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Historical Perspectives

Michael D. Scott

(Born 1950)

Michael Scott began his career studying dolphin communication as a graduate student with David and Melba Caldwell in 1972. He then began a decades-long association with Blair Irvine, Randy Wells, and the bottlenose dolphins of Sarasota Bay; and went on to study manatees for the U.S. Fish and Wildlife Service, sea turtles for the National Marine Fisheries Service, and pelagic dolphins for the Inter-American Tropical Tuna Commission (IATTC). He received his PhD from UCLA for his studies on the ecology of marine aggregations and is currently a Senior Scientist with the IATTC and an Affiliated Professor at the University of San Diego. His research includes mortality reduction of dolphins in purse-seine nets; studies of the movements, diving behaviors, and herd structure of pelagic dolphins; and why tuna and dolphin associate together.

Beginnings

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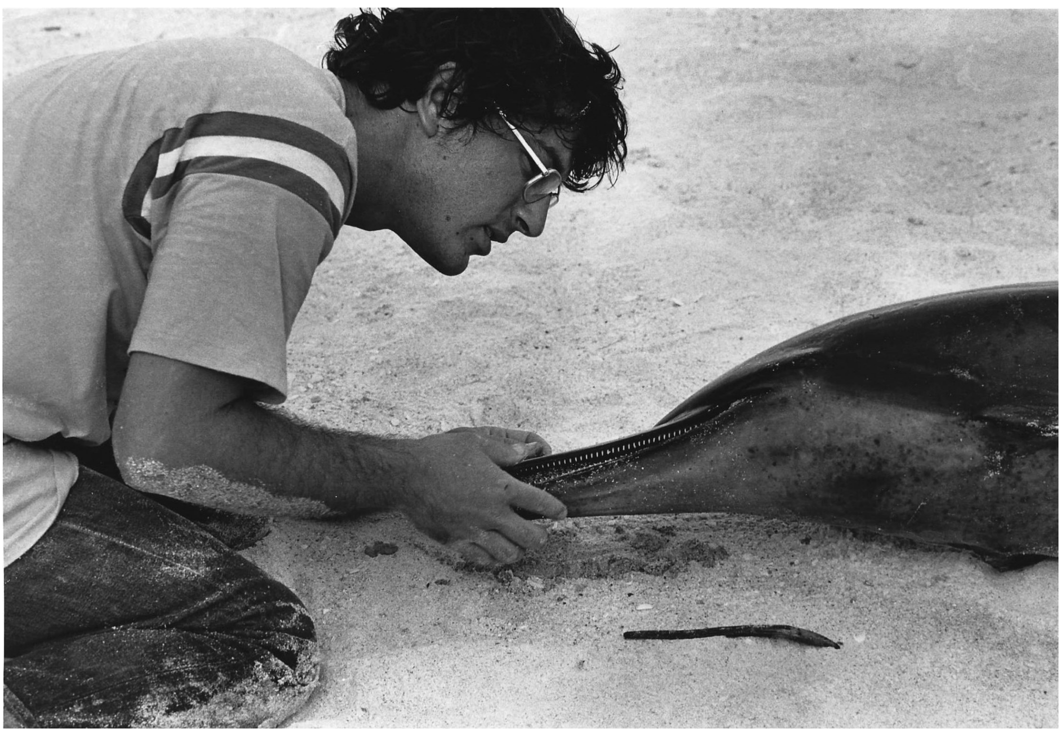
"Call me Ishmael."

I believe Herman Melville's opening line from *Moby Dick* is the best ever written, so I shamelessly stole it. Like Ishmael, I have been both a participant and observer caught up in the beginnings to great adventures. As a young graduate student of David and Melba Caldwell, I had a front row seat as they were pioneering the field of dolphin communication. Seduced by the prospect of studying wild dolphins, I joined Blair Irvine and Randy Wells in the early days of what was to eventually become the Sarasota Dolphin Research Program. I then became a part of the fledgling U.S. Fish and Wildlife Service research program on manatees. And, finally, intrigued by the prospect of studying deep-ocean dolphins, I joined the newly formed Tuna-Dolphin Program of the Inter-American Tropical Tuna Commission as it began its research program on dolphins and tuna and its monitoring program of the international fleet. These stories are meant for students, to describe what it was like to be present at the sometimes-chaotic beginnings of long-running research programs and to describe some of the pioneers in our field.

So, call me Michael. Not Mike. Michael. Would *Moby Dick* have become the Great American Novel if Melville's first line was "*Call me Ish*?" I think not.



Collecting data from stranded marine mammals is a messy labor of love and a potential entry for young biologists into the marine mammal field. Here, the author is examining a spinner dolphin (*Stenella longirostris*) from a mass stranding in 1976. (Photo courtesy of the Sarasota Dolphin Research Program)

> ***"I try all things; I achieve what I can."***
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> **–Ishmael in *Moby Dick* (Melville, 1851)**

I was an undergraduate and graduate student at UCLA in the 1960s and early 1970s, a time when some of the founders of modern marine mammalogy were either professors or students there. My interest in marine mammals was sparked by a class taught by Ken Norris. I was enchanted by Ken's stories, his creativity, and his keen insights into how the natural world works. I tried hard to emulate his quick and accurate drawings on the blackboard while he described what was known about a species and the people who studied them (professors didn't use slides much back then, and *PowerPoint* was decades in the future). In the classes that I now teach, you can still hear echoes of Ken's lessons. I sketch on the board. I tell stories because I think human beings are, at their very heart, storytellers. Opposable thumbs, sure. Big brains, bipedalism, and all that, but we are at our most human when we tell and retell stories. So, my students hear a few of Ken's stories and some of my own: stories about the scientists in the field, about learning from both failure and success, and how we discover great things by elegant scientific method and by complete accident.

