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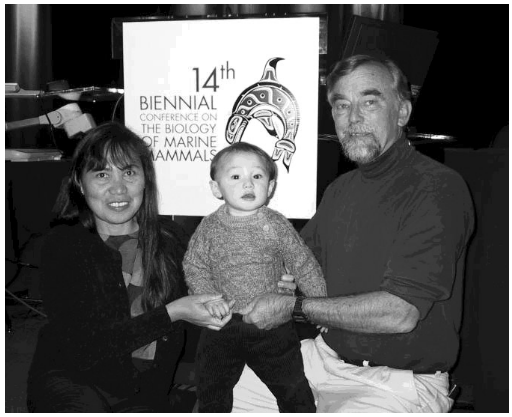
# Historical Perspectives

## William F. Perrin

(Born 1938)

Born in Wisconsin in 1938, Bill Perrin started his career with the Fishery-Oceanography Center of the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, in 1966 after four years in the U.S. Air Force as a Czech linguist, a stint as a sewing machine salesman, and graduation from San Diego State University. He obtained his Ph.D. in Zoology from UCLA under Ken Norris and Carl Hubbs; his thesis dealt with the taxonomy of the dolphins dying in the tuna purse-seine fishery in the eastern tropical Pacific. Much of his research in the following decades involved dolphins: life history, population and community ecology, and behavioral and fishing-gear research to reduce mortality. A recent product is the *Encyclopedia of Marine Mammals* (Academic Press, 2nd ed., 2009), edited with Bernd Würsig and Hans Thewissen. A past president of the Society for Marine Mammalogy and editor of *Marine Mammal Science*, he is presently the Senior Scientist for Marine Mammals at the Southwest Fisheries Science Center in La Jolla, focal point of the International Union for Conservation of Nature's Cetacean Red List Authority, Scientific Councilor for Aquatic Mammals of the Convention on Migratory Species, a member of the U.S. delegation to the




Bill Perrin with wife Louella Dolar and son Joey (2001)

Scientific Committee of the International Whaling Commission, Associate Editor of the *Journal of Mammalogy*, and chair of the Committee on International Relations of the Society for Marine Mammalogy, and he edits the World Cetacean Database. He shares fieldwork in the Philippines with his cetologist wife, Dr. Louella Dolar (SIO/UCSD, 1999), and son Joey, 8.

# Early Days of the Tuna/Dolphin Problem

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### The Accidental Cetologist

"Would you like to go out on a tuna boat?"

I hesitated for a moment, remembering that I get seasick, and then said,

"Yes. When do I start?"

The voice on the phone told me that the boat would leave for a month or two in the eastern tropical Pacific off Mexico and Central America in early July and that I should report to the Fishery-Oceanography Center on the campus of the Scripps Institution of Oceanography in La Jolla, California, as soon as possible for training and briefing.

It was spring of 1966. After four years in the Air Force, I was just graduating from San Diego State University (SDSU) with a B.S. in Biology and planned to continue at SDSU in the fall in a master's program in ichthyology or fisheries science. Meanwhile, I needed a summer job. After seeing the Fishery-Oceanography Center, local laboratory of the U.S. Bureau of Commercial Fisheries (now the National Marine Fisheries Service in NOAA) on a list of federal institutions in the San Diego area, I wandered in and asked about summer jobs. They told me there were none, but I insisted on leaving my name and phone number. A couple of weeks later, the scientist in charge of research on fishery technology at the Center, Roger Green, needed someone to collect data on performance of the tuna purse seine and called me.

My job on the *Conte Bianco* was to attach time-depth recorders ("bathykymographs," invented by staff scientist Frank Hester) along the bottom of the purse seine to record the rate at which the net sank. The idea was to look at sinking characteristics of the net in various areas to redesign it to more efficiently catch tuna.

The *Conte Bianco* was a 117-foot purse seiner with a fish capacity of 331 tons. She carried a 525 × 42-fathom net (a fathom is six feet) and was equipped with a large net skiff that sat on top of the tall net pile. She also had four high-powered speedboats for chasing and herding dolphins (although I didn't know what they were for when I got on the boat). The crew was mostly first or second generation Italian, with roots mainly in Genoa. The chief engineer was Scottish, the only non-Italian on the boat besides me. The boat was impressively clean and orderly, obviously a squared-away enterprise.

**Figure 1.** The *Conte Bianco*'s speedboats head off to intercept and direct a dolphin school.

**Figure 2.** The *Conte Bianco* sets its net; view from the net skiff, 1966.

**Figure 3.** The half-mile-long net pays out.

We made our first "set" on bluefin tuna on the "local banks" the first night out of San Diego. This was "schoolfish," not associated with dolphins. The night was moonless, and the fish were detected by the bioluminescence generated as they swam in a tight school just below the surface (a "fireball"). We missed the fish in two tries, but we caught a 130-lb swordfish, a blue shark, and a rare deep-sea oarfish (*Zu cristatus*), which I saved for the fish collection at Scripps Institution of Oceanography. We had very good eating the next day (the swordfish) as we moved on toward the tropical yellowfin tuna grounds another two days south.

