, 1935, for some early theories).

For larger or smaller animals that swallow potentially damaging objects, a flexible endoscope with various retrieval devices is required. Fortunately, such instruments have become available. They can be constructed in lengths suitable for very large animals. Endoscopes can be used to examine the stomach for disease, tumors, injury, parasites, or foreign objects. Endoscopes of various sizes are now used to examine the lungs (bronchoscopy), nasal system, and lower intestine of marine mammals. Dr. Jim McBain and other Sea World veterinarians have used 3-m endoscopes on killer whales for diagnostics and treatment. In our laboratory, Drs. Bill Van Bonn and Eric Jensen have accomplished a good methodology for employing endoscopy with California sea lions, belugas (*Delphinapterus leucas*), and dolphins by examining both ends of the gastrointestinal tract. They also can inspect the nasal cavities and bronchi of the lungs (*cf* chapters by Van Bonn, Jensen, and Dover in Dierauf & Gulland, 2001). Dr. Dover and a number of veterinarians who worked at Sea World in Orlando were mentored by Dr. Deke Beusse (another is Dr. Michael Walsh, now of the University of Florida, College of Veterinary Medicine). Dr. Dover has led the way in developing methodology for rigid endoscopy and minimally invasive laproscopic surgery whereby internal organs can be examined, biopsied for diagnostics, or removed (Dover et al., 1999). Some of these methods require sedation or general anesthesia.

Dr. Richard Linnehan (Figure 21), a U.S. Army veterinarian assigned to our laboratory (Linnehan & MacMillan, 1991), made additional progress with propofol/isoflurane anesthesia. Linnehan also did studies on antibiotic uptake and excretion in dolphins (Linnehan et al., 1999). After his Army tour with the NMMP, Dr. Linnehan joined the NASA astronaut corps in Houston, Texas. (He recently made a fourth space shuttle flight; on two of these flights, he helped to repair the Hubble space telescope and is now one of the most experienced space walkers in the U.S. space program.)

Drs. Haulena & Heath (2001) made improvements in pinniped anesthesia, and cetacean anesthesia also has been reviewed by Drs. Dold & Ridgway (2007) (in the same volume are chapters on phocid seals by Drs. Lynch & Bodley, on otariid seals by Dr. Haulena, on walrus by Dr. Brunson, and on manatees and dugongs by Drs Chittick & Walsh). Among significant developments were the further improvements in the capability to take advantage of the safety of gas anesthesia in the field (Heath et al., 1997).

In the 1980s, Dr. Tom Williams of Monterey, California, developed anesthesia and surgical methods for sea otters (*Enhydra lutra*). He implanted radio-tags and transponders abdominally in wild sea otters in order to study their movements and to evaluate survival of rehabilitated sea otters. Dr. Williams' methods are still used today (*cf* Thomas et al., 1987).

I mentioned earlier the first experience of dolphin X-ray in Dr. Miller's clinic in Thousand Oaks, California, at the beginning of the 1960s. My colleagues all over have continued to improve on our ability to image the internal organs of marine mammals. The images help us to learn more about their physiology and to diagnose diseases and injuries. With the help of Bill Gilmartin and Drs. D. G. Johnston and John Simpson, I used radiography and radioisotopes for imaging dolphins starting in the mid-1960s. Dr. Ted Hammond worked with Drs. Robert Elsner, Gerald Kooyman, and others at the University of California at Los Angeles and at Scripps Institution of Oceanography in La Jolla, California, on several X-ray imaging projects (*cf* Elsner et al., 1971). Recent advances have been made by Drs. James McBain, Tom Reidarson,

Figure 21. Dr. Richard Linnehan taking a blood sample from a dolphin with the help of trainer Mark Todd circa 1989 (lower left); in his spacesuit, upper mid-1990s (upper right); and performing "surgery" on the Hubble space telescope (lower right).

and other Sea World veterinarians, and especially by my associates Drs. Cynthia Smith, William Van Bonn, Eric Jensen (Figure 22), and others.

In the 1970s, Dr. Lanny Cornell and I received dolphin ultrasound assistance from Dr. George Leopold of the University of California at San Diego. Soon thereafter, in the 1980s, Drs. Rae Stone and Jay Sweeney moved ultrasound capabilities forward. They made several presentations and demonstrations at IAAAM meetings. Dr. Robert. E. Cartee of Auburn University spent a summer with us exploring dolphin ultrasound methodology (Cartee et al., 1995a, 1995b, 1995c). With the availability of modern portable ultrasound units, this diagnostic technology has spread throughout the marine mammal veterinary community (Brook et al., 2001). Some leaders in these efforts are Drs. Neils Van Elk and Geraldine Lacave in Europe and several in the U.S., including especially Drs. Cynthia Smith, William Van Bonn (Figure 22), and Eric Jensen.

As imaging equipment has advanced, we began to employ modern machines for computed tomography (CT), magnetic resonance imaging (MRI), single photon emission tomography (SPECT), and positron emission tomography (PET) (*cf* Houser et al., 2004; Ridgway et al., 2006). CTs and MRIs have been used more for clinical applications. My colleagues, Drs. Judy St. Leger, Cynthia Smith (Figures 15 & 16), and William Van Bonn (Figure 22) have been especially active in these efforts.

Scanning is easier because dolphins can be trained to cooperate in their medical examinations with sedation or anesthesia. Nuclear physicist Dr. C. Scott Johnson, who came to Point Mugu in 1963 from the Fermi Institute of the University of Chicago, provided me with one of the major advances in training. He began a study of dolphin hearing. Dr. Johnson completed the study that yielded the first underwater audiogram in bottlenose dolphins, defining their hearing from 75.0 Hz all the way up to 150.0 kHz. He was the

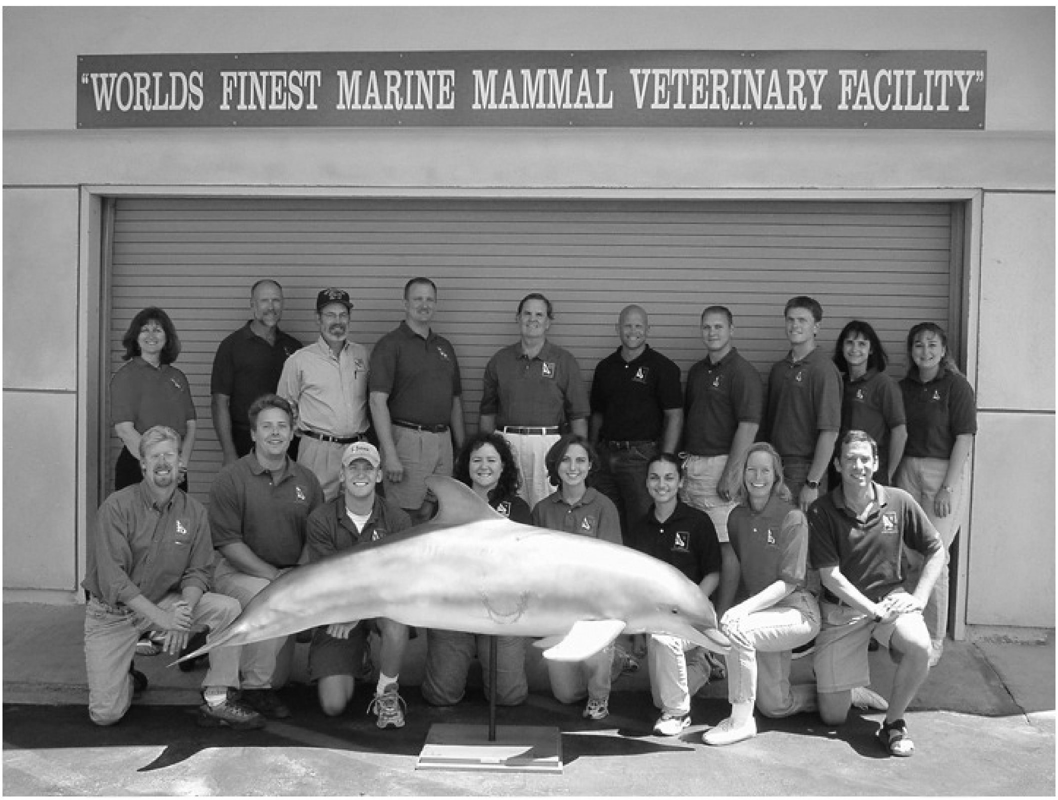


Figure 22. NMMP Veterinary Care and Research Group in 2000, posing behind a model of dolphin "Tuffy." *First Row (L to R)*: Dr. Eric Jensen; Graduate Student Peter Melynk; Techs Ian Mathey, Cheryl Short, Lisa Tanner, and Veronica Cendejas; Graduate Student Psychologist Carolyn Melka; Dr. Bill Van Bonn; *Back Row (L to R)*: Michelle Reddy, Donald Carder, Dr. W. G. Miller, Reserve Corpsman Chief Chuck Staats, the author, Sgt. Daniel Jermier, Reserve Corpsman HM2 Greg Adair, Tech Brian Saltzman, Dr. Tracy Romano, Records Tech Carrie Lomax.

first to demonstrate conclusively that dolphins have very sensitive hearing. His first papers on this subject are still cited today (but, of course, most people don't know that I was his veterinarian). Dr. Johnson also was the first person ever to train a dolphin for medical behaviors. He trained his bottlenose dolphin "Salty" to present his tail fluke so we could take blood; to present his open mouth so I could examine his teeth, throat, and tongue; and to present any other part of his body for examination (Figure 23). Salty would roll over so I could listen to his chest, for example. All of the examinations could be done without draining the pool, catching the animal, or interrupting the experiments. In the 1960s, we had no access to the portable ultrasound systems that are available today. Now, with progress in training methods and the realization that these husbandry behaviors save time and are safer for the animals and humans, we can get the dolphin's cooperation for all kinds of exams (Figures 23 to 25). For example, we can endoscope them; we can ultrasound them; and we can collect blood, urine, sperm, feces, aspirations from the blow hole, and so on. I am heartened by the tremendous cooperation we have now at most marine mammal facilities between veterinarians and trainers.

Marine mammal transport development required cooperation of multiple disciplines and individuals—trainers, veterinarians, biologists, and engineers. Wilkie et al. (1966), Dudok Van Heel (1972), and Ridgway (1972b) reviewed early cetacean transport methods. The cetaceans pose the greatest transport problems and care as semi-aquatic pinnipeds are somewhat easier to transport. Now, delphinids can travel long distances in apparent comfort and with few side effects (Figure 26).

In 1666, the year of the great London fire, Richard Lower performed the first animal-to-animal blood transfusion. For more than two centuries, blood transfusions did not go well for animals or humans. Patients could die of severe reactions to transfusion. Then, 234 years after the first blood transfusion, Dr. Karl Landsteiner in Vienna discovered the different human blood types—different combinations of A, B, and O. After Landsteiner's discovery, the blood could be matched with the patient, and blood transfusions became critical life-saving care. When I went into

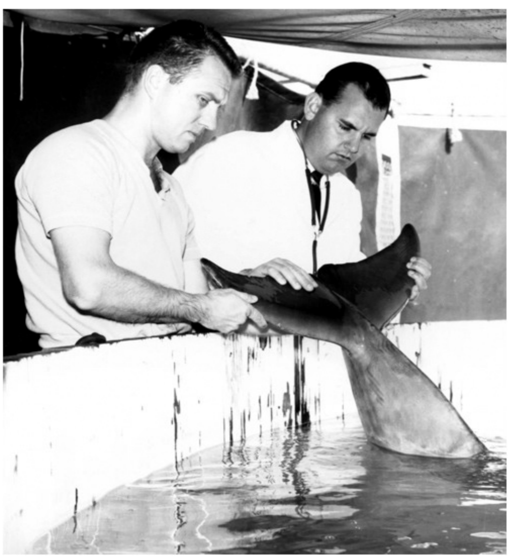


Figure 23. Dr. Scott Johnson's trained dolphin presenting his flukes for examination by the author, 1964

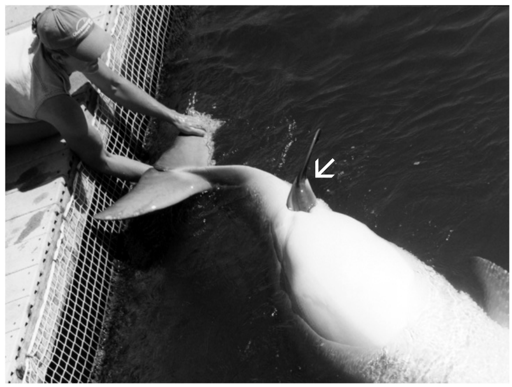


Figure 24. Trained bottlenose dolphin female presents herself for examination as the tail of her fetus (arrow) appears in the genital slit during a successful parturition. Trainer Joy Rothe holds the mother's flukes for the brief examination.

Figure 25. Lactating bottlenose dolphin presents herself for milking with a special suction cup device

the Air Force in 1960, they gave me metal "dog tags" with my blood type embossed on them to wear around my neck. At Point Mugu in the 1960s, we knew of some work being done on sperm whale (*Physeter catadon*) blood-typing (Cushing et al., 1959, 1963). Striped dolphins (*Stenella coeruleoalba*) had three blood types (Yamaguchi & Fujino, 1953). Dr. John Simpson and I wanted to be sure that we could give our bottlenose dolphins proper blood transfusions. With the help of Dr. Byron Myhre of the American National Red Cross in Los Angeles, we worked out a system for determining three blood types found in our bottlenose dolphins and then cross-matched blood from our animals to determine who was compatible with who (Myhre et al., 1971). Achieving that knowledge, we were satisfied that we could give safe blood transfusions and used this knowledge over the years. However, now that so many dolphins are reproducing under our care, and we have knowledge of parents and even grandparents, a wider investigation of dolphin blood types and their inheritance is in order.

To diagnose disease, veterinarians and trainers work together to take blood samples, urine samples, fecal samples, milk samples, and skin scrapings from our marine mammals. One of our trainers, Tricia Kamolnick, made an important advance by developing a milking device for use with dolphins and training female dolphins to accept milking. Trainers in our laboratory have perfected a method of collecting milk from a dolphin in the water twice each day. Trained lactating dolphins present ventrally at the side of the pen, allowing one trainer to support her body weight to keep the mammary slits out of the water. Meanwhile, the other trainer rinses the skin and mammary slit area with distilled water and applies a specially

Figure 26. Scene inside a U.S. Air Force transport plane at 12,000-m altitude. Cabin pressure is maintained under 2,000 m for dolphin comfort. Navy dolphins rest inside fleece-lined slings, in water, in their blue fiberglass transport pools as handlers watch over their animals. The author (upper left), as attending veterinarian, finds a nearby "quiet" place for a nap during the long transport. A staff veterinarian and veterinary technician always accompany transports along with the animals' experienced handlers.

constructed suction cup pump; then, the trainer collects 3 to 25 ml of milk rapidly (Figure 25). Freezing milk at -70° C allows for future analysis. Through this method, we can determine nutritional value, monitor secretion of medications, and evaluate health. Stored milk is also useful for feeding orphaned animals.

We also learned that female dolphins, even those that had never had an offspring, would lactate to nurse an orphan calf (Ridgway et al., 1995). Both of these advances were helpful because at times a female will not nurse her own calf. Milking obtains the early colostrum (first milk or immune milk) that contains the protective immunoglobulins, rich nutrients, and other substances essential for protecting the offspring in early life. Feeding this essential milk supports the orphan until another female begins lactating to nurse the calf. I mentioned the findings of Dr. Robert DeLong, Bill Gilmartin, and Dr. John Simpson (DeLong et al., 1973) regarding organochlorine pollutants in the ocean environment (also see Gaskin et al., 1971; LeBoeuf & Bonnell, 1971). For me, being able to collect milk from cooperating animals made clinical evaluation of contaminant effects possible.