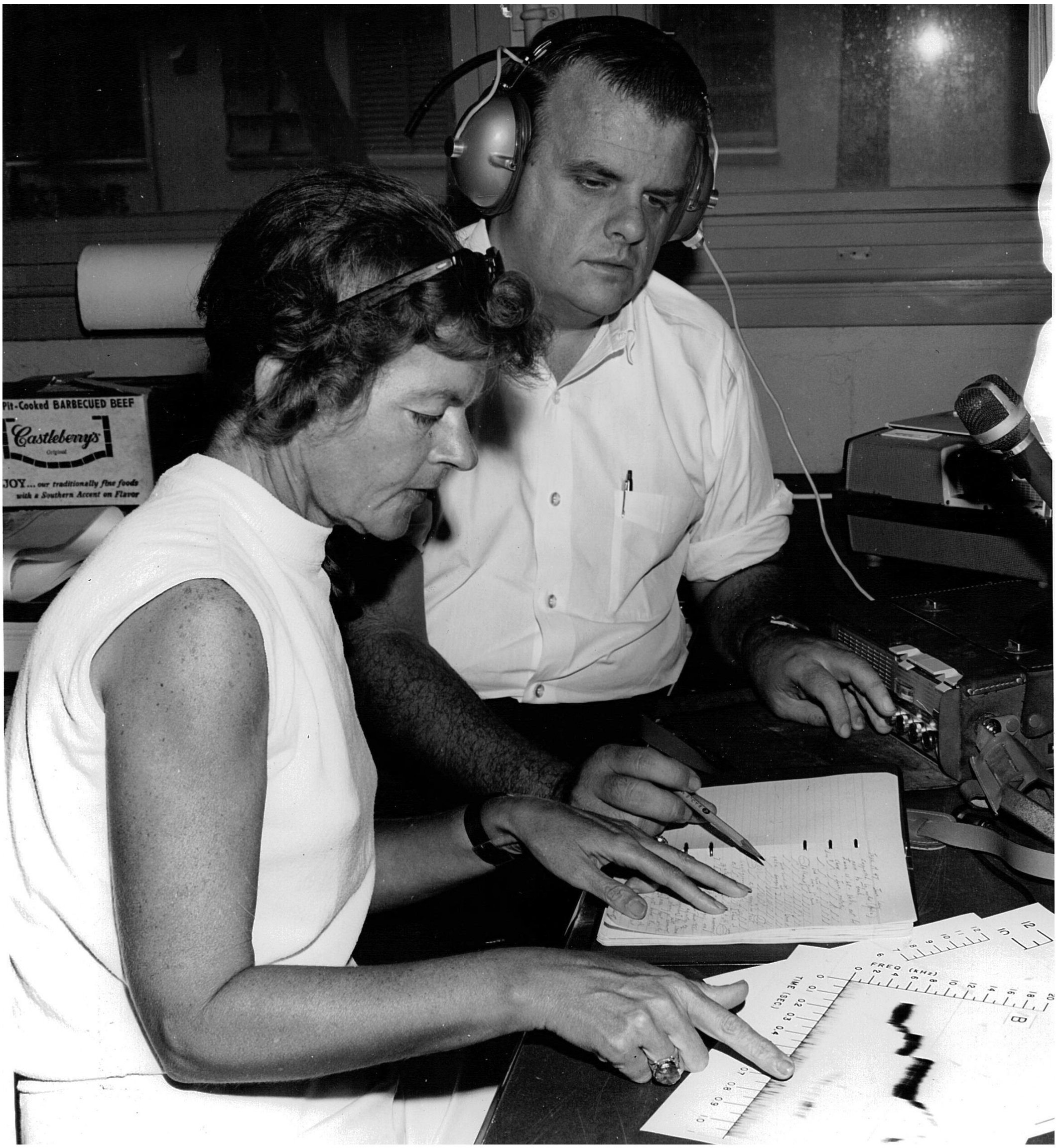
I started my doctoral research at the University of Florida studying dolphin communication with David and Melba Caldwell. The Caldwells were the oddest of odd couples. David was a very large man—thoughtful and slow-talking with a soft Kentucky drawl. Melba was a tiny woman with a keen, probing gaze and a ready and funny cackle of a laugh. She was often the one who spoke for the pair, often conducting her sentences with waves of her cigarette. As was common in that generation of marine mammalogists, they were naturalists with broad interests in biology who gravitated from other fields to marine mammals: David's background was in ichthyology; Melba's was in fisheries. Their laboratory was at Marineland of Florida, just outside of St. Augustine, and that was my home for two years. The Caldwells served as curators and directors of research for Marineland and professors at the University of Florida. They published *Cetology*, the first U.S. journal devoted to marine mammals. They even served as the mayor and deputy mayor of the small town of Marineland.

By the time I arrived in 1972, the field was transitioning from the popular conjectures by John Lilly and others that dolphin whistles constituted a complex language to the Caldwells' signature whistle hypothesis. The Caldwells had discovered that bottlenose dolphins (*Tursiops truncatus*) produce their own repetitive and individual whistle pattern (Caldwell & Caldwell, 1965). They suggested that these "signature whistles" allowed a dolphin to broadcast its identity and location to other dolphins. They reasoned that, for a social animal living in sometimes turbid waters, it is important for dolphins to keep track of one another. They found that newborns developed their own signature whistles within six months of their birth. Because subtle changes in these whistles were seen in some behavioral contexts, the Caldwells thought that the emotional state of the whistler could be communicated as well (Caldwell & Caldwell, 1972).

Critical evidence for the Caldwells' signature whistle hypothesis was provided by their research dolphin, "Twothirtytwo," who could discriminate among the signature whistles of multiple dolphins, maintain memories of these whistles for months afterwards, and mimic sounds (Caldwell & Caldwell, 1972). As the newest graduate student, it was my job to look after and train Twothirtytwo. He had a mischievous personality and a curiosity about human activities. He was keenly aware of things going on within 50 m of his tank. As he circled his tank, he typically would lift his head above the rim of the tank as he breathed. Once he had spotted anything going on, he would prop his head on the tank wall to get a better look (particularly my approach with his food bucket). Our morning and afternoon discrimination trials were often a battle of wits. While I would try to detect his limits in recognizing different signature whistles, he would test my ability to catch on that he was cheating farther and farther away from his homing position.

It was during the dawn hours at Marineland's main dolphin community tank, however, that I began to develop my own sense about what a dolphin's world was like. I would record whistles and behavior in the community tank while I had the whole park to myself. It could be difficult to determine which animal was whistling, but the dolphins sometimes helped by releasing a string of air bubbles as they whistled. At first, I focused on the splashy obvious behaviors associated with physical aggression and maintaining dominance hierarchies: who was nipping at or jaw clapping at or chasing whom. Soon I could sort out that one large female, "Liz," dominated over all the other females and subadult males. All except for one, a large female named "Mary." Mary stumped me. She just didn't fit into the hierarchy. She was never attacked by another dolphin nor was she the attacker; yet, she seemed central to the dolphin society, and she never swam alone. This was most clear at dawn before the tank became active. Mary would be placidly swimming at the center of the group, usually flanked by the largest females in the tank. Liz and the other dolphins sought her out but not the reverse. I began to suspect that Mary was a leader, and that being a leader in a dolphin herd can be quite subtle and quite different from an alpha male or female in a dominance hierarchy. Their social structure appeared to be a matriarchal one, glued together by females such as Mary and Liz.

I also learned much from the dead dolphins that stranded upon the beach. Strandings have long been a labor of love for marine mammalogists, and, to my surprise, I found that one of the most exciting parts of my routine was getting out of the lab to retrieve stranded dolphins. I also learned how dolphins worked on the inside by watching Dave Caldwell deftly perform necropsies. In those days, there was rarely much of a budget for collecting and examining dead dolphins, yet the only information that existed for many cetacean species came from strandings. Stranding networks are much more sophisticated and organized now, and becoming a part of a stranding team remains an entry-level opportunity to wriggle one's way into marine mammal field work.



David and Melba Caldwell using tape recordings, sonograms, and behavioral notes to study dolphin signature whistles (Photo courtesy of Marineland Dolphin Adventure, St. Augustine, Florida)

To an outside observer, it is sometimes not clear who is the researcher and who is the research subject. Twothirtytwo and Melba Caldwell studying each other. (Photo courtesy of Marineland Dolphin Adventure, St. Augustine, Florida)

One stranding of a live young spinner dolphin (*Stenella longirostris*) stands out for me. She had stranded alone north of Jacksonville, Florida, and some Good Samaritans picked her up off the beach, brought her to a freshwater swimming pool, and then called Marineland (people could do that sort of thing back in the days prior to the Marine Mammal Protection Act). I drove up to record the whistles and observe the behavior of this animal overnight until the Marineland crew could retrieve her the next morning. I spent the night recording and watching this little dolphin; it left me with reels of taped whistles, a journal with pages of sketches and notes, hundreds of mosquito bites, and a desire to study dolphins outside the laboratory.

