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REDUCING INCIDENTAL MORTALITY OF FRANCISCANA DOLPHIN *PONTOPORIA BLAINVILLEI* WITH ACOUSTIC WARNING DEVICES ATTACHED TO FISHING NETS

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ABSTRACT

We conducted a double blind experiment in an artisanal gillnet fishery in Argentina to determine the effectiveness of acoustic deterrents (pingers) at reducing bycatch of the Franciscana dolphin (*Pontoporia blainvillei*). The fishery was conducted by small inflatable and fiberglass vessels operating between 0.5 and 7 km from the coast. Each vessel carried an independent observer who was rotated from vessel to vessel throughout the course of the experiment. Information on the number of dolphins captured, geographic position, depth, configuration of fishing gear, soak time, biomass of fish caught, and sea lion predation in a string/net producing any damage was recorded. Equivalent numbers of active and silent pingers were used during the experiment. A total of 45 dolphins were caught in the silent nets, and seven were caught in the active pinger nets, demonstrating a highly significant reduction in bycatch for this species. However, sea-lions (*Otaria flavescens*) damaged the fish in active pinger nets significantly more than silent nets, and the damage increased over the course of the experiment. Although pingers show promise as a management tool for this species, pinniped depredation suggests that higher pinger frequencies will be needed to avoid a "dinner bell" effect.

Key words: bycatch, Franciscana dolphin, *Pontoporia blainvillei*, acoustic alarms, conservation.

The Franciscana dolphin, *Pontoporia blainvillei*, also known as La Plata dolphin or toninha, is one of the rarest and least known South American dolphins. Related to the Platanistoid river dolphins, it is primarily an estuarine/marine species inhabiting only the coastal areas of the Southwestern Atlantic Ocean. Its distribution range is from Itaúnas, Brazil (18°25′S) to the southern Province of Río Negro, Argentina (41°09′S).

Incidental capture represents the major threat to the species survival. Information on the fishery bycatch of this dolphin has been recorded by Brownell (1975), Praderi (1984), Pinedo *et al.* (1989), Corcuera (1994), Crespo *et al.* (1994), and Secchi *et al.* (1998). Throughout their distribution, Franciscana dolphins have been subject to a significant level of incidental mortality in gillnets for several years. Although the bycatch has been estimated, the real impact of these captures remains unclear as the effort to estimate abundance was small and only limited to a few areas (Secchi *et al.* 2000). A minimum annual catch of 500 dolphins was estimated from the fisheries of the Buenos Aires coastal area in Argentina (Corcuera *et al.* 1998). Previous studies have shown that in Argentina, small fishing camps situated along the Buenos Aires Province pose more of a threat to the species than operations from large fishing harbors (Corcuera *et al.* 1998). This is primarily due to the fact that the artisanal fishing is carried out in shallow waters.

The species is classified as "Data Deficient" in IUCN terminology (IUCN, 1996). However, the scientific committee of the Workshop on Conservation Biology of the Platanistoid Dolphins had recommended classifying Franciscana dolphin as a "Vulnerable" species (Perrin and Brownell 1989). The Franciscana dolphin is listed in the Appendix II of the Convention on the International Trade of Endangered Species (CITES), and in the Appendix I of the Convention on Migratory Species (CMS).

The most serious danger to dolphins and porpoises around the world is the threat from various forms of gillnets fishing. Bottom gillnets are responsible for the deaths of many tens of thousands of coastal cetaceans each year (Perrin *et al.* 1994). This potential impact of fisheries on dolphins and porpoises is underscored by their limited ability to sustain mortality rates that exceed more than a small percentage of the population each year (Reilly and Barlow 1986). It is not clear whether dolphins and porpoises become entangled because they do not detect the net or because they do not perceive the net as dangerous.

Acoustic behavior studies of the Franciscana dolphin are scarce. Busnel *et al.* (1974) recorded clicks of low, high, ultra high frequencies mainly with signals below 30 kHz on wild individuals. Von Fersen *et al.* (1998) recorded echolocation clicks around 130 kHz as the dominant frequencies in a captive individual; no whistle sounds and other lower frequency were recorded.

