

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

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## ABSTRACT

Incidental mortality of dusky and common dolphins was recorded on mid-water trawls in the coasts of the Argentine shelf during the 1990's. Argentine anchovy is an under-exploited resource among the Argentine fisheries which is usually taken in purse-seine fisheries. However in few occasions in which it was the target species of large mid-water trawlers, anchovy-eating dolphins were incidentally caught. Few events accounted for a high number of individuals but in most of the cases the information gathered was scarce to make any prognosis. In three cases (FV *Humbuck*, *Harengus* and *Mar Salvaje*) the information was enough to calculate mortality rates for the fishing period. Nevertheless those rates could be biased as a consequence of the short period considered. FV *Mar Salvaje* caught around 60 common dolphins (*Delphinus delphis*) in few days with one tow with 20 individuals. 18 common dolphins were recovered and they included 12 males and 6 females. Age composition of the herd was 5-10 for females and 2-18 for males.

KEY WORDS: ATLANTIC OCEAN, SOUTH AMERICA, COMMON DOLPHIN, *DELPHINUS DELPHIS*, DUSKY DOLPHIN, *LAGENORHYNCHUS OBSCURUS*, INCIDENTAL CATCHES, FISHERIES, TRAWLS

## INTRODUCTION

Interactions between marine mammals and fisheries have been monitored along the coasts of Argentina since the middle 1980's. Previous and 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) described 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 in the interactions of marine mammals with the trawling fishery off Patagonia.

During the 1990's, the Argentine fleet of high-sea trawlers was composed approximately by 250 vessels. Of them, 150 were based on Patagonia which showed interactions with several species of marine mammals. The interacting species included the dusky dolphin (*Lagenorhynchus obscurus*), the 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*) along with other by-catch species. Argentine hake is caught by bottom trawling, while Argentine red shrimp used to be caught by bottom trawling during daylight and mid-water trawling during night. Usually, mid-water trawls at night were employed by few factory vessels, which alternated their fishing gears between bottom trawling during daylight and mid-water trawling during night (Crespo *et al.*, 1997).

While the South American sea lions become entangled in any kind of trawl, the dolphins get entangled mostly in mid-water trawls at night with rates considered to be around 70-200 per year for dusky dolphins (Crespo *et al.*, 1997; Dans *et al.*, 1997a). From this figure, around 54 dusky dolphins per year corresponded exclusively to mid-water trawls performed by four factory vessels with an estimated catch rate about 0.148 dusky dolphins per fishing day using this gear (Crespo *et al.*, 1997). This fact indicates that few vessels using mid-water trawling could produce important numbers of dolphin catch (Dans *et al.*, 1997a; Schiavini *et al.*, 1999). However, the mid-water trawls were forbidden during 1994 to be used for fishing Argentine red shrimp and mortality was thought to have decreased. Since then, twin-beam trawlers were exclusively used for fishing Argentine red shrimp in order to decrease the by-catch of Argentine hake.

Nevertheless, mid-water trawls can be used for other species like Argentine anchovy (*Engraulis anchoita*) or Argentine shortfin squid (*Illex argentinus*).

The Argentine hake continued to be exploited during the 1990's over the recommended TAC and showed evidence of overfishing. In the late 1990's fishing effort started to be reduced by means of the increase of temporal and spatial restrictions for fishing. As a consequence, the Argentine hake based industry is looking for alternative targets. Argentine anchovies represent a very abundant pelagic resource, which is under-exploited. Annual catches (12,000ton/year) are far below the sustainable maximum annual removal (155,000ton/year) (Anonymous, 1999). Fishing operations for Argentine anchovies have been concentrated traditionally off Buenos Aires Province, using purse-seines. Dolphin mortality was recorded in the early 1990's associated to the purse-seines (Corcuera *et al.*, 1994; Crespo *et al.*, 1994a) in which at least dusky and common dolphins *Delphinus delphis* were included.

Nevertheless, during the past few years and due to market opportunities, several experimental and commercial hauls for Argentine anchovies were carried out off the Argentine shelf by mid-water trawling. Even it is not expected that the Argentine anchovy will replace the Argentine hake markets, this fact indicates that this species may represent an alternative target species, consequently leading to a potential increase in the fishing effort in the next future.