Very little field work had been done up to that point on wild dolphins, but new methods of radio-tracking, tagging, and photo-identification (Norris & Pryor, 1970; Evans, 1971; Irvine & Wells, 1972; Würsig & Würsig, 1977; Bigg, 1982; Irvine et al., 1982) were making field work a reality. While watching dolphins swim together in the Marineland tank and listening to their sounds provided me with insights into behavior, I was always left with questions about how these behaviors and sounds were used in the wild. When the opportunity arose to study wild bottlenose dolphins in Sarasota Bay, Florida, with Blair Irvine and Randy Wells, I left the University of Florida to join them.

In the following years, dolphin communication research would be hindered by a lack of funding.

Left: Recording a mother and calf with a handheld microphone and a reel-to-reel Uher tape recorder in 1974; *Center:* Recording a dolphin with a suction-cup-mounted hydrophone in 1989; *Right:* Recording a free-ranging dolphin using a suction-cup-mounted DTAG in 2010. (Photos courtesy of the Sarasota Dolphin Research Program)

Studies on the signature whistle hypothesis enjoyed a renaissance, however, when Peter Tyack and his students and colleagues expanded the research in both captive and field settings. A passing of the torch, of sorts, occurred when Peter collaborated with the Caldwells in a review of two decades of their research on the signature whistle hypothesis (Caldwell et al., 1990). Peter and his lab developed the "vocalight," a suction-cup-mounted hydrophone with LED lights that solved the problem of determining which dolphin in a group was whistling (Tyack, 1991). When a whistle was detected by the hydrophone, the LEDs lit up; the louder (and closer) the whistle, the greater the number of lights that would turn on. Using vocalights, Peter detected one dolphin mimicking another's signature whistle, which was followed by a social interaction between the two (Tyack, 1986). His lab also developed a DTAG (see figure above), a suction-cup-mounted hydrophone that allowed the recording of free-ranging dolphins (Johnson & Tyack, 2003). Further field and laboratory work confirmed that dolphins do copy the signature whistles of other dolphins, suggesting that these whistles may function as a "name" (Janik & Sayigh, 2013; King & Janik, 2013; King et al., 2013). Quintana-Rizzo et al. (2006) later calculated that the communication range of dolphin whistles could extend over long distances, from 487 m over grassflats to over 20 km in boat channels.

There is a lot of controversy now about the ethical, scientific, and educational value to keeping dolphins in captivity. For me, much of my understanding about dolphin society stems from those dawn sessions at Marineland when I watched Mary and Liz glide around the community tank. Even though most of my adventures have since been with wild dolphins, it all started with watching and listening to captive animals. And, over the years, our studies of behavior have been a continuing conversation between captive studies, where behaviors can be studied in continuous detail, and field studies, where the purposes and context of these behaviors become clearer.

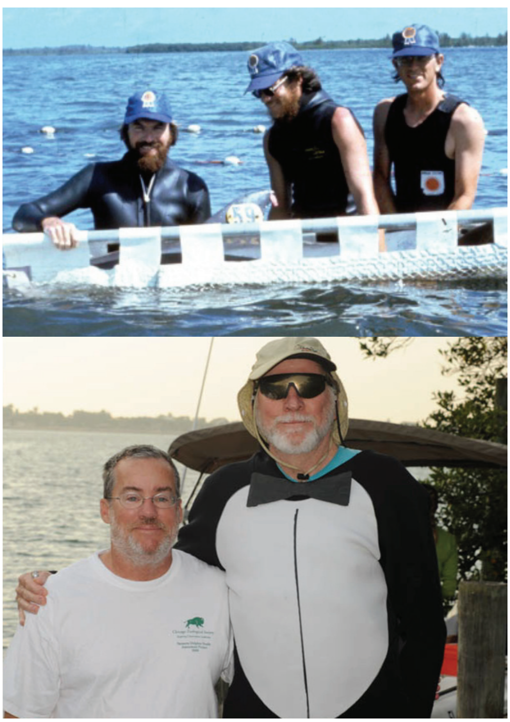
"Believe me, my young friend, there is NOTHING—absolute nothing—half so much worth doing as simply messing about in boats."

–The Water Rat in *The Wind and the Willows* (Graham, 1908)

The pathway that led me to a love for messing around in boats and to field work in Sarasota Bay started improbably enough in an electrical engineering class at the University of Florida. Despite the odds against meeting another Southern Californian, another marine mammalogist, and another ardent volleyball player, I met Blair Irvine in that class about transistors and diodes. I was taking the class to get a better background in the acoustical recording gear I would be using, while Blair was there to get a background in the radio-tracking gear he planned to use on bottlenose dolphins in Sarasota Bay.

Blair had been a trainer for the U.S. Navy's new dolphin program. He had worked with Sam Ridgway, Forrest Wood, and Bill Evans on open-ocean studies such as diving capabilities, detection, and underwater-object retrieval. Blair is tall and bearded, keenly curious and practical, and an enthusiastic problem solver, with a ready laugh and grin. His long arms were an asset because he could slip his arm down a dolphin's gullet to retrieve swallowed objects. He is also the consummate do-it-yourselfer. Do we need more storage space? Build wooden boxes. Need an amphibious trailer to haul dead manatees around? Buy a boat trailer and build a platform using marine plywood and eyebolts. And then add wooden boxes. He has a do-it-yourself teaching style to match. Teach Michael how to dock a boat? Throw out a floating buoy and let him try to park next to it without sinking it. (I sank it.) Teach Michael how to radio-track? Throw him the instruction manual and let him figure it out by trial and error. (Mostly error.)

The U.S. Navy proved to be a fertile training ground for young researchers at that time (Wood, 1973), and Blair transformed himself from a trainer into a researcher. The Navy wanted to find out whether dolphins could be trained to attack sharks and protect Navy divers (Irvine et al., 1973). While training and testing his research dolphin "Simo" to attack different species of sharks at the Mote Marine Lab in Sarasota, Florida, his interest expanded to studying the local bottlenose dolphin population, and he began accompanying a local oceanarium collector in 1970 to tag those dolphins that the collector did not want. A young high school student named Randy Wells volunteered to help him, and together they tagged and released 12 dolphins. Resightings suggested that these 12 tagged dolphins were residents of the area (Irvine & Wells, 1972), and the newly established Marine Mammal Commission (MMC) requested that Blair write a proposal to conduct a broader study using the relatively new tool of radio-tracking to study the movements and home ranges of Sarasota dolphins.



Top: Blair Irvine, Randy Wells, and author holding FB59 in 1976. *Bottom*: Randy Wells and Blair Irvine over 30 years later (author not included as the aging process has largely left him untouched). (Photos courtesy of the Sarasota Dolphin Research Program)

Sometimes opportunities happen in bunches. Blair's proposal to radio-track and tag bottlenose dolphins, which was one of the first to be funded by the MMC, was granted at the same time that he was offered a position with the newly formed U.S. Fish and Wildlife Service Manatee Program. As is typical of Blair (anything worth doing is worth overdoing), he took on both: he accepted the manatee position in Gainesville, Florida, in 1974, while also hiring and supervising Randy and me to conduct the dolphin research in Sarasota.

Here, I learned some of the crafts of a field biologist: radio-tracking, surveying the dolphins in Sarasota Bay, photo-identification of marked dorsal fins, repairing and modifying our boat, and creating do-it-yourself fiberglass radio packages. Randy, working on his master's degree in Gainesville, did the analyses and frequently made the 6-hour roundtrip from Gainesville to Sarasota just to spend a few hours on the water.