As gillnet fisheries will continue to operate in areas inhabited by the Franciscana dolphin, methods to reduce entanglement are urgently needed. Cetacean bycatch problems have been addressed in other locations with the use of acoustic deterrents, demonstrating that alarms or pingers work in some fisheries to reduce

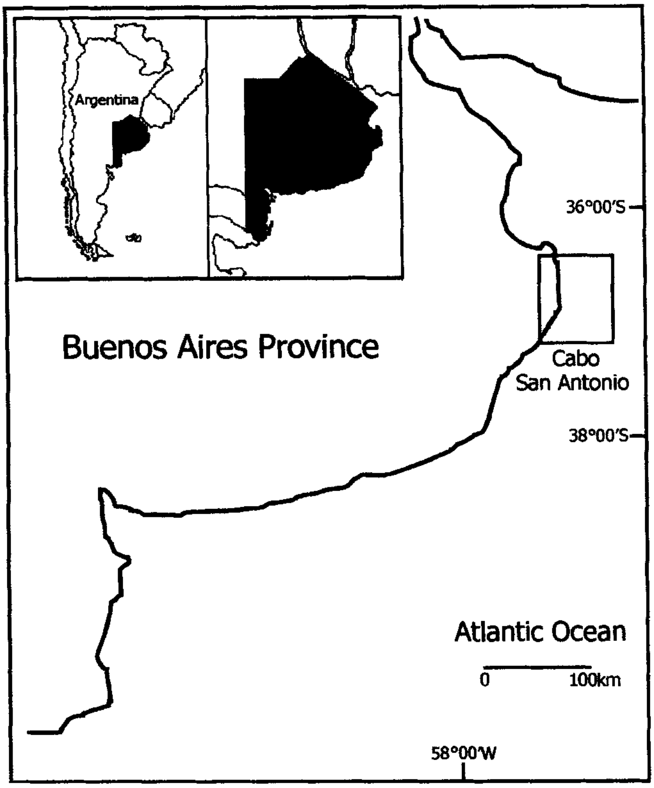

Figure 1. Location of study area, Cabo San Antonio.

both porpoise and whale bycatch (Lien *et al.* 1992, Kraus *et al.* 1997, Gearin *et al.* 2000). We therefore conducted an experiment to test whether acoustic deterrents would be effective in reducing a bycatch of *Pontoporia* in a subsistence gillnet fishery in Argentina.

METHODS

We conducted a double blind experiment using acoustic alarms in the Cabo San Antonio gillnet fishery between 19 October 1999 and 27 February 2000 (Fig. 1). The fishery consisted of 10–15 fishermen who fished from September to April, although some boats operated through the year. The fishery was conducted by small inflatable and fiberglass vessels 5–8 m in length operating between 0.5 and 7 km from the coast. The nets were composed of mono- or polyfilament nylon and were anchored on the bottom, placed in waters from 6 to 12 m. The nets were 50–75 m long and 2–2.5 m deep with a stretched mesh size from 9 to 12 cm, although fishermen sometimes used two to five nets together in a string. The fishery mainly targeted on sea trout (*Cynoscion striatus*), whitemouth croacker (*Micropogonias furniei*), Parona leatherjack (*Parona signata*), and Patagonian smooth-hound (*Mustelus* sp.).