We made 27 sets on dolphins in 20 days on the tropical grounds off southern Mexico and Central America. The huge industrial scale of the operation amazed me. The net sat on a turntable that occupied the entire stern area of the boat. The net skiff dropped off the 30-foot-tall net pile and pulled the net into the water while the boat moved forward. The massive net winch strained and groaned as it pulled in the purse cable at the bottom of the net to close it and trap the fish in a giant cup. After the fish were brailed and the dolphins removed from the net, it was restacked and the turntable was rotated in preparation for the next set. The forces acting on the purse cable and winch were tremendous. This was a far cry from the old pole-and-line mode of fishing for tuna.

The most amazing part was the use of dolphins—schools of tuna were found by looking for schools of dolphins. Then, the fishermen herded the dolphins with speedboats to move the associated tuna into a good configuration for setting the net. After the net was closed, they did their best to remove the dolphins without losing the fish. Many dolphins died despite the crew's rescue efforts and had to be removed from among the fish before they could be loaded into the "wells" or frozen compartments at the bottom of the boat. The whole fishing operation revolved around dolphins: how to find them, catch them, and deal with them. The crew called it "porpoise fishing." (*Porpoise* is a sea-going term for any dolphin- or porpoise-sized cetacean.)

I knew nothing about dolphins, other than having seen *Flipper* on television. These dolphins didn't look like Flipper; they were smaller and sleeker, with smaller heads, and they moved in large rapidly running schools instead of acting like Lassie. There were two sorts of dolphins; the fishermen called them "spotters" and "spinners." As the days progressed, it became clear that the behavioral bond between the dolphins and the tuna was very tight. On one of the early sets, we lost half the fish initially spotted (about 10 tons) when half the dolphin school escaped the net circle. I started to keep track of the number of dolphins captured and the larger dolphin kills. I estimated that up to a thousand dolphins, mostly spotters, were captured at a time and that 150 to 400 dolphins were killed in some sets. The total for the 20 sets, or those for which I made rough notes, was more than 1,200 killed, perhaps as many as 2,000. I didn't know what to make of the whole thing. I had never heard of the involvement of dolphins in fishing for tuna and vowed to myself to read up on it when I returned to San Diego.

The skipper, Louie Castagnola, treated me like a son. He was patient with my uselessness until I got my sea legs, forgave my landlubber gaffes, and did everything he could to make my job easier. I had long conversations with other members of the crew, especially the navigator, Andy Castagnola, the skipper's brother. After one set where things went very wrong and we killed 300 to 400 dolphins, he remarked to me,

"You know, the Government really should look into this and do something about it. There used to be a lot more porpoise than there are now."

He also said,

"It used to be a lot worse. Before we learned how to back down to get the live porpoise out, sometimes we spent a whole day getting dead ones out of the net."

**Figure 4.** The speedboats circle to prevent the dolphins (and the fish) from escaping before the net circle is closed.

Overall, my impression was of highly capable, decent, and independent-minded men engaged in a tough, competitive business, willing to do their best to avoid killing dolphins but not willing to give up "porpoise fishing" despite the slaughter.

The *Conte Bianco* returned to San Diego after 32 days at sea with over 300 tons of tuna in the wells. I followed up on my intention to educate myself about the dolphins and the fishery, but I could not find much published about "porpoise fishing" (other than noting use of the tuna/dolphin association) or anything at all about the massive kills. It slowly dawned on me that maybe I had been witnessing a huge ecological happening that hardly anyone in the public or in the scientific community knew about. The people at the Fishery-Oceanography Center were aware of the problem in a general way, but they did not consider it urgent. They told me that a graduate student from Wisconsin had been working on it for a couple of years but that his work had ended and no more was planned (more about Dave Waller later). My temporary job ended, and I returned to San Diego State University. I had planned to do research on comparative feeding habits of several species of rockfish and made several trips on local "party-boats" to collect stomach samples from sport-caught fish, but the tuna/dolphin scenario churned in my brain, and I persuaded my advisors to allow me to turn in that direction. What I proposed was a study of the comparative vulnerability of the two species of dolphins to the tuna-seining operation. The chairman of my graduate committee, David Jamison, an evolutionary biologist working mainly on amphibians, said he didn't know much about such things and suggested that I contact Ken Norris at the University of California at Los Angeles (UCLA) for advice since he "knows more about dolphins than just about anyone else." I caught Norris just as he was leaving Scripps to return to Los Angeles after a one-day visit and told him about my experience and plans while sitting in the cab of his pickup truck. He listened and said,

"Well, why don't you drop the master's degree and come up to UCLA and do a Ph.D.?"

My jaw dropped, but I managed to say "Yes, I'd like to do that." Roger Green agreed to let me go out on a tuna boat again to collect data for both him and myself, and so I was off and running. Ken approved of my research plan but said that since I would be out there anyway, I should collect a large series of specimens of the poorly known dolphins so that their taxonomy could be straightened out. In the final event, this became the main topic of my Ph.D. thesis.

I went to sea again in June 1967 on the *Independence*, a boat owned by the Westgate Corporation, but the boat spent the whole trip on the "local banks" (temperate waters off southern California and northern Mexico, where tuna do not associate with dolphins) and returned with a full load of bluefin tuna: no porpoise fishing and no data.