Randy and I struck up a close friendship that has lasted over 40 years. We looked quite similar with the same short and stocky build and the same metal-rim glasses, and particularly so while bobbing along in Blair's wake. Both of us were basically quiet, focused, meticulous, inherently cautious, and practical, yet with an off-kilter sense of humor and penchant for quoting movie lines with little provocation. We are both nerds, but we are adorable nerds.

Sarasota Bay proved to be a truly wonderful natural laboratory. A chain of barrier islands protects the bay so the waters are usually calm. The study area is easily accessible, and its "urban" dolphins are used to boat traffic so they don't spook when approached carefully. We found that the dolphins were long-term residents that could be studied year-round. There were also a reasonable number of dolphins, about 100, in the area at the time—abundant enough to be regularly spotted, but few enough for us to eventually identify nearly every member of the population.

Most days on the water were spent surveying the area for dolphins or following a radio-tagged dolphin. This seems commonplace now but back then this type of research was brand new, and we had to design and redesign sighting sheets, create and re-create databases, and devise and revise survey protocols. We had to develop terminology for everything. What is a "school" (or "herd" or "pod" or "group" or "aggregation")? How close together must dolphins be to be considered part of the same group? How do we define behaviors when we could only glimpse the dolphins at the surface for about a second at a time? Which environmental features were important to dolphins and which ones could we easily record? How often do we plot a position for our radio-tagged dolphin? Decisions about these questions had unexpected consequences down the road, and it took us a long time to finally settle on our protocols.

Every couple of months, Blair and Randy and a handful of volunteers would descend on Randy's parents' house, throw sleeping bags onto any available place to sleep, and then head out in the pre-dawn hours to capture and tag dolphins. Back then, we had a crew of no more than a dozen, a fisherman's net boat, a chase boat, and the project's tracking boat (named the *Black Cloud* for its unreliable inboard engine). The crew was a mix of local students from New College who frequently volunteered to help during radio tracks and surveys (mostly small females it seemed), an additional tall male or two who Blair recruited for "muscle," and whichever local gillnet fisherman was interested enough to catch dolphins for the day rather than mullet. To Blair and Randy, who sometimes had comprised the only crew for a dolphin collector when they tagged dolphins in these waters previously, our crew must have seemed a luxury.

Our capture-release operations have been described as a highly choreographed aquatic rodeo. First, we identify the dolphins and determine which dolphins we want to catch (those for which we need additional data) and which dolphins we want to avoid (the very young and the very old). A net boat rapidly sets a 500-m-long net around dolphins in water shallow enough for us to wade in. The crew quickly enters the water to discourage the dolphins from hitting the net and to quickly disentangle them if they do. We then partition the net to separate the dolphins, restrain them, and work them up one at a time. In the 1970s, our procedures were simple. We measured their length, determined the sex, freeze branded and tagged them, and then released them.

We identified almost half of the population's individuals, plotted their home ranges, determined that the dolphins were annual residents of the area, and tracked 10 dolphins for up to 21 days (Irvine et al., 1981). Round-the-clock tracking gave us a sense of what a day in the life of a dolphin was like. We tested and improved tagging techniques (Irvine et al., 1982) and described the dolphins' social structure (Wells et al., 1980). Our findings were incorporated into the management of live captures for public display that were prevalent in Florida in the 1970s to prevent too many

Dolphins being measured during health assessment studies in Sarasota Bay (Photo courtesy of the Sarasota Dolphin Research Program) individuals being removed from the same resident population.

And then, after 18 months, the funding ended. With the advantage of hindsight, I see now that long-term projects rarely enjoy continuous, adequate funding; those that survive often do so simply because one person is too stubborn to let it die. In our case, Randy was that stubborn person. While Randy was finishing up his master's degree at the University of Florida and I was beginning to work for Blair on manatees, we would often drive to Sarasota for weekends, hop into his parents' little boat, and survey the area for our dolphins. Even after Randy went off to the University of California at Santa Cruz for his doctorate, he would come home to visit the Sarasota dolphins, and they again contributed to his dissertation. After he had finished his PhD in 1986, and a post-doctoral fellowship at Woods Hole Oceanographic Institution in 1987, he committed himself to conducting full-time research on the Sarasota dolphin community. He wrote grant proposals, large and small. We formed a nonprofit research organization (now called the Dolphin Biology Research Institute) in 1982 to help attract small grants without having to pay the large overhead costs charged by major research institutions. We learned to keep the data collection one or more steps ahead of the funding process by anticipating what the critical management questions would be in 2 to 5 years. We established a relationship with Earthwatch, an organization that matches volunteers with research programs, and we re-initiated the capture-release operations, with a focus on life history and health assessment, and regular photo-identification surveys in 1984.

Eventually, all these efforts gained traction. The Chicago Zoological Society hired Randy as a conservation biologist in 1989 because they understood the importance of studying animals in the wild to improve the lives of the dolphins under their care at the Society's Brookfield Zoo and to better educate the public. Over the years, that same logic has gained the cooperation and support from other facilities holding dolphins (for example, Dolphin Quest, Disney, the U.S. Navy, Mote Marine Laboratory, and Georgia Aquarium). In 1992, Randy moved back to Florida to conduct full-time research, oversee his graduate students in the field, and build the program further.

We have followed the lives of five generations of known animals swimming in Sarasota waters. The oldest animals, including a few that we have known for over 40 years, are now in their 60s. The resident population has grown to over 150 dolphins since Florida reduced competition for the dolphins' prey by banning gillnetting in state waters. Our research questions have expanded, but our focus is now on health assessment of the population. With a fleet of about a dozen boats crammed with 90 or more researchers, we collect data for about 40 different research studies. Catching the dolphins requires more patience and guile now because the dolphins learned long ago to recognize the net boat. Fortunately, the dolphins have also learned to remain calm inside the net circle and are much easier to handle.

Over the 47-year duration of the project, the questions and the focus have changed. When we first started, we were concerned about the fates of individuals: their residency, movements, behavior, and reproduction. As we learned more, we broadened the focus to the community and population level: studying the social structure, particularly the female bands at the center of their society, and the interactions between adjacent communities. Ecological studies look at relationships between the dolphins and their prey, assessing the threat of mortality and injuries from sharks and stingrays, and observing the effects of red tide blooms on the dolphins. Sampling blood, blubber, and teeth allow us to estimate ages and monitor the health and contaminant loads of individuals. Metabolic studies allow us to discover more about their physiology. My first research love, dolphin communication, and my second, dolphin field research, were melded when we began testing David and Melba Caldwell's signature whistle hypothesis on wild dolphins. Playback experiments were first conducted by Peter Tyack, joined in turn by his graduate student Laela Sayigh, and then Laela's graduate students, and now Vincent Janik and his graduate students. With the combined knowledge of all these individual histories, our research continues to aid management agencies by comparing the health of the Sarasota dolphins with bottlenose dolphins whose populations have been affected by oil spills or disease.

"Blessed are the meek, for to them we shall say 'attaboy.'"

–*Lamb: The Gospel According to Biff, Christ's Childhood Pal* (Moore, 2002)

Manatees (*Trichechus manatus*) have been called ugly in multiple languages for at least 500 years. Christopher Columbus recorded a sighting in his log on 8 January 1493 of what he thought were three mermaids off Haiti that were "not so beautiful as they are painted" (translated in Markham, 1893, p. 154).