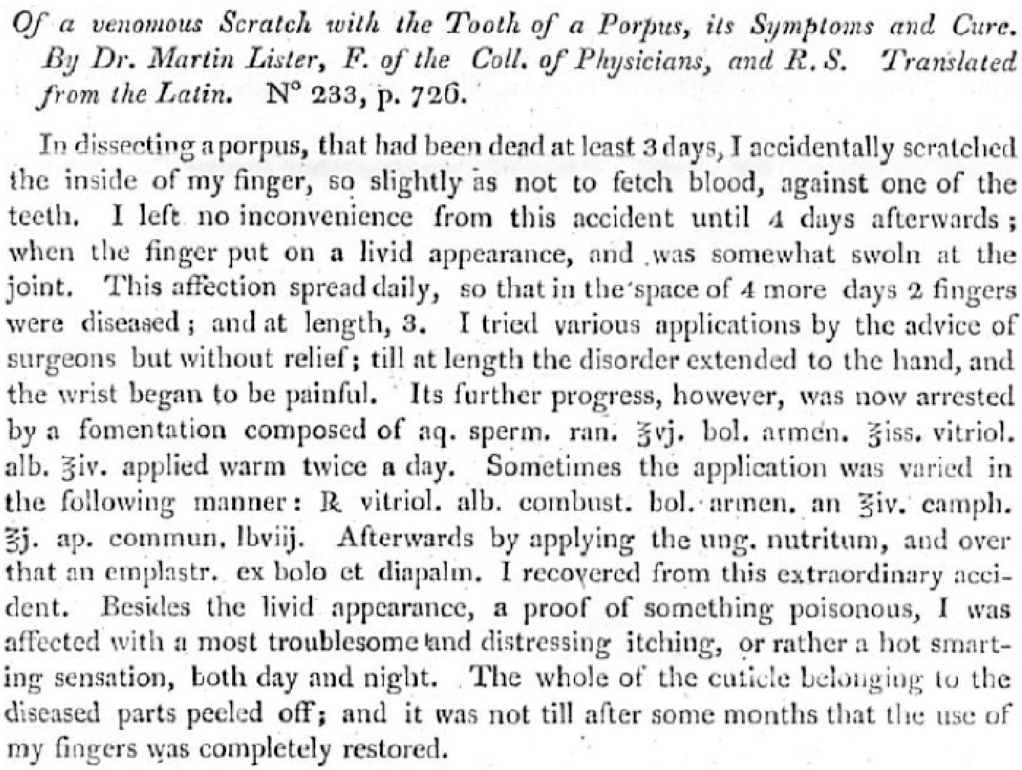
It is also practical to take small samples of blubber from a dolphin. Blubber is a storage reservoir for various potential harmful contaminants, and its analysis may be helpful in understanding reproductive problems and other health issues. (My associate, Michelle Lynn Reddy [Figure 22], became very knowledgeable on the contaminant issue with respect to marine mammals. She archived blubber samples to compare with milk and blood specimens to provide a contaminant baseline for healthy dolphins.) Many of those contaminants go into the blubber and, during lactation, can be carried into the milk, and nursing offspring may get the contaminants (Ridgway & Reddy, 1995; Ridgway et al., 1995; Reddy et al., 2001). Mother dolphins are fortunate in that they can eliminate their contaminants through milk with each calf that they nurse; in contrast, male dolphins keep their contaminant load in their blubber for life (see, also, Wells et al., 2005).

After that AVMA meeting in 1965 mentioned above and the publication of a paper on the medical care of marine mammals (Ridgway, 1965), I received a letter from Charles C Thomas, publisher. They asked me if I would like to do a book, perhaps with the help of others, on the field of marine mammal veterinary studies. I had seen a monograph by Dr. Masaharu Nishiwaki in Japanese with some excellent drawings of cetaceans, sirenians, and pinnipeds, so I asked him to contribute to this publication. Dr. Karl Kenyon agreed to cover sea otters; Drs. David and Melba Caldwell agreed to write about social behavior, senses, and communication; Dr. John Simpson recruited Dr. Murray Gardner to help with histology and pathology; Dr. Norbert Flanigan agreed to do the nervous system; Drs. Murray Dailey and Robert Brownell covered parasites; Dr. Debbie Duffield covered evolution; Dr. Robert Green covered gross anatomy; and I wrote the concluding chapter concerning physiology and medicine. These authors were all people that I knew well and had worked with from time to time, except for Professor Nishiwaki, whom I had only met once. We worked on *Mammals of the Sea: Biology and Medicine* together for over five years (Ridgway, 1972a). The book was focused on areas that I reasoned would be helpful to veterinarians caring for marine mammals. The late Steven Leatherwood aided me considerably in this effort. (An administrative assistant with our group at Point Mugu, Steven morphed into a full-fledged and productive marine mammal scientist within only a few years.) The book received good reviews and had some appeal to a wider audience of marine mammalogists as well as to veterinarians and aquarium specialists.

Soon after I arrived at Cambridge University in 1970 to enter a doctoral program in neurobiology, my professor, Richard Harrison, MD, D.Sc., FRS, asked me to join him in editing a series of books. *Handbook of Marine Mammals*, which turned out to be a six-volume series occupying considerable time over the next 24 years. The numerous experts on each species who came through to write chapters for this series would agree that I was not the best person for such a task. However, I learned a great deal; I became friends with many good and dedicated marine mammal scientists; and I think that all of these books are still of some use today and certainly served as a bridge of knowledge toward the more extensive and detailed compilations that are available in 2008 (*cf* Reynolds & Rommel, 1999; Dierauf & Gulland, 2001; Perrin et al., 2002). I point this out because more and more veterinarians are becoming members of collaborative teams. Such teams often need several scientific disciplines to learn more about the intriguing mammals that inhabit two-thirds of the Earth.

Veterinary pathologists at the Armed Forces Institute of Pathology examined numerous marine mammal tissues starting as early as 1970. This work began with Dr. George Migaki (*cf* Joseph et al., 1986) and continued with Drs. Thomas Lipscomb, Robert Moeller, Dale Dunn, and Brad Blankenship, among others. These pathologists contributed to many diagnoses. They published papers concerning disease conditions of different marine mammal species and from many different parks, laboratories, and oceans. Of course, a number of other veterinary pathologists have made important contributions. Among these are Drs. Antonio Fernandez, Stephen Raverty, Linda Lowenstine, Tanja Zabka, Judy St. Leger, Kathleen Colegrove, and Greg Bossart. Dr. Bossart is active in disease discovery and immunology. He also works in clinical medicine and trains veterinarians and graduate students in marine animal pathology. Dr. Linda Lowenstine of the University of California at Davis has contributed significantly by working with the California coastal stranding networks. She collaborates with Dr. Frances Gulland (*cf* King et al., 1995; Gulland et al., 1996, 1999; Stott et al., 2004) and has also trained pathologists such as Drs. Kent Osborne, Pam Yochem, Bruce Rideout (Lowenstine et al., 1990), Kathleen Colegrove (*cf* Colegrove et al., 2005), and Tanja Zabka (Zabka & Romano, 2003; Zabka et al., 2004) in marine mammal pathology.

Zoonosis is a term used for infection that can be transmitted from animals to humans or from humans to animals (*cf* Cates et al., 1986; Hicks & Worthy, 1987; Tryland, 2000). From time to time, many who dissect marine mammals or examine their mouths or their food fish with bare hands are likely to get a swollen painful red finger. This can result from the prick of a tooth or from handling sick animals (dead or alive) without gloves. An early medical report of this condition is from Dr. Martin Lister's letter to the Royal Society in 1694 (Figure 27). From Dr. Lister's description, we can make an educated guess as to what organism caused his painful infection. He explains that it took four days for his finger to "put on a livid appearance." This change is within the incubation period of erysipelas. Lister's condition, however, could have been caused by a number of different bacteria. Another likely bacterial cause is *Streptococcus*, the organism of human erysipelas that caused so much illness and death in the early days of surgery (namesake, Dr. Joseph Lister, British surgeon, promoted sterile surgery and antiseptics in the late 1800s and early 1900s, eliminating much of this suffering). Secondly, *Erysipelothrix rhusiopathiae*, the organism that caused dolphin erysipelas or the same disease in many other animals, such as pigs, is definitely a possibility. This disease is called erysipeloid in humans. In any case, I have always been able to dispatch my "livid" finger quite rapidly with penicillin. Others have had good success with tetracycline (*cf* Sargent, 1980; Hartley & Pitcher, 2002).


Of a venomous Scratch with the Tooth of a Porpus, its Symptoms and Cure. By Dr. Martin Lister, F. of the Coll. of Physicians, and R. S. Translated from the Latin. N° 233, p. 726.

In dissecting a porpus, that had been dead at least 3 days, I accidentally scratched the inside of my finger, so slightly as not to fetch blood, against one of the teeth. I left no inconvenience from this accident until 4 days afterwards; when the finger put on a livid appearance, and was somewhat swoln at the joint. This affection spread daily, so that in the space of 4 more days 2 fingers were diseased; and at length, 3. I tried various applications by the advice of surgeons but without relief; till at length the disorder extended to the hand, and the wrist began to be painful. Its further progress, however, was now arrested by a fomentation composed of aq. sperm. ran. ℥vj. bol. armen. ʒiss. vitriol. alb. ʒiv. applied warm twice a day. Sometimes the application was varied in the following manner: ℞ vitriol. alb. combust. bol. armen. an ℥iv. camph. ℥j. ap. commun. lbviij. Afterwards by applying the ung. nutritum, and over that an emplastr. ex bolo et diapalm. I recovered from this extraordinary accident. Besides the livid appearance, a proof of something poisonous, I was affected with a most troublesome and distressing itching, or rather a hot smarting sensation, both day and night. The whole of the cuticle belonging to the diseased parts peeled off; and it was not till after some months that the use of my fingers was completely restored.

Figure 27. Dr. Martin Lister's prescription treatment of the scratch of a "porpus tooth" for the Royal Society of London

Poor Dr. Lister had to suffer from his infection for months despite his creative treatment.

Putting aside bites and infections from a cut in contact with sea water (Flowers, 1970), disease transmission between marine mammals and humans in stranding networks, in laboratories, and in display facilities has been rare. This is true despite the close contact between the animals and their handlers. Personal sanitation is critical (*cf* Cowan et al., 2001). With the advent of numerous swim-with-a-dolphin adventure programs, where the public has close contact, the record of disease transmission to humans from healthy dolphins is still virtually nonexistent (Geraci & Ridgway, 1991).

During my time at Point Mugu in the early 1960s, I enjoyed my collaboration with D. Gordon Johnston, MD. Dr. Johnston was a pathologist at the local St. Johns Hospital in Oxnard, California. We published several articles together. We determined volumes of blood and other circulatory measures in several local cetacean species (Ridgway & Johnston, 1966). We also discovered unidentified ova (eggs of parasites) in the cerebrum and cerebellum that caused a stroke condition in a stranded common dolphin (*Delphinus delphis*) (Ridgway & Johnston, 1965; Johnston & Ridgway, 1969). This diagnosis was in tune with Ray's (1961) earlier contention that sickness was the cause of most single individual strandings. Dr. Murray Dailey (Figure 4) and I studied seven such cases. Dr. Dailey identified the parasitic flukes that migrated from the head sinuses through the brain, and together, we provided more detail on this stroke-like condition of common dolphins (Ridgway & Dailey, 1972).

When I began work with marine mammals, their viral diseases were unknown. Viral disease discovery depended on finding virus or virus particles in animal tissues with an electron microscope and the painstaking culture of the virus. This process was exacting, lengthy, and often depended on pure luck. In the late 1960s, Dr. T. M. Wilson showed up at our lab to do further studies on poxvirus in sea lions. He had recently found a case in a sea lion in an aquarium (Wilson et al., 1969). Soon after that, Dr. Alvin Smith (see Smith et al., 1973; Smith & Skilling, 1979), who worked at the Naval Biomedical Laboratory in Oakland, California, and later with me in San Diego, discovered a calicivirus, the San Miguel sea lion virus, that has periodic impacts on the sea lion population. This was especially important because caliciviruses cause disease in livestock and many other animals. The invention of the polymerase chain reaction (PCR) process and other modern methods have made virus discovery more straightforward. Numerous virus discoveries followed the early work on pox- (Figure 28) and calicivirus. Some that come to mind are by Flom & Houck (1979) and Geraci et al. (1979) on poxvirus; by Dierauf et al. (1981) on Adenovirus hepatitis; by Osterhaus et al. (1985) and Kennedy-Stoskopf et al. (1986) on herpes virus; and by Osterhaus & Vedder (1988), Domingo et al. (1992), Kennedy (1990), Duignan et al. (1997), and others on phocine distemper virus, dolphin Morbillivirus, and other viruses (Van Bressem et al., 1999). Papillomaviruses were found in sperm whales by Lambertsen et al. (1987) as well as in other species (Van Bressem et al., 1999). More recently, parapoxviruses and parainfluenza viruses have been found in marine mammals (Nollens et al., 2006a, 2006b, 2008). Gammaherpes virus has been found to be associated with a high incidence of cancer in California sea lions (Lipscomb et al., 2000; King et al., 2002; Buckles et al., 2006, 2007). This virus has also been found in endangered Hawaiian monk seals, (*Monachus schauinslandi*) (Goldstein et al., 2006), and more recently it was implicated in orogenital papillomas of coastal bottlenose dolphins (Bossart et al., 2008). Of particular note are the morbilliviruses. According to Di Guardo et al. (2005), until 1988, only four morbilliviruses had been identified: (1) rinderpest—an acute, highly contagious, and lethal disease of cloven-hoofed animals; (2) peste des petits of ruminants (PPR)—a significant viral disease of goats and sheep; (3) canine distemper—an often fatal disease of dogs and their relatives; and (4) measles in humans—a disease which can be very serious in unprotected or immunocompromised individuals. Like these terrestrial diseases, morbillivirus epidemics have now been seen in cetaceans and pinnipeds, and at least eight large outbreaks with high mortality have been identified since the first discovery of phocine distemper virus in 1988 and dolphin morbillivirus shortly thereafter. Thus, through the efforts of these veterinarians and virologists, we have started to recognize a continuum between the types of disease seen in terrestrial and marine mammals.

After 30 years of dealing with pneumonia, erysipelas, fungal pathogens, etc., this sharing of disease types was again brought strikingly to my attention in early 1992. One of our bottlenose dolphins aborted a 79-cm fetus on January 27 of that year. A full-term calf would have been over 100 cm in length, so we knew right away that this was a spontaneous abortion. My colleague, Dr. W. G. Miller, did a careful necropsy on the fetus and submitted specimens for culture to Deanne Harley, the microbiologist at Balboa Hospital, who cultured a *Brucella*—an organism from a family of bacteria that causes brucellosis and results in spontaneous abortions in many terrestrial species. We submitted the placenta to Dr. Kerry Mahoney, the pathologist at the office of the San Diego County veterinarian, and she found histological evidence that pointed to brucellosis. For confirmation, Dr. Miller sent the *Brucella* culture to the National Veterinary Services Laboratory of the U.S. Department of Agriculture in Ames, Iowa. That laboratory confirmed and published the diagnosis (Payeur et al., 1992; Ewalt et al., 1994). Dr. Miller also contacted Dr. A. P. MacMillan in Britain who had also found *Brucella* in harbor seals (Ross et al., 1994). Later, Dr. Miller found three other dolphin cases and suggested the new species of *Brucella* from the dolphin abortions be named *Brucella delphini* (Miller et al., 1999). Even though the naming conventions of the marine *Brucella* changed, we know that antibodies to various types of *Brucella* appear in every major cetacean and pinniped group and from every major ocean (*cf* Foster et al., 2002). Most likely, the ancestor of the infectious organism we called *Brucella delphini* was present in the terrestrial ancestor of the delphinids.