After returning to San Diego, I wrote a semi-popular article, "The Porpoise and the Tuna," which was published the next spring in *Sea Frontiers*. I moved my family to Santa Monica and began a required year in residence at UCLA, supported by a teaching assistantship and the G.I. Bill. In the spring of the following year, I was hired on at the Fishery-Oceanography Center as a full-time fishery biologist and moved back to San Diego, continuing my Ph.D. program under the joint supervision of Ken Norris at UCLA and Carl L. Hubbs at Scripps Institution of Oceanography. While Roger Green and his boss, Frank Hester, agreed that I would be allowed to continue my dolphin/tuna research, I would have to put in a major part of my time on an economic study of the fleet of small purse seiners taking mackerel and anchovies out of Los Angeles, the "wetfish fleet."

In April 1968, I returned to the tropical tuna grounds on the *Carol Virginia*, captained by Gerry Thomas, a Canadian from British Columbia. The rest of the crew (11 men) was Italian, Portuguese (from the Azores), and Mexican. Whereas the *Conte Bianco* was a family-owned and operated boat, the *Carol Virginia*, like the *Independence*, was part of a fleet owned by the Westgate Corporation.

We made 15 sets on dolphins in 30 days off Central America for 312 tons of yellowfin tuna. This time I came prepared to collect data and specimens. The dolphin kill ranged from 1 to 385 per set for a total of 1,697, about three-fourths of these were spotted dolphins (*Stenella attenuata*). For each dead dolphin that came across the deck, I noted species and sex, collected external measurements, and photographed the color pattern. I collected reproductive tracts and stomach contents for a subsample, and I placed 66 dead spotted dolphins (from two sets) and 19 spinner (*Stenella longirostris*) and spotted dolphin heads in the fish wells and cold boxes for transport back to San Diego (at a cost of $1,700 for the storage space on the boat; later put in frozen storage in Los Angeles and worked up during the following year). I tagged large tuna for later retrieval at the cannery for comparison of stomach contents with those of the dolphins taken in the same sets. I also noted the size of the dolphin school before the set, the tons of tuna landed, and the behavior of the dolphins in the net. Additionally, I shot 16-mm movie film of the seining operation.

This trip was not as enjoyable as my first. The captain and crew treated me well and made my work possible, but the novelty was gone, the long intervals between days of active fishing were tedious, and the implications of the fishery occupied my mind. From my log:

> The worst time of the day is when the cook rings the bell for breakfast, and you wake up and realize you are still on the boat. You lie still for a moment, then you swing out of the bunk and shuffle to the rail to urinate and then down to the galley.

The constant parade of dead and dying dolphins across the deck weighed on me:

> The only real thing that happened yesterday was when the porpoise flinched. I touched him near the eye with one of the caliper points, and he blinked and flinched. When I finished measuring him, I threw him over the side, but I'm sure he died; he lost a lot of blood and had been dragged across the deck.

Frequently, dolphins entangled in the net were run through the power block (the huge hydraulically driven pulley that pulled the seine back out of the water and onto the deck) and fell about 25 feet to the deck bleeding, with lacerations and obviously broken bones; these were food for the sharks that constantly circled the boat when it drifted after a set.

I worked until the early hours on many nights, measuring and dissecting dead dolphins and dragging them to the rail to throw them over the side. During the pursing operation, I stacked net along with the crew until I staggered with exhaustion. In this process, the crew takes the slack from the net as it comes through the power block and stacks it under their feet as the boat rocks from side to side. At the end, the stack of net is about 25 feet high, so falling off the net stack means either into the water or onto the hard deck. I got in serious trouble with the cook and the crew for stowing specimens in the vegetable cooler. On the long haul back to San Diego, I chipped paint and stood watch, depressed by the news of Martin Luther King's assassination and what followed. Not a happy trip.

Back home, I spent the next few months shuttling between San Diego and Los Angeles, collecting fiscal data and completing the economic study of wetfish boats. I returned to my dolphin research in the fall and began to work up the specimens and data from the *Carol Virginia* trip. I began several months of necropsies of the 66 whole dolphins and 19 spinner and spotted dolphin heads in frozen storage, collecting measurements, weights, organ weights, reproductive tracts, stomach contents, photographs, and parasites and defleshing the skeletons to send to the Smithsonian for preparation and curation. About this time, the *Sea Frontiers* article came out, and I got some favorable feedback on it and encouraging signs of interest in the problem. At the suggestion of Craig Orange of the Inter-American Tropical Tuna Commission (IATTC), housed in the same building as the Fishery-Oceanography Center, I decided to try to estimate the total number of dolphins being killed in the tuna fishery. He pointed out that the IATTC had been collecting logbook data from the fishermen for many years and that those data might serve as a basis for extrapolating the dolphin kill. After permission for access to these data was requested by our Center Director and granted, I was allowed to extract the date and position of a set, whether or not it was a dolphin set, and the species of dolphin if it were noted. Extracting the data from the hundreds of logbooks took a couple of months, but I wound up with a fairly definitive picture of the scale and geographical extent of the "porpoise fishery." The IATTC estimated that in 1966, roughly 60% of the yellowfin tuna caught in the eastern tropical Pacific was taken by fishing on dolphins.[1] This amounted to about 45,000 tons. On my trip on the *Carol Virginia*, we killed 1,697 dolphins for 312 tons of tuna, or 5.44 dolphins per ton. If this ratio prevailed for the entire fleet in 1966, that would mean an annual total kill of about a quarter of a million dolphins.