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

## MATERIALS AND METHODS

### Study area and information gathering

Since 1989, we have been recording the events of incidental mortality of marine mammals in the trawling fishery of Patagonia. This information is obtained by long-term contacts with fishing companies, interviews to the fishermen (captains and officers), shipments and information supplied by national authorities related to marine resources (Fisheries Secretary and Natural Resources Secretary). Most of the information obtained is related to the trawling fishery conducted for fishing Argentine hake and Argentine red shrimp. During this period, some trawls were conducted for Argentine anchovy using mid-water trawling. These mid-water trawls were sporadic and opportunistic, depending mostly on the market conditions. When these events took place we concentrated efforts in order to obtain information about them because the previous reports indicated that dolphin by-catch was frequent in mid-water trawls (Crespo *et al.*, 1994a; 1997; Dans *et al.*, 1997a). The information quality regarding these events was different in each case. In all cases we obtained data about the occurrence or not of dolphin by-catches, but in some cases we could obtain a relatively detailed data about geographic position, time, depth, weather conditions, species affected, size and other features of fishing gear, etc.

In this context and during the 1989-1999 period, the records of incidental mortality of small cetaceans in mid-water trawls for Argentine anchovies were surveyed off Argentine shelf between 38°S and 48°S and between the coast and the 200nm EEZ in which the vessels of the national fleet operate (Fig. 1).

Data were analysed as deeply as possible depending on the quality of the information obtained. Even when the proximal causes of the entanglements could not be determined, the FV *Mar Salvaje* case allowed to evaluate the incidence of some variables possibly related to the entanglements. This vessel operated in two different geographical areas: to the north of 42°S and to the south of this latitude. The northern area is mostly influenced by subtropical waters, while the southern one is mostly influenced by subantarctic waters. Additionally, this vessel employed mid-water trawling both during daylight and night.

In those cases that had enough amount and quality of information, capture rates were calculated. These rates were calculated as number of dolphins per tow or per fishing day. This last level of detail was chosen because it allowed comparisons with previous studies (Crespo *et al.*, 1997).

### Biological data of the catch

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. The sample was stored at the Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, where the necropsies were carried out. 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 to 18µm thick were obtained (Crespo *et al.*, 1994b; Hohn, 1980; Perrin and Myrick, 1980). Growth layer groups in dentine and cementum were counted, assuming annual deposition. Mammary glands were examined for presence of milk production and uterine horns were examined in order to search for foetuses.

## RESULTS AND DISCUSSION

Eight events were recorded regarding mortality of dolphins in mid-water fishing operations conducted for Argentine anchovies during the 1990's. Table 1 summarises this information and Figure 1 shows the locations for these events.

The first five of those records lack of essential information on fishing operations and they simply take account of the events of entanglement. Among those, the number of individuals entangled by FV *Esturión* was considerably high even it is not known the total number of days in which the vessel was fishing and the number of tows in which the dolphins were entangled.

Three of those events (Table 1: cases 6, 7 and 8) were closely controlled and more precise information was gathered. For those events, which occurred during 1998 and 1999, a deep analysis was conducted.

#### **Catches occurred in April 1998 in FV *Humbuck* and FV *Harengus***

Both fishing vessels were operating for Argentine hake with bottom trawling nets. The low catches of Argentine hake leaded both vessels to redirect the target species from Argentine hake to Argentine anchovy during few days. From 2 to 13 April 1998 mid-water trawls were used for Argentine anchovies and dusky dolphins were caught in those fishing operations (Table 1) both during diurnal and nocturnal trawls. The fishing area was between 39°S and 40°S and depth ranged between 50 and 70m. The mouth of this net is usually around 40m high and 40m wide. FV *Humbuck* completed during this period 41 trawls, while FV *Harengus* between 38 and 44 trawls.

#### **Catches occurred in January 1999 in FV *Mar Salvaje***

FV *Mar Salvaje* conducted fishing operations with the Argentine anchovy as the main target species. The vessel conducted operations between 22 December 1998 and 17 January 1999. The vessel employed mid-water nets with mouth around 40m high and 40m wide. Between 22 December 1998 and 31 December 1998 the vessel operated to the south 42°S and since 1 January 1999 to the north. During that period it was recorded the incidental catch of 60 common dolphins, all of which were caught to the north of 42°S.

Even when detailed information was obtained about haul characteristics and CPUE values for Argentine anchovy (Table 2), the information about common dolphins catches was less precise and avoided the estimation of CPUE for this species.