Using *Brucella* tests that worked for livestock, we found no antibody titers to this disease before 1992. The earlier tests were not specific enough to detect the dolphin species of *Brucella*. Since the 1960s, we have done screening titers on our cetaceans and pinnipeds. W. G. Gilmartin began this work at Point Mugu. Dr. John Allen in our Hawaii laboratory also took up screening. Erysipelas had caused disease and death in some dolphins at Marineland of Florida in the 1950s (Seibold & Neal, 1956; Simpson et al., 1958). We were especially concerned about erysipelas. Killed erysipelas bacterins (vaccine consisting of killed bacteria) normally used for pigs were employed to immunize dolphins. Injections often caused swelling at the injection site. Occasionally, a dolphin would appear to feel poorly and refuse food for a day or two after the injection. Gilmartin tested dolphin blood samples for titers to erysipelas. We tried to work out vaccination schedules using different products (*cf* Gilmartin et al., 1971) to improve results. Gilmartin also tested clostridial bacterins normally used in cattle. Dr. G. W. Klontz had found clostridial disease in a killer whale, and we had found clostridial myositis in dolphin muscle (Ridgway, 1972b). Reading the work of Heller (1920), we knew that clostridial diseases might be a threat to cetaceans. However, their incidence was low. Antibiotics turned out to be a better choice for treatment.

Erysipelas was a continuing concern because the septicemic or blood form of the disease could be so rapidly fatal. Dr. Gary Colgrove came to the U.S. Navy's Hawaii laboratory in the early 1970s. He continued to work on erysipelas and other diseases in addition to his veterinary care duties (*cf* Colgrove, 1975; Colgrove & Migaki, 1976). Dr. Colgrove also started some basic work on the dolphin immune system (Colgrove, 1978).

By the 1970s, it was apparent that a high percentage of bacterial and fungal diseases of marine mammals resulted from depression of the animals' immune system. Animals with healthy immune systems fight off disease. Those that were immune-compromised readily succumbed to a variety of disease-causing agents.

In the 1980s, I met Dr. Vito Quaranta of the Scripps Research Institute (SRI). SRI scientists invented the monoclonal antibody process and many other methods in immunology. Dr. Quaranta began studying lymphocytes from our dolphins. The progress was very slow, however, until a young graduate student, Tracy Romano, came to my laboratory to work with dolphins. Tracy was able to spend considerable time in Dr. Quaranta's lab. She learned modern immunological methods to add to her studies at Rochester University. Tracy graduated from Rochester with a dissertation on neural and immune interactions. Dr. Romano (Figure 22) then did a post-doctoral fellowship with us, continuing to explore the cetacean immune system (*cf* Romano et al., 1992, 1999, 2002, 2004). Dr. Romano has continued her path of work on the cetacean immune system, presenting progress every year at the IAAAM conference.

Dr. Sylvain De Guise, a contemporary of Dr. Romano, studies marine mammal immunology, specifically the effects of ocean contaminants on the immune system (*cf* De Guise & Levin, 2004; De Guise et al., 2004; also see Lahvis et al., 1995). This special interest was stimulated, in part at least by Dr. Daniel Martineau and colleagues of the veterinary school in Quebec. They have investigated numerous deaths of belugas from the St. Lawrence Estuary. Martineau's team found such high levels of contaminants in these white whales that the carcasses were regarded as hazardous waste (Martineau et al., 1987). As time passed, Dr. Martineau's group, including Dr. De Guise, discovered a very high incidence of cancer in the St. Lawrence belugas. Likely, these cancers resulted from cellular injury by contaminants and suppression of the whales' immune systems.

Another center for marine mammal immunology research is at the University of California at Davis, School of Veterinary Medicine. The laboratories of Drs. Jeffery Stott and Linda Lowenstine are active in association with Drs. Frances Gulland and Jeff Boehm of the Marine Mammal Center in Sausalito, California, and Drs. James McBain and Tom Reidarson of Sea World in San Diego. A number of their collaborative studies have already been cited.

In my earliest experiences with dolphins in the wild—at Marineland of Florida and in our laboratory—I noticed curious markings, "tattoos," that sometimes appeared on dolphins' skin. Woody told me that new dolphins introduced to the Marineland tanks often got tattoos. Later, we learned that tattoos are signs of dolphin poxvirus. Tattoos have strange behavior. Sometimes they appear around a rake mark made on the dolphin from the tooth of another dolphin. At other times, a simple cut on a tattoo will cause part of it to disappear. Often, young dolphins will get tattoos around the time of weaning. As the dolphin gets older, the tattoos frequently disappear. Then, after many years, tattoos may again appear on the dolphin's skin. I have seen numerous types of tattoo designs on dolphin skin. Just a few examples are shown in Figure 28. The immunology, behavior, and anatomy of dolphin tattoos deserve further investigation.

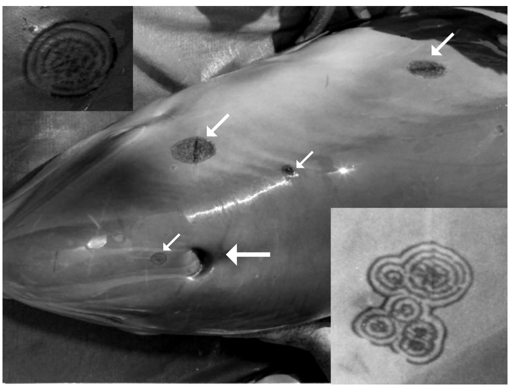


Figure 28. Three year-old bottlenose dolphin with tattoos (small white arrows); Inset 1 is a blow-up of the tattoo (medium-sized arrow) just forward of the blowhole (large arrow). Inset 2 is another interesting type of tattoo design that we see on dolphin skin both in the wild and in managed populations.

Working at a U.S. Navy laboratory, I have long been interested in what might be learned from diving animals like dolphins, whales, and seals that might give clues to human diving diseases such as bends, aeroembolism, nitrogen narcosis, and high pressure nervous syndrome (*cf* Ponganis et al., 2003). In the late 1960s, I worked with John Kanwisher, Ph.D., and Bill Scronce to show that dolphins could dive deep and return to the surface rapidly, even when taking down a lung full of air, without any problem of the bends (Ridgway et al., 1969). The secret was in the dolphin's flexible thorax that allowed the lungs to collapse at about a 70-m depth. This collapse limited nitrogen absorption in the blood and, thus, they had no problem from the bends. In the next step taken in the 1970s, with Red Howard, Ph.D., MD, we addressed the issue of rapid shallow dives to 100 m. Trained bottlenose dolphins dived to 100 m and returned to the surface 20 to 25 times within a period of one hour. With this rapid, repetitive dive schedule, dolphins did build up nitrogen in their muscle. The level of nitrogen in the dolphins at the end of the dive schedule was at a level where nitrogen bubbles might begin to develop (Ridgway & Howard, 1979). The dolphins were ready and willing to repeat this rapid dive schedule, however, and showed no ill effects from the effort. The question of diving diseases and bubbles in blood and other tissues of cetaceans has recently been revisited by several authors (*cf* Houser et al., 2001; Jepson et al., 2003, 2005; Moore & Early, 2004; Fernandez et al., 2005; Zimmer & Tyack, 2007). Theoretically, intense sonar signals from anthropogenic activities could activate bubble formation in cetaceans that carried excess nitrogen due to diving (Houser et al., 2001). Of particular note, scientists who investigated a mass stranding of beaked whales (*Ziphius cavirostris*, *Mesoplodon densirostris*, *M. europaeus*) off the Canaries in 2002 said all of the animals showed signs of acute bubble formation in their soft tissues. They suggested that military sonar exercises that occurred proximate to the strandings might have caused signs of the bends in the stranded whales (Jepson et al., 2003, 2005; Fernandez et al., 2005). In another approach, Moore & Early (2004) found lesions in sperm whale bones suggestive of osteonecrosis. Among other causes, osteonecrosis can result from a history of the bends in human divers. I commend the veterinarians who led these investigations. Drs. Jepson, Fernandez, and Moore made careful analyses and provided new insight. However, bubbles in the tissue of stranded cetaceans may have many causes. The relationship between stranding, military sonar use, and cetacean diving disease is still a puzzle that needs further investigation.

The Center for Coastal Studies in Massachusetts rescues humpback and right whales that become entangled in fishing gear. Dr. Michael Moore of Woods Hole Oceanographic Institution studies the best means to release baleen whales entrapped in fishing gear (*cf* Woodward et al., 2006). Some whales might require dart administration of sedatives to calm them for the rescue efforts. Dr. Moore's darts came in handy when it became necessary recently to deliver antibiotics to two misguided humpback whales in the Sacramento River in California. The mother and calf whales had gone up the river, had suffered injuries, and their survival was in doubt. Numerous attempts to drive or lure the whales out to the ocean failed. Dr. Teri Rowles, veterinarian for the federal NOAA Fisheries Service, decided to treat obvious infections using the special darts provided by Dr. Moore (*cf* Gulland et al., 2008). The treatment apparently worked and, fortunately, the whales soon swam back out to sea.

There is a continuing need for euthanasia of marine mammals to prevent suffering of hopelessly ill or severely injured animals. As discussed above, rapid and deep anesthesia to prevent pain is critical. When it comes to killing marine mammals for food, fuel, fur, or other resources, the situation is somewhat different. In the past 30 years, veterinarians also have become more involved in humane issues. The International Whaling Commission (IWC) has held several workshops on the "humane killing" of whales often in association with humane advocacy groups. I attended several of these workshops. In 1980, there was a conference entitled "The Intelligence of Cetaceans and the Ethics of Killing Whales" (Figure 29). In 1982, a workshop was hosted by the Royal Society for Prevention of Cruelty to Animals (RSPCA) in England (Figures 30 & 31) (*cf* Barzdo & Vodden, 1983). Certainly, there is continuing debate over whether marine mammals should be killed at all. If animals are to be killed, it is the veterinarian who is in general best trained to devise methods to humanely treat the animal. The humane killing debate is especially reflected in the numerous reports of the IWC on the humane killing of whales subject. Since there will likely be continued resource-based killing, a number of veterinarians have been involved in trying to establish the most humane killing methods based on knowledge of marine mammal anatomy, physiology, and anesthesia. These veterinarians include Drs. Egil Ole Øen of Norway; Harry Rowsell of Canada; Nick Gales of Australia; and Tom Albert, Todd O'Hara, and Joseph Geraci of the U.S.; and the author.

Figure 29. At the Smithsonian in 1980 for "The Intelligence of Cetaceans and the Ethics of Killing Whales" conference; this conference focused attention on the humane issues involved in whaling. The author holds an umbrella over (*L to R*) Drs. Karen Pryor, Masaharu Nishiwaki, and John Lilly.

Figure 30. Dr. Jim Mead (Smithsonian), Dr. Bill Jordan (RSPCA veterinarian), and the author discuss humane issues at the RSPCA conference in 1982.

There is a long-term, year-round resident community of about 140 bottlenose dolphins in Sarasota Bay, Florida. The community provides an opportunity to learn about the natural history of this species. Research on these dolphins was initiated by Drs. A. B. Irvine, R. S. Wells, and M. B. Scott (*cf* Irvine et al., 1981; Scott et al., 1990). They identified many individual dolphins of known age, sex, and maternal lineage. Close observation provides data on dolphin spatial and temporal occurrence, births, fates of calves, and birth order. Temporary capture operations conducted for veterinary examinations provide biological data, life history information, and contaminant residue measurement. Over the years, veterinarians and veterinary students have participated in the safe capture, evaluation, and release of this dolphin community (*cf* Wells et al., 2004, 2005). Veterinary personnel, especially Drs. Forrest Townsend, Charles Manire, and Jay Sweeney, have contributed to the success of this long-term program. In turn, veterinary personnel have gained valuable experience applicable to dolphin care.

When I began working in the early 1960s, one was free to go out and catch a dolphin or a small whale at any time. Bottlenose dolphins could be bought from some fishermen for as little as $100. For the coastal marine park displays along Florida and the Gulf of Mexico, it was sometimes cheaper to buy a new dolphin than to treat a sick one in the aquarium. In general, however, the availability of experienced veterinarians and the increase of veterinary knowledge led to slow improvement. Things changed even more rapidly after passage of the Marine Mammal Protection Act (MMPA) in 1972. With the establishment of the Marine Mammal Commission (MMC), Chairman Dr. Victor Scheffer

Figure 31. Group picture at the RSPCA conference, 1982

and Executive Director John Twiss made a decision to have a veterinarian on the nine-member Scientific Advisory Committee. Dr. Jesse White (Figure 32) was first to serve in this role. When I replaced Jesse, a major issue was to develop regulations on the care of marine mammals on public display in aquaria, zoos, and marine parks. There was much debate about these regulations because they would involve economic impacts on those holding marine mammals. There would also be additional responsibilities for the U.S. Department of Commerce for permitting and the U.S. Department of Agriculture (USDA) for inspections of facilities because marine mammals would now be brought under the Animal Welfare Act (AWA), which was administered by the USDA. After three or four years of effort and input from hundreds of people, Robert Eisenbud, the MMC attorney, came to San Diego to work with me. We sat together for a week in my office, a converted metal field kitchen that Chief Skilling at Point Mugu had "liberated" from the U.S. Park Service 15 years before. With a background of dolphin whistles and creaks from adjacent pools and sea lions barking a few meters away, Bob Eisenbud made sure the document was legal, and I made sure it was technically accurate. In the end, we came up with regulations that annoyed everyone, but not too much. Marine mammals were now required to have certain minimal space, a clean water supply, access to veterinary care, and any animal that died was to have a postmortem examination so that we could learn more about their diseases and avoid repeating mistakes. The MMPA and the regulations both underscored the value of the marine mammals in keeping with public sentiment and, to a great extent, are responsible for the improved situation today in which dolphins in aquaria and facilities like ours remain healthier and live longer than the average of their cousins in the wild.

Figure 32. Dr. and Mrs. Jesse White

Veterinarians have continued to contribute to the work of the nine-member Scientific Advisory Committee to the MMC. Dr. Geraci replaced me on the Committee, Dr. William Medway replaced Joe, and now Dr. Frances Gulland continues that veterinary contribution. Of course, all of these members have Ph.D. degrees in related scientific fields as well.

One effort supported by the MMC was the development of self-sustaining populations of marine mammals in display facilities. Breeding has largely replaced taking animals from the wild. Along with the Zoological Society of San Diego, the MMC sponsored the first workshop on breeding dolphins, which was held at the San Diego Zoo in 1975. This workshop was international in scope. There were attendees from Europe, South Africa, and other countries as well as the United States. Along with veterinarians, curators, and animal keepers, several prominent marine mammalogists were in attendance: Drs. Carl Hubbs, David Caldwell, Melba Caldwell, Richard Harrison, W. H. Dudok Van Heel, F. G. Wood, John Prescott, Graham Saayman, and others (Figure 33). Dr. Kurt Benirschke chaired the meeting and worked with me in editing the proceedings (Ridgway & Benirschke, 1977). This meeting really set the course for a sustained population of bottlenose dolphins from North America and in some facilities around the world. Momentum for breeding marine mammals continued in follow-up meetings (*cf* Duffield et al., 2000).