Working in association with five local artisanal fishermen, active and silent (inactive) pingers, were used during the experiment. The active pingers (Dukane Netmark 1000) emitted a broadband signal every four seconds centered at 10 kHz, with a source level of 132 dB re 1 µPa @ 1 m. The choice of this type of pinger seemed to be the appropriate because: (1) another experiment had demonstrated its effectiveness on harbor porpoises (*Phocoena phocoena*), (Kraus *et al.* 1997); and (2) there are similarities between *Pontoporia* and *Phocoena* acoustic characteristics (Busnel *et al.* 1974). Active devices were equipped with a salt water switch that triggered the alarm on complete immersion. The silent alarm was identical to the active alarm, but was rendered inactive by turning the internal position of the battery pack. Each net/string was equipped with either a set of active or silent alarms, and identified as active or inactive nets in the analysis. Two alarms were placed on 50 m long nets attached to the head rope at the end of each net. When fishermen used a string with two nets, the alarms were placed every 50 m in the string. The choice of active or silent alarms for each string/net was made with a coin toss the night before the string/net was retrieved and reset. In this way, alarms were randomly assigned and placed on the nets by onboard observers. Neither fishermen nor observers were aware of which type of alarms was being placed on each string. Observers carried a new set of dry alarms aboard each day and replaced the alarms they retrieved. All alarms were changed on a string/net each time it was retrieved. Wet active alarms were still emitting sound as they came on board, but the subsequent set of alarms was independent of the prior set. Because fishing in the area is territorial, strings/nets were placed at least 300 m apart, minimizing the potential for any confounding effects between silent and active gear. Each alarm was coded and it allowed us to track battery life, malfunctions, and losses. Each vessel carried an independent observer who was rotated from vessel to vessel throughout the course of the experiment.

The number of dolphins captured, geographic position, depth, configuration of fishing gear, soak time, and the biomass of fish caught was recorded. We also recorded if target fish species in a string/net had been damaged by sea lion (*Otaria flavescens*) predation, and if the sea lion attack had produced any damage to the net. Where possible, bycaught dolphins were collected and necropsies were performed to determine diet and reproductive condition based on Kasuya and Brownell (1979).

Due to several differences in nets and strings used by the fishermen, and the different soak times during the experiment, fishing effort was defined in $m^2 \times h$. The capture per unit effort for dolphins (CPUE *dolphins*) was expressed as the number of dolphins caught/fishing effort. The capture per unit effort for fish (CPUE *fish*) was expressed as kg of fish/fishing effort. The experiment tested the hypothesis that dolphins have the same probability of being caught in active and silent nets. We assumed that nets had a constant catch per unit effort.

RESULTS

A total of 309 silent (inactive) and 295 active nets/strings were set in similar locations and water depths with similar soak times (Fig. 2). The frequency of fishing effort for both types of nets and dolphin incidental mortality per week are showed in Figure 3. Forty-five dolphins were caught in silent nets and seven

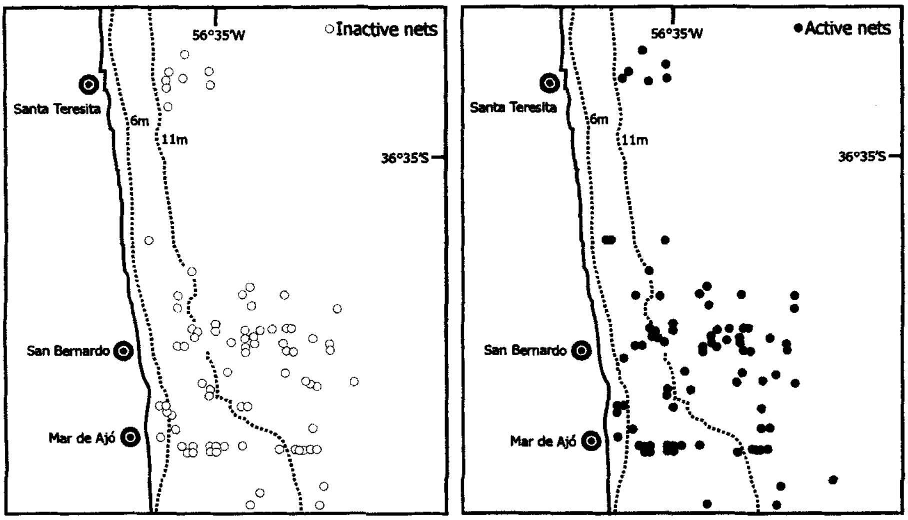

Figure 2. Location of inactive and active nets/strings.

