DOLPHIN INTERACTIONS WITH THE MULLET ARTISANAL FISHING ON SOUTHERN BRAZIL: A QUALITATIVE AND QUANTITATIVE APPROACH

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ABSTRACT. A detailed analysis of the interactions between *Tursiops truncatus* (Montagu, 1821) and the artisanal fishing of mullets (*Mugil* spp.) is presented at two localities in the south of Brazil: Laguna (Santa Catarina) and Imbé/Tramandaí (Rio Grande do Sul). Its behavioral strategies and the advantages of their association are re-described and quantified based on the success of the capture and on the selectivity of the prey sizes. The mullets are the main resource involved (92 % to 75%) both at numerical level and as biomass. Twenty individuals of *Tursiops truncatus* participated in the interactions in Laguna and 9 in Imbé/Tramandaí. The participation and learning of calves is also reported.
KEY WORDS. Cetacea, Delphinidae, *Tursiops truncatus*, ecology, behavior, artisanal fishery.

In some areas *Tursiops truncatus* (Montagu, 1821) has adapted its feeding strategies in order to take profit of human activities (LEATHERWOOD & REEVES 1983). It often behaves as a commensal, taking advantage of the rejected organisms or of those attracted by fishing boats (NORRIS & PRESCOTT 1961; CALDWELL & CALDWELL 1972; LEA-THERWOOD 1975; CORKERON *et al.* 1990). It sometimes competes with the fishermen by feeding from the entangled fishes, thus damaging the nets (GUNTER 1942; CATO & PROCHASKA 1976). However, other kinds of association were reported. FAIRHOLME (1856) describes an interaction with mutual advantage between dolphins and Australian aborigines. BUSNEL (1973) and PELLETIER (1975) report "symbiotic" associations at the coast of Mauritania. Recently, an equivalent event was mentioned for southern Brazil in simultaneous and preliminary works which describe "cooperative" associations between men and dolphins (PRYOR *et al.* 1990; SIMÕES-LOPES 1991).

The behavioral strategies employed by *T. truncatus* during their interactions with the artisanal fishery of mullets (*Mugil* spp.) in southern Brazil are redescribed and quantified in the present study, as well as the use of the food resources.

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MATERIALS AND METHODS

Areas and time of study

Associations between coastal groups of *T. truncatus* with the artisanal fishing of mullets (*Mugil* spp.) can be seen at four localities in the south coast of Brazil (SIMÕES-LOPES 1991), but our regular observations were focused on two areas of interest: Laguna's and Imbé/Tramandaí's inlets.

Laguna's inlet (28°30'S, 48°45'W) is 1.6 km long and 200 m wide, linking the sea to Mirin-Imaruí-Sto. Antônio lagoons' system on the Santa Catarina coast, southern Brazil. The lagoons spread over an area of 255 km^2, including the delta of Tubarão river. It is the most productive system in that state, accounting for 30% of the artisanal fishery. The second area is located at about 350 km to the south (30°S, 50°W) and is also composed of a shallow lagoons system. The estuary is linked to the sea by means of a narrow bar between the districts of Imbé and Tramandaí.

Sporadical observations were made from 1984 to 1994. Direct and systematic observation totalised 1,024 hours, of which 880 hours in Laguna (from August 1989 to March 1992) and 144 hours in Imbé/Tramandaí (from April to June 1994).

Record of Data and Field Procedures

It was employed a combination of methods of sequence sampling and sampling of all occurrences of some behaviors (ALTAMNN 1974). Whenever possible, a positive identification of the dolphins was made. Only the participation of the traditional fishermen were considered, while the tourists and casual fishermen were not taken into account. The conditions for observation were excellent without any kind of obstacles, and the distance ranging from 4 to 25 meters. The samplings were carried out from land stations. *Ad libitum* sampling (typical field notes) were made at the mouth of Tubarão river.

The observations were made during 12 hours continuously, from 6:00 a.m. to 6:00 p.m. Casual nightime observations were also considered, but excluded from statistical analyses. The counts and measurements of the fishes captured in each net were made assuming preestablished classes of size: <10, 10-19, 20-29, 30-39, 40-49, and >50 cm. Six researchers participated in the field work, who took turns of two hours, in order to avoid fatigue.

Statistical treatment

The comparison between the slopes, which represent the efficiency of the capture (with and without the participation of dolphins), followed the *Student* test (ZAR 1974: 228). The level of significance was $P<0.05$ and used one-tailed hypothesis, were $H0: B1 \leq B2$ and $HA: B1 > B2$. Kurtosis (shape) and symmetry were used to detect differences among the frequency distributions of size classes of the captured fishes (SNEDECOR & COCHRAN 1967: 86-88). In both cases the *t* test was used to prove the significance.

RESULTS

Sites of interaction in the study areas

The spontaneous interactions between *T. truncatus* and the artisanal fishing of mullets occurred in internal waters. In Laguna twelve sites were confirmed, while

in Imbé/Tramandaí the interactions occurred always at the mouth of the canal, rarely moving more than a hundred meters in (Fig. 1).

