

# Incidental catches of dolphins in mid-water trawls for Argentine anchovy (*Engraulis anchoita*) off the Argentine shelf

ENRIQUE A. CRESPO, MARIANO KOEN ALONSO, SILVANA L. DANS, NÉSTOR A. GARCÍA, SUSANA N. PEDRAZA, MARIANO COSCARELLA AND RAÚL GONZÁLEZ\*

Centro Nacional Patagónico and Universidad Nacional de la Patagonia, Blvd. Brown 3600 (9120) Puerto Madryn, Chubut, Argentina

Contact e-mail: kike@cenpat.edu.ar

## ABSTRACT

Information on the incidental mortality of dusky and common dolphins in mid-water trawl fisheries along the Argentine shelf was obtained for the 1990s. The Argentine anchovy is believed to be an under-exploited resource and is usually taken in purse seine fisheries. However, on the few occasions when it was the target species of large mid-water trawlers, anchovy-eating dolphins were incidentally caught. A few incidents accounted for relatively high numbers of dolphins but in most of the cases the information obtained was insufficient for detailed analysis. For three cases, however, sufficient information was obtained to estimate mortality rates. Nevertheless, interpretation of these rates is difficult for a number of reasons. FV *Mar Salvaje* caught around 60 common dolphins (*Delphinus delphis*) in only a few days and in one tow 20 dolphins were caught. Biological information on 18 common dolphins (12 males and 6 females) was obtained and ages ranged from 5-10 for females and 2-18 for males.

KEYWORDS: ATLANTIC OCEAN; SOUTH AMERICA; COMMON DOLPHIN; DUSKY DOLPHIN; INCIDENTAL CATCHES; FISHERIES; TRAWLS

## INTRODUCTION

Interactions between marine mammals and fisheries have been monitored along the coasts of Argentina since the mid-1980s. Previous detailed studies include Pérez-Macri and Crespo (1989) who surveyed the mortality of franciscana (*Pontoporia blainvillei*) in coastal fisheries of Buenos Aires Province; Corcuera *et al.* (1994), Crespo *et al.* (1994a) and Goodall *et al.* (1994) who reviewed all types of interactions between marine mammals and fisheries along the Argentine coasts; and Crespo *et al.* (1997) and Dans *et al.* (1997a) who concentrated mainly on the interactions of marine mammals with the trawl fishery off Patagonia.

During the 1990s, the Argentine fleet of high-sea trawlers comprised some 250 vessels, of which 150 were based in Patagonia. Interactions with several species of marine mammals have been shown for that region, including the dusky dolphin (*Lagenorhynchus obscurus*), Commerson's dolphin (*Cephalorhynchus commersonii*) and the South American sea lion (*Otaria flavescens*). The target species of the trawls were mainly the Argentine hake (*Merluccius hubbsi*) and the Argentine red shrimp (*Pleoticus muelleri*); bycatch species other than marine mammals were also caught.

Argentine hake is caught by bottom trawling; Argentine red shrimp by bottom trawling during daylight and mid-water trawling at night. This latter approach was only used by a few factory vessels (Crespo *et al.*, 1997).

While South American sea lions can become entangled in any kind of trawl, dolphins are usually caught in the mid-water trawls at night with estimated rates of around 70-200 per year for dusky dolphins (Crespo *et al.*, 1997; Dans *et al.*, 1997a). Of this, Crespo *et al.* (1997) had estimated an annual catch of around 54 dusky dolphins by four factory vessels using mid water trawls (estimated rate 0.148 dolphins per fishing day). Thus, even only a small number of vessels using this technique could result in

relatively large catches of dolphins (Dans *et al.*, 1997a; Schiavini *et al.*, 1999). In 1994, mid-water trawls were forbidden in the Argentine red shrimp fishery and dolphin mortality was thought to have decreased. Since then, twin-beam trawlers have been exclusively used for fishing Argentine red shrimp in order to decrease bycatches of Argentine hake. Nevertheless, mid-water trawling is not forbidden for other species such as the Argentine anchovy (*Engraulis anchoita*) or the Argentine shortfin squid (*Illex argentinus*).