in active nets (Table 1). Sixty-one percent of entangled dolphins were females ($n = 52$) and the 56% of these females were immature ($n = 32$). Among males, the 90% ($n = 20$) were immature individuals. The mean CPUE *dolphins* in active and inactive nets were 0.002 and 0.014, respectively. This CPUE was six times lower in active nets than in silent nets and was significantly different ($P < 0.001$, log likelihood ratio test). The expected number of dolphins caught if alarms were not used would have been 88 (accounting 100% of nets as inactive nets, and determined by the CPUE dolphins recorded in inactive nets during this experiment), as opposed to the 52 takes which were observed. Similar

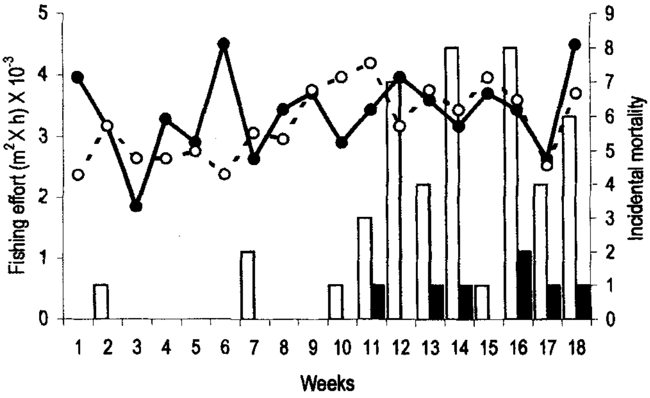

Figure 3. Weekly summary of fishing effort in active (solid line) and inactive (dashed line) nets/strings, and incidental number of entangled dolphins in active (solid bars) and inactive (open bars) nets/strings.

Table 1. Summary of data recorded during the pinger's experiment in Cabo San Antonio.

	Net type		
	Inactive	Active	P^a
Number of nets	309	295	
Mean soak time ± SD (h)	25.9 ± 6.2	25.4 ± 8.7	NS, $P = 0.878$
Mean effort ± SD ($m^2 \times h$)	3,232 ± 589.8	3,185 ± 660.8	NS, $P = 0.525$
# of dolphins entangled	45	7	
Mean depth ± SD (m)	10.5 ± 1	10.5 ± 1	
CPUE (fish) ± SD	2.25 ± 1.12	2.17 ± 1.33	NS, $P = 0.525$
Total catch of fish (kg)	7,269	6,913	

[a] Mann-Whitney test

biomass of fish (CPUE *fish*) was recorded for both types of nets/strings ($P < 0.001$, Mann Whitney test). Sea lion attacks were more frequent on active nets than on silent nets ($P = 0.016$, *RxC* test of independence), and those on active nets increased throughout the experiment (Fig. 4).

Fishermen and observers retrieved 29 of the 52 dolphins entangled during the experiment. Carcasses were also examined on board. Additionally, six Burmeister's porpoises, *Phocoena spinnipinnis*, were caught in inactive nets only. Post mortem examination of these 29 individuals showed that all entangled Franciscana dolphins had almost full stomachs dominated by Sao Paulo squid (*Loligo sanpaulensis*), Patagonian red shrimp (*Pleoticus mulleri*), and king weakfish (*Macrodon ancylodon*). Necropsies also revealed that 5 of 17 retrieved females were pregnant.

Discussion

The alarms were effective at reducing the incidental mortality of the Franciscana dolphin in bottom-gillnets in the study area. However, to implement the use of these alarms will require finding a solution for reducing the sea lion attacks on active nets. One possibility could be to add an alarm with higher frequencies. Our results suggest that the alarms appear to be attracting sea lions over time, and that they learned to associate the alarm with the presence of food about two months from the beginning of the experiment. It is likely that a small number of sea lions visiting the area are responsible for a large portion of the interaction. Early studies suggested that acoustic deterrents increased the problem by alerting the seals to the presence of caught fish, creating a "dinner bell" effect (Mate and Harvey 1986).