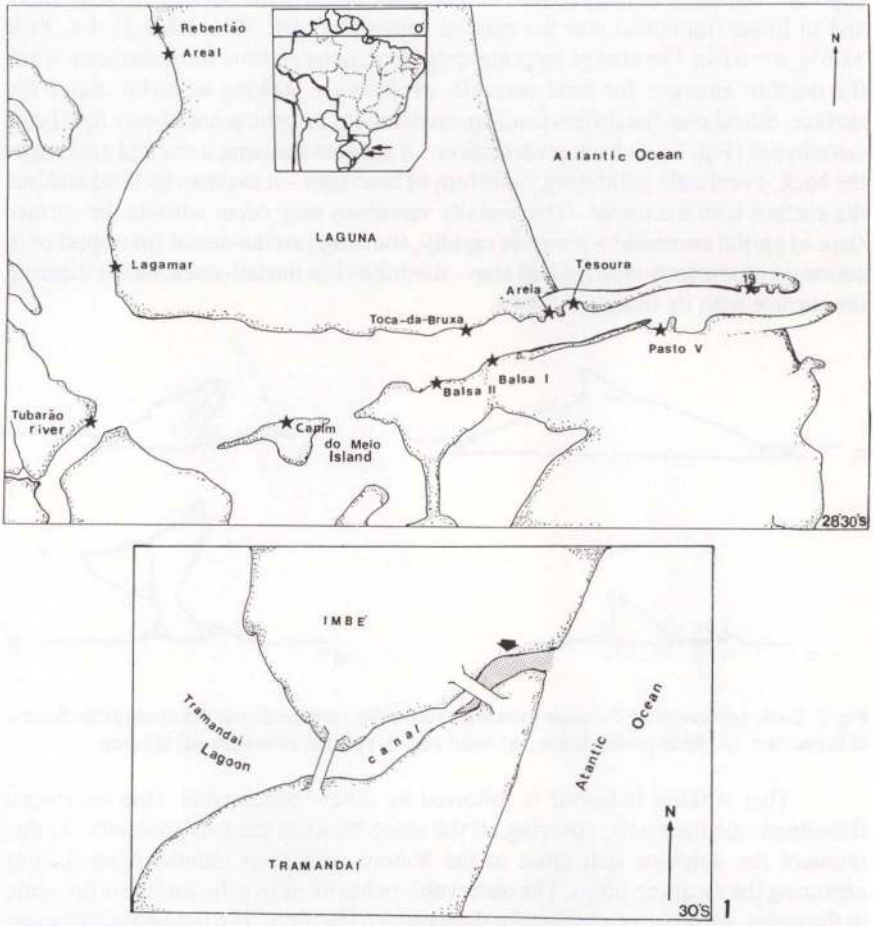


Fig. 1. Laguna (Santa Catarina) and Imbé/Tramandaí (Rio Grande do Sul) inlets and the places where occur the interactions between *Tursiops truncatus* and the mullet artisanal fishing.

Capture Strategies

Dolphins in exploratory activity get close to the line of fishermen. In a first step the dolphins make rolling movements in order to group the schools close to the margin. The fishermen await without moving in a single line side by side with water up to their waists and holding their nets at the level of their chests. They remain watchful to the movements of the dolphins, almost without casting their nets.

The association is always initiated by the dolphins, and is composed by ritualized movements which demand a precise coordination between both parts. Suddenly, one of several animals converge to the line of fishermen in a vigorous

dive. The approximation can be oblique, parallel or perpendicular to the line of fishermen, with marked differences between the study areas. In Laguna the oblique approach was more frequent (OBL 41.8%, PAR 38.2%, PER 20%, $n = 2395$ events), and in Imbé/Tramandaí was the parallel approach (OBL 30%, PAR 51.4%, PER 18.6%, $n = 630$). The charge halts abruptly, four meters before the fishermen, when the dolphin emerges for brief seconds, exhibiting a striking behavior above the surface. Such behavior differs from an emersion for breathing and shows four basic stereotypes (Fig. 2): a) back presentation – it appears showing a marked arching of the back, eventually exhibiting its melon; b) head slap – it exposes its head and hits the surface with the throat. Occasionally variations may occur without the surface slap; c) partial emersion – it moves rapidly, showing just the dorsal fin or part of it, causing a momentary whirl; d) tail slap – it exhibits just the tail-stock, barely clearing the surface with its flukes just once.

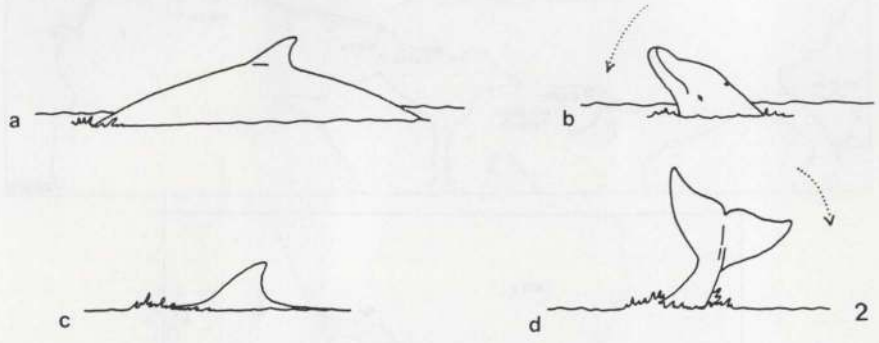


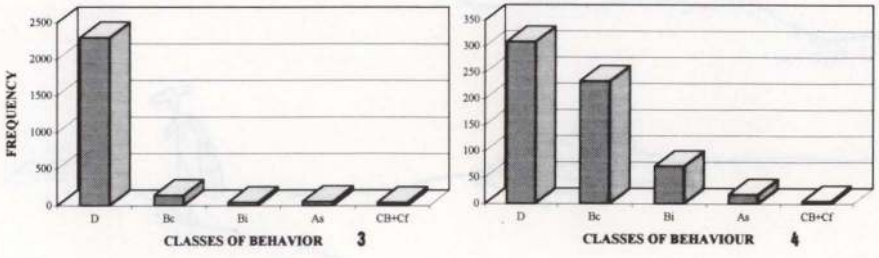
Fig. 2. Basic behaviors of *Tursiops truncatus* above the surface during the charges to the line of fishermen. (a) Back presentation, (b) head slap, (c) partial emersion, (d) tail slap.

That striking behavior is followed by a new submersion. One or several fishermen cast their nets, covering all the space between the two predators. At this moment the dolphins halt close to the bottom with their mouths opened, thus capturing the escaping preys. The observable behavior above the surface is the acme to the event, working as a trigger for the casting of the nets. The frequencies of these behaviors in the inlet of Laguna showed a great homogeneity from year to year, without significant differences ($X^2 = 7.908$, $g1 = 4$, $P > 0.05$), being back presentation the most frequent one. The behaviors observed at Imbé/Tramandaí belong with the same categories, but head slaps were almost as frequent as back presentation. A significant difference in the frequencies were verified when the two localities are compared (Figs 3-4, $X^2 = 668.554$, $g1 = 4$, $P < 0.001$).

In case a dolphin moves close to the line of fishermen without performing the sequence of behaviors, the nets are not cast. The dolphins usually select those beaches with fishermen and may spyhope before approximation.