When I joined the U.S. Fish and Wildlife Service as a part-time research technician in 1976, little was known about this meekest of all marine mammals, the manatee, and very few

Manatee (*Trichechus manatus*) (Photo courtesy of R. Bonde, U.S. Geological Survey)

people had experience studying them. The head of the program, Howard "Duke" Campbell, was a herpetologist; many of the research technicians he hired were herpetologists; and it seemed that our field work was just as likely to be on alligators or snakes as on manatees. The head of the National Fish and Wildlife Laboratory, Clyde Jones, had a penchant for hiring herpetologists, even for mammal programs. He claimed that the herpetologists were needed to clear out the rattlesnakes so the mammalogists could set their traplines in safety (Lovitch et al., 2012). Duke's successor, Galen Rathbun, at the other extreme, had studied elephant shrews in Africa. It was quite the eclectic group but the bond that united us was the focus on field work. Whether it was aerial surveys to monitor population size, observing and identifying manatees at warm-water springs or capturing them to tag and track, or recovering dead manatees from a swamp or sticky mudflat, we were in the field much of the time. It was here that I learned the doctrine "It's easier to get forgiveness than permission." We just got the job done and then were properly apologetic when we got back. Here, I also learned the value of veteran government secretaries. Ours would look over the rim of her glasses at me and sigh deeply when I would sheepishly bring her a fistful of receipts from the field before using her years of experience to get me on the right side of the bureaucracy.

The only researcher on the staff who actually had experience with manatees back then was James "Buddy" Powell. Buddy had virtually grown up with manatees and, like Randy Wells, had started working as a high school volunteer. He worked with Daniel "Woody" Hartman, a PhD student, who was the first to focus on the behavior and ecology of manatees living in the Crystal River, a warm-water refuge for manatees on the west coast of Florida (Hartman, 1979). Buddy is the quintessential field biologist, and his intimate knowledge of the Crystal River waters and individual manatees from the scarring patterns on their backs made him a uniquely valuable member of the team. He spent as much time as he could in and on the water; he even bought a houseboat so he could live at his study sites. He has spent the last 40 years studying manatees and working to establish refuges to protect them in Florida, Cuba, West Africa, and Belize. In the process, he has become a respected conservation biologist who founded Sea to Shore Alliance, an organization that builds working relationships between scientists and the public to reverse habitat degradation and prevent the loss of species diversity.

Buddy Powell conducting field work in Belize (Photo courtesy of the Sea to Shore Alliance)

Manatees are a paradox. They look homely, but in the cutest possible way. They are extremely vulnerable to getting hit by boat propellers, yet their skin is so tough and thick that they often survive these injuries. You might expect to hear bellows or roars from a 1,000+ kg mammal, yet manatees chirp. Manatees look slow, yet they sprinted away from our first capture attempts, covering 30 m in about 3 seconds, leaving us stunned and empty-netted. You might think that the mental capacity of an animal that spends a good part of its time stalking sea grasses would be limited, yet they are often curious about people and our toys, and they are ingenious enough to escape from a net in ways that dolphins never do. For example, during one capture, we had trapped manatees inside a small cove at Cape Canaveral, Florida. We had blocked their exit with a wire fence that was supported by poles and secured to the bottom of the cove, along with a nylon net that was secured to both shores. The manatees responded, as they often do, by sinking out of sight for about 10 minutes. As we prepared to seine the manatees out of the cove, one manatee made a bold (albeit slow) bid for freedom. It had hoisted its body with its flippers up onto the beach and was inching its way around the net and fence along the beach. We watched in slack-jawed amazement but recovered in time to chase it back into the water, after which it sank out of sight again. While seining the manatees toward shore, this same manatee probed the net in several places without tangling and then stuck its nose under the weighted leadline at the bottom of the net and freed itself by wedging the rest of its body under the net. Again, the manatee sank out of sight for 10 minutes. Once the manatee surfaced, it probed the chickenwire fence a few times, and then put its head on top of the wire fence, forced it down and powered over it to freedom. Three entirely different escape solutions—all preceded by the manatee sitting on the bottom as it apparently pondered its next move. Manatees never failed to surprise me.

In the early days, each program had to be built from scratch, and virtually every device we used had to be designed and built ourselves. For the stranding program, we had to devise ways to retrieve large carcasses from boat ramps, mudflats, and swamps and transport them to our lab, devise portable structures that could weigh live and dead manatees in the field, design a sampling protocol, and arrange for carcass and sample storage. For the tagging and tracking studies, we tried different ways to safely attach sonic and radio transmitters and to mark individual animals. Aerial surveys had to be designed for different habitats and timed during the winter to occur when the winds were calm but the temperature cold so that we could count the manatees concentrated in their warm-water refuges. Computer programs had to be written and rewritten using punch cards. A simple task like plotting manatee sightings on a map was long, arduous, and expensive. Without any mapping databases at the time, Florida's coastline, rivers, and lakes had to be digitized by hand just to produce our crude plots of sightings.

Our first study of manatee distribution started by encouraging the public to report manatee sightings to us. Pre-paid postcards that prompted people to report details of sightings were sent out to virtually anyone who spent time near the water —marina owners, employees at gas and fishing docks, fishermen, and interested boaters. These postcard returns were not particularly useful in a quantitative sense, but they did provide basic distribution information. It was also a first step for public education, perhaps an early example of citizen science where the public and scientist collaborate to collect data. Public relations and education turned out to be an important part of our jobs so people would know what manatees were (many Floridians had never even seen one), who we were, and who to call if somebody sighted a dead manatee or a manatee in trouble.

The ever-present knowledge that manatees were endangered meant that there was the constant weighing of risks of harm to an individual with the scientific and management benefits of any procedure. There was the fear that every winter could bring a wave of cold-related mortalities and that the ever-increasing boat traffic in Florida could push the manatee population to extinction. I always thought that if we failed to preserve them in Florida, with all the resources available in the U.S., how could we hope to preserve sirenians elsewhere? From the outset, there was always an international concern in the program for sirenian conservation, so collaboration with scientists around the world was an early priority.

The Sirenian Project grew into an outstandingly successful program after I left (see O'Shea et al., 1995), and I have admired their progress from afar. Early on, we tried several different ways to tag manatees by suturing or darting with a crossbow or a lance or by freeze branding (Irvine & Scott, 1984) before John Bengtson (1981) successfully tested a floating transmitter tethered around the tail stock. Galen Rathbun's careful research refined this design to carry a satellite tag equipped with breakaway links to avoid entanglements (Rathbun et al., 1990). The tag is so well-designed that divers can remove old transmitters and replace them with new ones without even capturing the manatee. Jim Reid and colleagues have now tracked so many manatees by satellite, radio, and GPS (Reid et al., 1995; Deutsch et al., 1998) that, as a radio-tracker myself, I stand in awe.

In the early days of the stranding program, we were in constant danger of being engulfed in dead manatees and had to conduct primitive necropsies in the middle of the woods. Bob Bonde and Cathy Beck brought museum standards to our stranding program, however, and now veterinarians conduct necropsies in a lab custom-built for handling manatees. Still, perhaps it is the fact that the dead manatees do not float until decomposition gases have built up for a few days, perhaps it is the effect of the broiling Florida sun after they do strand, or perhaps it is the special chemical that decomposing manatees produce that is like a No. 1 scalpel blade to the olfactory center of the brain, but decomposing manatees smell worse than any other dead thing I have ever encountered.

We used to identify individual manatees from their propeller-scar patterns recorded by sketches of underwater slates. Buddy Powell could then identify some of his favorites from memory and others by comparing them to his catalog of sketches. Soon, as more and more manatees were identified, photographs, and eventually digital photographs, were used to build a photo catalog (Reid et al., 1991). Now, an automated Manatee Individual Photo-Identification System is being used to match photographs (Beck & Reid, 1995). And when once the minimum population estimate of Florida manatees was under 800 (Irvine & Campbell, 1978) and alternated between slow growth and dramatic declines caused by severe cold snaps, boat strikes, and red tides, the estimated population has increased to over 6,000 animals (Martin et al., 2015).