During the 1990s, Argentine hake catches were greater than the recommended Total Allowable Catch level, and evidence of overfishing was apparent. In the late 1990s, fishing effort began to be reduced by increasing both temporal and spatial restrictions on fishing. As a consequence, the hake-based industry is looking for alternative targets. In this context, the Argentine anchovy represents an abundant pelagic resource, whose present annual catches (12,000 tonnes) are well below the estimated sustainable maximum annual removal of 155,000 tonnes (Anon., 1999). The fishery has been concentrated traditionally off Buenos Aires Province, using purse seines. Some dolphin mortality in purse seines was recorded in the early 1990s (Corcuera *et al.*, 1994; Crespo *et al.*, 1994a); at least dusky and common dolphins (*Delphinus delphis*) were included.

In recent years, several experimental and commercial mid-water trawling operations for Argentine anchovies were carried out off the Argentine shelf. Although it is not expected that the market for Argentine anchovy will replace that for hake, the species does represent a potential alternative target species, with the consequent possibility of an increase in fishing effort in the near future.

The objective of this paper is to summarise unpublished information regarding the bycatch of dolphins in mid-water trawls conducted for Argentine anchovy with special reference to common and dusky dolphins.

\* Instituto de Biología Marina y Pesquera Alte. Storni, Casilla 104 (8520) San Antonio Oeste, Río Negro, Argentina.

## MATERIALS AND METHODS

### Study area and information gathering

This paper reviews the 1989-99 records of incidental mortality of small cetaceans in mid-water trawls for Argentine anchovies off the Argentine shelf between 38°S and 48°S and between the coast and the 200 n.miles EEZ in which the vessels of the national fleet operate (Fig. 1).

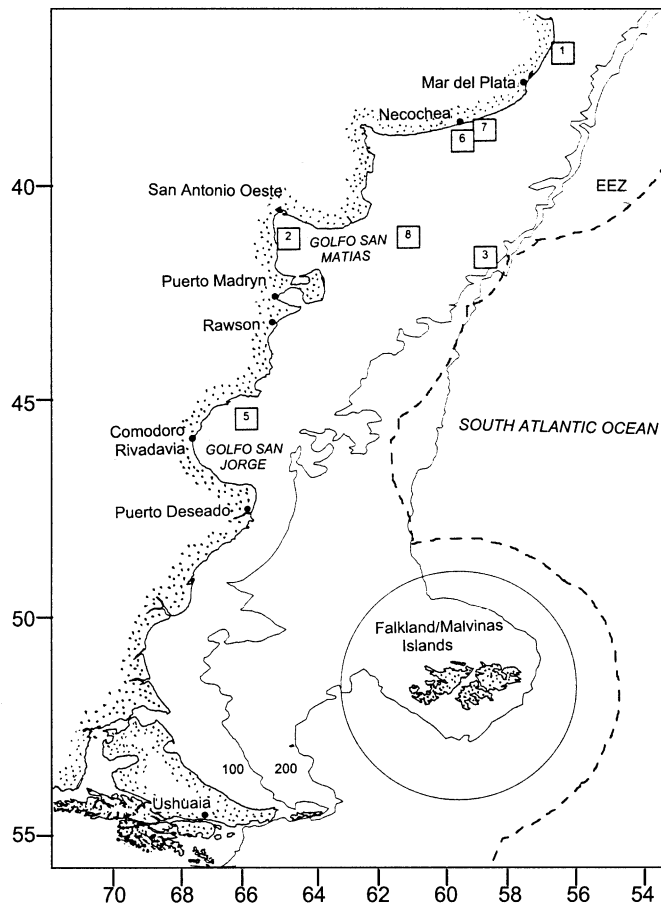


Fig. 1. Location of incidental catch events along the coast of Argentina. The location of event number 4 is unknown.

We have collected information on the incidental mortality of marine mammals in the Patagonian trawl fishery since 1989. This has been obtained from a number of sources including: long-term contacts in fishing companies; interviews with fishermen (captains and officers); and information related to marine resources supplied by the national authorities (Fisheries Secretary and Natural Resources Secretary).

Although most information was related to Argentine hake and red shrimp trawl fisheries, some related to mid-water trawls for Argentine anchovy. These were sporadic and opportunistic and largely dependent on market conditions. A special effort was made to obtain information from these given the previous reports of frequent dolphin bycatches (Crespo *et al.*, 1994a; 1997; Dans *et al.*, 1997a). The quality of information varied by event, but in all cases data were obtained as to whether or not dolphin bycatches occurred. Other information occasionally obtained included relatively detailed data on geographic position, time, depth, weather conditions, species affected, size, and other features of the fishing gear and operations.

