A curious sight: a long line of throw-net fishermen, standing hip deep in the water, wait for a dolphin to drive fish into net range.

CHAPTER TWENTY

A Dolphin-Human Fishing Cooperative in Brazil

by Karen Pryor, Jon Lindbergh, Scott Lindbergh, and Raquel Milano[1]

In the town of Laguna, in the state of Santa Catarina near the southern tip of Brazil, a cooperative fishing method has arisen between local fishermen and members of an apparently resident population of bottlenose dolphins, *Tursiops truncatus*. Laguna is on the Atlantic coast at the entrance to the Lagoa Santo Antonio, one of three large connected brackish lagoons totaling over 30 km in length. The cooperative fishing occurs primarily on the shores of the inlet from the ocean to the lagoon, near the center of town. The authors observed this fishing during 3–6 April 1988, and 15–18 February 1989. During our visits typically 30–40 fishermen and one to four dolphins were present in the principal fishing location throughout the daylight hours.

Fishermen and townspeople report that the fishing takes place all day every day except during bad weather, and all year except in the winter months of July and August. Town records state that the cooperative fishing began in 1847. Some fishermen report that their fathers and grandfathers fished before them,

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sometimes with the same individual dolphins. Currently at least three generations of dolphins are involved (as evidenced by a female, "Chinela," with at least two known adult offspring, one with a calf, active in the fishery).

The primary prey fish is the mullet, *Mugil cephalus:* juveniles are caught in November through March, as we observed in February, and breeding adults in April (as we observed) and May and June. Fishing with dolphins largely ceases in July and August; in September and October other species are reported to be exploited, including the Brazilian croaker, *Micropogonias furnieri,* and the black drum, *Pogonias chromis.* While some people fish with the dolphins for sport, for most participants this is a commercial rather than a subsistence fishery. The catch is sold in nearby metropolitan markets. The dolphin-associated fishery is said to be the primary source of income for about one hundred families.

On both visits we observed and photographed the fishing from shore and by boat, either traveling in the lagoon or anchored among the fishermen or among the dolphins. The fishing is highly ritualized, and appears to involve learned behavior in both men and dolphins. The fishermen, each with a circular nylon throw-net rimmed with weights, position themselves in a single line, a net's diameter apart, standing in approximately 1 m of water parallel to the shore. One or two dolphins station themselves several meters outside the line of men, facing seaward, floating or moving slowly at the surface. From time to time a dolphin submerges, usually moving seaward; the men then brace themselves. The dolphin reappears, usually in a few seconds, travelling toward the line of men. It comes to an abrupt halt and dives just out of net range, 5–7 m from the line, thus making a surging roll at the surface, a movement markedly different from normal respiratory surfacings. Men who are in front of the dolphin as it rolls then cast their nets. Fish are caught under the nets and become entangled in the meshes. Successful fishermen return to the beach to harvest their catch, and others replace them in the line.

The water is extremely turbid; visibility is less than 1 m. The men cannot see the fish, and must depend on the dolphin's

behavior to know when to cast the nets. They state that the dolphins detect fish, round them up, and deliver them to the line; the fishing depends on this behavior. Occasionally we observed and photographed mullet jumping just ahead of a dolphin returning to the line; but even when we could not see the fish until they were netted, the dolphins certainly appeared to us to be detecting and herding fish. We never saw a dolphin perform the roll toward the line without exhibiting the submerge-depart-and-return behavior sequence first. The men rarely cast without a dolphin's cue (refolding the net takes time, and one might thereby miss a better opportunity); and nets were not cast behind a dolphin, or in its general vicinity, or in front of dolphins that had not signaled, but only in front of dolphins performing the correct behavioral sequence indicating the arrival of fish.

The cue is quite informative: the timing of the dolphin's roll indicates that fish are present; the direction of the dolphin's movement indicates the location of the fish, and the vigor of the movement appears to indicate whether the school is large or small: the dolphin may show the head, back and dorsal fin, or just the head or blowhole. A spectator can quickly learn to predict whether one fishermen or several will respond to a particular signal.

The dolphins apparently take advantage of the confusion which the falling nets cause among the fish schools to catch fish for themselves. Episodes which are successful for the fishermen are often followed by bouts of dolphin feeding behavior, including rapid changes of direction underwater, waving the flukes in the air, and heads in the air with fish in the jaws. We have seen individual dolphins working at the line for a single pass or for two hours or more, before moving away, often to be replaced by newcomers.