"And now for something completely different . . ."

–Monty Python (1971)

In 1979, I was offered the opportunity to study pelagic dolphins, and I became embroiled in the tuna–dolphin issue. Yellowfin tuna (*Thunnus albacares*) often swim with spotted dolphins *(Stenella attenuata*), spinner dolphins, and sometimes common dolphins (*Delphinus delphis*). Baitboat fishermen had first used this relationship to assist them in finding tuna because the dolphins were easier to sight. However, with the advent of synthetic purse-seine nets and winches powerful enough to pull the nets, the fishermen could encircle the entire group of dolphins and tuna with a net that is about 1,600 m long and about 200 m deep. This led to large catches of tuna at the expense of high mortalities of dolphins that entangled in the nets. The issue came to the public's attention in 1969 when a young Bill Perrin reported that a high dolphin mortality was occurring incidental to tuna purse-seine fishing in the eastern tropical Pacific (ETP) by the largely U.S. fleet (Perrin, 1968, 1969, 1970, 2009).

By the time I showed up, this controversy had already been raging for a decade. The National Marine Fisheries Service (NMFS) had created an

Purse-seine set on tuna associated with dolphins (Aerial photo by Wayne Perryman)

observer program in the 1970s to monitor the dolphin mortality in the U.S. fleet and had worked with the fleet to conduct research on dolphin behavior, mortality reduction, and life history. However, as the fleet became more international, the need for an international research and management program became apparent. The Inter-American Tropical Tuna Commission (IATTC), initially created by international treaty to research and manage tuna stocks in the ETP in 1948, established the Tuna-Dolphin Program in 1978 to build an international observer program and conduct research on dolphin abundance, mortality estimation and reduction, and the association between tunas and dolphins.

Dr. Robin Allen was chosen to build this new international program from the ground up, and he offered me the chance to study the behavior and ecology of pelagic dolphins. Robin was a native of New Zealand with a background in population dynamics and fisheries. He was built tall and broad like a rugby forward; he had a wide, ever-present grin, large ears, and an even larger heart. He was an extraordinarily kind and patient man with a penetrating, analytical mind. He recruited a group of energetic, young biologists—a mix of brilliant quantitative biologists like Phil Hammond and Jeff Laake; field grunts like Dave Bratten and me;

Robin Allen (in white) stacking net alongside a crewmember of the tuna purse seiner *Gina Anne* (Photo courtesy of the Inter-American Tropical Tuna Commission)

Rafael Guillen, a savvy fisherman with a talent for gear innovations; and former NMFS observers to help build our new observer program. He led our diverse staff by promoting an atmosphere for doing science. He encouraged us and challenged us to take on projects that asked interesting questions—not just for management, but to improve our biological understanding.

One of Robin's first priorities was to build an observer program to monitor dolphin mortality caused by the international fleet. However, convincing the entire fleet to take observers onboard proved long and arduous. It wasn't until 1986 that Martin Hall, the third head of the program, cajoled every vessel from every country fishing in the ETP to accept an observer. These observers have been the heart of our program. Not only do they bring back information to estimate dolphin mortality (Hall & Boyer, 1986; IATTC, 2015), but their data and observations have provided opportunities to estimate relative abundance and density (Hammond & Laake, 1981, 1983; Buckland & Anganuzzi, 1988; Lennert-Cody et al., 2001), distribution and stock structure (Perrin et al., 1983, 1985), behavior (Scott & Cordaro, 1987; Scott & Cattanach, 1998; Lennert-Cody & Scott, 2005; Scott & Chivers, 2009), and life history (Hohn & Hammond, 1985; Scott & Perryman, 1991). Currently, 100% of the purse-seiner trips in the ETP are monitored by IATTC or national program observers. Anticipating that the issue of other bycatch from the fishery besides dolphins would become more and more important, Martin expanded the observer data collection to include information on sharks, sea turtles, and large pelagic fishes.

Bill Perrin holding a pygmy killer whale (*Feresa attenuata*) calf in 1968 (Photo courtesy of the Southwest Fisheries Science Center)

It has been our good fortune to share lab and office space with NMFS scientists at the Southwest Fisheries Science Center in La Jolla, California. While the relationship between the IATTC and NMFS has been contentious at times, on a day-to-day basis, IATTC and NMFS scientists work together quite closely. One of the first NMFS scientists I met was Bill Perrin. It was hard not to be awed by his gruff-looking exterior and penetrating gaze, but eventually I learned that his gaze was often full of mischief, and that inside that gruff exterior was a warm-hearted and modest man. He is the most efficient scientist I know, accomplishing in one day what normally took me about three.

Bill introduced me to the term "best available science." As fisheries or wildlife biologists, we often do our science with impending management decisions in mind even though the data we have in hand may be incomplete, biased, imprecise, or just absent. So, whether it is defining a stock, calculating reproductive rates, or estimating population size, we present advice to policymakers based on the data we have available and not the data we wish we had. It was a distressing lesson for me to accept that being "right" can often be short-lived.

Studying dolphins that live hundreds to thousands of kilometers offshore requires money and creativity and a great deal of patience. For example, we radio-tracked dolphins from a sailboat to test whether lower-cost, long-term tracking was feasible (Scott & Wussow, 1983). We worked with Wayne Perryman of NMFS to test whether aerial photographs taken from helicopters or airplanes could be used to ground truth observer estimates of herd size (Allen et al., 1980; Scott et al., 1985) and to measure dolphin lengths, inter-animal spacing, swimming behavior, and the length at which young dolphins become independent of their mothers (Au et al., 1988; Scott & Perryman, 1991).

Research on reducing dolphin mortality was a critical part of the program, as well as spreading promising dolphin-saving techniques throughout the international purse-seine fleet (Bratten, 1983).

We implemented international agreements hammered out in the 1990s that set dolphin mortality limits on each tuna seiner and on each dolphin stock, and instituted 100% observer coverage on the international fleet (IATTC, 2015). All these efforts produced an amazing decline in dolphin mortality from over 130,000 per year in 1986 to less than 700 in 2017.

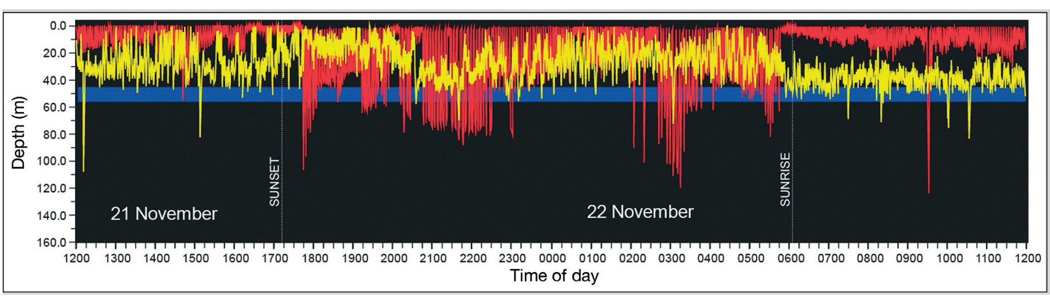
A week after I reported to the Commission, I was lucky enough to find myself at sea aboard a tuna purse seiner, the *Gina Anne*. I learned how to sight large dolphin herds far off on the horizon using 25X binoculars and how to estimate their numbers. I learned from the fishermen how to rescue dolphins; mend nets; navigate by satellite and sextant; and curse in Spanish, Italian, and Portuguese. I snorkeled with hundreds of spotted and spinner dolphins swimming beneath me and around me inside the net circle. The yellowfin tuna swam below the dolphins, and I became intrigued by the puzzle of why these species swim together. The fishermen told me that the large yellowfin tuna typically swam with dolphins; that it was the spotted dolphins that "carried" the tuna; and that in the hook-and-line fishing days, the fishermen could stop the tuna school by chumming with bait only while the dolphins remained present.