In rare occasions one sees modifications at the end of the sequence of behaviors. A certain animal rolls its body with vigorous movements in a way to delay the fall of the net, or even rising it from the bottom, allowing it to capture

fishes entangled in the meshes. When this happens, the animal stirs the mud at the bottom where the nets were cast. The fishermen detect that movement and immediately throw sand or rocks in order to drive the dolphin away. However, these constitute sporadic events related to those periods of low fishing availability like the end of the mullets migration.



Figs 3-4. Frequencies of striking behaviors of *Tursiops truncatus* above the surface during the interactions in the study areas. (D) Back presentation, (Bc) head slap, (Bi) incomplete head slap, (As) partial emersion, (CB+Cf) tail slap.

The interactions are usually individual, but there are cases in which groups of up to six animals cooperate with combined movements (Fig. 5).

At the mouth of Tubarão river a different kind of interaction occurs. Three to five boats move in line close to the margin of the river, each with a fisherman holding his net at the prow. The dolphins come close in exploratory fishing and then accelerate their move in a half moon trajectory with several partial leaps. The first boats to throw their nets are those at the center, followed by the others.

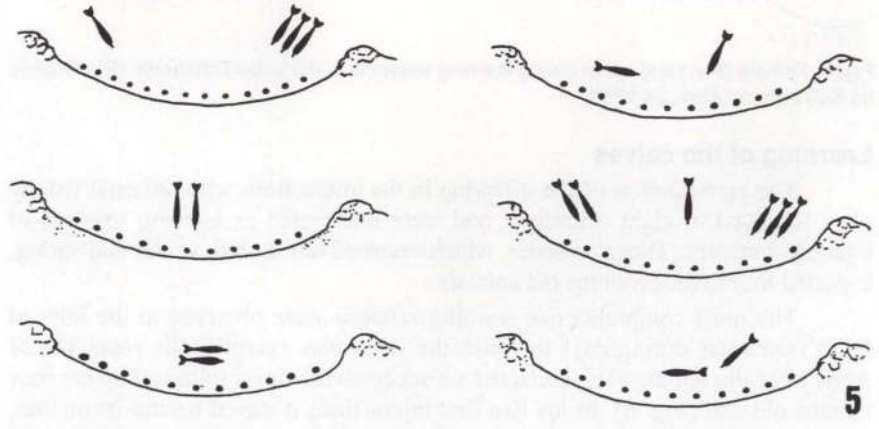


Fig. 5. Participation of joined groups of *Tursiops truncatus* during the interactions in the study areas.

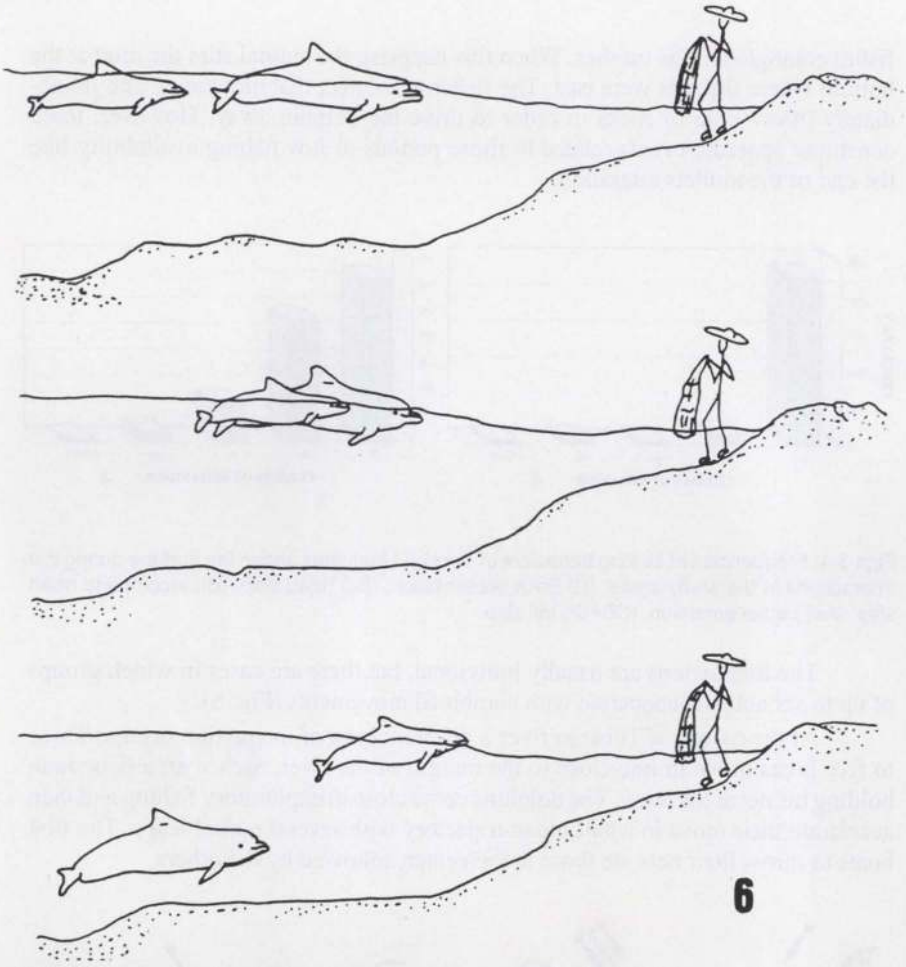


Fig. 6. Female (#I_{11}) and calve during learning sessions in the Imbé/Tramandaí (Rio Grande do Sul) inlet, on April, 24 1994.

Learning of the calves

The participation of the offspring in the interactions with artisanal fishery were followed in eight occasions, and were interpreted as learning sessions of hunting strategies. Those episodes, which occurred during fall, winter and spring, included four to nine months old animals.

The most comprehensive learning sessions were observed in the inlet of Imbé/Tramandaí during days in which the water was exceptionally clear. On 24 April 1994 the female #I_{11} interacted six successively times followed by her four months old calf (Fig. 6). In the two first interactions it stayed behind its mother, while in the following three charges it kept by her side. In the last charge the calf interacted by himself against the line of fishermen, performing accurately all the displays, while the mother remained some meters behind at the bottom. At least in

five of the net casts mullets ranging from 30-40 cm were captured. According to the fishermen, that same animal was captured in a net a few weeks later, being immediately released and then moving away from that site with its mother.