On the technical side, Dr. J. P. Schroeder made early progress on semen collection at the U.S. Navy facility in Hawaii (Schroeder & Keller, 1989, 1990; Figure 34). He began attempts at artificial insemination. Dr. Cornell at Sea World of San Diego made major steps forward by collaborating with the Center for Research in Endangered Species of the Zoological Society of San Diego. They worked out methodologies for collecting and assessing urine samples. They learned to predict ovulation and reproductive cycling in killer whales and dolphins (Walker et al., 1988). Subsequently, Dr. Todd Robeck and his collaborators at the various Sea World Parks extended this technology (Robeck et al., 1993). They have been successful in producing offspring of bottlenose and Pacific white-sided dolphins and killer whales by artificial insemination (Robeck et al., 2004, 2005), and, recently, they have been successful with a beluga. In addition, considerable progress also has been made in caring for mothers, in rearing neonates

Figure 33. Dolphin Breeding Workshop, 1975

Figure 34. Karl Keller trained the dolphins for semen collection to aid in reproductive studies, including artificial insemination technology.

(Figure 35), and in supporting orphaned animals (see chapters in Duffield & Robeck, 2000).

In 1986, I attended a conference on the biology and conservation of the river dolphins—*Lipotes vexillifer*, *Platinista gangetica*, and *Inia geoffrensis* (Figure 36). Specialists on each of the river dolphin species attended (e.g., Perrin et al., 1989). We made suggestions about the potential for propagation of river dolphins, especially the baiji (*L. vexillifer*, Yangtze River dolphin). A large ox bow of the river some 20 km in length had been set aside as a baiji sanctuary. We made suggestions about the capture, handling, veterinary care, husbandry, housing, nutrition, and social considerations for propagating these highly endangered dolphins (Ridgway et al., 1989). Alas, pollution, damming of the river, heavy river traffic, and fisheries bycatch had taken their toll on the species. By 2007, the baiji was apparently extinct before controlled propagation measures could be instituted in the ox bow.

Social groupings are very important considerations for successful dolphin breeding and care of young. In the early history of dolphin care, most of the dolphin breeding occurred in large aquarium tanks or enclosures with several adult females and

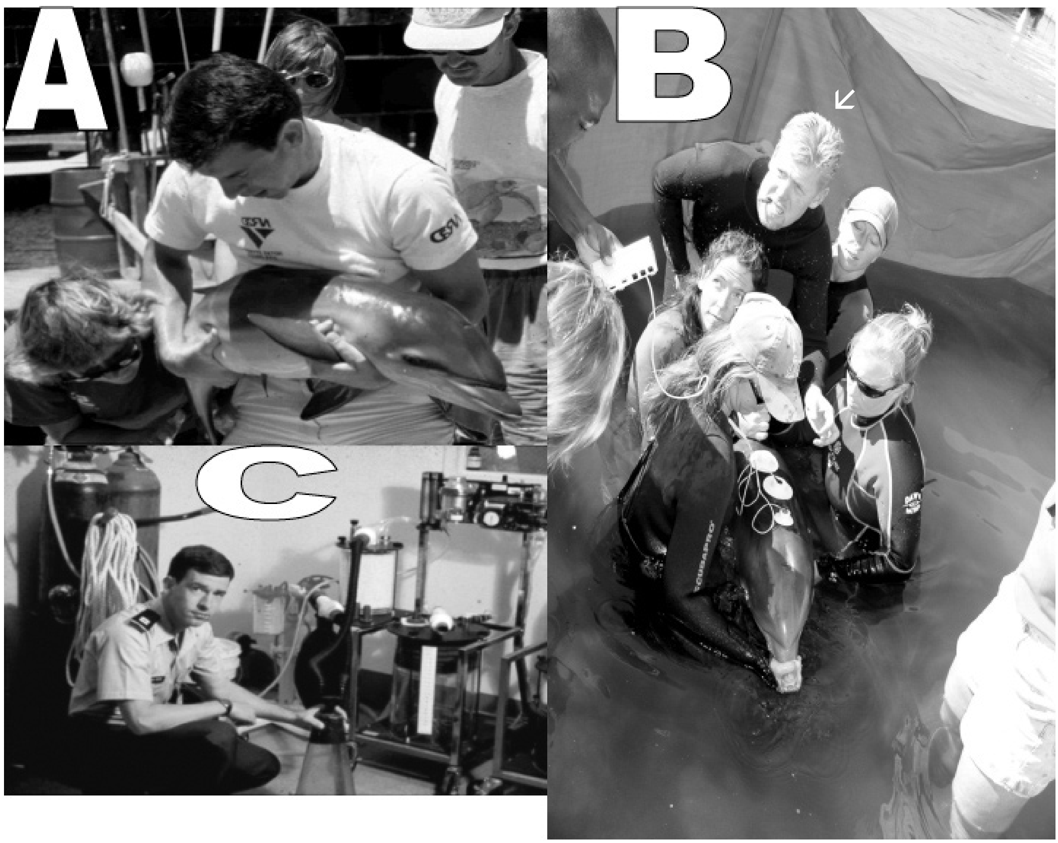


Figure 35. (A) Dr. Bill Van Bonn weighing dolphin neonate; (B) Dr Eric Jensen (arrow) supervises a physical examination of a 3-month-old dolphin. The suction cups on the animal's back monitor the cardiogram during the procedure; and (C) Dr. William Van Bonn, CPT U.S. Army with dolphin gas anesthesia equipment circa 1993.

Figure 36. On the Yangtze in 1986 on a mission to save the baiji (Yangtze River dolphin). *Front Row (L to R):* Randall Brill, Natasha Atkins, Maria Cristina Pinedo, Toshiro Kamiya, Kevin Chu; *Second Row (L to R):* Phyllis Norris, Katherine Ralls, Robert L. Brownell, William F. Perrin, Sandi Schreib, R. L. Lal Mohan, Toshio Kasuya; *Back Row (L to R):* Vera M. F. da Silva, Kenneth Norris, Liu Renjun, Enrique A. Crespo, Tej Kumar Shrestha, Kahn Muhammad Kahn, the author, Robin C. Best.

one or more adult males. When births occurred in the same group, aggression at the time of birth and soon afterward often occurred (Wood, 1977). Bull dolphins can be aggressive toward each other and sometimes toward mothers and calves (McBride & Hebb, 1948; Essapian, 1963; Wood, 1977). On occasions, mature males can inflict severe injury or even death (*cf* Caldwell & Caldwell, 1972). Early on, we learned that managing social groupings is very important and requires vigilance on the part of husbandry and veterinary personnel. Possibly as a result of this male aggression and competition between some of the females, there were many stillbirths, and calf mortality was high; survival of bottlenose dolphin calves was only about 30% (Wood, 1977). Since these earlier groupings were successful in breeding dolphins but not in rearing them, many collections devised new strategies. Zookeepers moved pregnant females off on their own or with other compatible females to "nursery" tanks or pens. In a significant majority of 40 pregnancies handled in this manner that were documented by Cornell et al. (1987), the calves survived to be weaned at Sea World in San Diego. There are similar practices in other facilities with successful breeding groups today.

Debbie Duffield (Figure 37) started her work with marine mammals as a student in my laboratory in the summer of 1964. She was my first Navy trainer of Tuffy, a bottlenose dolphin that went on to be our first working open-ocean release dolphin. This training opened the door to understanding the diving physiology of this species (*cf* Ridgway et al., 1969; Ridgway, 1987). Duffield was the first of four trainers who were primary with Tuffy. She was followed in that position by Wally Ross, Blair Irvine, and Bill Scronce. As she progressed through her graduate studies, Debbie gained expertise in genetics. She spent many years applying these techniques to the husbandry and breeding of marine mammals in oceanaria and aquaria in North America. This interest expanded to the genetic variability in natural populations. She worked on the long-term field study on bottlenose dolphins in Sarasota Bay with Dr. Randy Wells (Duffield & Wells, 1991, 2002).

Figure 37. Student and trainer Debbie Duffield and the author examine Tuffy in 1964. The sponge over Tuffy's right eye keeps it moist and protects it against the glare of the sun.

Since obtaining her Ph.D. at UCLA, Dr. Duffield has made a major contribution to the reproduction of marine mammals in human care. She uses genetic techniques to track paternity for bottlenose dolphins, killer whales, belugas, Commerson's dolphins, harbor seals, and California sea lions (Duffield, 1990, 1994, 1998, 2000, 2005; Duffield & Chamberlin-Lea, 1990; Andrews & Duffield, 1992; Joseph & Duffield, 1994; Duffield et al., 1993, 1995, 2000). She helped a number of North American facilities document animal parentage. These breeding programs are producing second and third generation offspring with no loss of genetic variability. Dr. Duffield establishes and manages DNA banks as invaluable resources for future research.

A long-term interest of Dr. Duffield's has been the study of marine mammal hybrids. She and her students have documented both pinniped and cetacean hybrids in aquaria and in the wild (Duffield & Kang, 1973; Duffield, 1975; Jameyson et al., 1981; Nishiwaki et al., 1983; Zornetzer & Duffield, 2003). These observations offer a view of what types of interspecies interactions are possible. Many of these hybrids are fertile.

Dr. Duffield has also contributed to the development of physiological databases for marine mammals, drawing on the wealth of hematologic and blood chemistry data collected by facilities holding these species (Cornell et al., 1988; Asper et al., 1990; Duffield & Shell, 1999a, 1999b, 1999c, 1999d; Reidarson et al., 2000). This work has contributed to the understanding of hematological parameters associated with the varying oxygen demands on coastal versus deep-diving cetaceans and pinnipeds (Ridgway & Johnston, 1966; Duffield et al., 1983; Hedrick et al., 1986; Hedrick & Duffield, 1991). Early contributions to blood evaluation also included those by Medway & Geraci (1964), Andersen (1966), Bryden & Lim (1969), Ridgway et al. (1970), and Medway et al. (1970).

Iatrogenic disease is disease caused by a physician, especially by a treatment. (*Iatros* means physician in Greek, and -genic, meaning producing or forming.) Veterinarians have also recognized the possibility that treatment may make things worse or, in rare instances, even cause disease or death. Thus, like physicians, we subscribe to the dictum *Primum non nocere*: "first do no harm." The dictum is not always possible to follow because, like physicians treating cancer, sometimes we are left with choices between various approaches, all of which may cause some harm. For example, when a young beluga was diagnosed with severe nocardiosis, there was little choice to save the animal's life except to use the potent antibiotic amikacin in a prolonged treatment. Extended treatment with amikacin may cause deafness, so the choice made in this case was between a possibility of some deafness or of death. The most reasonable chance to take was the possibility of some deafness. While this white whale did indeed lose a good deal of its high-frequency hearing, it successfully survived the disease (Finneran et al., 2005).

Since hearing is crucial for their echolocation and communication, the problem of deafness is a special concern for dolphins and many other marine mammals. Severe infections such as meningitis can cause deafness. Deafness can also be caused by parasites, especially flukes, and certain medications as mentioned above (*cf* Dailey & Ridgway, 1976; Ridgway & Carder, 1997). At the NMMP, we are concerned with dolphin audiometry and in improving diagnostic methods for hearing assessment (*cf* Seeley et al., 1976; Ridgway et al., 1981; Szymanski et al., 1999; Ridgway & Carder, 2001; Nachtigall et al., 2005; Schlundt et al., 2007). Dr. James Finneran has developed a portable system and software for rapidly testing hearing in marine mammals (Finneran et al., 2008). The system, called EVREST, is based on a laptop computer. A trained operator with this system can rapidly acquire audiograms at distant marine parks or on beaches where whales or dolphins have stranded.

Veterinarians (or physicians for that matter) are generally untrained in the analysis of large sets of data. To achieve accuracy, they either need help from specialists or need some graduate training in epidemiology. In the early days of marine mammal medicine, this was not a serious problem because we did not have large data sets. Things have changed with the multiplication of databases on animals and their vital signs, diagnoses, lesions, cultures, and other useful medical data. I have found a veterinarian who is also specialized in epidemiology to be very useful in informing us on so many things that are not obvious. Veterinarians who work with stranded animals, such as Drs. Paul Jepson and Stephanie Norman, track ocean-wide geographic information on diseases. In my case, I have found Dr. Stephanie Venn-Watson (Figure 17) to be an especially astute veterinary epidemiologist. She illuminated much data to the benefit of our NMMP marine mammals (*cf* Venn-Watson & Ridgway, 2007; Venn-Watson et al., 2007, 2008).

In the 1960s, mortality and morbidity of marine mammals maintained in oceanaria, aquaria, and laboratories was high overall. I have been fortunate to witness tremendous progress in the veterinary care of marine mammals. Today, it is common for marine mammals in human care to live longer lives, on the average, than their relatives in the wild. In the 1960s, it was very unusual for a stranded marine mammal to be rehabilitated and released back into its population. Now this is commonplace. We know more about human-marine mammal interrelationships. Along the way, we have contributed very significantly to the knowledge of these interesting animals that populate the aquatic world encompassing two thirds of the Earth.

At the outset, I quoted the famous American actor, writer, commentator, and philosopher of the 1920s and 1930s, Will Rogers. He said, "The best doctor in the world is the veterinarian. He can't ask his patients what is the matter—he's got to just know." I have indeed wondered if we could improve on that situation by just listening to the dolphins for a long time through hydrophones mounted in their pools with the sound piped into my laboratory/office. Serious people often remarked, "What is that racket!" Bioacoustician Don Carder and Sue Moore, then a student at San Diego State University, helped me to record and analyze many 24-hour recordings of "that racket." We have made some progress (Ridgway, 1983; Moore & Ridgway, 1996); however, we have a long way to go before the dolphin can tell us where it hurts.

I also began this account of advancements in marine mammal medicine with a quote from Mahatma Gandhi, a lifelong vegetarian. Although I myself am not a vegetarian, I still believe the quote is applicable. That is to say, we should have empathy for animals as individuals and, therefore, treat them in the best way possible. Whales (or any animal) should be killed humanely. When sick or injured marine mammals are on the beach, or entrapped, and rescue and rehabilitation is not promising, they must be dispatched in the most humane way. We should treat marine mammals in human care respectfully and with the maximum means that our knowledge will allow.

When F. G. Wood toured me around Marineland of Florida near the outset of my career, he showed me an area behind the dolphin tanks where the staff had a social area near the beach to celebrate a good day's work—to have drinks and to grill seafood on special occasions. At this location was an incongruous sight. There was an old double-roller type washing machine on the sand. Woody told me, perhaps with tongue in cheek, but seemingly with great seriousness, that the rollers were used for tenderizing octopus. He explained that sometimes a large octopus would not adapt to the social life of the aquarium and become a rogue feasting on other aquarium occupants. The best solution was to eat the rogue octopus! Octopus, being a rather tough meat, had to be tenderized for proper culinary preparation—thus, the double-roller washing machine! Woody further instructed me that if the octopus had not been properly dispatched prior to the tenderizing process, it would wrap its tentacles around the operator and struggle mightily against the process—sometimes causing injury to the machine operator! I asked Jim Corey to imagine this scene and to illustrate such a process (Figure 38).

Figure 38. A battle between man, machine, and cephalopod—tenderizing the rogue octopus. Jim Corey imagined and illustrated the event after the author's description of Woody's story. Was Woody "pulling my leg"?

I have toured several dozens of aquaria and marine parks during my career. I have never seen another roller washing machine. If the late Forrest Glenn Wood was not pulling my leg, then we may have still further evidence of some moral progress during the past half century!

Figure 39. Dr. Frances Gulland on the back of a large beached blue whale, three days dead, to begin necropsy as Dr. Sam Dover looks on in awe; note that observers are a safe distance away on a hill. (Photo by Ken Weiss, *L.A. Times*)

Acknowledgments

I thank all the veterinarians, scientists, and technicians who have worked around me over the past 48 years. I have left out many important people around the world, but I thank them as well. I especially thank Dr. Frances Gulland (Figure 39) and my wife of 48+ years, Dr. Jeanette Ridgway (Figure 40). Both of these fine women read the manuscript at various stages and made helpful suggestions. I also express my appreciation to Christopher Hammell who carefully organized and checked all the references.