I mentioned this crude but startling estimate in passing to our regional director, the late Gerald V. Howard, in the coffee room. He raised his eyebrows and said that it was "just a horseback estimate" (very crude) and that I should not talk it around or "first thing you know, we'll have a big porpoise program here." I didn't take this very seriously, being naïve in the ways of realpolitik. A few months later, the late Thomas Poulter of the Stanford Research Institute (near Stanford University but not part of it) wrote to my professor at Scripps, the late Carl Hubbs, and asked if he knew of any students who might be willing to give talks at his upcoming annual Conference on Biological Sonar and Diving Mammals in 1969. Carl recommended me, and I said, "Sure." My talk was billed as "The Problem of Porpoise Mortality in the U.S. Tropical Tuna Fishery." I put together some film footage from my *Carol Virginia* trip and showed it, followed by a brief description of the problem and my estimate of 244,000 dolphins killed per year. I noted that about 20% of the dolphins in the schools chased by the *Carol Virginia* died in the net and that this rate of mortality could not likely be sustained, given the relatively low

[1] For unknown reasons, dolphins in the western tropical Pacific do not "carry" tuna. The tuna do not swim with dolphins.

**Figure 5.** A large school of dolphins in the net

**Figure 6.** Spotted dolphins in the net waiting to be backed out (Photo by Bill High)

reproductive rate in marine mammals compared to most fishes. I drew a parallel with the Russian direct fishery for the common dolphin (*Delphinus delphis*) in the Black Sea. That population crashed precipitously in the early 1960s due to overhunting. At its peak, the fishery yielded 3,500 tons of dolphins annually for production of meal, fertilizer, and leather, but it was stopped by governmental edict in 1966. In its early days, the fishery was carried out with harpoon and rifle and may have been sustainable, but purse seines were adopted after World War II, and the resulting massive catches bankrupted the populations.

The talk went very poorly; my amateur film splices broke twice. At the end, someone in the audience stood up and said (roughly),

"The presentation was not the best, but we appreciate you telling us this story. We realize that you may lose your job for doing so."

This was followed by a question, which I don't remember. My inner reaction was,

"Say WHAT?!!!!!"

Sure enough, when I returned to La Jolla, I learned that the regional director had heard about me spilling the beans and ordered me fired. The official reason was that I had not cleared the talk in advance as required by regulations. I was green and did not know about this requirement. But I did not lose my job. Our center director, Alan Longhurst, responded that he had approved the talk in advance. He had not seen it, of course (but had been briefed on the issue). Alan continued to be highly supportive in the months that followed, while the government rushed to put together a program of research to address and mitigate the tuna/dolphin problem. The program chief, Frank Hester, also came to my defense, saying that if they fired me, they would have to fire him as well.

### The Developing Problem (1959-1965)

By 1966, when I went out on the *Conte Bianco*, the tuna/dolphin problem had been simmering for a number of years. Shortly after the tuna fleet started to switch from pole-and-line fishing to purse seining in the late 1950s, a government gear specialist accompanied a trip to the tropical fishing grounds, and in 1961, he published a description of the "purse-seine revolution" in tuna fishing in *The Pacific Fisherman*, a trade journal. He noted the co-occurrence of tuna and dolphins, but by agreement with the fishing industry, dolphin kills were not mentioned in the article and none of the photographs included dolphins, outside or inside the net. In fact, the article stated, "When sets are made on mixed schools (porpoises and yellowfin), considerable care is exercised to avoid capture of porpoises." This was most assuredly a misstatement since the fishermen made every effort to capture the dolphins.

At this point, there could be no doubt that dolphins were dying in the fishery. The "backdown" operation was developed over the period 1959 to 1961 as a way of getting dolphins out of the net without having to handle them one by one. In the backdown process, the tuna boat maneuvers the net from a circle to an elongated, narrow ellipse and speedboats and fishermen tend the far end of the net to help the dolphins escape over the corkline. Many dolphins didn't make it out in the 1960s.

In a note on the aerial acrobatics of the spinner dolphin in the *Journal of Mammalogy* in 1963, Frank Hester and his co-authors stated, "Schools of yellowfin tuna (*Thunnus albacares*) are often associated with porpoise of the genus *Stenella*. Owing to this association, the U.S. Bureau of Commercial Fisheries in conjunction with its studies of tuna behavior recently has begun observations on the ecology and behavior and these porpoises" (pp. 586-588).