Most of the catch of dolphins (80% of the individuals) occurred during trawls at night while the remaining entanglements occurred during the day. The proportion of nocturnal hauls for Argentine anchovy was not significantly different from 0.5 (Binomial test  $p=0.3284$ ), while the proportion of dolphins caught at night was significantly higher than this figure (Binomial test  $p<0.001$ ). Then, even when it is not conclusive, these results suggest that the by-catch of common dolphins was mostly a night related phenomenon. Additionally, dolphin by-catches appear to present a contagious distribution. Between 1 January 1999 and 3 January 1999, 25 dolphins were caught, most of them (around 20) in the first tow. Between 4 January 1999 and 5 January 1999 another 18 individuals were caught. The remaining 17 dolphins were caught between 6 January 1999 and 17 January 1999. The number of individuals caught per tow was between 1 and 2. Nevertheless, few tows reached between 8 and 20 individuals. More detailed information about the number of dolphins caught in each tow could not be obtained.

Therefore, the former results suggest that dolphin by-catches were associated to nocturnal operations. One probable explanation could be that dolphins get entangled while feeding inside the net. 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 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. Data were transformed as:  $\sqrt{CPUE+1}$  to accomplish the ANOVA assumptions. Results indicate statistical differences in CPUE values between areas but not between diurnal and nocturnal tows (Table 3). In other words, the abundance of Argentine anchovy was higher to the north of 42°, where the dolphins were caught, but the trend of dolphins to get entangled at night could not be related to differences in the abundance of Argentine anchovy.

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

Even that the available information between cases 6, 7 and 8 is of different quality, capture rates could 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. Very high rates reaching almost 9 individuals per day and per vessel were calculated (Table 4). In those cases the capture rate of common dolphins was higher when compared to incidental catch of dusky dolphins in April 1998 (cases 6 and 7) (Table 5).

Furthermore, capture rates in Argentine anchovy nets are also higher to those obtained in Argentine red shrimp nets (0.148 dolphins per day) (Crespo *et al.*, 1997). Nevertheless, those comparisons should be considered 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 estimated here for the FV *Mar Salvaje* were calculated on a single and short period of time. At first sight it could be thought that two variables are implicit in this comparison: the fishing gear and the target species but in fact this is only apparent. The pelagic (mid-water) nets are or have been used for catching Argentine red shrimp, Argentine shortfin squid (*Illex argentinus*), Argentine anchovy or Argentine hake. The fishing gear is almost the same. Regarding the target species and when the mid-water trawls are used close to the surface of the sea, in most cases the

same assemblage of species seems to be caught. In other words Argentine squids, Argentine anchovies, small Argentine hakes and Argentine red shrimps perform a group of species in which any of its components could be in a higher concentration but seems to be always associated with the remaining ones (Crespo *et al.*, 1997; Koen Alonso *et al.*, 1998).

Caution should also be taken when making comparisons between capture rates because there are differences between the fishing areas and the season for fishing. In the present cases there is not enough information to test this kind of differences. Most of the dolphin captures were located in a transition zone between the opposing flows of subtropical and subantarctic water masses (33° to 39° S) for cases 1, 2, 3, 6, 7 and 8. Case 5 was located in an area which is more under the influence of subantarctic water masses (39°S to the south) (Boltovskoy 1986, Gayoso and Podestá 1996, Crespo *et al.*, 1998). Therefore it could be some difference due to the fishing area where the entanglements took place. Regarding the fishing season again there is no much information to conclude about. Five of the events took place between October and April in what can be defined as “summer conditions”. The remaining three lack of the precise season of the year in which the dolphins were caught.

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

The sample studied from the FV *Mar Salvaje* catches included 12 males and 6 females but the difference from parity was not statistically significant (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). Regarding age composition, the females ranged between 5 and 10 years old, while the males showed a wider range between 2 and 18 years old (Fig. 2). Even the small sample size there was a higher proportion of males between 9 and 10 years. There were found neither foetuses nor lactating females. Corpora lutea were not found in histological analysis.

Even the sample is small, the age and sex composition seems to be different from the age and sex classes of dusky dolphins affected by mid-water trawls for Argentine red shrimp. For dusky dolphins females were mostly affected (around 70%) and the average age of females was  $5.9\pm 2.1$  (Crespo *et al.*, 1997; Dans *et al.*, 1997a and b). In the present case none sex predominate in the sample and the age distribution is widely spread.