In some cases where information was limited, inferences could be drawn from good information for other events. For example, even when the direct causes of entanglements could not be determined, information from one vessel, the FV *Mar Salvaje*, allowed an evaluation of the incidence of certain variables that might have been related to entanglements. This particular vessel operated in two different geographical areas. The northern area (north of 42°S) is mostly influenced by sub-tropical waters, while the southern area (south of 42°S) is mostly influenced by sub-Antarctic waters. Additionally, this vessel used mid-water trawling both during daylight and at night.

For those cases where sufficient information was available, capture rates were calculated. Rates were calculated as number of dolphins per tow or per fishing day. The latter was chosen because it allowed comparisons with previous studies by Crespo *et al.* (1997).

### Biological data

Out of 60 common dolphins caught by the FV *Mar Salvaje*, a total of 18 specimens were collected and frozen on board at -20°C. Necropsies were carried out at the Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata. Standard length was recorded following Norris (1961) and several teeth were collected from each individual for age determination. After decalcifying them in 5% formic or nitric acid, haematoxylin-stained sections 16-18µm thick were obtained (Hohn, 1980; IWC, 1980; Crespo *et al.*, 1994b). Growth layer groups (GLGs) in dentine and cementum were counted, assuming annual deposition. Mammary glands were examined for presence of milk and uterine horns were examined for foetuses.

## RESULTS AND DISCUSSION

Eight occasions of dolphin mortality were recorded for the mid-water trawl anchovy fishery during the 1990s (Table 1 and Fig. 1). The first five records merely reflect that entanglement occurred and have no associated fishing effort data. Of them, the number entangled by FV *Esturión* was particularly high.

However, for three records (Table 1: cases 6, 7 and 8), reliable and detailed information was collected. For these, which occurred in April 1998 and January 1999, a more thorough analysis could be carried out.

### April 1998

Two fishing vessels, the FV *Humbuck* and FV *Harengus*, had been fishing for Argentine hake with bottom trawling nets but the low catches caused both vessels to change the target species to Argentine anchovy for a short period. From 2-13 April 1998, mid-water trawls were used and dusky dolphins were caught during both diurnal and nocturnal trawls (Table 1). The fishing area was between 39°S and 40°S, and depth ranged between 50 and 70m. The mouth of the trawl is usually around 40m high and 40m wide. The FV *Humbuck* completed 41 trawls during the period, while the FV *Harengus* completed between 38 and 44 trawls.

### January 1999

The FV *Mar Salvaje* conducted fishing operations with the Argentine anchovy as the main target species. The vessel employed mid-water nets (mouth *ca* 40mx40m). From 22-31 December 1998, the vessel operated to the south of 42°S and from 1-7 January 1999 it operated to the north. A total catch of 60 common dolphins was recorded, all to the north of 42°S.

Table 1

Records of dolphin bycatch in mid-water fishing operations for southern anchovy off the Argentine shelf. Exact locations are shown in Fig. 1.

Case no.	Date	Vessel	Type of vessel	Species	No. of indiv.	Fishing area	Comments	Source of information
1	1989-1992		Coastal	Delphinids	4	Near Mar del Plata	Presumably <i>Stenella</i> sp.	Bastida <i>et al.</i> 1992
2	October 1995	<i>I de Mayo</i>	Coastal	Dusky dolphin	1	Golfo San Matías	-	Scientist
3	1995	<i>Esturión</i>	Factory	Common dolphin	40	Slope near Golfo San Matías	-	Sailor
4	1995-1998	<i>Poseidón</i>	Factory	Delphinids	?	Unknown	Incidental catch is a common event	Sailor
5	December 1995	<i>Oca Balda</i>	Research	Dusky dolphin	5	Golfo San Jorge	Trials with MWT	Scientist
6	2-13 Apr. 1998	<i>Humback</i>	Factory	Dusky dolphin	5	Near Necochea	-	Captain
7	2-13 Apr. 1998	<i>Harengus</i>	Factory	Dusky dolphin	10	Near Necochea	-	1st Officer
8	1-17 Jan. 1999	<i>Mar Salvaje</i>	Factory	Common dolphin	60	Near Golfo San Matías	-	Fishing inspector

MWT: mid-water trawls.