As a veterinarian and scientist working within a very large organization, I am aware of a number of individuals who took on the administrative burden that allowed me to progress in my field. During the past eight years, Dr. Lynette Corbeil, Department of Pathology, School of Medicine, University of California at San Diego, has been very helpful. From my many years with the Navy, I especially thank, B. A. Powell, H. O. Porter, L. W. Bivens, R. W. Kataoka, J. E. Haun, M. J. Xitco, and M. J. Rothe.

Figure 40. The author with Jeanette Ridgway, Ph.D., after 48 years of marriage and many adventures in the world of marine mammals

Literature Cited

Amemiya, I. (1962). The dolphin that swallowed a football. *International Zoo Yearbook, 4*, 34.

Andersen, S. (1966). The physiological range of formed elements in the blood of the harbor porpoise, *Phocoena phocoena*. *Nordisk Veterinary Medicine, 18*, 51-65.

Andrews, B. A., & Duffield, D. A. (1992). Captive propagation of marine mammal species in aquariums, zoos and marine zoological parks in North America. *Proceedings of the AAZPA Conference*, pp. 215-222.

Asper, E. D., Young, W., & Walsh, M. (1988). Observations on the birth and development of a captive-born killer whale. *International Zoo Yearbook, 27*, 295-304.

Asper, E. D., Cornell, L. H., Duffield, D. A., & Odell, D. K. (1990). Hematology and serum chemistry values in bottlenose dolphins. In S. Leatherwood & R. R. Reeves (Eds.), *The bottlenose dolphin* (pp. 479-488). San Diego: Academic Press.

Balcomb, K. (1994). *An annotated bibliography of cetacean releases*. Friday Harbor, WA: Center for Whale Research. 29 pp.

Barzdo, J., & Vodden, P. (1983). Report of a stranded whale workshop: A practical and humanitarian approach. *Proceedings of the Royal Society for the Prevention of Cruelty to Animals,* Horsham, UK.

Blair, W. R. (1912). *Report of the veterinarian* (Seventeenth Annual Report of the New York Zoological Society). New York: New York Zoological Society.

Bodner, E. M. (2007). Veterinary medicine. In *Microsoft encarta online encyclopedia*. Retrieved December 4, 2008, from http://encarta.msn.com/encyclopedia_761570560/Veterinary_Medicine.html.

Bossart, G. D., Romano, T. A., Peden-Adams, M. M., Rice, C. D., Fair, P. A., Goldstein, J. D., et al. (2008). Hematological, biochemical, and immunological findings in Atlantic bottlenose dolphins (*Tursiops truncatus*) with orogenital papillomas. *Aquatic Mammals*, *34*(2), 166-177.

Breland, K., & Breland, M. (1966). *Animal Behavior.* New York: Macmillan.

Brook, F., Van Bonn, W., & Jensen, E. (2001). Ultrasonography. In L. A. Dierauf & F. M. D. Gulland (Eds.), *CRC handbook of marine mammal medicine* (2nd. ed.) (pp. 593-620). Boca Raton, FL: CRC Press.

Brown, D. H., McIntyre, R. W., Delli Quardri, C. A., & Schroeder, R. J. (1960) Health problems of captive dolphins and seals. *Journal of the American Veterinary Medical Association*, *137*(9), 534.

Bryden, M. M., & Lim, G. M. K. (1969). Blood parameters of the southern elephant seal *(Mirounga leonine,* Linn.) in relation to diving. *Comparative Biochemistry and Physiology, 28*, 139-148.

Buckles, E. L., Lowenstine, L. J., DeLong, R. L., Melin, S. R., Vittore, R. K., Wong, H. N., et al. (2007). Age-prevalence of otarine herpesvirus-1, a tumor-associated virus, and possibility of its sexual transmission in California sea lions. *Veterinary Microbiology, 120*, 1-8.

Buckles, E. L., Lowenstine, L. J., Funke, C., Vittore, R. K., Wong, H. N., St. Leger, J. A., et al. (2006). Otarine herpesvirus-1, not papillomavirus, is associated with endemic tumours in California sea lions (*Zalophus californianus*). *Journal of Comparative Pathology*, *135*(4), 183-189.

Burnes, R. H. (1952). *Handbook of cetacean dissections.* London: British Museum (Natural History).

Caldwell, M. C., & Caldwell, D. K. (1972). Behavior of marine mammals. In S. H. Ridgway (Ed.), *Mammals of the sea: Biology and medicine* (pp. 419-465). Springfield, IL: Charles C. Thomas.

Cartee, R. E., Broesmer, K., & Ridgway, S. H. (1995a). The eye of the bottlenose dolphin (*Tursiops truncatus*) evaluated by B-mode ultrasonography. *Journal of Zoo and Wildlife Medicine*, *26*, 414-421.

Cartee, R. E., Gray, B. W., John, J., & Ridgway, S. H. (1995b). B-mode ultrasound evaluation of dolphin skin. *Journal of Diagnostic Medical Sonography*, *11*, 76-80.

Cartee, R. E., Tarpley, R. J., Mahoney, K., Ridgway, S. H., & Johnson, P. L. (1995c). A case of cystic adrenal disease in a common dolphin, *Delphinus delphis*. *Journal of Zoo and Wildlife Medicine, 26*(2), 293-297.

Case, R. A. M. (1948). A study of the incidence of disease in a whaling expedition to the Antarctic pelagic whaling ground, 1946-7. *British Journal of Social Medicine*, *2*, 1-17.

Cates, M. B., Kaufman, L., Grabau, J. H., Pletcher, J., & Schroeder, J. P. (1986). Blastomycosis in an Atlantic bottlenose dolphin. *Journal of the American Veterinary Medical Association, 189*, 1148-1150.

Clark, L. S., Cowan, D. F., & Pfeiffer, D. C. (2006). Morphological changes in the Atlantic bottlenose dolphin (*Tursiops truncatus*) adrenal gland associated with chronic stress. *Journal of Comparative Pathology, 135*, 208-216.

Cockrill, W. R. (1960a). Pathology of the cetacea, Part I. *British Veterinary Journal, 116*, 133.

Cockrill, W. R. (1960b). Pathology of the cetacea, Part II. *British Veterinary Journal, 116*, 175.

Colegrove, K. M., Lowenstine, L. J., & Gulland, F. M. D. (2005). *Leptospirosis* in northern elephant seals (*Mirounga angustirostris*) stranded along the California coast. *Journal of Wildlife Diseases*, *41*, 426-430.

Colgrove, G. S. (1975). A survey of *Erysipelothrix insidiosa* agglutinating antibody titers in vaccinated porpoises (*Tursiops truncatus*). *Journal of Wildlife Diseases, 11*, 234-236.

Colgrove, G. S. (1978). Stimulation of lymphocytes from a dolphin (*Tursiops truncatus*) by phytomitogens. *American Journal of Veterinary Research, 39*, 141-144.

Colgrove, G. S., & Migaki, G. (1976). Cerebral abscess associated with stranding in a dolphin. *Journal of Wildlife Diseases, 12*, 271-274.

Cornell, L. H., Duffield, D. A., Joseph, B. E., & Stark, B. (1988). Hematology and serum chemistry of the beluga (*Delphinapterus leucas*). *Journal of Wildlife Diseases*, *24*(2), 220-224.

Cornell, L. H., Asper, E. D., Antrim, J. E., Searles, S. S., Young, W. G., & Goff, T. (1987). Progress report: Results of a long-range captive breeding program for the bottlenose dolphin, *Tursiops truncatus* and *Tursiops truncatus gilli. Zoo Biology*, *6*(1), 41-53.

Cowan, D. F. (1968). Lung diseases in whale and dolphins. In *Proceedings of Second Conference on Diseases of Aquatic Mammals* (pp. 145-151), Boca Raton, FL.

Cowan, D. F., & Curry, B. E. (2008). Histopathology of the alarm reaction in small odontocetes. *Journal of Comparative Pathology, 139*, 24-33.

Cowan, D. F., House, C., & House, J. F. (2001). Public health. In L. A. Dierauf & F. M. D. Gulland (Eds.), *CRC handbook of marine mammal medicine* (2nd ed.) (pp. 767-778). Boca Raton, FL: CRC Press.

Cowan, D. F., Walker, W. A., & Brownell, R. L., Jr. (1985). Pathology of small cetaceans stranded along southern California beaches. In M. M. Bryden & R. J. Harrison (Eds.), *Research on dolphins* (pp. 323-367). Oxford, UK: Oxford University Press.

Cushing, J. E., Fujino, K., & Calaprice, N. (1963). The Ju blood typing system of the sperm whale (*Physeter catodon*) and specific soluble substances. *Scientific Reports of the Whales Research Institute, 17*, 67-77.

Cushing, J. E., Fujino, K., & Takahashi, K. (1959). Glycerol-freezing technique as an aid in blood typing of whales. *Scientific Reports of the Whales Research Institute, 14*, 89-100.

Dailey, M. D. (1970). The transmission of *Parafilaroides decorus* (Nematoda*:* Metastrongyloidea) in the California sea lion (*Zalophus californianus*). *Helminthological Society of Washington, 37*, 215-222.

Dailey, M. D., & Ridgway, S. H. (1976). A trematode from the round window of an Atlantic bottlenosed dolphin's ear. *Journal of Wildlife Diseases, 12*, 45-47.

Dailey, M. D., Odell, D. K., & Walsh, M. T. (1990). Lungworm transmission of *Halocercus lagenorhynchi* (Nematoda*:* Pseudaliidae) in the bottlenosed dolphin (*Tursiops truncatus*). *International Association for Aquatic Animal Medicine Proceedings, 21*, 94.

De Guise, S., & Levin, M. J. (2004). Cetacean-reconstituted severe combined immuno-deficient (*SCID*) mice respond to vaccination with canine distemper virus. *Veterinary Immunology and Immunopathology, 97*, 177-186.

De Guise, S., Erickson, K., Blanchard, M., DiMolfetto, L., Lepper, H., Stott, J. L., et al. (2004). Characterization of F21.A, a monoclonal antibody that recognize a leucocyte surface antigens for killer whale homologue to ß-2 integrin. *Veterinary Immunology and Immunopathology, 97*, 195-206.

DeLong, R. L., Gilmartin, W. G., & Simpson, J. G. (1973). Premature births in California sea lions: Association with high organochlorine pollutant residue levels. *Science, 181*, 1168-1170.

Delyamure, S. L. (1955). *Helminthofauna of the marine mammals* [Translated from Russian]. Moscow: Academy of Science USSR. Retrieved from the U.S. Department of the Interior and Natural Science in Washington, DC, in 1968.

Di Guardo, G., Marruchella, G., Agrimi, U., & Kennedy, S. (2005). Morbillivirus infections in aquatic mammals: A brief review. *Journal of Veterinary Medicine, 52*, 88-93.

Dierauf, L. A., & Gulland, F. M. D. (Eds.). (2001). *CRC handbook of marine mammal medicine*. (2nd ed.). Boca Raton, FL: CRC Press. 1,063 pp.

Dierauf, L. A., Lowenstine, L. J., & Jerome, C. (1981). Viral hepatitis (*adenovirus*) in a California sea lion. *Journal of the American Veterinary Medical Association, 179*, 1194-1197.

Dold, C., & Ridgway, S. H. (2007). Cetaceans. In G. West, D. Heard, & N. Caulkett (Eds.), *Zoo animal and wildlife immobilization and anesthesia* (pp. 485-496). Ames, IA: Blackwell Publishing.

Domingo, M., Visa, J., Pumarola, M., Marco, A. J., Ferrer, L., Rabanal, R., et al. (1992). Pathologic and immunocytochemical studies of morbillivirus infection in striped dolphins, *Stenella coeruleoalba*. *Veterinary Pathology, 29*, 1-10.

Dover, S. R., Beusse, D., Walsh, T., McBain, J. F., & Ridgway, S. (1999). Laparoscopic techniques for the bottlenose dolphin, *Tursiops truncatus*. *International Association for Aquatic Animal Medicine Proceedings*, *30*, 128-129.

DuBois, K. P., Geiling, E. M. K., McBride, A. F., & Thompson, J. F. (1940). Studies on intermediary carbohydrate metabolism of aquatic animals I. The distribution of acid-soluble phosphorous and certain enzymes in dolphin tissues. *Journal of Biological Chemistry, 31*, 347-359.

Dudok van Heel, W. H. (1972). Transport of dolphins. *Aquatic Mammals, 1*(1), 1-32.

Duffield, D. A. (1975). Cytogenetics evaluation of cetacean hybrids. *Proceedings of the Conference on the Biology and Conservation of Marine Mammals*, Santa Cruz, CA.

Duffield, D. A. (1990). Genetic and physiological research applications in marine mammal medicine. In L. A. Dierauf (Ed.), *Practical handbook of marine mammal medicine: Health, disease and rehabilitation* (pp. 371-380). Boca Raton, FL: CRC Press.

Duffield, D. A. (1994). Keynote address: The past, present and future of marine mammal management. *Proceedings of the IMATA Conference*, Tacoma, WA.

Duffield, D. A. (1998). Invited papers: (1) Status of captive breeding in cetaceans and pinnipeds; (2) Captive hybridization: Examples in captivity and a genetic viewpoint. *Proceedings of the World Marine Mammal Science Conference Reproduction Workshop*, Monaco.

Duffield, D. A. (2000). Genetic analysis as a tool for population management. In D. A. Duffield & T. Robeck (Eds.), *Bottlenose Dolphin Reproduction Workshop report* (pp. 163-173). Silver Springs, MD: Marine Mammal Taxon Advisory Group.

Duffield, D. A. (2005). Management of genetic variability in representative North American facilities. *Proceedings of the Steering Committee Bottlenose Dolphin Reproduction Workshop*, Parc Asterix, Paris, France.

Duffield, D. A., & Chamberlin-Lea, J. (1990). Use of chromosome heteromorphisms and hemoglobins in studies of bottlenose dolphin populations and paternities. In S. Leatherwood & R. R. Reeves (Eds.), *The bottlenose dolphin* (pp. 609-622). San Diego: Academic Press.

Duffield, D. A., & Kang, I. (1973). *Steno-Tursiops truncatus* hybrid: Biochemical and karyotypic analysis. *Proceedings of International Association for Aquatic Animal Medicine*, Vancouver, BC.

Duffield, D. A., & Robeck, T. R. (Eds.). (2000). *Bottlenose Dolphin Reproduction Workshop report*. Silver Springs, MD: Marine Mammal Taxon Advisory Group. 376 pp.

Duffield, D. A., & Shell, E. D. (1999a). *Hematology and serum chemistry clinical normal values, Vol. 1* (Cephalorhynchus commersonii, Lagenorhynchus obliquidens) (Technical Booklet prepared for SeaWorld, Inc.).

Duffield, D. A., & Shell, E. D. (1999b). *Hematology and serum chemistry clinical normal values, Vol. 2* (Delphinapterus leucas, Pseudorca crassidens) (Technical Booklet prepared for SeaWorld, Inc.).

Duffield, D. A., & Shell, E. D. (1999c). *Hematology and serum chemistry clinical normal values, Vol. 3* (Tursiops truncatus) (Technical Booklet prepared for SeaWorld, Inc.).

Duffield, D. A., & Shell, E. D. (1999d). *Hematology and serum chemistry clinical normal values, Vol. 4* (Orcinus orca) (Technical Booklet prepared for SeaWorld, Inc.).