Utilization of food resources

The casting of the nets covers the whole space between the dolphins and the fishermen, thus providing a reliable sampling of the number and diversity of preys available for both predators at the moment of the interaction. The capture of fish performed during the interaction included 12 species belonging to 8 families (Tab. I). Some of the genera mentioned might have contributed with a larger number of species, but such a fact cannot be verified in the field.

Table I. Species captured during the associations of *Tursiops truncatus* and the artisanal fishing at Laguna (Santa Catarina) and Imbé/Tramandaí (Rio Grande do Sul), respectively, between August, 1989 and December, 1991 and between April and June, 1994. Areas of occurrence (OA): (1) just in the first area, (2) just in the second area, (3) both areas.

Species	Local name	Family	OA
Brevoortia pectinata	Savelha	Clupeidae	2
Sardinella brasiliensis	Sardinha		1
Lycengraulis grossidens	Manjubão, sarda *	Engraulidae	3
Anchoa marinii	Anchoveta, cardosa *		1
Centropomus parallelus	Robalo	Centropomidae	1
Pomatomus saltator	Enchova	Pomatomidae	1
Trachinotus marginatus	pampo	Carangidae	3
Eucinostomus melanopterus	gordinho, carapicu	Gerreidae	1
Eucinostomus gula	gordinho		1
Micropogonias furnieri	Corvina	Sciaenidae	1
Mugil platanus	Tainha	Mugilidae	3
Mugil curema	tainha		3

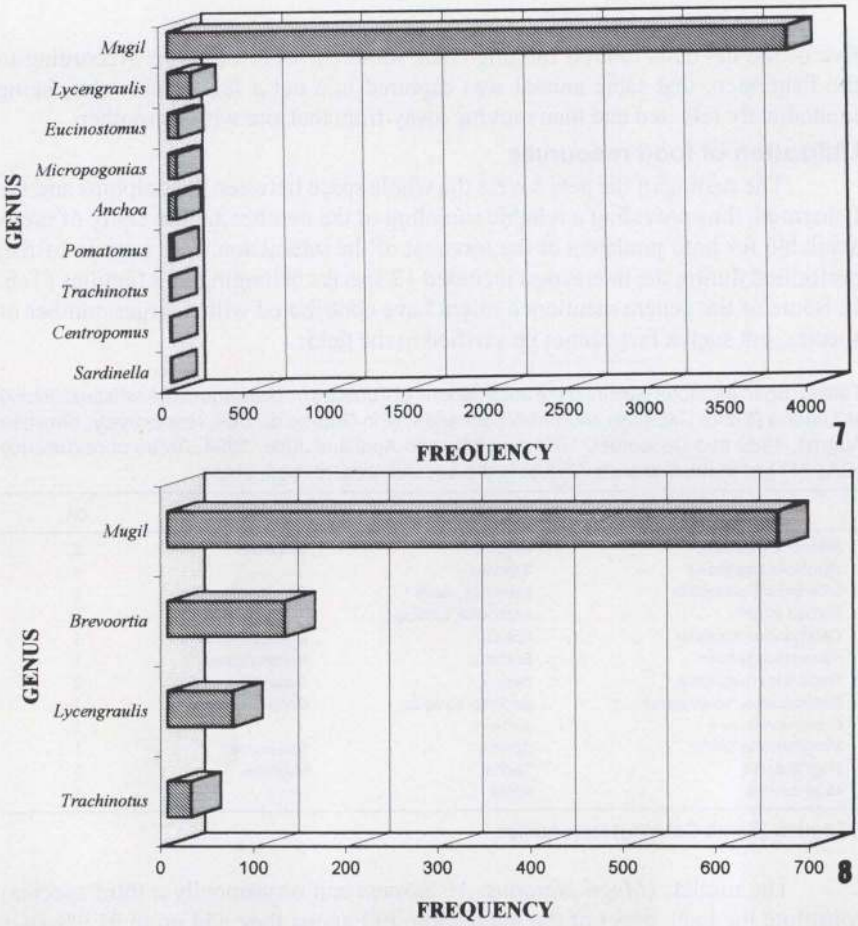
*) Laguna (Santa Catarina) local names.

The mullets (*Mugil platanus*, *M. curema* and occasionally a third species) constitute the main preys of the interaction. In Laguna they add up to 91.9% (n = 4,186), and in Imbé/Tramandaí 74.9% (n = 881) (Figs 7-8).

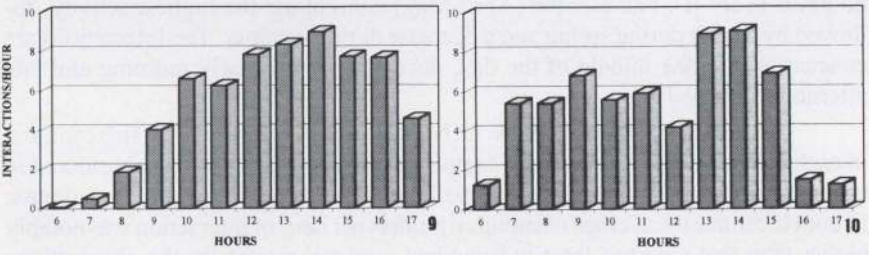
The Interference by the dolphins: a comparative approach

The average number of interactions/hour means the level of activity of the dolphins (Tab. II). Fall months (April-May) concentrate the highest activity, followed by a peak during spring and a decrease during summer. The interactions are concentrated in the middle of the day, decreasing in the early morning and late afternoon (Figs 9-10).

Interferences by the dolphins can be expressed by the number of fish captured in each casting of the net. Only the capture of mullets (*Mugil* spp.) is considered in order to avoid distortions caused by small preys, which have a negligible biomass. In both localities the average of captured mullets per hour of interaction was notably higher than that obtained from independent captures, except for the observations during summer, when almost no interactions man/dolphin occurred (Figs 11-13). The highest averages of mullets with the interference by the dolphins were coincident with the periods of mullets migration, while the lowest ones happened during



Figs 7-8. Frequency of captured fishes by Genus during the interactions of *Tursiops truncatus* with the artisanal fishing. (7) Laguna (Santa Catarina); (8) Imbé/Tramandaí (Rio Grande do Sul).