In 1962, a graduate student at the University of Wisconsin, David Waller, was invited to develop research on the dolphins involved in the tuna fishery. He was employed by the U.S. Bureau of Commercial Fisheries during the summers of 1962, 1963, and 1964. In 1962 and 1963, Waller went on research cruises on the chartered *Red Rooster* with members of the Tuna Research Program to collect dolphin specimens with harpoon and rifle and carry out acoustic experiments. In 1964 and 1965, he accompanied a tuna boat, the *Independence*, to the fishing grounds, supported by a small research grant from the National Science Foundation (NSF). He collected data and specimens and wrote a research prospectus after corresponding with leaders in cetology such as Dale W. Rice, Ken Norris, Charles Handley, and Masaharu Nishiwaki of Japan (the latter three all now deceased). Before proceeding very far in this direction, however, he moved to a teaching position at Kent State University, and he ultimately gave up on his dolphin research goals. In 1966, a report from the director of the Fishery-Oceanography Center noted that "Studies on porpoises associated with tuna have been discontinued." After starting my own dolphin research in 1967, I came across Waller's prospectus and correspondence in the files and found that we had been thinking along the same lines. His ideas and questions on the taxonomy and ecology of the animals gave me added direction in my subsequent research. In essence, I stood on his shoulders.

In 1964, a fisherman named Gerald H. Lopes wrote a letter to the California Department of Fish & Game describing the massive kills of dolphins that he saw take place while a crew member on an American tuna boat working off Mexico. In two trips, his vessel, the *Concho*, made 106 purse-seine sets on dolphin schools. Based on this, he estimated dolphin mortality at 25,200 for one round of trips for the tuna fleet. He asked, "Will this cause a depletion or perhaps an extinction of porpoise?" and "How long can this go on?" He

**Figure 7.** When the tuna swim near the boat, the skipper backs the net down, sinking the corkline and releasing dolphins.

**Figure 8.** The skipper sinks the corkline and pulls the net from under the dolphins to release them. The dolphins don't always cooperate. (Photo by Bill High)

noted that "perhaps a new net or a modification to the net they are now using is the solution." Since California Fish & Game had authority only in California waters, the letter was referred to the then U.S. Bureau of Commercial Fisheries as well as to a number of other agencies and individuals (IATTC, Scripps Institution of Oceanography, U.S. Fish & Wildlife Service, the American Embassy in Mexico, the National Wildlife Federation, and the IUCN). In its response to Mr. Lopes, Director Donald McKernan of the Bureau thanked him for his interest and for forwarding the information and enclosed a statement authored by Waller on "porpoise mortality due to tuna purse seining." Waller indicated that the government was studying the dolphins, that it was unknown how many were being removed by the fishery, and that the fishery mortality was not necessarily significant for the populations. He suggested that Lopes's estimate of six dolphins killed per ton might be unrealistically high and may have been due to an unusual number of sets on dolphins made by the particular boat he was aboard. He also noted that density-dependent compensation (increased reproduction) might make up for the dolphins killed in the fishery. He said that solutions would involve restriction of the commercial activities of the purse seiners and that there would be no means of enforcing such regulations. Lopes responded directly to Waller,

> I want you to understand that my figures were way under actual, I'm sure. I think from 8 to 10 porpoises killed per ton of tuna would be a lot closer to the truth. What made me wonder was a statement one of my fellow fishermen came up with: "You think this is bad; I've been on some boats where none of them get way." Can this be true?

In February of 1967, the *San Diego County Independent* carried an article on the tuna fishing practices of the United States by a "Captain Nemo."

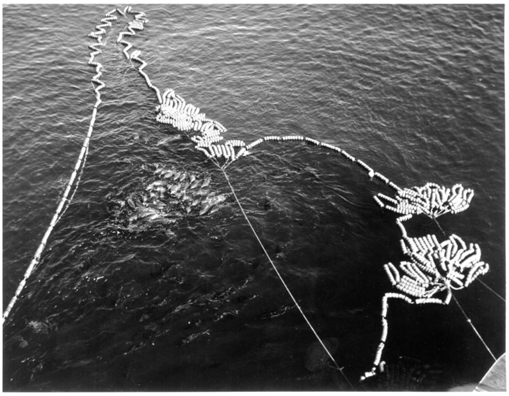

**Figure 9.** A group of dolphins remaining in the net after backdown

It said among other things that the purse-seine gear used by U.S. fishermen swept up everything in the ocean like "vacuum cleaners," leaving nothing, and "all kinds of other fish," including whales, sharks, and porpoises, were wantonly killed in the netting process. The U.S. Bureau of Commercial Fisheries responded that dolphins were known to be associated with tuna schools and that it was often impossible to avoid taking dolphins in the nets. It was further stated that fishermen recognized that this method of fishing depends on conservation of porpoises and that they had modified their fishing techniques to permit the porpoises to escape after their capture. Dolphins were sometimes caught despite these efforts, but this was not considered to be doing significant damage to the dolphin resource.

Thus, while fishery scientists and zoologists became actively interested in the dolphins and their biology, and even fishermen had become worried about their fate, the government essentially took a head-in-the-sand position until the story of mass kills broke nationally, and the public and the U.S. Congress began to demand action.

### Research to Reduce the Kill Begins

"Oh no; they're going into the net!" We watched in horror as hundreds of common dolphins (*Delphinus delphis*) ("whitebelly porpoise" to the fishermen) dived *en masse* and ran into the purse-seine webbing below an opening we created for them to exit the net. When the net was "dried up," the bottom (the "sack") contained 71 dead dolphins. A photographer from *Life* magazine documented the debacle. This did not happen during commercial purse seining on the tropical tuna grounds but during a test off southern California of experimental gear designed to help save dolphins trapped in fishing nets. Not our proudest moment.