Duffield, D. A., & Wells, R. S. (1991). The combined application of chromosome, protein and molecular data in the determination of social unit structure and dynamics in *Tursiops truncatus.* In A. R. Hoelzel (Ed.), *Genetic ecology of whales and dolphins* (IWC Special Issue 13, pp. 155-169). Cambridge, UK: International Whaling Commission.

Duffield, D. A., & Wells, R. S. (2002). Molecular profile of a resident community of bottlenose dolphins, *Tursiops truncatus*. In C. J. Pfeiffer (Ed.), *Cell and molecular biology of marine mammals* (pp. 3-11). Malabar, FL: Krieger Publishing Co.

Duffield, D. A., Ridgway, S. H., & Cornell, L. H. (1983). Hematology distinguishes coastal and offshore forms of dolphins (*Tursiops*). *Canadian Journal of Zoology, 61*(4), 930-933.

Duffield, D. A., Shell, E. D., & Dudley, M. (2000). Demographic analysis of breeding bottlenose dolphins in North American zoological facilities: 1976-1998. In D. A. Duffield & T. Robeck (Eds.), *Bottlenose Dolphin*

Reproduction Workshop report (pp. 139-155). Silver Springs, MD: Marine Mammal Taxon Advisory Group.

Duffield, D. A., Odell, D. K., McBain, J. F., & Andrews, B. (1995). Killer whale reproduction at Sea World. *Zoo Biology, 14*, 417-430.

Duffield, D. A., Young, W. G., Hayes, K. A., & Sheehy, R. R. (1993). Genetic assessment of a captive beluga breeding group: A comparison of techniques for examining genetic variability in wild beluga populations. *Proceedings of the Tenth Biennial Conference on the Biology of Marine Mammals*, Galveston, TX.

Duignan, P. J., Nielsen, O., House, C., Kovacs, K. M., Duffy, N., Early, G., et al. (1997). Epizootiology of morbillivirus infection in harp, hooded, and ringed seals from the Canadian Arctic and Western Atlantic. *Journal of Wildlife Diseases, 33*, 7-19.

Dunn, J. L. (1990). Bacterial and mycotic diseases of cetaceans and pinnipeds. In L. A. Dierauf (Ed.), *Handbook of marine mammal medicine: Health, disease and rehabilitation* (pp. 73-96). Boca Raton, FL: CRC Press.

Durrant, G. R. (2003). A. J. Williams: A tropical veterinary pioneer. *Journal of the Royal Society of Medicine, 96*, 465-466.

Eichelberger, L., Fetcher, E. S., Geiling, E. M. K., & Vos, B. J. (1940a). The distribution of water and electrolytes in the blood of dolphins. *Journal of Biological Chemistry, 133*(1), 145-152.

Eichelberger, L., Fetcher, E. S., Geiling, E. M. K., & Vos, B. J. (1940b). The composition of dolphin milk. *Journal of Biological Chemistry, 134*(1), 171-176.

Eichelberger, L., Fetcher, E. S., Geiling, E. M. K., & Vos, B. J. (1940c). The distribution of water and electrolytes in skeletal muscle of the dolphin (*Tursiops truncatus*). *Journal of Biological Chemistry, 133*, 661-666.

Elsner, R., Hanafee, W. N., & Hammond, D. D. (1971). Angiography of the inferior vena cava of the harbor seal during simulated diving. *American Journal of Physiology, 220*, 1155-1157.

Essapian, F. S. (1963). Observations on abnormalities of parturition in captive bottlenosed dolphins, *Tursiops truncatus*, and concurrent behavior of other porpoises. *Journal of Mammalogy, 44*, 405-414.

Evans, W. E. (1974). Telemetering of temperature and depth data from a free ranging yearling California gray whale. *Marine Fisheries Review, 36*(4), 52-58.

Ewalt, D. R., Payeur, J. B., Martin, B. M., Cummins, D. R., & Miller, W. G. (1994). Characteristics of a species from a bottlenose dolphin (*Tursiops truncatus*). *Journal of Veterinary Diagnostic Investigation,* 6, 448-452.

Fernandez, A., Edwards, J. F., Rodriguez, F., Espinosa de los Monteros, A., Herraez, P., Castro, P., et al. (2005). "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. *Veterinary Pathology, 42*, 446-457.

Fetcher, E. S., & Fetcher, G. W. (1942). Experiments on the osmotic regulation of dolphins (*Tursiops truncatus*). *Journal of Cellular and Comparative Physiology, 19*, 123-130.

Finneran, J. J., Houser, D. S., Blasko, D., Hicks, C., Hudson, J., & Osborn, M. (2008). Estimating bottlenose dolphin (*Tursiops truncatus*) hearing thresholds from single and multiple simultaneous auditory evoked potentials. *Journal of the Acoustical Society of America, 123*, 542-551.

Finneran, J. J., Carder, D. A., Dear, R., Belting, T., McBain, J., Dalton, L., et al. (2005). Pure tone audiograms and possible aminoglycoside-induced hearing loss in the belugas (*Delphinapterus leucas*). *Journal of the Acoustical Society of America, 117*, 3936-3943.

Flom, J. O., & Houk, E. J. (1979). Morphologic evidence of poxvirus in "tattoo" lesions from captive bottlenosed dolphins. *Journal of Wildlife Diseases, 15*, 593-596.

Flowers, D. J. (1970). Human infection due to *Mycobacterium marinum* after a dolphin bite. *Journal of Clinical Pathology, 23*(6), 475-477.

Foster, G., MacMillan, A. P., Godfroid, J., Howie, F., Ross, H. M., Cloeckaert, A., et al. (2002). A review of *Brucella* sp.: Infection of sea mammals with particular emphasis on isolates from Scotland. *Veterinary Microbiology, 90*, 563-580.

Gaskin, D. E., Holdrinet, M., & Frank, R. (1971). Organochlorine pesticide residues in harbour porpoises from the Bay of Fundy region. *Nature, 233*, 499-500.

Geiling, E. M. K., Vos, B. J., Jr., & Oldham, J. K. (1940). The pharmacology and anatomy of the hypophysis of the porpoise. *Endocrinology, 27*, 309-316.

Geraci, J. R. (1989). *Clinical investigation of the 1987-88 mass mortality of bottlenose dolphins along the U.S. central and south Atlantic coast* (Final Report to the National Marine Fisheries Service and U.S. Navy, Office of Naval Research and Marine Mammal Commission). ii + 63 pp.

Geraci, J. R., & Gerstmann, K. E. (1966). Relationship of dietary histamine to gastric ulcers in the dolphin. *Journal of the American Veterinary Medical Association, 149*, 884-890.

Geraci, J. R., & Keyes, M. C. (1970). Veterinary medicine in the conservation and management of marine mammal resources. *Journal of the American Veterinary Medical Association, 157*, 1970-1974.

Geraci, J. R., & Lounsbury, V. J. (1993). *Marine mammals ashore: A field guide to strandings.* College Station: Texas A&M Sea Grant Publication.

Geraci, J. R., & Lounsbury, V. J. (2005). *Marine mammals ashore: A field guide to strandings* (2nd ed.). College Station: Texas A&M Sea Grant Publication.

Geraci, J. R., & Ridgway, S. H. (1991). On disease transmission between dolphins and humans. *Marine Mammal Science, 7*, 191-194.

Geraci, J. R., & St. Aubin, D. J. (1979). *Biology of marine mammals: Insights through strandings.* Washington, DC: National Technical Information Service. vi + 343 pp.

Geraci, J. R., & Sweeney, J. (1986). Clinical techniques. In M. E. Fowler (Ed.), *Zoo and wild animal medicine* (pp. 771-776). Philadelphia: W. B. Saunders.

Geraci, J. R., Dailey, M. D., & St. Aubin, D. J. (1978). Parasitic mastitis in the Atlantic white-sided dolphin, *Lagenorhynchus acutus*, as a probable factor in herd productivity. *Journal of the Fisheries Research Board of Canada, 35*, 1350-1355.

Geraci, J. R., Hicks, B. D., & St. Aubin, D. J. (1979). Dolphin pox: A skin disease of cetaceans. *Canadian Journal of Comparative Medicine, 43*(4), 399-404.

Geraci, J. R., Saver, R. M., & Medway, W. (1966). Erysipelas in dolphins. *American Journal of Veterinary Research, 27*(117), 597-606.

Geraci, J. R., Anderson, D. M., Timperi, R. J., St. Aubin, D. J., Early, G. A., Prescott, J. H., et al. (1989). Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. *Canadian Journal of Fisheries and Aquatic Sciences, 46*(11), 1895-1898.

Gilmartin, W. G., Allen, J. F., & Ridgway, S. H. (1971). Vaccination of porpoises (*Tursiops truncatus*) against *Erysipelothrix rhusiopathiae* infection. *Journal of Wildlife Diseases*, *7*, 292-295.

Gilmore, R. M. (1976). The friendly whales of Leguna Ignacio. *Terra, 15*, 24-28.

Goldstein, T., Gulland, F. M. D., Braun, R. C., Antonelis, G. A., Kashinsky, L., Rowles, T. K., et al. (2006). Molecular identification of a novel gamma herpesvirus in the endangered Hawaiian monk seal (*Monachus schauinslandi*). *Marine Mammal Science, 22*(2), 465-471.

Greenwood, A. G., Ridgway, S. H., & Harrison, R. J. (1971). Blood values in young gray seals. *Journal of the American Veterinary Medical Association, 159*(5), 571-574.

Gulland, F. M. D., Haulena, M., Lowenstine, L. J., Scholin, C., Trainer, V., & Van Dolah, F. (1999). Domoic acid toxicity in California sea lions (*Zalophus californianus*) stranded along the California coast. *Proceedings of the Thirteenth Biennial Conference on the Biology of Marine Mammals*, Maui, HI.

Gulland, F. M. D., Koski, M., Lowenstine, L. J., Colagross, A., Morgan, L., & Spraker, T. (1996). *Leptospirosis* in California sea lions (*Zalophus californianus*) stranded along the central California coast, 1981-1994. *Journal of Wildlife Diseases, 32*, 572-580.

Gulland, F. M. D., Haulena, M., Fauquier, D., Langlois, G., Lander, M. E., Zabka, T., et al. (2002). Domoic acid toxicity in California sea lions (*Zalophus californianus*): Clinical signs, treatment and survival. *The Veterinary Record, 150*(15), 475-480.

Gulland, F. M. D., Nutter, F., Dixon, K., Calambokidis, J., Schorr, G., Barlow, J., et al. (2008). Health assessment, antibiotic treatment, and behavioral responses to herding efforts of a cow-calf pair of humpback whales (*Megaptera novaeangliae*) in the Sacramento River Delta, California. *Aquatic Mammals, 34*(2), 182-192.

Hamlin, R. L., Jackson, R. F., Himes, J. A., Pipers, F., & Townsend, A. C. (1970). Electrocardiogram of bottlenosed dolphin (*Tursiops truncatus*). *American Journal of Veterinary Research, 31*, 501-505.

Hartley, J. W., & Pitcher, D. (2002). Seal finger—tetracycline is first line. *Journal of Infection, 45*(2), 71-75.

Haulena, M., & Heath, R. B. (2001). Marine mammal anesthesia. In L.A. Dierauf & F. M. D. Gulland (Eds.), *Marine mammal medicine* (pp. 655-688). Boca Raton, FL: CRC Press.

Heath, R. B., DeLong, R., Jameson, V., Bradley, D., & Spraker, T. (1997). Isoflurane anesthesia in free-ranging sea lion pups. *Journal of Wildlife Diseases, 33*, 206-210.

Hedrick, M. S., & Duffield, D. A. (1991). Haematological and rheological characteristics of blood in seven marine mammal species: Physiological implications for diving behaviour. *Journal of Zoology (London), 225*, 273-282.

Hedrick, M. S., Duffield, D. A., & Cornell, L. H. (1986). Blood viscosity and optimal hematocrit in a deep-diving mammal, the northern elephant seal (*Mirounga angustirostris*). *Canadian Journal of Zoology, 64*, 2081-2085.

Heller, H. H. (1920). Etiology of acute gangrenous infections of animals: A discussion of blackleg, braxy, malignant edema and whale septicemia. *Journal of Infectious Diseases, 27*, 385-451.

Hernandez-Mora, G., Gonzalez-Barrientos, R., Morales, A-J., Chaves-Olarte, E., Guzman-Verri, C., Baquero-Calvo, E., et al. (2008). Neurobrucellosis in stranded dolphins, Costa Rica. *Emerging Infectious Diseases, 14*, 1430-1433.

Hicks, B. D., & Worthy, G. A. (1987). Sealpox in captive grey seals (*Halichoerus grypus*) and their handlers. *Journal of Wildlife Diseases, 23*(1), 1-6.

Houser, D. S., Howard, R., & Ridgway, S. H. (2001). Can diving-induced tissue nitrogen supersaturation increase the chance of acoustically driven bubble growth in marine mammals? *Journal of Theoretical Biology, 213*, 183-195. Retrieved December 5, 2008, from www.oceannet.org/medag/reports/IACMST_reports/underwater_noise/Ridgeway%20et%20al%20%20Bubble%20inducement%20paper.pdf.

Houser, D. S., Finneran, J., Carder, D., Van Bonn, W., Smith, C., Hoh, C., et al. (2004). Structural and functional imaging of bottlenose dolphin (*Tursiops truncatus*) cranial anatomy. *Journal of Experimental Biology*, *207*, 3657-3665.

Hubbard, R. C., & Poulter, T. C. (1968). Seals and sea lions as models for studies in comparative biology. *Laboratory Animal Care, 18*, 288-297.

Irvine, A. B., Scott, M. D., Wells, R. S., & Kaufmann, J. H. (1981). Movements and activities of the Atlantic bottlenose dolphin, *Tursiops truncatus*, near Sarasota, Florida. *Fishery Bulletin, 79*, 671-688.

Jameyson, E. D., Duffield, D. A., Cornell, L. H., Antonellis, G., & DeLong, R. L. (1981). Discovery of a *Callorhinus ursinus* x ? hybrid within the San Miguel

Island population. *Proceedings of the Fourth Biennial Conference on the Biology of Marine Mammals*, San Francisco, CA.

Jepson, P. D., Arbelo, M., Deaville, R., Patterson, I. A. P., Castro, P., Baker, J. R., et al. (2003). Gas-bubble lesions in stranded cetaceans. *Nature, 425*, 575-576.

Jepson, P. D., Deaville, R., Patterson, I. A. P., Pocknell, A. M., Ross, H. M., Baker, J. R., et al. (2005). Acute and chronic gas bubble lesions in cetaceans stranded in the United Kingdom. *Veterinary Pathology, 42*, 291-305.

Johnston, D. G., & Ridgway, S. H. (1969). Parasitism in some marine mammals. *Journal of the American Veterinary Medical Association*, *155*, 1064-1072.

Joseph, B. E., Antrim, J. E., & Cornell, L. H. (1987). Commerson's dolphin (*Cephalorhynchus commersonii*): A discussion of the first successful captive birth. *Zoo Biology, 6*, 69-77.

Joseph, B. E., Cornell, L. H., & Migaki, G. (1986). Metastatic squamous cell carcinoma in a California sea lion (*Zalophus californianus*). *Journal of Wildlife Diseases, 22*, 281-283.

Joseph, J., & Duffield, D. A. (1994). Using DNA fingerprinting to determine parentage in harbor seals, or pondering phocid paternity puzzles. *Proceedings of the Twenty-Second Annual Conference of the International Marine Animal Trainers Association*, Tacoma, WA.

Kellogg, W. N. (1961). *Porpoises and sonar.* Chicago: University of Chicago Press.

Kennedy, S. (1990). A review of the 1988 European seal morbillivirus epizootic. *The Veterinary Record, 127*, 563-567.