### **CONCLUSIONS AND RECOMMENDATIONS**

Mortality rates on marine mammals in trawlers have been less surveyed than other fishing gear like purse seines or gillnets and probably underestimated (Fertl and Leatherwood, 1997). Incidental catch of dolphins in mid-water trawling nets seems to be a serious problem to be evaluated deeply. This fishing gear seems to affect mainly small cetaceans like common dolphins and those of the genus *Lagenorhynchus*. A similar situation was recorded with the white-sided dolphins *L. acutus* which are caught in the Dutch mid-water trawl fishery for mackerel (*Scomber scombrus*) in the north Atlantic Ocean (Couperus, 1997). The incidental catch of common dolphins was also reported in mid-water trawling for sardines (*Sardina pilchardus*) and mackerel (*Scomber japonicus*) in the eastern Central Atlantic (Northridge, 1984).

The few events recorded in this paper were gathered when the trawling fishery was almost in full dedicated to fish Argentine hake and Argentine red shrimp. Occasionally and in the absence of the main target species and to opportunistic market conditions, trawlers dedicated to the catch of Argentine anchovy with pelagic nets. Those conditions changed in the late 1990's when Argentine hake was depleted and temporal and spatial restrictions were imposed in order to reduce the fishing effort.

Within this background, some fishing companies started to increase the catch of Argentine anchovy. This species is in present days an under-exploited resource. If the catches of Argentine anchovy are going to increase, there exists a potential risk of high rates of mortality for those small cetacean species, which like the dusky or the common dolphin are anchovy-eating species.

Furthermore, this fact should lead to the authorities to consider seriously the impact on dolphin's populations and to include the impact on fishery management models for Argentine anchovy or similar pelagic species, like the mackerel *Scomber japonicus*.

Tentatively the following management recommendations should be taken into account:

- a) Verify the presence of dolphin herds when fishing for Argentine anchovies with mid-water trawls
- b) Do not soak the net in the water if dolphins are present especially at night
- c) If individual dolphins get entangled move from the fishing area

Within research recommendations the Fishery Agency should start to collect basic systematic information on dolphin catches as part of the observer programs as well as recover dolphin carcasses for biological studies.

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Table 1

Records of dolphin by-catch in mid water fishing operations for southern anchovy off the Argentine shelf

Event N°	Date	Vessel	Type of vessel	Species	N° of indiv.	Fishing area	Comments	Source of information
1	1989-1992		Coastal Vessel	Delfinids	4	In front of Mar del Plata	Presumably <i>Stenella</i> sp.	Bastida <i>et al.</i> 1992
2	October 1995	<i>1 de Mayo</i>	Coastal Vessel	L.o.	1	Golfo San Matías	-	Scientist
3	1995	<i>Esturión</i>	Factory vessel	D.d.	40	Slope in front of Golfo San Matías	-	Sailor
4	1995-1998	<i>Poseidón</i>	Factory vessel	Delfinids	?	Unknown	Incidental catch is a common event	Sailor
5	December 1995	<i>Oca Balda</i>	Research vessel	L.o.	5	Golfo San Jorge	Trials with MWT	Scientist
6	2 April 1998 to 13 April 1998	<i>Humbuck</i>	Factory vessel	L.o.	5	In front of Necochea	-	Captain
7	2 April 1998 to 13 April 1998	<i>Harengus</i>	Factory vessel	L.o.	10	In front of Necochea	-	1st Officer
8	1 Jan. 1999 to 17 Jan. 1999	<i>Mar Salvaje</i>	Factory vessel	D.d.	60	In front of Golfo San Matías	-	Fishing Inspector

Ref: P.s. Burmeister's porpoise, C.c.: Commerson's dolphin, L.o.: dusky dolphin, D.d.: common dolphin, MWT: mid-water trawls. Locations are shown in Fig. 1.

Table 2

Mean features of the tows carried out by FV *Mar Salvaje*, regarding fishing area and time of the operation. Standard deviation between brackets.

		Time of the Tow		
Area	Variable	Diurnal	Nocturnal	Total
South of 42° S	CPUE(kg/h)	316.43 (478.74)	538.53 (1199.39)	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)
	N° of Tows	14	12	26
North of 42° S	CPUE(kg/h)	2121.72 (2957.55)	1286.79 (1187.49)	1760.33 (2382.36)
	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)
	N° of Tows	38	29	67
Total	CPUE(kg/h)	1635.68 (2656.72)	1067.79 (1225.36)	1385.32 (2155.43)
	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)
	N° of Tows	52	41	93



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	10047.122	21.620	<0.001
Daytime x Area	1	367.805	0.791	0.376
Error	89	464.722		

Table 4

Capture rates of common dolphins (*Delphinus delphis*) in FV *Mar Salvaje*, from 22 December 1998 to 17 January 1999