The research to save dolphins in the tuna fishery began in 1970 after word reached the headquarters of the U.S. Bureau of Commercial Fisheries in Washington that the public now knew (as a result of my talk at SRI in late 1969) that hundreds of thousands of dolphins were likely dying each year in the fishery and after letters and inquiries began to come in from constituents and the Congress. In response to a memo from our director, Alan Longhurst, relayed to the Washington planning office by the Regional Director, Gerald Howard, our laboratory was directed to prepare a proposal for research funding. I prepared the proposal, stating the immediate objectives of finding out more about the fishery mortality and the dolphin population size, structure, and dynamics. If, as was anticipated, the dolphin kills were unsustainable, ways should be found through research on gear modification to reduce them. The effort to estimate mortality and its impacts was to include placing observers aboard tuna boats to collect data on kill numbers and specimens for analysis. I also proposed tagging dolphins to examine the frequency of capture, movements, and school integrity. The proposed mitigation research was aimed at developing a way to get the dolphins out of the net while the net circle was still large and entanglement had not yet begun.

Headquarters approved the proposed research in principle but did not have the money to do it all. Due to the urgency of the problem, they suggested that we proceed on the assumptions that the dolphin kill was high, that dolphin schools were important to the fishery, and that we give immediate priority to the proposed mitigation and gear research. A start-up fund of $30,000 was transferred to our laboratory.

With the $30,000, we promised to (1) contract an engineering firm for development of an electronic sound emitter to herd dolphins and test

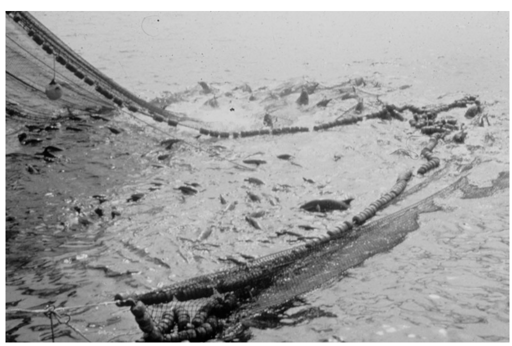

**Figure 10.** During "sacking up," dolphins remaining in the net often became entangled in the "canopies" and suffocated. Federal regulations later required release of all live dolphins before sacking up.

it in the net at sea, (2) pay overtime for observers on tuna boats said to be particularly skilled at "backing down" to remove dolphins from the net, (3) test reactions of captive dolphins to the concept of a quick-opening gate, and (4) build an experimental gate in the net for testing at sea in the 1971 season. The purpose of the second item was really to collect more data on dolphin kills, but we had to proceed with that under the guise of gear research.

While agreeing to concentrate on these tasks, Alan Longhurst pointed out the danger inherent in a piecemeal approach, noting that success would be problematical and that it would be unrealistic to expect no mortality after new gear were introduced; some mortality would certainly be inherent in any tuna fishery over dolphins. He saw the start of a study of tropical dolphin population dynamics as urgent, noting that it would be a pity if the only way the protesters were satisfied was by elimination of the fishery because the dolphins disappeared. It would be vital to be able to state, in a couple of years' time, what the biologically acceptable level of dolphin mortality would be. Headquarters maintained its position that the mortality-reduction work must come first. At the laboratory, we did our best to proceed with the population biology as well as the gear research with the money at hand. The agency did eventually come around, and additional funds were allocated for population research.

The work to develop a way to get the dolphins out of the net went forward on three parallel paths: (1) finding a way to herd the dolphins inside the net, (2) finding out what kind of opening in the net dolphins would swim through, and (3) building an escape gate in the net.[2] Our first effort on herding was to try something used by the Japanese in their *oikomi* drives to herd schools of dolphins into shallow bays for slaughter. In this method, the end of a large-diameter bamboo pole was placed below the water surface, and a hammer or metal bar was used to bang on the top to produce a very loud sharp sound under water, which dolphins reportedly avoided. While contracted work to produce electronic sound emitters proceeded, we ordered a number of giant bamboo poles from Japan (where the giant species grows in the mountains) and tested them on schools of common dolphins off San Diego with the help of U.S. Navy researchers and their vessel, *Sea See.* We also placed them on a tuna boat for testing from speedboats inside the net, the idea being to move the dolphins toward the backdown end of the net. This low-tech method did not work. The dolphins seemingly ignored the sounds in both situations. It was a long shot anyway, and we moved on to other kinds of sounds: white noise and, later, playbacks of killer whale sounds.

The initial idea for an electronic sound emitter was a self-contained package that could be placed on the webbing near the bottom of the net during a set. Much mortality seemed to occur when the dolphins dove to the bottom of the net to find a way out and became entangled in the mesh. War-surplus echo-sounders carried by tuna boats in the 1940s and 1950s emitted sound at 40 to 60 kHz, and the fishermen reported that when such an echo-sounder was switched on, any nearby dolphins left the vicinity quickly. We thought that a similar device near the bottom of the net might reduce mortality by keeping the dolphins at the surface. After consulting with the fishermen and sonar manufacturing firms, this concept evolved to include submerged sound emitters suspended from speedboats that could be used to herd the dolphins toward an escape gate in the net. The plan was to place two small speedboats equipped with emitters with forward-beaming transducers inside the net circle immediately after the net circle was completed. A third transducer directed upward would be suspended at approximately 50 feet below the surface from a third small skiff in the middle of the net circle (in actual operations, this third emitter was suspended from the deck of the tuna boat). Delivery was taken on eight white-noise emitters in September 1970, and at-sea trials began in December.