Kennedy-Stoskopf, S., Stoskopf, M. K., Eckhaus, M. A., & Strandberg, J. D. (1986). Isolation of a retrovirus and a herpes virus from a California sea lion. *Journal of Wildlife Diseases, 22*, 156-164.

Keyes, M. C. (1965). Pathology of the northern fur seal. *Journal of American Veterinary Medical Association, 147*, 1090-1095.

King, D. P., Gulland, F. M. D., Reidarson, T. H., Hanni, K., Stott, J. L., & Ferrick, D. A. (1995). Cloning and sequencing of harbor seal (*Phoca vitulina*) and killer whale (*Orcinus orca*) Interleukin 6 (IL-6). *Fourth International Veterinary Immunology Symposium*, Davis, CA.

King, D. P., Hure, M. C., Goldstein, T., Aldridge, B. M., Gulland, F. M. D., Saliki, J. T., et al. (2002). Otarine herpesvirus-1: A novel gammaherpesvirus associated with urogenital carcinoma in California sea lions (*Zalophus californianus*). *Veterinary Microbiology*, *86*, 131-137.

Klontz, G. W. (1970, Summer). Medical care of newly captured killer whales. *The Southwestern Veterinarian*, 267-269.

Lahvis, G. P., Wells, R. S., Kuehl, D. W., Stewart, J. L., Rhinehart, H. L., & Via, C. S. (1995). Decreased lymphocyte responses in free-ranging bottlenose dolphins (*Tursiops truncatus*) are associated with increased concentrations of PCBs and DDT in peripheral blood. *Environmental Health Perspectives, 103*, 67-72.

Lambertsen, R. H., Sundberg, J. P., & Buergelt, C. D. (1987). Genital papillomatosis in sperm whale bulls. *Journal of Wildlife Diseases, 23*(3), 361-367.

Lawrence, B., & Schevill, W. E. (1954). *Tursiops* as an experimental subject. *Journal of Mammalogy, 35*, 225-232.

Lawrence, B., & Schevill, W. E. (1956). The functional anatomy of the delphinid nose. *Bulletin of the Museum of Comparative Zoology, 114*, 103-151.

Lawrence, B., & Schevill, W. E. (1965). Gular musculature in delphinids. *Bulletin of the Museum of Comparative Zoology*, *133*(1), 1-65.

Le Boeuf, B. J., & Bonnell, M. L. (1971). DDT in California sea lions. *Nature, 234*, 108-110.

Lilly, J. C. (1962). *Man and dolphin*. London: Gallancz.

Linnehan, R. M., & MacMillan, A. D. (1991). Propofol/isoflurane anesthesia and debridement of a corneal ulcer in an Atlantic bottlenosed dolphin (*Tursiops truncatus*). *Proceedings of the American Association of Zoo Veterinarians*, pp. 290-291.

Linnehan, R. M., Ulrich, R. W., & Ridgway, S. H. (1999). Enrofloxacin serum bioactivity in bottlenose dolphins, *Tursiops truncatus*, following oral administration of 5 mg/kg in whole fish. *Journal of Veterinary Pharmacology and Therapeutics, 22*, 170-173.

Lipscomb, T. P., Schulman, F. Y., Moffett, D., & Kennedy, S. (1994). Morbilliviral disease in Atlantic bottlenose dolphins (*Tursiops truncatus*) from the 1987-1988 epizootic. *Journal of Wildlife Diseases, 30*, 567-571.

Lipscomb, T. P., Scott, D. P., Garber, R. L., Krafft, A. E., Tsai, M. M., Lichy, J. H., et al. (2000). Common metastatic carcinoma of California sea lions (*Zalophus californianus*): Evidence of genital origin and association with novel gammaherpesvirus. *Veterinary Pathology, 37*, 609-617.

Lister, M. (1694). Letter to the Royal Society of London. *Philosophical Transactions*, 1694-1702.

Lowenstine, L. J., Groff, J., Rideout, B., Wong, A., & Gage, L. (1990). Necropsy findings in two juvenile beaked whales (*Mesoplodon* sp.) maintained in captivity for rehabilitation after stranding. *Proceedings of the Twenty-First Annual International Association for Aquatic Animal Medicine Conference, 21*, 117.

Martineau, D., Beland, P., Desjardins, C., & LaGace, A. (1987). Levels of organochlorine chemicals in tissues of beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Quebec, Canada. *Archives of Environmental Contamination & Toxicology, 16*, 137-147.

McBain, J. F. (2001). Cetacean medicine. In L. A. Dierauf & F. M. D. Gulland (Eds.), *Marine mammal medicine* (pp. 895-905). Boca Raton, FL: CRC Press.

McBain, J. F., & Reidarson, T. (1997). Rehabilitation of a neonatal gray whale (*Eschrichtius robustus*). *Proceedings of the Twenty-Eighth Annual International Association for Aquatic Animal Medicine Conference*, Harderwijk, The Netherlands.

McBain, J. F., & Reidarson, T. (1998). Long term rehabilitation of a gray whale (*Eschrichtius robustus*) calf. *Proceedings Twenty-Ninth Annual International Association for Aquatic Animal Medicine Conference*, San Diego, CA.

McBride, A. F. (1956). Evidence for echolocation in cetaceans. *Deep Sea Research, 3,* 153-154.

McBride, A. F., & Hebb, D. O. (1948). Behavior of the captive bottle-nose dolphin, *Tursiops truncatus. Journal of Comparative Physiology and Psychology, 41*(2), 111-123.

McBride, A. F., & Kritzler, H. (1951). Observations on pregnancy, parturition, and postnatal behavior in the bottlenosed dolphin. *Journal of Mammalogy, 32*, 251-266.

Medway, W., & Geraci, J. R. (1964). Hematology of the bottlenose dolphin (*Tursiops truncatus*). *American Journal of Physiology, 207*, 1367-1370.

Medway, W., McCormick, J. G., Ridgway, S. H., & Crump, J. F. (1970). Effects of prolonged halothane anesthesia on some cetaceans. *Journal of the American Veterinary Medical Association, 157*, 576-582.

Miller, R. M., & Ridgway, S. H. (1963). Clinical experience with dolphins and whales. *Small Animal Clinician, 3*, 189.

Miller, W. G., Adams, G., Ficht, T., Cheville, N. F., Payeur, J. P., Harley, D. R., et al. (1999). *Brucella*-induced abortions and infection in bottlenose dolphins. *Journal of Zoo and Wildlife Medicine, 30*, 100-110.

Moore, M. J., & Early, G. A. (2004). Cumulative sperm whale bone damage and the bends. *Science, 306*(5705), 2215.

Moore, S. E., & Ridgway, S. H. (1996). Patterns of dolphin sound production and ovulation. *Aquatic Mammals, 22*, 175-184.

Myers, D. G., & Stephenson, L. R. (1999). *Mister zoo: The life and legacy of Dr. Charles Schroeder*. San Diego: Zoological Society of San Diego. 271 pp.

Myhre, B. A., Simpson, J. G., & Ridgway, S. H. (1971). Blood groups in the Atlantic bottle-nosed porpoise (*Tursiops truncatus*). *Proceedings of the Society for Experimental Biology and Medicine, 137*(2), 404-407.

Nachtigall, P. E., Yuen, M. M., Moosey, T. A., & Taylor, K. A. (2005). Hearing measurements from a stranded infant Risso's dolphin, *Grampus griseus*. *Journal of Experimental Biology, 208*, 4181-4188.

Nagel, E. L., Morgane, P. J., & McFarland, W. L. (1964). Anesthesia for the bottlenosed dolphin. *Science, 146*, 1591-1593.

Nishiwaki, M., Duffield, D. A., & Tobayama, T. (1983). The genetic profile of a captive-born hybrid between *Pseudorca crassidens* and *Tursiops gilli*. *Proceedings of the Fifth Biennial Conference on the Biology of Marine Mammals*, Boston, MA.

Nollens, H. H., Gulland, F. M. D., Jacobson, E., Hernandez, J., Klein, P., Walsh, M., et al. (2006a). Parapoxviruses of seals and sea lions make up a distinct subclade within the genus Parapoxvirus. *Virology, 349*, 316-324.

Nollens, H. H., Jacobson, E. R., Gulland, F. M. D., Beusse, D. O., Bossart, G. D., Hernandez, J. A., et al. (2006b). Pathology and preliminary characterization of a parapoxvirus isolated from a California sea lion (*Zalophus californianus*). *Journal of Wildlife Diseases, 42*(1), 23-32.

Nollens, H. H., Wellehan, J. F., Saliki, J. T., Caseltine, S. L., Jensen, E. D., Van Bonn, W., et al. (2008). Characterization of a parainfluenza virus isolated from a bottlenose dolphin (*Tursiops truncatus*). *Veterinary Microbiology, 128*(3-4), 231-242.

Norris, K. S. (Ed.). (1966). *Whales, dolphins and porpoises*. Berkeley: University of California Press. 789 pp.

Osterhaus, A. D., & Vedder, E. J. (1988). Identification of virus causing recent seal deaths. *Nature*, *335*(6185), 20.

Osterhaus, A. D., Rimmelzwaan, G. F., Martina, B. E., Bestebrorer, T. M., & Fouchier, R. A. (2000). Influenza B virus in seals. *Science, 288*(5468), 1051-1053.

Osterhaus, M. E., Yang, H., Spijkers, H. E. M., Groen, J., Teppema, J. S., & van Steenis, G. (1985). The isolation and partial characterization of a highly pathogenic herpesvirus from the harbor seal (*Phoca vitulina*). *Archives of Virology, 86*, 239-251.

Payeur, J. P., Ewalt, D. R., Martin, B. M., Cummins, D., & Miller, W. G. (1992). Characteristics of a *Brucella* species from a bottlenose dolphin (*Tursiops truncatus*). *Proceedings of the Annual Meeting of the American Association for Veterinary Laboratory Diagnostics, 35*, 4.

Perrin, W. F. (2002). Common dolphins (*Delphinus delphis, D. capensis*, and *D. tropicalis*). In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.), *Encyclopedia of marine mammals* (pp. 245-248). San Diego: Academic Press.

Perrin, W. F., Brownell, R. L., Zhou, K., & Liu, J. (Eds.). (1989). *Biology and conservation of river dolphins* (pp. 159-167) (International Union for Conservation of Nature Species Survival Commission Occasional Papers, No. 3). Gland, Switzerland: IUCN. 173 pp.

Pier, A. C., Takayama, A. K., & Miyahara, A. Y. (1970). Cetacean nocardiosis. *Journal of Wildlife Diseases, 6*, 112-118.

Ponganis, P. J., Kooyman, G. L., & Ridgway, S. H. (2003). Comparative diving physiology. In A. O. Brubakk & T. S. Neuman (Eds.), *Bennett and Elliott's physiology and medicine of diving* (pp. 211-226). London: Harcourt.

Ray, C. (1961). A question of whale behavior: Most solitary strandings seem to be in response to sickness. *Natural History, 70*, 46-53.

Reddy, M. L., Reif, J. S., Bachand, A., & Ridgway, S. H. (2001). Opportunities for using Navy marine mammals to explore associations between organochlorine contaminants and unfavorable effects on reproduction. *The Science of the Total Environment*, *274*, 171-182.

Reddy, M. L., Kamolnick, T., Skaar, D., Curry, C., & Ridgway, S. H. (1991). Bottlenose dolphins: Energy consumption during pregnancy, lactation, and growth. *Proceedings from the 1991 International Marine Animal Trainer's Association Conference*, Vallejo, CA.

Reidarson, T. H., Duffield, D. A., & McBain, J. (2000). Hematology of marine mammals. In B. F. Feldman, J. G. Zinkl, & N. C. Jain (Eds.), *Williams and Wilkins Schalm's veterinary hematology* (5th ed.) (pp. 1164-1173). Baltimore: Lippincott Williams and Wilkins.

Rewell, R. C., & Willis, R. A. (1949). Some tumors found in whales. *Journal of Pathology and Bacteriology, 1*, 454.

Reynolds, J. E., & Rommel, S. A. (1999). *Biology of marine mammals*. Washington, DC: Smithsonian Institution Press. 578 pp.

Ridgway, S. H. (1965). Medical care of marine mammals. *Journal of the American Veterinary Medical Association, 147*, 1077-1085.

Ridgway, S. H. (Ed.). (1972a). *Mammals of the sea: Biology and medicine.* Springfield, IL: Charles C. Thomas. 812 pp.

Ridgway, S. H. (1972b). Homeostasis in the aquatic environment. In S. H. Ridgway (Ed.), *Mammals of the sea: Biology and medicine* (pp. 590-747). Springfield, IL: Charles C. Thomas.

Ridgway, S. H. (1983). Dolphin hearing and sound production in health and illness. In R. R. Fay & G. Gourevitch (Eds.), *Hearing and other senses: Presentations in honor of E. G. Wever* (pp. 247-296). Groton, CT: The Amphora Press.

Ridgway, S. H. (1987). *The dolphin doctor: A pioneering veterinarian remembers the extraordinary dolphin that inspired his career*. Dublin, NH: Yankee Books. 159 pp.

Ridgway, S. H., & Benirschke, K. (Eds.). (1977). *Breeding dolphins, present status, suggestions for the future*. Springfield, VA: U.S. National Technical Information Service for Marine Mammal Commission. 308 pp.

Ridgway, S. H., & Carder, D. A. (1997). Hearing deficits measured in some *Tursiops truncatus*, and discovery of a deaf/mute dolphin. *Journal of the Acoustical Society of America, 101*, 590-594.

Ridgway, S. H., & Carder, D. A. (2001). Assessing hearing and sound production in cetaceans not available for behavioral audiograms: Experiences with sperm, pygmy sperm, and gray whales. *Aquatic Mammals, 27*, 267-276.

Ridgway, S. H., & Dailey, M. D. (1972). Cerebral and cerebellar involvement of trematode parasites in dolphins and their possible role in stranding. *Journal of Wildlife Diseases, 8*, 33-43.

Ridgway, S. H., & Howard, R. (1979). Dolphin lung collapse and intramuscular circulation during free diving: Evidence from nitrogen washout. *Science, 206*, 1182-1183.

Ridgway, S. H., & Johnston, D. G. (1965). Two interesting disease cases in wild cetaceans. *American Journal of Veterinary Research, 26*, 771-775.

Ridgway, S. H., & Johnston, D. G. (1966). Blood oxygen and ecology of porpoises of three genera. *Science, 151*(3709), 456-458.

Ridgway, S. H., & McCormick, J. G. (1967). Anesthetization of porpoises for major surgery. *Science, 158*, 510-512.

Ridgway, S. H., & McCormick, J. G. (1971). Anesthesia of the porpoise. In L. R. Soma (Ed.), *Textbook of veterinary anesthesia* (pp. 394-403). Baltimore: Williams & Wilkins Co.

Ridgway, S. H., & Reddy, M. (1995). Residue levels of several organochlorines in *Tursiops truncatus* milk collected at varied stages of lactation. *Marine Pollution Bulletin*, *3*0, 609-614.

Ridgway, S. H., & Simpson, J. G. (1969). Anesthesia and restraint for the California sea lion, *Zalophus californianus*. *Journal of the American Veterinary Medical Association, 155*, 1059-1063.

Ridgway, S. H., Norris, K. S., & Cornell, L. H. (1989). Some considerations for those wishing to propagate platanistoid dolphins. In W. F. Perrin, R. L. Brownell, Jr., Z. Kaiya, & L. Jiankang (Eds.), *Biology and conservation of river dolphins* (IUCN Species Survival Commission Occasional Papers, No. 3) (pp. 159-167). Gland, Switzerland: IUCN.

Ridgway, S. H., Scronce, B. L., & Kanwisher, J. (1969). Respiration and deep diving in the bottlenose porpoise. *Science, 166*, 1651-1654.