However, even when detailed information was obtained about the haul characteristics and CPUE values for Argentine anchovy (Table 2), the information on common dolphins catches was not sufficient to estimate a reliable CPUE value for this species.

Table 2

Characteristics of the operations of the FV *Mar Salvaje*, regarding fishing area and time of the operation. Standard deviation given in brackets.

Variable	Time of the tow		Total
	Diurnal	Nocturnal	
South of 42° S			
CPUE(kg/h)	316.43 (478.74)	538.53 (1,199.39)	418.94 (874.58)
Depth (m)	58.43 (16.31)	48.67 (15.25)	53.92 (16.28)
Tow duration (hours)	1.29 (0.68)	1.74 (0.69)	1.5 (0.71)
Speed (knots)	4.51 (0.19)	4.44 (0.12)	4.48 (0.16)
No. of tows	14	12	26
North of 42° S			
CPUE(kg/h)	2,121.72 (2,957.55)	1,286.79 (1,187.49)	1,760.33 (2,382.36)
Depth (m)	40.55(4.14)	39.93 (2.78)	40.28 (3.6)
Tow duration (hours)	1.73 (1.29)	1.89 (0.55)	1.8 (1.03)
Speed (knots)	4.94 (0.59)	4.77 (0.37)	4.86 (0.51)
No. of tows	38	29	67
Total			
CPUE(kg/h)	1,635.68 (2,656.72)	1,067.79 (1,225.36)	1,385.32 (2,155.43)
Speed (m)	45.37 (12.01)	42.49 (9.25)	44.1 (10.92)
Tow duration (hours)	1.61 (1.17)	1.84 (0.59)	1.71 (0.96)
Speed (knots)	4.82 (0.55)	4.67 (0.35)	4.76 (0.48)
No. of tows	52	41	93

Most of the catch of dolphins (80%) occurred during night trawls with the rest during daylight. The proportion of nocturnal hauls was not significantly different from 0.5 (Binomial test  $p = 0.3284$ ), while the proportion of dolphins caught at night was significantly higher (Binomial test  $p < 0.001$ ). Thus, although not conclusive, these results suggest that the bycatch of common dolphins was mostly a night-related phenomenon. In addition, the dolphin bycatches appeared to show a contagious distribution: from 1-3 January 1999, 25 dolphins were caught, most of them (around 20) in the first tow; from 4-5 January another 18 individuals were caught; the remaining 17 dolphins were caught between 6 and 17 January 1999. Although the usual number of individuals caught per tow was reported between 1 and 2, in a few cases this increased to between 8 and 20 individuals. Unfortunately, more detailed information on the number of dolphins caught in each tow was not available.

One probable explanation for the bycatch is that dolphins became entangled whilst feeding inside the net. Although the stomach contents of only three animals have been analysed to date, anchovy comprised between 76-88% of prey items by number. Other prey items included a few pelagic fish and the Patagonian squid (*Loligo sanpaulensis*). If this hypothesis is true, the higher nocturnal dolphin catches could be associated with higher Argentine anchovy abundance during the night. Table 2 summarises CPUE values for Argentine anchovy catches as kg/hour trawling, depth, tow duration and trawling speed. In order to test the former hypothesis, the differences in Argentine anchovy CPUE (transformed as  $\sqrt{\text{CPUE}+1}$ ) were tested by means of a two-way analysis of variance considering diurnal and nocturnal tows, and fishing areas to the north and south of 42°S. Statistical differences were found by area but not time of day (Table 3). Thus, although the abundance of Argentine anchovy was higher to the north of 42°S, where the dolphins were caught, the nocturnal trend in entanglement could not be related to differences in the abundance of Argentine anchovy in the simple manner tested for here, based on the available data.

Table 3

Analysis of variance of CPUE values for anchovy catches of FV *Mar Salvaje*. df: degrees of freedom; MS: mean squares; F: Fisher statistic; p: probability associated with F.