The method is efficient. In one half-hour period in April we observed a single dolphin bringing fish to the line of fishermen six times. In four of these episodes one or more fishermen caught fish, typically 10 or more adult mullet weighing up to an estimated 2 kg each. On February 17 we observed one man, working from a small boat with a single dolphin, who took over 100 kg of juvenile mullet in approximately two hours. The system

is probably efficient for the dolphins as well. Based on captive studies, 10-12 kg of mullet would be an ample daily ration for an average-sized adult bottlenose dolphin (Defran and Pryor 1980). Bel'kovich reported dolphins in the Black Sea hunting mullet in groups, using a variety of cooperative strategies; search time could be long, and individual pursuit was often unsuccessful (Bel'kovich *et al.*, 1991). Others have described strenuous pursuit of mullet in shallow waters by individual dolphins (Hamilton and Nishimoto 1977, Shane 1987). The Laguna fishing method provides a reliable, easily located resource, and allows successful fish capture by individuals, including females with calves, with minimal effort.

The fishing appears to be initiated and controlled by the dolphins, not by the men. On four occasions we have seen a dolphin leave the line of men and move to another section of the beach; immediately some or all of the men ran through the water to reform a line in the new site selected by the dolphin. In other parts of the lagoon on several occasions we have seen one or more men waiting on shore in the hope of a dolphin's arrival. Fishing does not begin until a dolphin initiates it.

While wild bottlenose dolphins in other parts of the world have been known to play or socialize with swimmers and boaters, notably at Monkey Mia in Australia (Connor and Smolker 1985), such informal interaction apparently does not occur at Laguna. At no time did we observe a fisherman call out, signal to, or in any way attempt to affect the behavior of a dolphin. The fishermen do not consider that they train the dolphins. They never give them fish. They do not attempt to touch them. Several fishermen said that it is important not to distract the dolphins from their work.

The local population of bottlenose dolphins is estimated by experienced fishermen at about 200. Of these an estimated 25-30, referred to as "good" dolphins, are said to be participants in the cooperative fishery. On 17 February from a boat in the inlet we saw six separate groups (varying in size from 1-3 dolphins and 4-40 men) engaged in cooperative fishing in different locations simultaneously. We were able to see a maximum of 10 adult dolphins working at the same time. Including juveniles

and calves at least 10 more dolphins, which may or may not have been associated, were also present in the inlet.

The participating dolphins are named and recognized by many fishermen. Animals which we ourselves could recognize by marks and scars were correctly identified by several fishermen at a distance of 50 m or more, sometimes before the identifying marks could be seen. The men have deliberately marked some dolphins with dorsal fin notches or cuts for identification purposes (the opportunity typically arises when a calf rushes ahead of its mother and is accidentally caught under a net). In February in the lagoon inlet we saw and photographed five such individuals, including one we had photographed in the same location the previousApril.

Dolphins which do not work with the fishermen are called "bad" dolphins (*ruim* in Portuguese). The *ruim* may occasionally interfere with the fishing, typically by dispersing fish and by damaging nets and netted fish. "Good" dolphins are said to defend their resource by displaying aggression toward the *ruim;* we did not witness any encounters between the two (we have seen several groups of 2–7 dolphins, identified by the fishermen as *ruim,* offshore and in central parts of the lagoon). The fishermen consider that the "good" dolphins are largely resident in the lagoon. Some believe that there are at least two separate populations of *ruim,* one in the lagoon and one coastal or offshore. Confirmation of the distribution and range of these groups awaits future investigation.

We interviewed eight experienced dolphin fishermen, as well as some townspeople and family members. We have collected 22 names of individual dolphins so far, some with preliminary identification sketches or photographs, and some with life history information. The age of an animal is sometimes known, especially if it has distinguishing marks or if it shares a birthdate with a person in the fishing community. Matrilineal relationships are recognized for some animals. Laurenci Zeferino, a Laguna fisherman locally considered to be an expert on working with the dolphins, provided extensive information on dolphin associations and kinship. However disparities exist in reports from different informants (for example some animals may have two names) which will require further investigation and clarification.

The "good" dolphins appear to constitute an interactive social group consisting of several females, their calves, some but not all of their previous offspring and their descendants, and a mixed-age group of males. Calves are said to remain with the mother for about three years. They then join juvenile bands which do not participate in the fishing. Animals begin participating in the fishery as young adults; the calf of a fishing female may or may not rejoin the "good" dolphins, but at this stage in our investigations all recruitment appears to be from such calves. This picture, if accurate, is consonant with the social structure of female-calf bands and associated male bands described by Wells and others in the resident bottlenose dolphin population in Sarasota Bay on the west coast of Florida (Wells *et al.*, 1980, 1987).