The idea of the escape gate was to create an opening at the top of the net through which the dolphins could escape, one that could be closed very quickly to prevent loss of tuna if they swam toward it. After some experiments with a miniature model of a purse seine in a swimming pool, one of the most resourceful and inventive men to ever work at the laboratory, George Kalin, designed the gate and the machinery to sink and raise it, and he and another technician, Dave Holts, built a prototype. The basic working principle was to evacuate a collapsible float-line substituted for a section of the seine's corkline, using a vacuum pump, and then to re-inflate the line quickly with a large burst of air from a pressurized reservoir. For the 50-foot prototype, we used large-diameter rubber tubing (10" when inflated) of the type used by California fishermen with a pump to suck up squid attracted to very bright lights (known as the "squid slurp"). First, we tried a continuous long tube, but it took too long to evacuate. We then tried a series of 10 "pillows" constructed of sections of tubing, each with an individual hose back to the vacuum pump. We

[2] One perplexing fact about dolphin entanglement is that even though dolphins can jump and leap, they never attempt to jump over the corkline to escape the pursed net.

tested the gate in quiet waters off Catalina Island (from the *R/V Miss Behavior*) with an experimental 150-foot full-scale section of purse seine built for the trials. The gate worked; we could evacuate and lower it to 4 to 5 feet below the surface in 20 to 25 seconds and bring it back to the surface with a blast of air in 6 to 10 seconds. Our next task was to strengthen the gate overall to withstand being run through the power block with the net on the tuna boat. This led to replacing the "pillows" with a continuous 80-foot length of tubing and beefing up the vacuum pump and re-inflation tank. The gate performed as promised, coming through a power block with no leaks. Further trials from a research vessel (*R/V Cromwell*) near Catalina Island yielded times to sink and raise the gate of 30 and 10 seconds, respectively. After a dry-land demonstration to fishermen and boat owners at the American Tuna Boat Association (ATA) in San Diego, we moved to at-sea water hauls of the gate and the sound emitters on local dolphin schools with a tuna boat in December 1970. The use of the *Conquest* for one day off San Diego was arranged by Augie Felando of the ATA.

The initial sea trial with dolphins was less than successful. The dolphins were long-beaked common dolphins (*Delphinus capensis*), not one of the major species involved in the tropical tuna fishery. We had hoped they would be a useful surrogate. The gate worked well mechanically, and the emitters had a repelling effect on the dolphins, inducing them to swim away. It was impossible to herd them toward the gate, however, as they seemed to be more afraid of the net's corkline than the emitters. They melted away from the herding speedboats in all directions to a distance of 30 to 40 feet and reassembled behind them. The deep, upward-directed emitter seemed to have some effect because the dolphins did not dive to the bottom of the net but made only short shallow dives of 10 to 15 feet lasting only a few seconds. After several unsuccessful tries at moving the dolphins to the open gate, the captain decided to get them out of the net by backing down, with the open gate centered in the backdown area. All but seven of the animals escaped the net in this way. Those who died became entangled during the backdown operation.

In addition to the difficulty with recalcitrant dolphin behavior, it was obvious that the prototype system was too cumbersome and potentially unsafe for the operating crew. The air pump and reservoir tank were very heavy, and it was difficult to launch the loaded 16-foot speedboat into the net circle. Then the hoses from the gate had to be connected to the pump and tank in the skiff, which is difficult in a sea of any size. All agreed that this took too much time and effort in the midst of a set and should be streamlined.

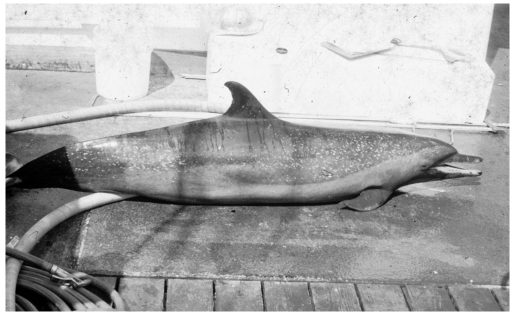

**Figure 11.** The pantropical spotted dolphin (*Stenella attenuata*) is the species most affected by the tuna fishery; the northeastern offshore population has been reduced to about a fifth of its original size. However, the kill has been greatly reduced (by more than 99%) since the mid-1960s, and the decline at this writing has ceased. (Photo by Mike Green)

We redesigned the system to be operated from the deck and looked into the potential use of different and louder sounds to herd the dolphins. A lead came from researchers at the Naval Undersea Research and Development Center (NURDC) at Point Loma in San Diego. Jim Fish had recently succeeded in driving beluga whales (*Delphinapterus leucas*) out of a salmon stream in Alaska by broadcasting killer whale sounds at high power. The sounds were clicks and "screams" recorded from killer whales at sea. Source levels in the salmon stream ranged from 103 to 170 db. Fish and another senior researcher at NURDC, Bill Evans, offered to help test the killer whale sounds for herding dolphins in the purse seine, contributing tapes of the sounds and a high-powered amplifier.