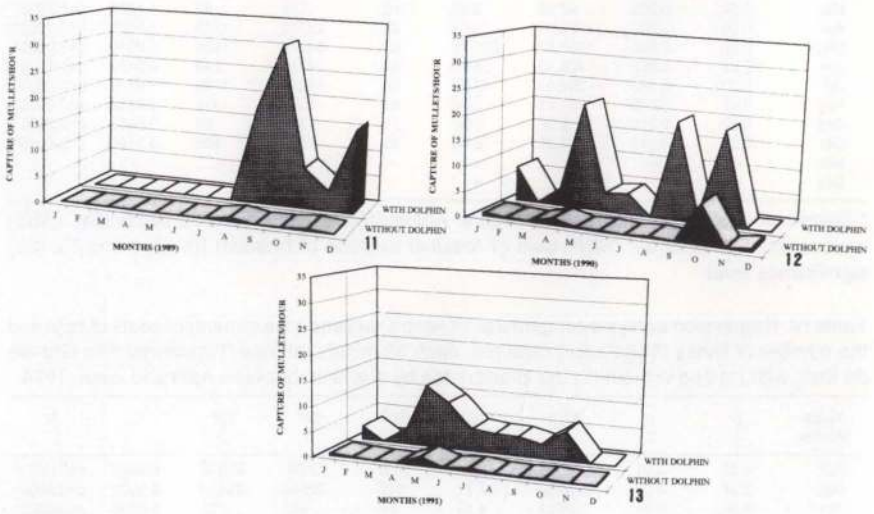
Figs 9-10. Frequency of interactions/hour of Tursiops truncatus during daylight. (9) Laguna (Santa Catarina), August 1989 to December 1991; (10) Imbé/Tramandaí inlet (Rio Grande do Sul), April to June 1994.

after that. The highest number of captures occurred during fall, while in spring a second peak was reported. If the months with no interactions are not considered the percentage of captures with the dolphins ranged from 71% to 100%, while independent fishery ranged from 0% to 29%.

Table II. Average number of interactions/hour of *Tursiops truncatus*, during the mullets (*Mugil* spp.) artisanal fishing in Laguna (Santa Catarina) and Imbé/Tramandaí (Rio Grande do Sul) inlets, respectively, between August, 1989 and December, 1991 and between April/June, 1994.

Months	Laguna			Imbé/Tramandaí
	1989	1990	1991	1994
January	–	2.50	2.50	–
February	–	0.08	0.12	–
March	–	0.70	1.79	–
April	–	16.58	10.21	5.02
May	–	3.08	14.83	7.33
June	–	2.45	4.75	3.20
July	–	0.00	10.88	–
August	12.08	2.37	3.41	–
September	13.42	1.87	3.50	–
October	3.33	5.08	7.66	–
November	2.58	–	–	–
December	6.58	0.83	0.00	–

The ratio of net casting per unit of time and the number of captured mullets is expressed by the general equation for a straight line. The slope *(b)* expresses the "capture efficiency" with and without the interference by the dolphins.



Figs 11-13. Average number of captured mullets per hour in Laguna inlet (Santa Catarina), with and without the participation of *Tursiops truncatus*. (11) 1989; (12) 1990; (13) 1991.

Twenty six out of the 29 months sampled in Laguna presented higher slopes *(b)* with the interference by the dolphins, that is, a higher "capture efficiency" (Tab. III). Only three months exhibited the reverse. In Imbé/Tramandaí the slopes were also superior with the dolphins participation (Tab. IV). In Laguna they were significantly superior to those of independent fishery in 12 out of 23 months of interaction. Those months coincide largely with the highest capture observed in fall and spring, in none of the cases the reverse occurred.

Table III. Regression analysis comparision (Y=a+bX) between the number of casts of nets and the number of fishes (*Mugil* spp.) captured, each 30 minuts, at Laguna (Santa Catarina), with (1) and without (2) the interference by dolphins, between August, 1989 and December, 1991.

Years Months	β 1	β 2	RSS 1	RSS 2	SDF 1+2	ΣX^2 1	ΣX^2 2	t_{cal}	SL
89 Aug	0.52	0.041	1029.34	33.53	24	9210	408	0.1498	p<0.1000
Sep	2.04	0.250	7048.94	0.50	20	3795	376	1.7652	p<0.0500*
Oct	0.57	0.600	379.24	0.30	14	1657	20	-0.0256	p>0.2500
Nov	0.19	0.120	314.79	2.21	19	916	413	0.2916	p>0.2500
Dec	1.10	0.500	2000.84	0.50	18	140	23	0.2530	p>0.2500
90 Jan	1.06	0.620	3349.44	56.75	11	1720	16	0.0990	p>0.2500
Feb	–	–	–	–	–	–	–	–	–
Mar	7.34	0.160	204.44	1.26	15	77	51	10.7646	p<0.0005*
Apr	0.32	0.120	2096.77	187.91	54	60859	3878	2.0000	p<0.0500*
May	0.23	0.070	160.26	2.85	40	2834	753	1.9500	p<0.0500*
Jun	0.81	0.310	233.54	14.07	27	784	194	2.1739	p<0.0250*
Jul	–	–	–	–	–	–	–	–	–
Aug	2.67	1.200	22163.98	27.15	20	1246	46	0.2940	p>0.2500
Sep	0.27	0.280	48.93	0.97	13	426	26	-0.0253	p>0.2500
Oct	2.78	1.080	17803.29	736.17	45	6083	897	2.3287	p<0.0250*
Nov	–	–	–	–	–	–	–	–	–
Dec	0.32	0.050	0.83	12.09	24	39	683	2.1833	p<0.0250*
91 Jan	0.53	0.040	41.20	17.28	42	3805	591	9.6000	p<0.0005*
Feb	–	0.620	–	–	–	–	–	–	–
Mar	0.54	0.200	97.55	0.80	19	1171	57	1.1074	p<0.2500
Apr	0.36	0.007	2709.04	5.07	48	20762	1274	1.6809	p<0.0500*
May	0.20	0.040	1058.87	201.78	61	64349	11821	3.9318	p<0.0005*
Jun	0.23	0.050	426.19	33.90	44	4921	290	0.9473	p<0.1000
Jul	0.20	0.080	285.01	17.84	58	15293	1189	1.6470	p<0.1000
Aug	0.47	0.040	151.23	2.39	26	3573	333	3.0525	p<0.0050*
Sep	0.52	0.210	418.38	0.61	21	1333	69	0.5636	p>0.2500
Oct	0.53	0.140	462.86	6.58	36	7590	958	3.2500	p<0.0025*
Nov	–	–	–	–	–	–	–	–	–
Dec	–	–	–	–	–	–	–	–	–

* Statistical difference between two slopes. *Abbreviations*: (β) regression coefficient; (RSS) residual sum of squares; (SDF) sum of residual degrees of freedom [$(n_1$-2) + (n_2-2)]; (SL) significance level.