Source of variation	df	MS	F	p
Daytime	1	269.590	0.580	0.448
Area	1	10,047.122	21.620	<0.001
Daytime x Area	1	367.805	0.791	0.376
Error	89	464.722		

#### Comparison between capture rates of cases 6, 7 and 8

Although the available information for cases 6, 7 and 8 are of varying quality, it was sufficient for capture rates to be calculated. FV *Mar Salvaje* capture rates were calculated both for the whole fishing period and for the area to the north of 42°S. High rates of almost nine individuals per day and per vessel were calculated (Table 4). The capture rates for common dolphins were higher than those for dusky dolphins for cases 6 and 7 in April 1998 (Table 5).

In addition, these capture rates are also higher than those estimated for the Argentine red shrimp fishery (0.148 dolphins per day; Crespo *et al.*, 1997). Nevertheless, any comparisons should be treated with caution. Capture rates for Argentine red shrimp nets were calculated on the basis of one fishing vessel monitored for a period of two years. Those

for the FV *Mar Salvaje* were calculated on a single and short period of time. It should also be recognised that the fishing gear for both hake and red shrimp (and indeed Argentine anchovy and Argentine shortfin squid, *Illex argentinus*) is almost identical. With respect to the target species (and when the mid-water trawls are used close to the surface), the same assemblage of species is usually caught. Thus, Argentine squid, anchovies, small hake and red shrimps comprise an assemblage of species in which the proportions of individual species may vary but all are always present (Crespo *et al.*, 1997; Koen Alonso *et al.*, 1998).

Table 4

Capture rates of common dolphins in FV *Mar Salvaje*, from 22 December 1998 to 17 January 1999.

Date	Area	Depth	No. of dolphins	
			per day	per tow
22-31 Dec. 1998	42°S-47°S	22-94m	0.000	0.000
1-3 Jan. 1999	41°S-42°S	39-48m	8.333	1.667
4-5 Jan. 1999	40°S-41°S	35-49m	9.000	2.250
6-17 Jan. 1999	39°S-41°S	32-58m	1.545	0.386
Whole trip	39°S-47°S	22-94m	2.308	0.645

Caution should also be exercised when comparing capture rates, given the differences between fishing areas and seasons. At present there is insufficient information to test for this. Most dolphin captures (cases 1-3, 6-8) occurred in the transition zone between the opposing flows of sub-tropical and sub-Antarctic water masses (33°-39°S). By contrast, case 5 was located in an area (south of 39°S) which is more under the influence of sub-Antarctic water masses (Boltovskoy, 1986; Gayoso and Podestá, 1996; Crespo *et al.*, 1998). Thus, some differences may be related to the fishing area where the entanglements took place. Similarly, there is insufficient information to examine for seasonal events. Five cases occurred between October and April ('summer conditions') whilst there is no precise information on season for the remaining cases (Table 1).

#### Age and sex composition of the catch of common dolphins

Of the 60 animals caught by the FV *Mar Salvaje*, biological information was available for 18 (12 males and 6 females); it is not possible to determine whether these are representative of the 60 animals. The difference in sex ratio was not statistically significant from parity (Binomial test  $p=0.238$ ). The standard length of the females ranged between 174 and 210cm and their weight between 67 and 102kg. The standard length of males ranged between 170 and 219.5cm and their weight between 56 and 138kg (Table 6). With respect to age, the females ranged between 5 and 10 years old, while the males showed a wider range between 2

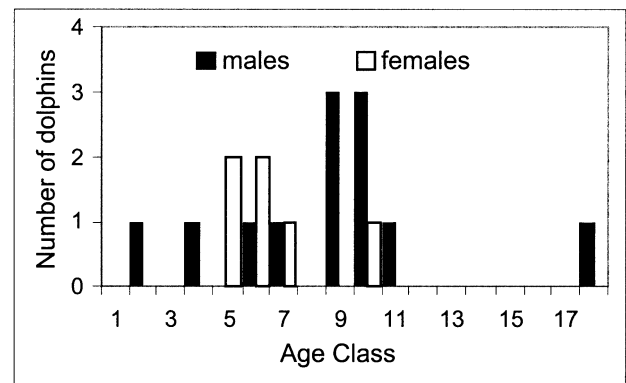


Fig. 2. Age and sex composition of the collected sample of common dolphins ( $n=18$ ) caught in mid-water trawls for southern anchovies by the FV *Mar Salvaje* during January 1999, off northern Patagonia.

and 18 years old (Fig. 2). Within this small sample size there was a higher proportion of males between 9 and 10 years. No foetuses or lactating females were caught and histological analysis revealed no corpora lutea.