In September 1971, we set out on the *Westport* to test the reworked system, this time on schools of the short-beaked common dolphin (*D. delphis*; called "whitebellies" by the fishermen), with a photographer from *Life* magazine aboard. We made two sets in two days. In the first set, the dolphins responded with more alacrity to the killer whale screams than the long-beaked common dolphins had to the white noise, but their behavior was erratic; they refused to be herded to the gate and, again, had to be released with a backdown. Fifteen dolphins died.

The second day was a disaster. The dolphins responded to the killer whale sounds suddenly as a group and slammed into the net just below the open gate. Only about two-thirds of them resurfaced; the toll was 71 dolphins. The *Life* photographer took lots of shots of piles of dead dolphins on the deck. Perhaps luckily, the pictures never appeared; the story was preempted by the death of Khrushchev the next week.

We later learned from the fishermen and from data returned by our observers that behavior of


**Figure 12.** The author with a pygmy killer whale (*Feresa attenuata*) calf that died in the tuna fishery, 1968

this species of dolphin was not like that of the dolphins more commonly involved in the fishery. Whereas spotters and spinners spent most of their time "rafting" at the surface in the net and only diving sporadically, individually or in small groups, "whitebellies" typically dove as a school and probed the bottom of the net, often escaping before the bottom was pursed. This led to very high kill rates, 10 or 15 times those for spotters and spinners. We concluded that the system still might have value for the other species and planned for further trials on the tropical fishing grounds where spotters and spinners reside.

The work with captive dolphins went on concurrently with the development of a gate and herding equipment. We set out to learn how a dolphin, in this case a spinner, would react to being offered an escape route while being crowded in a net enclosure.[3] With the help of Ken Norris, we contracted use of "Bateson's Bay" at the Oceanic Institute in Hawaii (the nonprofit institution associated with Sea Life Park), a pool 80 feet in diameter and about 12 feet deep at the center. An old netmaker in San Pedro, the late Borti Petrich, built the net walls of the crowding chamber out of purse-seine webbing. The frame was of aluminum. At the last minute, a medical emergency occurred in my family, and I was unable to go to Hawaii. John Hunter, a fish behaviorist at our laboratory, stepped in and took my place, saving the project. He ran experiments in June and July of 1970 with three previously trained spinner dolphins (Waimea, Nani, and Hohea) and two naïve animals (Westward and Moana), varying the width and depth of the escape opening and other factors. The trained dolphins achieved high rates of success in using the opening within a very few trials, regardless of size of the opening until the width was decreased to less than three feet. There was a slight effect of width and depth for greater openings. A simple float-line strung across the top of the opening caused the dolphins to ignore it and run into the net. The naïve animals took longer to learn to use the opening, and they balked at openings less than a couple of feet deep or wide. Again, a corkline across the top caused them to ignore the opening completely. Based on these results, we concluded that either some learning or a strong stimulus would be required to get dolphins to use a gate in the purse seine, that the open gate should be at least several feet deep and as wide as practical, and that there should be no line or other obstruction across the top of the opening. These considerations went into our design of an escape gate and herding techniques.

While all this was going on, the fishermen themselves made a breakthrough in dolphin-saving technology. At a meeting of government and industry representatives in La Jolla in April 1971, the head of the ATA, Augie Felando, announced that a tuna captain, Joe Medina, had devised a net modification that greatly reduced the kill of dolphins during backdown. The Medina panel, as it became known, consisted of a section of small-mesh webbing (2-inch vs 4.25-inch in the rest of the net) at the top of the net in the backdown area. According to Medina, fewer dolphins became entangled in this small mesh than in the ordinary net, and mortality was reduced almost to zero. Several other captains announced their intention to modify their nets in this way, and we placed observers on several boats with the new nets to collect data on the number of dolphins entangled and killed. We also tested the small mesh on common dolphins with a two-day charter of the *San Juan* in local waters. No dolphins became entangled in the small mesh; the only fatality was an animal

[3] Dolphin trainers know that dolphins do not swim through restricted spaces easily and often need substantial training to "gate" from one pool to another.

**Figure 13.** Aftermath of an abortive experiment to herd and release common dolphins in the net with killer whale sounds, 1971; the dolphins panicked and ran into the net instead of through an open gate. Bill Evans (left) and author.

entangled outside the backdown area. As the data came in from our observers and as more fishermen converted their nets, it became apparent that the fastest route to reducing dolphin kill would be through modifying the existing backdown operation rather than by trying to remove the dolphins at an earlier stage of the set, and, thus, we abandoned the work to develop an escape gate.

The Medina panel led to a long series of experimental modifications and innovations devised by both fishermen and gear technologists that were tested on chartered cruises of purse seiners, some 25 cruises over the next 10 years. The results led eventually to a rapid decline in dolphin kill per set and total kill by the fleet.

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[More to come in a book in progress]

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