Table IV. Regression analysis comparision (Y=a+bX) between the number of casts of nets and the number of fishes (*Mugil* spp.) captured, each 30 minuts, at Imbé/Tramandaí (Rio Grande do Sul), with (1) and without (2) the interference by dolphins, between April and June, 1994.

Years Months	β 1	β 2	RSS 1	RSS 2	SDF 1+2	ΣX^2 1	ΣX^2 2	t_{cal}	SL
Apr	0.27	0.04	1475.81	171.94	128	12530	93810	6.9696	p<0.0005*
May	0.37	0.03	3076.16	97.77	147	22540	29974	8.5000	p<0.0005*
Jun	0.25	0.04	35.53	4.13	46	955	1753	5.6756	p<0.0005*

* Statistical difference between two slopes. Abbreviations: (β) regression coefficient; (RSS) residual sum of squares; (SDF) sum of residual degrees of freedom [$(n_1$-2) + (n_2-2)]; (SL) significance level.

The influence of the dolphins can also be verified in the selectivity of the preys size, since they were bigger when interaction occurred (Figs 14-15). In Laguna the majority of the fishes captured with the participation of dolphins belong to the 21-30 cm class, while the size of those of independent capture ranged from 1 cm to 10 cm. In Imbé/Tramandaí that ratio was of 31-40 cm with the dolphins and 21-30 cm without them. The frequencies of size classes generated curves significantly different from a symmetrical one. In Laguna, the curve with the participation of the dolphins presented a negatively skewed distribution with a significance different from zero (g_1 = -0.2137; t_{cal} (2) = 3.2378; $P < 0.002$; n = 1344). For independent fishing it presented a positive skew significantly different from zero (g_1 = 3.4212; t_{cal} (2) = 41.7; $P < 0.001$; n = 888). In Imbé/Tramandaí the curves differed in symmetry and kurtosis. With the interference by the dolphins a negative skewed and kurtosis was obtained, significantly different from zero (g_1 = -0.3; t_{cal} (2) = 3.67; $P < 0.001$; g_2 = -0.9062; t_{cal} (2) = 5.55; $P < 0.001$; n = 894), while without the participation of the dolphins the curve was symmetrical and mesokurtic (g_1 = 0.0091; t_{cal} = 0.0483; $P > 0.5$; g_2 = -0.6155; t_{cal} = 1.6635; $P < 0.1$; n = 166).

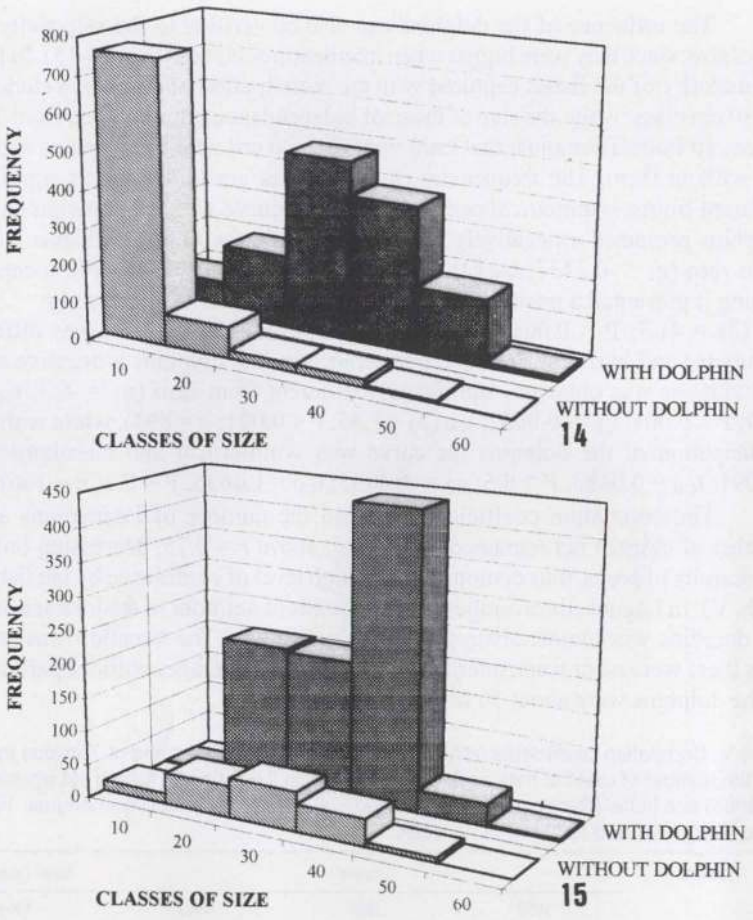
The correlation coefficients between the number of interactions and the number of casts of net remained, in general, above $r = 0.75$, decreasing only with the scarcity of preys, thus demonstrating a high level of confidence by the fishermen (Tab. V). In Laguna, the average number of casts of net/hour in the interactions with the dolphins was almost always higher (Figs 16-18). The situation was reversed only there were no or weak interactions. The highest averages with the participation of the dolphins were about 50 casts of net/hour.

Table V. Correlation coefficients (r) between the number of interactions of *Tursiops truncatus* and the number of casts of nets each 30 minuts, during the artisanal fishing at Laguna (Santa Catarina) and Imbé/Tramandaí (Rio Grande do Sul), respectively, between August, 1989 and December, 1991 and April and June, 1994.

Months	Laguna			Imbé/Tramandaí
	1989	1990	1991	1994
January	–	0.96	0.97	–
February	–	–	–	–
March	–	0.89	0.90	–
April	–	0.82	0.78	0.82
May	–	0.51	0.88	0.93
June	–	0.89	0.85	0.71
July	–	–	0.94	–
August	0.96	0.71	0.93	–
September	0.83	0.89	0.81	–
October	0.91	0.95	0.66	–
November	0.84	–	–	–
December	0.88	0.53	–	–

Did all dolphins participate?