These observations by fishermen were complemented by one of the early scientific studies on the food habits of dolphins and tuna (Perrin et al., 1973), which showed overlap in the prey of yellowfin tuna and spotted dolphins but not with spinner dolphins. This hinted that the relationship between yellowfin tuna and spotted dolphins could be food-related. The tuna could take advantage of the dolphins' ability to echolocate prey, the dolphins could take advantage of the tuna's superior sense of smell, or both could be feeding on flying fish flushed by a large moving aggregation (Norris, 1978; Norris & Dohl, 1980; Au, 1991; Pryor & Kang-Schallenberger, 1991; Edwards, 1992; Norris et al., 1994). Tuna do associate with spinner dolphins even though there is little overlap in their prey, but the association could be an indirect one based on the spinner dolphins' strong tendency to associate with the spotted dolphins (Perrin et al., 1973). But, if the association was food-related, why did the tuna stop feeding on the baitfish the fishermen were chumming and leave whenever the dolphins did?

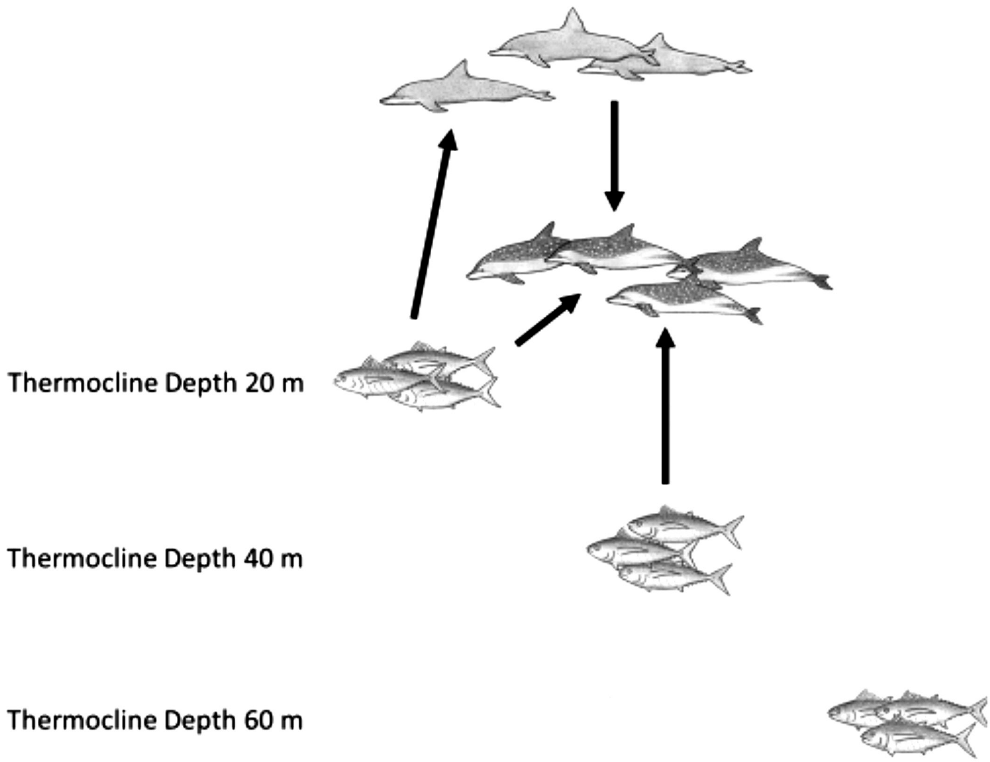
IATTC and NMFS scientists whittled away at this puzzle. Ecosystem modelling suggested that the relationship must benefit the tuna for the association to be stable (Mullen, 1984), and energetics modelling suggested that the association would typically be possible only for tuna large enough to keep up with the dolphins (Edwards, 1992); both studies supported the fishermen's observations that it is the tuna that follow the dolphins. Daily patterns in tuna and dolphin group sizes suggested that the tuna–dolphin association breaks up at night and reforms during the day (Scott & Cattanach, 1998). Spinner dolphins appear to also seek out the company of spotted dolphins during the day, but this association also breaks up at night.

Eventually, we combined three different studies to solve the puzzle: (1) we compared the food habits of the spotted and spinner dolphins and yellowfin tuna, (2) we simultaneously tracked spotted dolphins and yellowfin tuna, and (3) we explored the oceanic conditions that favored the association among these species (Scott et al., 2012). The food habits studies, led by Robert Olson of the IATTC, showed that the tuna fed primarily on epipelagic prey during the day, that the spinner dolphins fed primarily at night on vertically migrating prey, and that the spotted dolphins fed on both of these types of prey, primarily at night.

The movements and diving patterns of the spotted dolphins and the tuna showed that, although captured and released together, the dolphins and tuna did not swim together permanently, and they



Sample of vertical movements of a yellowfin tuna (*Thunnus albacares*) in yellow, and a spotted dolphin (*Stenella attenuata*) in orange, simultaneously tracked during 21 to 22 November 1993. The depth of the thermocline is represented as a blue band (reproduced from Scott et al., 2012). ©Inter-Research 2012



The effect of thermocline depth on the association between yellowfin tuna, spotted dolphins, and spinner dolphins in the ETP. During the daytime, the tuna typically swim near the thermocline, the spotted dolphins swim at a depth of 15 to 20 m, and the spinner dolphins swim near the surface. Where the thermocline is less than 25 m (near the coast of the Americas), the vertical swimming depth differences between the tuna, swimming at the thermocline, and the surface-swimming spinner dolphins and the deeper-swimming spotted dolphins are close enough to maintain both associations. Further to the west where the thermocline is less than 45 m, the association with the spotted dolphins still occurs, but the direct association with spinner dolphins is too deep to maintain. Spinner dolphins do maintain an association with spotted dolphins, however, and associate with tuna only as part of a mixed spotted-spinner herd. Even further to the west, the thermocline deepens beyond the point where the tuna and dolphins can still associate. (Illustration by Caitlynn Birch; used with permission)

swam at different depths (see figure below). The tuna swam near the thermocline during the day, and then ascended into the mixed layer above the thermocline at night, while the spotted dolphins travelled at depths of 15 to 20 m during the day and then began deep diving bouts at dusk, apparently to forage on vertically migrating prey associated with the deep scattering layer. Both the food habits and dive patterns suggest that the tuna–dolphin association was not prey-based because the yellowfin tuna and spotted dolphins feed at different times, on different prey, and at different depths.