The widespread use of acoustic alarms to reduce cetacean bycatch was suggested by Dawson *et al.* (1998). In general, the scientific community has been skeptical about the value of acoustic alarms for this purpose. One of the most important concerns is that the acoustic alarms might become ineffective over time. This study showed that acoustic alarms reduced the by-catch of Franciscana dolphins in gillnets over a four-month trial; nevertheless, the potential for habituation needs to be addressed.

The Franciscana's diet recorded from stomach contents was not different from previous reports for this species (*e.g.*, Pinedo *et al.* 1989). Entangled dolphins

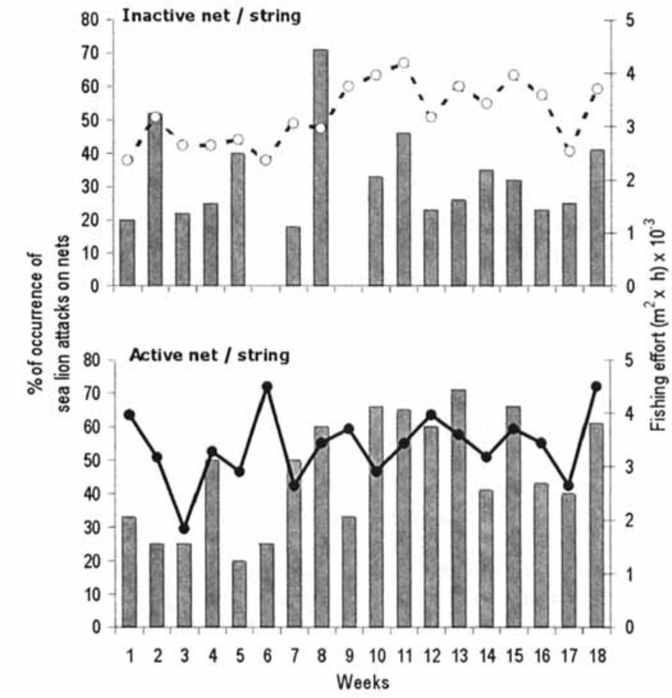

Figure 4. Percentages of sea lion attacks (bars) on inactive (dashed line) and active (solid line) nets/strings.

were not eating the target species of the fishery. The full stomachs of the entangled individuals indicates that capture occurred either during or after feeding activities. Thus, the feeding behavior of Franciscana dolphin may be a primary contributing factor in entanglement. Two mechanisms could account for a dolphin's entanglement in this case: (1) dolphins do not detect the net or do not perceive it as dangerous, or (2) dolphins are not using echolocation while traveling between feeding areas. Jefferson *et al.* (1992) provided evidence that the nets are probably detected visually in clear water and calm sea and acoustically. In turbid coastal waters, however, vision is of little use in the detection and capture of prey and sonar is probably its primary sense use by Franciscana dolphins. Au and Jones (1991) showed that gillnets reflect acoustic energy and that echolocating bottlenose dolphins (*Tursiops truncatus*) should be able to detect a net at a sufficient range to avoid entanglement. However, different dolphin species produce different frequency sounds, and consequently the detection of nets could also differ. Wood and Evans (1980) provided strong evidence that dolphins do not constantly need to interrogate their environment with sonar pulses.

The high rate of incidental Franciscana dolphin mortality recorded during this study suggests that the impact of the Cabo San Antonio fishery has increased, although the fishery effort has been the same or lower than previous years. The historic average of 10 dolphins caught per fisherman per season (Albareda and Albornoz 1994) increased to 17 during our experiment. It is likely that the accidental mortality of the Franciscana dolphins along the Argentina coastal area has been underestimated during the last 10 yr. This is consistent with reports elsewhere in the world, that estimating mortality values through interviews with local fishermen will underrepresent actual mortality rates. Seasonal mortality of more Franciscana dolphin females than males is consistent with the mortality rates reported by Albareda and Albornoz (1994). It also supports the idea that females are closer to the coast during spring and summer as suggested by Bordino *et al.* (1999). The high proportion of immature animals could be explained in terms of lack of experience of the young dolphins (Perrin *et al.* 1994), or by differential use of the habitat.