Ridgway, S. H., Simpson, J. G., Patton, G. S., & Gilmartin, W. G. (1970). Hematologic findings in certain small cetaceans. *Journal of the American Veterinary Medical Association, 157*, 566-575.

Ridgway, S. H., Kamolnick, T., Reddy, M., Curry, C., & Tarpley, R. J. (1995). Orphan-induced lactation in *Tursiops* and analysis of collected milk. *Marine Mammal Science, 11*, 172-182.

Ridgway, S. H., Reddy, M. L., Kamolnick, T., Skaar, D., & Curry, C. (1992). Calorie consumption of growing adult, pregnant, and lactating *Tursiops*. *Proceedings of the Twenty-Third Annual Conference of the International Association for Aquatic Animal Medicine*, p. 44.

Ridgway, S. H., Bullock, T. H., Carder, D. A., Seeley, R. L., Woods, D., & Galambos, R. (1981). Auditory brainstem response in dolphins. *Proceedings of the National Academy of Sciences, 78*(3), 1943-1947.

Ridgway, S. H., Houser, D. S., Finneran, J. J., Carder, D. A., Keogh, M., Van Bonn, W., et al. (2006). Functional imaging of dolphin brain metabolism and blood flow. *Journal of Experimental Biology, 209*, 2902-2910.

Rigdon, R. H., & Drager, G. A. (1955). Thiamine deficiency in sea lions (*Otaria californianus*) fed only frozen fish. *Journal of the American Veterinary Medical Association, 127*, 453-455.

Robeck, T. R., Steinman, K. J., Gearhart, S., Reidarson, T. R., McBain, J. F., & Monfort, S. L. (2004). Reproductive physiology and development of artificial insemination technology in killer whales (*Orcinus orca*). *Biology of Reproduction*, *71*, 650-660.

Robeck, T. R., Schneyer, A. L., McBain, J. F., Dalton, L. M., Walsh, M. T., Czekala, N. M., et al. (1993). Analysis of urinary immunoreactive steroid metabolites and gonadotropins for characterization of the estrous cycle, breeding period, and seasonal estrous activity of captive killer whales (*Orcinus orca*). *Zoo Biology, 12*, 173-187.

Robeck, T., Steinman, K., Yoshioka, M., Jensen, E., O'Brien, J., Katsumata, E., et al. (2005). Estrous cycle characterisation and artificial insemination using frozen-thawed spermatozoa in the bottlenose dolphin (*Tursiops truncatus*). *Reproduction*, *129*, 659-674.

Romano, T. A., Ridgway, S. H., & Quaranta, V. (1992). MHC class II molecules and immunoglobulins on peripheral blood lymphocytes of the bottlenosed dolphin, *Tursiops truncatus*. *Journal of Experimental Zoology, 263*, 96-104.

Romano, T. A., Ridgway, S. H., Felten, D. L., & Quaranta, V. (1999). Molecular cloning and characterization of CD4 in an aquatic mammal, the white whale, *Delphinapterus leucas*. *Immunogenetics, 49*, 376-383.

Romano, T. A., Felten, D. L., Stevens, S. Y., Olschowka, J. A., Quaranta, V., & Ridgway, S. H. (2002). Immune response, stress, and environment: Implications for cetaceans. In C. J. Pfeiffer (Ed.), *Molecular and cell biology of marine mammals* (pp. 253-279). Malabar, FL: Krieger Publishing Co.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., et al. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences, 61*(7), 1124-1134.

Ross, H. M., Foster, G., Reid, R. J., Jahans, K. L., Thompson, P. M., & MacMillan, A. P. (1994). *Brucella* species infection in sea-mammals. *The Veterinary Record, 134*(14), 359.

Sargent, E. (1980). Tetracycline for seal finger. *Journal of the American Medical Association*, *244*(5), 437.

Schlundt, C. E., Dear, R. L., Green, L., Houser, D. S., & Finneran, J. J. (2007). Simultaneously measured behavioral and electrophysiological hearing thresholds in a bottlenose dolphin (*Tursiops truncatus*). *Journal of the Acoustical Society of America*, *122*, 615-622.

Schroeder, C. R., & Wegeforth, H. M. (1935). The occurrence of gastric ulcers in sea mammals of the California coast: Their etiology and pathology. *Journal of the American Veterinary Medical Association, 87*, 333-342.

Schroeder, J. P., & Keller, K. V. (1989). Seasonality of serum testosterone levels and sperm density in *Tursiops truncatus*. *Journal of Experimental Zoology, 249*, 316-321.

Schroeder, J. P., & Keller, K. V. (1990). Artificial insemination of bottlenose dolphins. In S. Leatherwood & R. R. Reeves (Eds.), *The bottlenose dolphin* (pp. 447-460). San Diego: Academic Press.

Schulman, F. Y., Lipscomb, T. P., Moffett, D., Krafft, A. E., Lichy, J. H., Tsai, M. M., et al. (1997). Histologic, immunohistochemical, and polymerase chain reaction studies of bottlenose dolphins from the 1987-1988 United States Atlantic Coast epizootic. *Veterinary Pathology, 34*, 288-295.

Scott, M. D., Wells, R. S., & Irvine, A. B. (1990). A long-term study of bottlenose dolphins on the west coast of Florida. In S. Leatherwood & R. R. Reeves (Eds.), *The bottlenose dolphin* (pp. 235-244). San Diego: Academic Press.

Seeley, R. L., Flanigan, W. F., Jr., & Ridgway, S. H. (1976). A technique for rapidly assessing the hearing of the bottlenosed porpoise, *Tursiops truncatus*. *Naval Undersea Center (NUCTP), 522*, 1-15.

Seibold, H., & Neal, J. E. (1956). *Erysipelothrix septicemia* in the porpoise. *Journal of the American Veterinary Medical Association, 128*(11), 537-539.

Simpson, C. F., Wood, F. G., & Young, G. (1958). Cutaneous lesions on a porpoise with erysipelas. *Journal of the American Veterinary Medical Association, 133*, 558-560.

Simpson, J. G., & Gardner, M. B. (1972). Comparative microscopic anatomy of selected marine mammals. In S. H. Ridgway (Ed.), *Mammals of the sea: Biology and medicine* (pp. 298-418). Springfield, IL: Charles C. Thomas.

Simpson, J. G., & Gilmartin, W. G. (1970). An investigation of elephant seal and sea lion mortality on San Miguel Island. *BioScience, 20*, 289.

Skinner, B. F. (1957). The experimental analysis of behavior. *American Scientist, 45*, 343-371.

Slipjer, E. J. (1962). *Whales*. New York: Basic Books.

Smith, A. W., & Skilling, D. E. (1979). Viruses and virus diseases of marine mammals. *Journal of the American Veterinary Medical Association, 175*, 918-920.

Smith, A. W., Akers, T. G., Madin, S. D., & Vedros, N. A. (1973). San Miguel sea lion virus isolation, preliminary characterization and relationship to vesicular exanthema of swine virus. *Nature, 244*, 108-110.

Smithcors, J. F. (1963). *The American veterinary profession: Its background and development*. Ames: Iowa State University Press.

Stolk, A. (1950). Tumors in whales. *Amsterdam Natural, 1*, 28-33.

Stott, J., Aldridge, B., Bowen, L., Johnson, M., Lowenstine, L., Gulland, F. M. D., et al. (2004). Diversity of immune response (major histocompatability complex, MHC) genes in free-ranging pinnipeds. *35th Annual Conference of the International Association for Aquatic Animal Medicine*, Galveston, TX.

Sweeney, J. C., & Ridgway, S. H. (1975). Common diseases of small cetaceans. *Journal of the American Veterinary Medical Association, 167*, 533-540.

Sweeney, J. C., Reddy, M. L., Lipscomb, T. P., Bjorneby, J. M., & Ridgway, S. H. (1999). *Handbook of cetacean cytology*. San Diego: Dolphin Quest. 41 pp.

Szymanski, M. D., Bain, D. E., Kiehl, K., Pennington, S., Wong, S., & Henry, K. R. (1999). Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. *Journal of the Acoustical Society of America, 106*, 1134-1141.

Tarpley, R. J., & Ridgway, S. H. (1991). Orbital gland structure and secretions in the Atlantic bottlenose dolphin, *Tursiops truncatus*. *Journal of Morphology, 207*, 1-12.

Tarpley, R. J., & Ridgway, S. H. (1994). Corpus callosum size in delphinid cetaceans. *Brain, Behavior and Evolution, 44*, 156-165.

Tarpley, R. J., Gelderd, J. B., Bauserman, S., & Ridgway, S. H. (1994). Dolphin peripheral visual pathway in chronic unilateral ocular atrophy: Complete decussation apparent. *Journal of Morphology, 222*, 91-102.

Thomas, J. A., Cornell, L. H., Joseph, B. E., & Williams, T. D. (1987). An implanted transponder chip used as a tag for sea otters (*Enhydra lutris*). *Marine Mammal Science, 3*, 271-274.

Townsend, C. H. (1914). The porpoise in captivity. *Zoologica, 16*, 289.

Townsend, F. I., Jr., & Gage, L. J. (2001). Hard-rearing and artificial milk formulas. In L. A. Dierauf & F. M. D. Gulland (Eds.), *Marine mammal medicine* (pp. 829-849). Boca Raton, FL: CRC Press.

Tryland, M. (2000). Zoonoses of Arctic marine mammals. *Infectious Disease Review, 2*, 55-64.

Turnbull, B. S., & Cowan, D. F. (1998). Myocardial contraction band necrosis in stranded cetaceans. *Journal of Comparative Pathology, 118*, 317-327.

Van Bressem, M-F., Van Waerebeek, K., & Raga, J. A. (1999). A review of virus infections in cetaceans and the potential impact of morbilliviruses, poxviruses, and papillomaviruses on host population dynamics. *Diseases of Aquatic Organisms, 38*(1), 53-65.

Van Dolah, F. M., Doucette, G. J., Gulland, F. M. D., Rowles, T., & Bossart, G. D. (2003). Impacts of algal toxins on marine mammals. In J. G. Vos, G. D. Bossart, M. Fournier, & T. O'Shea (Eds.), *Toxicology of marine mammals* (pp. 247-270). London: Taylor & Francis.

Vedros, N. A., Smith, A. W., Schonewald, J., Migaki, G., & Hubbard, R. C. (1971). *Leptospirosis* epizootic among California sea lions. *Science, 172*, 1250-1251.

Venn-Watson, S., & Ridgway, S. H. (2007). Big brains and blood glucose: Common ground for diabetes mellitus in humans and dolphins. *Comparative Medicine, 57*, 241-246.

Venn-Watson, S., Jensen, E. D., & Ridgway, S. H. (2007). Effects of age and sex on the clinicopathologic reference ranges in a healthy managed Atlantic bottlenose dolphin population. *Journal of the American Veterinary Medical Association, 231*, 596-601.

Venn-Watson, S., Smith, C. R., Dold, C., & Ridgway, S. H. (2008). Use of a serum-based glomerular filtration rate prediction equation to assess renal function by age, sex, fasting, and health status in bottlenose dolphins (*Tursiops truncatus*). *Marine Mammal Science, 24*(1), 71-80.

Walker, L. A., Cornell, L., Dahl, K. D., Czekala, N. M., Dargen, C. M., Joseph, B., et al. (1988). Urinary concentrations of ovarian steroid hormone metabolites and bioactive follicle-stimulating hormone in killer whales (*Orcinus orca*) during ovarian cycles and pregnancy. *Biology of Reproduction*, *39*, 1013-1020.

Ware, J., & Hunt, H. (1979). *The several lives of a Victorian vet*. New York: St. Martin's Press. 213 pp.

Webster, R. G., Geraci, J., Petursson, G., & Skirnsson, K. (1981). Conjunctivitis in human beings caused by influenza: A virus of seals. *New England Journal of Medicine, 304*(15), 911.

Wells, R. S., Rhinehart, H. L., Hansen, L. J., Sweeney, J. C., Townsend, F. I., Stone, R., et al. (2004). Bottlenose dolphins as marine ecosystem sentinels: Developing a health monitoring system. *EcoHealth, 1*(3), 246-254.

Wells, R. S., Tornero, V., Borrell, A., Aguilar, A., Rowles, K., Rhinehart, H. L., et al. (2005). Integrating life-history and reproductive success data to examine potential relationships with organochlorine compounds for bottlenose dolphins (*Tursiops truncatus*) in Sarasota Bay, Florida. *Science of the Total Environment, 349*, 1-20.

White, J. R. (1970). Thiamine deficiency in an Atlantic bottle-nosed dolphin (*Tursiops truncatus*) on a diet of raw fish. *Journal of the American Veterinary Medical Association, 157*, 559-562.

White, J. R., Stevens, R., Hopkins, T., Litz, C., & Morris, T. (1990). Reproductive biology and husbandry of captive West Indian manatees. *International Association for Aquatic Animal Medicine Proceedings, 21*, 55-61.

Wilkie, D. H., Bell, G. B., & Coles, J. S. (1966). A method of dolphin transport and its physiological evaluation. *International Zoo Yearbook, 8*, 198-202.

Williamson, W. M., Lombard, L. S., & Getty, R. E. (1959). North American blastomycosis in a Northern sea lion. *Journal of the American Veterinary Medical Association, 135*, 513-515.

Wilson, T. M., Cheville, N. F., & Karstad, L. (1969). Seal pox. *Bulletin of the Wildlife Disease Association, 5*, 412-418.

Wolman, A. A. (1985). Gray whale, *Eschrichtius robustus* (Lilljeborg, 1861). In S. H. Ridgway & R. J. Harrison (Eds.), *Handbook of marine mammals*, *Vol. 3* (pp. 67-90). London: Academic Press.

Wood, F. G., Jr. (1953) Underwater sound production and concurrent behavior of captive porpoises, *Tursiops truncatus* and *Stenella plagiodon*. *Bulletin of Marine Science of the Gulf and Caribbean, 3*, 120-133.

Wood, F. G., Jr. (1977). Births of porpoises at Marineland, Florida, 1939 to 1969, and comments on problems involved in captive breeding of small cetacea. In S. H. Ridgway & K. Benirschke (Eds.), *Breeding dolphins: Present status, suggestions for the future* (pp. 47-60). Washington, DC: Marine Mammal Commission.

Woodward, B., Winn, J., & Moore, M. (2006). Experimental modeling of large whale entanglement injuries. *Marine Mammal Science, 22*, 299-310.

Yamaguchi, K., & Fujino, K. (1953). On the serological constitution of the striped dolphin, *Prodelphinus caeruleo-albus* (Meyen). *Proceedings of the Japan Academy, 29*(2), 61-67.

Zabka, T. S., & Romano, T. A. (2003). Distribution of MHC II (+) cells in skin of Atlantic bottlenose dolphins (*Tursiops truncatus*): An initial investigation of dolphin dendritic cells. *Anatomical Record Part A, 273A*, 636-647.

Zabka, T. S., Buckles, E. L., Gulland, F. M. D., Haulena, M., Naydan, D. K., & Lowenstine, L. J. (2004). Pleomorphic rhabdomyosarcoma with pulmonaryn metastasis in a stranded Steller (northern) sea lion (*Eumetopias jubatus*). *Journal of Comparative Pathology, 130*, 195-198.

Zimmer, W. M. X., & Tyack, P. L. (2007). Repetitive shallow dives pose decompression risk in deep-diving beaked whales. *Marine Mammal Science, 23*, 888-925.

Zornetzer, H., & Duffield, D. A. (2003). Captive-born bottlenose dolphin × common dolphin intergeneric hybrids (*Tursiops truncatus* × *Delphinus delphis*). *Canadian Journal of Zoology, 81*, 1755-1762.