A total of 20 dolphins interacted with the fishery in Laguna, where 14 of those were regulars (Tab. VI). The total number of dolphins which use that area is much larger. At Imbé/Tramandaí just 9 animals interacted with the fishery, including a calf of unknown sex (Tab. VII).

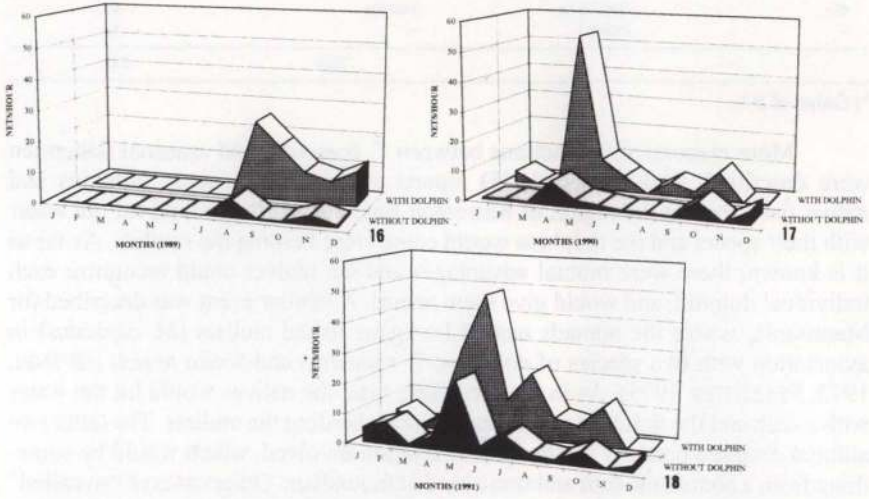


Figs 14-15. Frequency of size classes (1-10, 11-20, 21-30, 31-40, 41-50, 51<60 cm) of captured fishes with and without the participation of *Tursiops truncatus*. (14) Laguna (Santa Catarina; (15) Imbé/Tramandaí (Rio Grande do Sul) inlets.

DISCUSSION

The coastal waters comprise a mosaic of habitats which differ both in their physical and biological aspects. This is evident in the lagoon complexes, mangroves, salt marshes and inlets connecting the ocean with lagoons. The food resources and limiting environmental factors originate specific ecological requirements which might promote special surviving strategies. *T. truncatus* usually takes advantages of these unique ecological conditions by adapting its behaviors, specially in relation to hunting strategies. One of the tactics used by solitary animals or small groups consists in pushing the schools toward the seashore or other obstacles like stationary nets (TOMLIN 1957; LEATHERWOOD 1975; SANTOS & LACERDA 1987; BEL'KOVICH

et al. 1991; FELIX 1994). In the salt marshes of Georgia and South Carolina the dolphins may even get stranded in the mud banks, catching those fishes jumping out of the water (HOESE 1971; RIGLEY 1983). They are also used to adapt feeding strategies which take advantage of human activities (LEATHERWOOD & REEVES 1983). LEATHERWOOD (1975) describes associations with shrimp trawlers, when dolphins take profit of the clouds of mud caused by the net's movement on the bottom, and situations in which they eat rejected fishes or take advantage of anchored boats which attract oceanic fishes.



Figs 16-18. Frequency of casts of nets/hour with and without the participation of *Tursiops truncatus* in Laguna (Santa Catarina). (17) 1989; (18) 1990; (19) 1991.

Table VI. Individuals of *Tursiops truncatus* that participate of the interactions with the artisanal fishing (*Mugil* spp.) at Laguna (Santa Catarina), between August, 1989 and December, 1991.

Catalogue number	Local name	Sex	1989	1990	1991	Frequency
#L_{15}	Mandala	–	+	+	+	463
#L_2	Scooby	Female	+	+	+	459
#L_{14}	Prego	–	+	+	+	373
#L_8	Caroba	Female	+	+	+	271
#L^6	Figueiredo	Female	+	+	+	252
#L_9	Tafarel	Female	+	+	+	160
#L_{32}	–	–	-	+	+	145
#L_{19}	Chega-mais	–	+	+	+	117
#L_{28}	–	–	-	+	+	82
#L_{10}	Riscadeira	–	+	-	+	65
#L_{12}	Bate-cabeça	Male	+	+	+	59
#L_{21}	–	Female	-	+	+	43
#L_7	Latinha	Female	+	+	+	31
#L_{18}	–	–	+	+	-	19
#L_5	–	–	-	-	+	12
#L_{11}/$_3$	–	Male	+	-	+	9
#L_{35}	Meleca	Female	-	-	+	8
#L_{17}	Chapa-branca	–	-	-	+	7
#L_{20}	–	–	-	+	-	4
#L_{16}	Carochão	Male	+	-	-	3
					Total	2583

Table VII. Individuals of *Tursiops truncatus* that participate of the interactions with the artisanal fishing (*Mugil* spp.) at Imbé/Tramandaí (Rio Grande do Sul), between April and June, 1994.

Catalogue number	Local name	Sex	Frequency
#I_6	Catatau	Female	176
#I_7	–	Female	167
#I^1	Barata	Female	89
#I^5L_{34}	Lobisomem	Male	65
#I^8	–	Female	59
#$L_{11}I_3$	Pomba	Male	42
#I_9	–	–	14
#I_{11}	Geraldona	Female	11
–	Inseto *	–	15
		Total	638

*) Calve of # I_1.

More elaborated interactions between *T. truncatus* and artisanal fishermen were described. FAIRHOLME (1856) reports associations between dolphins and native fishermen at the region of Morenton Bay. The natives would hit the water with their spears and the dolphins would come close herding the mullets. As far as it is known, there were mutual advantages and the natives could recognize each individual dolphin, and would give them names. A similar event was described for Mauritania, where the nomads named Imragens fished mullets (*M. cephalus*) in association with two species of dolphins, *T. truncatus* and *Souza teuszii* (BUSNEL 1973; PELLETIER 1975). As in the preceding case, the natives would hit the water with a club and the dolphins would approximate herding the mullets. The latter two authors disagree partially on the kind of relation involved, which would be something from a commensalism and some kind of mutualism. Other cases of "so called" cooperative fishing were described for the Irrawaddy dolphin, *Orcaella brevirostris*; the Amazon river dolphin, *Inia geoffrensis*; the Ganges river dolphin, *Platanista gangetica*; and Baiji, *Lipotes vexillifer* (respectively, THEIN 1977; LAMB 1954; LOCKYER 1990).