Although this was a subsistence fishery, most of fishermen operating in the area were interested in adding alarms to their nets and to face the cost if alarms could be made that also minimize sea lion attacks.

Our study suggests that the use of the alarms in small fisheries under appropriate controls should be considered as a tool in developing a strategy for conservation of the Franciscana dolphin.

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LITERATURE CITED

ALBAREDA, D., AND N. ALBORNOZ. 1994. Mortalidad de franciscana en la pesqueria artesanal de San Bernardo y Mar de Ajo, Buenos Aires, Argentina. Pages 54–60 *in* M. C. Pinedo and A. Barreto, eds. Anais do 2° Encontro sobre cordenacao de pesquisa e manejo da franciscana, Florianopolis, Brasil, October 22–23, 1994, Available at Editora da FURG, Luiz Lorea 261, CEP 96201-900, Rio Grande, RS-Brasil.

AU, W. W. L., AND L. JONES. 1991. Acoustic reflectivity of nets: Implications concerning the incidental take of dolphins. Marine Mammal Science 7:358–373.

BORDINO, P., G. THOMPSON AND M. INIGUEZ. 1999. Ecology and behaviour of the Franciscana dolphin *Pontoporia blainvillei* in Bahía Anegada, Argentina. Journal of Cetacean Research and Management 1:213–222.

BROWNELL, R. L., JR. 1975. Progress report on the biology of franciscana dolphin, *Pontoporia blainvillei*, in Uruguayan waters. Journal of Fishery Research Board Canada 32:1073–1078.

BUSNEL, R. G., A. DZIEDZIC AND G. ALCURI. 1974. Etudes preliminaries de signaux acoustiques de *Pontoporia blainvillei* Gervais et D'Orbigny (Cetacea, Platanistidae). Mammalia 38:449–459.

CORCUERA, J. 1994. Incidental mortality of franciscanas in Argentine waters: The threat of small fishing camps. Reports of the International Whaling Commission. (Special Issue 15):291–294.

CORCUERA, J., F. MONZON, I. CORNEJO, J. PEREZ, A. BEILIS, M. GINGARELLI, D. ALBAREDA AND A. ARIAS. 1998. Mortalidad de *Pontoporia blainvillei* en el Norte de la Provincia de Buenos Aires. UNEP/CMS. 2000. Report of the Third Workshop for Coordinated Research and Conservation of the Franciscana Dolphin *Pontoporia blainvillei* in the Southwestern Atlantic. Available from UNEP/CMS Secretariat, United Nations Premises in Bonn, Martin Luther King Str. 8, 53 175 Bonn, Germany.

CRESPO, E., J. CORCUERA AND A. LOPEZ CAZORLA. 1994. Interactions between marine mammals and fisheries in some coastal fishing areas of Argentina. Reports of the International Whaling Commission (Special Issue 15):268–281.

DAWSON, S. M., A. READ AND E. SLOOTEN. 1998. Pingers, porpoises and power. Uncertainties with using pingers to reduce bycatch of small cetaceans. Biology Conservation 84:141–146.

GEARIN, P. J., J. L. GOSHO, J. L. LAAKE, L. COOKE, R. L. DELONG AND K. M. HUGHES. 2000. Experimental testing of acoustic alarms (pingers) to reduce bycatch of harbour porpoise, *Phocoena phocoena*, in the state of Washington. Journal of Cetacean Research and Management 2:1–9.

IUCN. 1996. IUCN Red Data List of Threatened Animals. IUCN, Gland, Switzerland.

JEFFERSON, T. A., B. WÜRSIG AND D. FERTL. 1992. Cetacean detection and responses to fishing gear. Pages 663–684 *in* J. A. Thomas, R. A Kastelein and A. Supin, eds. Marine mammal sensory systems. Plenum Press, New York, NY.

KASUYA, T., AND R. L. BROWNELL, JR. 1979. Age determination, reproduction and growth of frnaciscana dolphin *Pontoporia blainvillei*. Scientific Reports of the Whale Research Institute, Tokyo 31:45–67.