Date	Area	Depth	Dolphins per day	Dolphins 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

Table 5

Capture rates of dolphins for events 6, 7 and 8

Event	Vessel	Date	Area	Depth	Dolphins per day	Dolphins per tow
6	<i>Humback</i>	2 - 13 April 1998	39°S - 40°S	50-70m	0.417	0.122
7	<i>Harengus</i>	2 - 13 April 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

Table 6

Size and age data of common dolphins (*Delphinus delphis*) 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

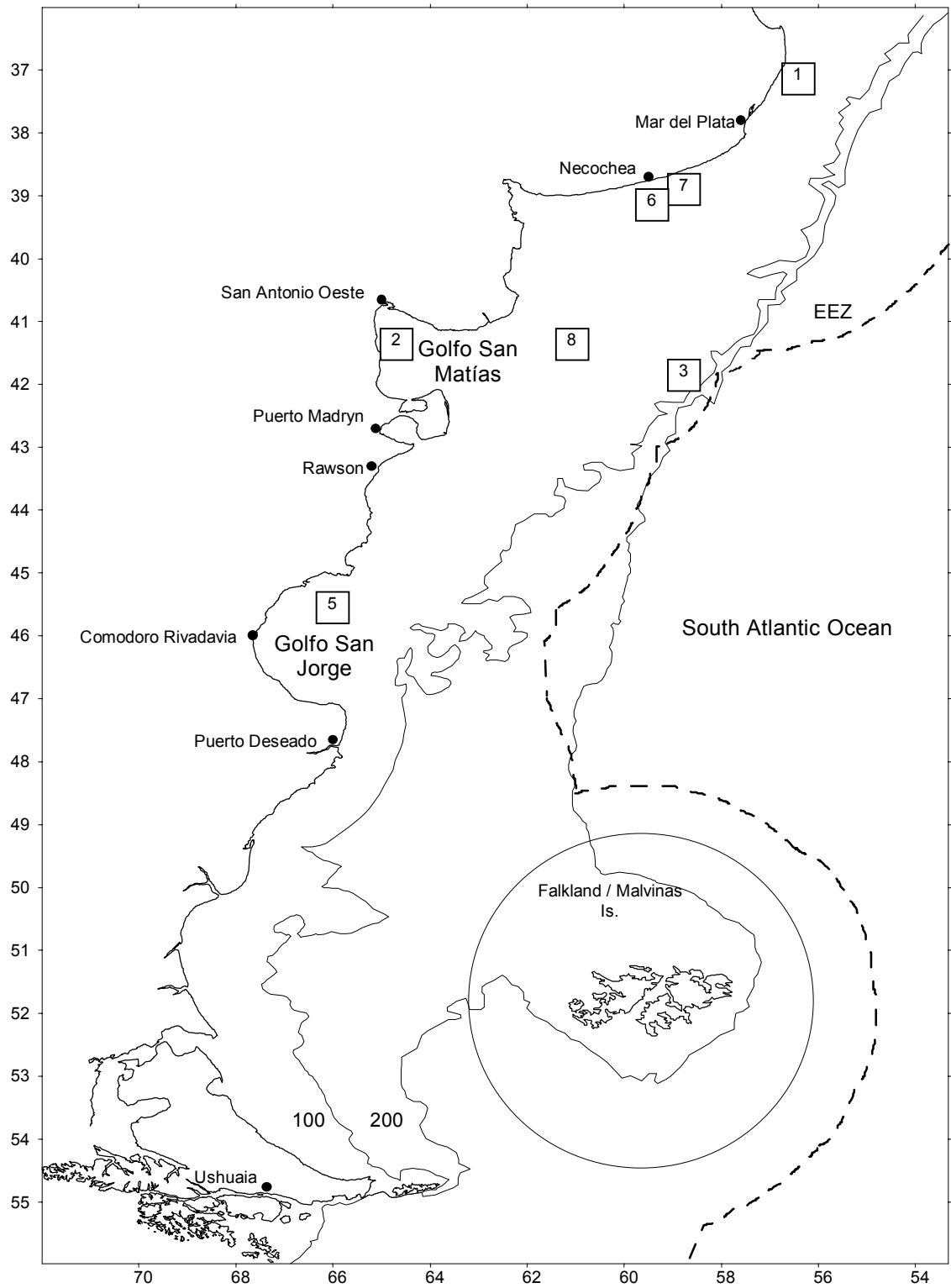


Figure 1. Location of incidental catch events along the coast of Argentina. The location of event number 4 is unknown.



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