Several historical accounts exist of dolphin-human interaction in the catching of mullet (Pliny the Elder, A.D. 23—79, Longman 1926, Busnel 1973, Ascherson 1982). Ranging from the Mediterranean to North Africa to Australia, these accounts are strikingly similar. Men on shore observe mullet travelling along the coast, too far out to reach from land. Then, if bottlenose dolphins happen to be passing simultaneously, the men shout, whistle, or slap the water to attract the dolphins. If the dolphins then move inshore, the mullet are trapped against the beach, and a great melee follows, with men scooping or spearing mullet in the shallows and fish and dolphins leaping in every direction.

The similarity of these accounts, centuries and continents apart, suggests that they are basically accurate. These previous accounts, however, do not resemble the complex choreography of the Brazilian dolphin-human fishery, in which dolphins work individually, and in which the fishing is initiated and controlled by the dolphins. Furthermore these earlier episodes of joint predation, while surely involving some learned behavior, appear to have been sporadic, opportunistic, and seasonal, related to the inshore movement of adult breeding mullet. The Laguna dolphins in contrast have developed techniques which can be adapted to juvenile mullet or other prey and which provide the dolphins and the humans with a reliable and almost year-round resource.

Shane (1987) has shown that bottlenose dolphins in the Gulf of Mexico fish in varied ways. Dolphins may fish in deep water or in shallow; some have learned to take fish discarded by shrimp boats. Shane postulates that individual dolphins may specialize in particular feeding behaviors, as has been shown for humpback whales (Weinrich 1982) and for killer whale pods (Felleman *et al.*, 1991). Since dolphins learn by observation (Herman 1980) feeding specializations might be transmitted culturally within long-term associations of related individuals. Laguna's "good" dolphins may represent an example of a culturally transmitted fishing specialization.

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References

Ascherson, P. 1892. Note in *Sitzungsberichte der Gesellschaft naturforschender Freunde zu Berlin* 8:145-148.

Bel'kovich, V.M., E. E. Ivanova, O. V. Yefremenkova, L. B. Kozarovitsky and S. P. Kharitonov. 1991. Searching and hunting behavior in the bottlenose dolphin *(Tursiops truncatus)* in the Black Sea.. In *Dolphin Societies: Discoveries and Puzzles,* K. Pryor and K. S. Norris, Eds., University of California Press, Berkeley, CA.

Busnel, R.G., 1973. Symbiotic relationship between man and dolphins. *Transactions of the New York Academy of Sciences* 35:112-131.

Conner, R.S., and R.S. Smolker, 1985. Habituated dolphins *(Tursiops* sp.) in western Australia. *Journal of Mammalogy* 66:398-400.

Defran, R.H., and K. Pryor, 1980. Social behavior and training of eleven species of cetaceans in captivity. In: *Cetacean Behavior: Mechanisms and Functions.* L. M. Herman, Ed., John Wiley and Sons, New York.

Felleman, F.L., J.R. Heimlich-Boran and R.W. Osborne. 1991. The feeding ecology of killer whales *(Orcinus orca)* in the Pacific Northwest. In *Dolphin Societies: Discoveries and Puzzles,* K. Pryor and K. S. Norris, Eds. University of California Press, Berkeley, CA.

Hamilton P.V., and Nishimoto, R.T., 1977. Dolphin predation on mullet. *Florida Science* 40:251-252.

Herman, L.M., 1980. Cognitive characteristics of cetaceans. In *Cetacean Behavior: Mechanisms and Functions,* L. M. Herman, ed. John Wiley and Sons, New York.

Longman, H.A., 1926. New records of Cetacea, with a list of Queensland species. *Memoirs of the Queensland Museum* 8:266-278.

Pliny the Elder, A.D. 23—79. *Natural History, Vol. III, Libri VIII-XI;* H. Rackham, translator, 1940. Loeb Classical Library, Harvard University Press.

Shane, S., 1987. The behavioral ecology of the bottlenose dolphin. Ph.D. thesis,University of California at Santa Cruz. 147 pp.

Weinrich, M., 1982. The humpback whales of Stellwagen Bank. *Whalewatcher* 16(4):12-15.

Wells, R.S., A.B. Irvine, and M.D. Scott, 1980. The social ecology of inshore odontocetes. In: *Cetacean Behavior: Mechanisms and Functions,* L. M. Herman, Ed. John Wiley and Sons, New York.

Wells, R.S., M.D. Scott and A.B. Irvine, 1987. The social structure of free-ranging bottlenose dolphins. *Current Mammalogy, Vol. I.,* H. H. Genoways, Ed. Plenum Press, New York.