A third group of associations might be considered negative. CATO & PROCHASKA (1976), LEATHERWOOD (1979) and SCHLAIS (1984) investigated the damages caused by *T. truncatus* to fishing lines and nets both at Florida and Hawaii.

CORKERON *et al.* (1990) considered the majority of these dolphin/man fishing associations to be commensalist, but such an interpretation seems too simplistic, since distinct phenomena occur. The relationships of the first and third kind are examples of commensalism and interspecific competition, respectively.

The case studied in Brazil is more elaborated than those previously described. There are complex behavioral sequences, clearly ritualized, and demanding a precise coordination between both parts. In Laguna 20 dolphins (39% of the population) interact with the artisanal fishing of mullets, but there is no such thing as a division between populations of "good and bad dolphins", as suggested by PRYOR *et al.* (1990). All animals interact socially, including courtship and copula. The association is always initiated by the dolphins, while the fishermen await for the right moment.

The results obtained share two aspects with those cases described for Morenton Bay and El-Memghar: a) the resources are seasonal and abundant,

comprising large migrating schools of mullets; b) the events occurred in inshore waters with the presence of natural obstacles and fishermen. The feeding range of *T. truncatus* is extremely wide and its coastal populations tend to specialize in estuary preys. It is usually considered a generalist and opportunist, taking profit of the most abundant preys of the season (GUNTER 1942; NORRIS & PRESCOTT 1961; CALDWELL & CALDWELL 1972; HAMILTON & NISHIMOTO 1977; WELLS *et al.* 1980; IRVINE *et al.* 1981; SHANE 1990b), but BARROS & ODELL (1990) suggest that there is an overestimation of the importance of the mullets, due to hunts and captures on the surface. The mullets are the most explored resource during the interactions in southern Brazil (74.9% Imbé/Tramandaí and 91.9% Laguna). The inshore waters function as a feeding zone, as a refuge and as a recruiting zone for new mullets for the migratory schools.

The behavioral patterns of *T. truncatus* change according to environmental factors and the distribution of preys (SHANE 1990a). The migrating mullets draw together toward the mouth of the estuaries, advancing in smaller schools that follow the inlet's margins. Those schools have a great biomass and high caloric level due to the energy accumulated for migration, but the costs for the predator are usually high. MAJOR (1978) observed that isolated predators have a smaller success if the preys are gathered in schools. A fundamental condition in order to have access to that resource is to minimize the energetic costs. NORRIS & DOHL (1980) mention that species of dolphins with small herds tend to employ specialized patterns for getting food. In the case under study the dolphins gather the mullets against a natural obstacle. The participation of human predators requires intricate behavioral bonds, fixed by means of ritualized sequences. The term ritualized is here used in its simplest sense, when repetitive and stereotyped movements function to reduce ambiguities (KREBS & DAVIES 1987: 332). As an answer to the behavioral sequences the nets are casted and the school is disrupted. Disoriented and isolated fishes are captured with a simple head movement by the dolphins. Many dolphins remain unmoving close to the bottom, exhibiting a strategy that implies in an economy of energy. A number of authors have explored the adaptive value of schools, claiming that isolated preys have their surviving capacity decreased, and that the success of the predator lies in its ability to disorganize the school (BREDER 1967; WILSON 1975; MAJOR 1978). Both the dolphins and the artisanal fishermen take profit in such association. The dolphins capture disoriented preys, utilizing the sit-and-wait tactic (PIANKA 1978: 260). Two conditions assure the success of that strategy: high density and mobility of the preys. The artisanal fishermen are unable to see the mullets in the turbid waters of the estuary and benefit themselves from the resource concentrated by the dolphins. Pairs of species with mutual benefits presuppose a mutualist relation in which the advantages must exceed the costs (*e.g.* BOUCHER *et al.* 1984; BEGON *et al.* 1988). Though the costs are eventual they are not insignificant. The nets are cast just in front of the dolphins, which may cause them to get accidentally entangled in the meshes. During the period of study two such cases of entanglement involving calves were confirmed. Although the dolphins are immediately released, one must consider the "stress" caused by the capture. The fishermen act not only as an obstacle, but as an active barrier, thus striking the preys back. In

southern Brazil the dolphins gather the schools in places where there are fishermen, and not randomly against any barrier at the margin. Fortuitously they perform spyhope behavior, appraising the position of the fishermen along the margins.

The advantages brought by the participation of the dolphins become evident through the increase in the efficiency of capture when compared to independent fishery. The influence of the dolphins was significant in the periods of plentifulness, and decreased in the periods of scarcity, showing that the mutualist bonds are optional. Face the unavailability of resource enough to fulfill food requirements, the association is disadvantageous and becomes hardly perceptible or even absent. Such a case is in accordance with the prevision that the foragers tend to focus their efforts on the best items, specializing in times or sites of plentifulness and generalizing in times or areas of scarcity (MACARTHUR & PIANKA 1966; SCHOENER 1971; KREBS 1979). The preys captured during the interaction were significantly larger than those in independent fishery, showing size selectivity, that is, the association gives access to a more energetic supply than that available to the isolated predator.

A variation in that relation rarely occurs, in which individuals steal fishes from the nets. That is an individual specialization which is done in times of scarcity like the end of the migration of the mullets. Thus, when the resource is limited it is possible to observe sparse cases of interspecific competition. For instance, dolphins #L_{15} and #L_5L_{34} show sepecial skills in that kind of interaction.

ACKNOWLEDGEMENTS. We are grateful to Giselle de S. Paula, Jaqueline de Araujo, Karla Z. Scherer and M.C. Both for his invaluable assistance at the field. Drs. B. Würsig, L. von Fersen, N.B. Barros, K. Pryor, L.M. Herman, A.M. de Araujo, C.O. Diefenbach, M. Marmontel, and F.X. Pelletier kindly helped us with literature. The support of Barddal Fundation and of FAPERGS grant is greatly appreciated. We are indebted the fishermen of Laguna and Imbé who have contributed with many information and with your patience.

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Recebido em 05.VI.1997; aceito em 03.VIII.1998.