Although the sample is small, it does suggest differences in age and sex composition from the dusky dolphins affected by mid-water trawls for Argentine red shrimp. In the latter case, females predominated (around 70%) and their average age was  $5.9 \pm 2.1$  (Crespo *et al.*, 1997; Dans *et al.*, 1997a; b). In the present case no sex predominates in the sample and the age distribution is widely spread.

Table 6

Size and age data of common dolphins incidentally caught by FV *Mar Salvaje* using mid-water trawls for anchovies, in January 1999, in northern Patagonia.

Field number	Sex	St. length (cm)	Weight (kg)	Age (GLGs)
Dd145	F	174	67.65	5
Dd147	F	182	68.10	5
Dd141	F	188.5	79.00	6
Dd138	F	191	86.26	6
Dd143	F	198	90.80	7
Dd135	F	210	102.15	10
Dd149	M	170	56.30	2
Dd142	M	192	79.45	4
Dd146	M	196	95.34	6
Dd148	M	187	86.26	7
Dd137	M	200	113.95	9
Dd136	M	209	90.80	9
Dd134	M	212	117.59	9
Dd139	M	192.5	102.15	10
Dd140	M	197	103.06	10
Dd144	M	206	90.80	10
Dd150	M	219.5	138.47	11
Dd133	M	210	124.85	18

Table 5

Capture rates of dolphins for Cases 6, 7 and 8 (see Table 1).

Case	Vessel	Date	Area	Depth	No. of dolphins	
					per day	per tow
6	<i>Humback</i>	2-13 Apr. 1998	39°S-40°S	50-70m	0.417	0.122
7	<i>Harengus</i>	2-13 Apr. 1998	39°S-40°S	50-70m	0.833	0.227-0.263
8	<i>Mar Salvaje</i>	22 Dec.1998-17 Jan.1999	39°S-47°S	22-94m	2.308	0.645
		1-17 Jan. 1999	39°S-42°S	32-58m	3.750	0.896

## CONCLUSIONS AND RECOMMENDATIONS

Efforts to monitor marine mammal mortality in trawl fisheries have been considerably less than for other fishing gear (e.g. purse seines, gillnets) and the extent of the problem has probably been underestimated (Fertl and Leatherwood, 1997). In the North Atlantic, Couperus (1997) reported white-sided dolphin (*L. acutus*) catches in the Dutch mid-water trawl fishery for mackerel (*Scomber scombrus*) and Northridge (1984) reported common dolphins caught in mid-water trawls for sardines (*Sardina pilchardus*) and mackerel (*Scomber japonicus*). Thus, the available data suggest that bycatches in mid-water trawls are potentially a serious problem that requires thorough evaluation. This gear appears to affect mainly small cetaceans such as common dolphins and those of the genus *Lagenorhynchus*.

The few events recorded in this paper occurred when the trawl fishery was almost completely directed towards Argentine hake and Argentine red shrimp. Occasionally, in the absence of the main target species and under specific market conditions, the target species changed to Argentine anchovy with pelagic nets. This situation changed in the late 1990s when Argentine hake was depleted and temporal and spatial restrictions were imposed in order to reduce the fishing effort.

Given this background, some fishing companies began to increase catches of Argentine anchovy, which at present is considered an under-exploited resource. Clearly, if mid-water trawl effort for the Argentine anchovy is going to increase, this represents a potential risk to those small cetacean species, such as the dusky and common dolphin, that feed on anchovy.

Therefore, the authorities should seriously consider the possible impact on dolphin populations when developing fishery management models for Argentine anchovy or similar pelagic species, such as the mackerel.

From a management perspective, a number of possible strategies are apparent, e.g.:

- (a) determine whether dolphin schools are present before fishing for Argentine anchovies using mid-water trawls;
- (b) do not deploy the nets if dolphins are present, especially at night;
- (c) if dolphins are entangled, change the fishing area.

With respect to research recommendations, it is clear that the Fishery Agency should begin to systematically collect information on dolphin catches as part of an observer programme and to recover dolphin carcasses for biological studies. In the longer term it is important to establish a research programme in order to assess the impact of bycatches on the relevant cetacean populations (e.g. see Donovan, 1994).

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