KRAUS, S. D., A. READ, E. ANDERSON, K. BALDWIN, A. SOLOW, T. SPRADLIN AND J. WILLIAMSON. 1997. Acoustic alarms reduce porpoise mortality. Nature 388:525.

LIEN, J., W. BARNEY, S. TODD, R. SETON AND J. GUZZWELL. 1992. Effects of adding sounds to cod traps on the probability of collisions by humpback whales. Pages 701–708 *in* J. Thomas, R. A Kastelein and A. Supin, eds. Marine mammal sensory systems, Plenum Press, New York, NY.

MATE, B. R., AND T. HARVEY. 1986. Acoustical deterrents in marine mammal conflicts with fisheries. Oregon Sea Grant Report ORESU-W-86-001. 116 pp.

PERRIN, W. F., AND R. L. BROWNELL, JR. 1989. Report of the Workshop on Conservation and Biology of the Platanistoid Dolphins. Pages 1–22 *in* W. F. Perrin, R. L. Brownell, Jr., Z. Kaiya and L. Jiankang, eds. Biology and conservation of the river dolphins. Ocassional Papers IUCN SSC 3, Gland, Switzerland.

PERRIN, W. F., G. P. DONOVAN AND J. BARLOW, EDS. 1994. Gillnets and cetaceans. Reports of the International Whaling Commission. (Special Issue 15).

PINEDO, M. C., R. PRADERI AND R. L. BROWNELL, JR. 1989. Review of the biology and status of the franciscana *Pontoporia blainvillei*. Pages 46–51 *in* W. F. Perrin, R. L. Brownell Jr., Zhou Kaiya and Liu Jiankang, eds. Biology and conservation of the river dolphins. Ocassional Papers IUCN SSC 3, Gland, Switzerland.

PRADERI, R. 1984. Mortalidad de franciscana *Pontoporia blainvillei* en pesquerias artesanales de Tiburon de la costa Atlantica Uruguaya. Revista del Museo Argentino de Ciencias Naturales Bernardino Rivadavia 13(25):259–272.

REILLY, S. B., AND J. BARLOW. 1986. Rates of increase in dolphin population size. Fishery Bulletin, U.S. 84:527–533.

SECCHI, E. R., A. N. ZERBINI, M. BASSOI, L. DALLA ROSA, L. M. MOLLER AND C. C. ROCHA CAMPOS. 1997. Mortality of franciscanas, *Pontoporia blainvillei*, in coastal gillneting in southern Brazil: 1994–1995. Report of the International Whaling Commission 47:653–658.

SECCHI, E. R., J. Y. WANG, B. W. MURRAY, C. C. ROCHA-CAMPOS AND B. N. WHITE. 1998. Population differentiation in the franciscana *Pontoporia blainvillei* from two geographic locations in Brazil as determined from mitocondrial DNA control region sequences. Canadian Journal of Zoology 76:1622–1627.

SECCHI, E. R., P. H. OTT, E. A. CRESPO, P. G. KINAS, S. N. PEDRAZA AND P. BORDINO. 2000. Abundance estimation of a franciscana dolphin, *Pontoporia blainvillei*, stock from aerial surveys. International Whaling Commission SC/52/SM12.

VON FERSEN, L., C. KAMMINGA AND A. SEIDL. 1998. Estudios preliminaries sobre el comportamiento de un ejemplar de Franciscana *Pontoporia blainvillei* en Mundo Marino, Argentina. UNEP/CMS. 2000. Report of the Third Workshop for Coordinated Research and Conservation of the Franciscana Dolphin *Pontoporia blainvillei* in the Southwestern Atlantic. Available from UNEP/CMS Secretariat, United Nations Premises in Bonn, Martin Luther King Str. 8, 53 175 Bonn, Germany.

WOOD, F. G., AND W. E. EVANS. 1980. Adaptiveness and ecology of echolocation in toothed whales. Pages 381–425 *in* R. G. Busnel and J. F. Fish, eds. Animal sonar systems. Plenum Press, New York, NY.

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