The oceanographic study showed that the association can occur where the swimming depths of the tuna and dolphins are close enough to maintain contact and this, in turn, depends on the presence of warm surface waters, a shallow thermocline, and a thick layer of oxygen-poor waters just below the thermocline (see illustration above). When the thermocline depth is less than 25 m, the yellowfin tuna can maintain an association with the surface-swimming spinner dolphins, the deeper-swimming spotted dolphins, or mixed spotted-spinner dolphin herds. As one goes farther west in the ETP, the thermocline deepens and the tuna–dolphin association weakens. The association with spinner dolphins weakens first, and then, when the thermocline deepens below 45 m, the difference in swimming depths is too great to maintain the association with spotted dolphins. The ETP is the largest area in the world where yellowfin tuna and spotted and/or spinner dolphins co-exist in warm waters with a shallow thermocline and a shallow oxygen minimum zone. The shallow thermocline compresses the yellowfin tuna's habitat to the mixed layer above the thermocline (Prince & Goodyear, 2006). These conditions are found in other oceans of the world, and the tuna–dolphin association also occurs in these areas (Scott et al., 2012).

The spotted dolphins are central to the association with both spinner dolphins and the tuna. The most likely hypothesis is that the association reduces the risk of predation for the tuna and perhaps the dolphins as well. Tunas and dolphins have the same potential predators—large sharks, killer whales (*Orcinus orca*), false killer whales (*Pseudorca crassidens*), and occasionally pilot whales (*Globicephala macrorhynchus*) (Leatherwood et al., 1973; Perryman & Foster, 1980; Maldini, 2003). By forming larger groups, even those made up of multiple species, the risk of predation can be reduced (Scott & Cattanach, 1998). There is safety in numbers due to the encounter effect (a single predator is less likely to encounter prey that are in a few large groups than many scattered single individuals), the dilution effect (the risk of predation is spread among many individuals), the confusion effect (predators find it difficult to fixate on a single prey within a large group of rapidly moving, nearly identical individuals), and the vigilance effect (a large group can more effectively detect predators).

As a child of the social and environmental movements of the 1960s and 1970s, I have been guided by a strong sense of stewardship for nature, and I think that is why I have spent most of my career working for government and inter-governmental agencies in the service of managing marine populations. In doing so, I have found deep satisfaction both in the applied research and management that helped dramatically reduce dolphin mortality and in the basic research that led to our discoveries about why dolphins and tuna swim together.

Snarg

Aleta Hohn, life history expert and lover of good museums, introduced me to the term "snarg." After a dolphin necropsy comes the cleanup. Samples are labeled and stored; the remnants of the carcass are cut up, bagged, and discarded; and the area is hosed down and scrubbed. The very last chore is to pick out all the bits and pieces of slimy tissue caught in the drain screen. That is the snarg. Leftovers with attitude.

I have been present at the beginnings of several long-term research programs. At the time,

Aleta Hohn handling a forklift, one of the blunter tools in the biologist's toolkit (Photo by Michael Scott) we didn't know that they would survive or prove to be particularly important. Most of these studies, at various times, have weathered storms, both literal and figurative, and have survived the whims of politics and funding priorities; pressures by fishery groups, conservationists, and animal rights activists; the frustrations of the permitting processes; and the slow pace of institutional bureaucracy. None of these projects was pre-ordained to last decades, and I certainly gave little thought to our long-term prospects at the outset of these projects.

Over time, I have seen dramatic improvements in our methods and technology and increasing sophistication of the questions we could answer. My cell phone has more computing power than the mainframe computers of my early career. With small, sophisticated transmitters and satellite receivers, we now receive the daily locations and dive history of an animal while sitting at our computer and sipping our morning beverage of choice. Computerized photo-identification and digital cameras; dataloggers that record time, depth, velocity, sounds, and physiological data; and drones that can take high-resolution aerial photographs and sample whale blows are now standard tools in a field biologist's tool box. All these advances have given us keener insights into the lives of marine mammals. However, I should pass on some old-tech advice that has served me well my entire career: life is too sweet, our span on Earth is too short, and Mother Nature is too generous to ever mess around with cheap electrical tape. (The rot in our society begins with such moral laxity.)

Equally remarkable have been the changes in the people entering the field. They are far more knowledgeable and formidable than I ever was as a student. They find creative new uses for technology, they have grown up processing a torrent of information, and they are, more often than not, female. When I first started working for Melba Caldwell, there was only a handful of women in the field. Of the 50 participants in the First International Symposium on Cetacean Research held in 1963 (Norris, 1966), only two were women: Melba Caldwell and behaviorist Margaret Tavolga. Women in marine sciences back then had to contend with older male scientists who were pretty open in their beliefs that women couldn't do field work because they were too distracting and too distractible. Some believed that taking on a female graduate student was a waste of time because she would eventually leave the field to get married and have kids. Even the old superstition that women were bad luck on boats still held sway by some males. It took women of remarkable ability and self-confidence to survive in those waters.

However, with role models such as Eugenie Clark, Rachel Carson, and Jane Goodall for inspiration, young women entered the field in greater numbers. Aleta Hohn was one of these women. A graduate student of Eugenie Clark, she found a niche in cetacean age estimation and life history that she developed at the Smithsonian Museum working with Jim Mead and Charlie Potter. When she came to the Southwest Fisheries Science Center in 1980, she discovered, as had many other women, that there was a limited ability to break through the "glass ceiling" that kept many in technician roles and at lower salaries. It took tenacity and will to keep pounding at that ceiling. The singular rise of Dr. Nancy Foster within the U.S. National Oceanic and Atmospheric Administration and her advocacy of equal treatment to all employees also spurred more opportunities for women. Aleta and many other women have ascended to high positions and, today, the majority of marine mammalogists are women. So, yes, this section has been about women in our field and, yes, I am a male, but one of the advantages of longevity is that I have had a pretty good ringside seat to observe the social changes going on around me.

I started my career as a marine mammalogist armed with little more than a fascination with watching critters, an appreciation for good writing, a reality-resistant shield of naiveté, and luck. Mostly luck. Now when I encourage students to prepare themselves for a career in marine mammalogy, I advise them to learn to write well, to get a good grounding in statistics and quantitative biology, to learn how to handle (and repair!) boats, to become equally comfortable working with animals in the field and with large matrices on the computer, and to develop a skill or expertise that few other people possess. It is, of course, ironic that the skills that I tell students they should have and the skills that I actually possessed when I was starting out should overlap so little. Eventually, I did learn enough statistics and electrical engineering, acoustics, and seamanship to get myself into and out of trouble. I did become adept in the art of radio-tracking, a skill that has given me my best insights into the lives of marine mammals as well as a relatively uncrowded career niche. So far, however, the modern tools of GIS, Bayesian statistics, and programming in *R* have evaded me. But the world will always be full of new technologies, new methods, and new tricks and toys. Do try to keep up. And when you can't keep up, send your children to good schools so that they can explain it all to you. I recommend daughters: they are my children of choice.

Acknowledgments

"The last ever dolphin message was misinterpreted as a surprisingly sophisticated attempt to do a double-backwards-somersault through a hoop whilst whistling the 'Star Spangled Banner,' but in fact the message was this: So long and thanks for all the fish."

–The Hitchhiker's Guide to the Galaxy (Adams, 1979)

This essay is an acknowledgment of the people who have worked with me, influenced me, and taught me, and have continued to make my career such a fun ride. The writing of this essay has been aided by the editorial skills and judgment of the following responsible adults: Cathy Beck, Martin Hall, Aleta Hohn, Blair Irvine, Bill Perrin, Buddy Powell, James Powell, Katie Scott, and Randy Wells. I am also indebted to the people who contributed to this paper with their stories even though they are no longer with us: Robin Allen, Dave Bratten, David and Melba Caldwell, Duke Campbell, Ken Norris, and Twothirtytwo.

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