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Spanish driftnet fishing and incidental catches in the western Mediterranean

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Abstract

The Spanish driftnet fishery operating since 1994 on the Mediterranean side of the Gibraltar Straits was an illegal activity whose main target was the swordfish *Xiphias gladius* but which also caught other species incidentally, particularly sunfish *Mola mola*. Observations during the 1993 and 1994 seasons showed that the fleet was composed of 27 boats deploying nets 3–4 km long. Swordfish constituted 7% of the catch in 1992, 5% in 1993 and 7% in 1994. Sunfish represented 71% of the catch in 1992, 93% in 1993 and 90% in 1994. Sea turtles, mainly loggerhead turtles *Caretta caretta*, constituted 0.32% of the total catch in 1993 and 0.92% in 1994. The incidental capture of small cetaceans, composed entirely of common dolphins *Delphinus delphis* in 1992 and of striped dolphin *Stenella coeruleoalba* and common dolphins in roughtly equal proportions in 1993 and 1994, constituted 0.9% of the catch in 1992, 0.6% in 1993 and 1% in 1994. The bycatch rate of dolphins was 0.1 individuals per km of net set. The total catch of dolphins can therefore be estimated at 366 (95% confidence interval 268–464) animals for the 1993 fishing season and 289 (CI 238–340) for that of 1994. If these figures are added to the undetermined catches of dolphins by the Italian and Moroccan driftnet fleets also operating in the region, it is possible that these catches are not sustainable.

Keywords: Striped dolphin; Common dolphin; Driftnet fishery; Bycatch; Southwestern Mediterranean

1. Introduction

The mortality associated with incidental catches in fishing gear is a major cause of concern for the conservation of cetaceans, sea turtles, marine birds, and some non-commercial fish species. In particular, offshore-drift nets have attracted attention in recent years as they give rise to an abundant bycatch, particularly of marine mammals (Perrin et al., 1994). Driftnets are gillnets which are left to drift and which act as passive filters that entangle a wide range of wild organisms, both target and non-target. Gillnets of limited size have been in worldwide use for centuries in inshore waters, but since the 1950s the use of synthetic fibres has allowed the production of very long nets. The large scale use of this gear has led to the killing of massive numbers of marine mammals and other non-target species in diverse regions, for which reason in 1991 the United Nations General Assembly adopted a series of resolutions establishing a worlwide moratorium on driftnet fishing (Richards, 1994).

In the Mediterranean Sea, where fishing activities are particularly intense, this resolution was not enforced and the conflicts between marine mammals and the driftnet fisheries multiplied (Collet, 1983; I.W.C., 1992; Di Natale and Notarbartolo-di-Sciara, 1994). In the Alboran Sea, situated in the western basin of the western Mediterranean, traditional fisheries have been responsible for many years for the killing of numerous dolphins (*Stenella. coeruleoalba*, *Delphinus delphis* and *Tursiops truncatus*) and, to a more limited extent, killer whales *Orcinus orca*, baleen whales *Balaenoptera physalus*, and even monk seals *Monachus monachus* (Silvani, 1993).

Because of the unregulated nature of most driftnet fisheries, the information describing their operational characteristics and associated bycatch is limited. This is particularly true for the Alboran Sea region, where no studies have been made until recently to determine the magnitude of incidental catches of cetaceans. This brought the International Whaling Commission (I.W.C.)

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repeatedly to urge research on and monitoring of these operations in order to obtain reliable estimates of bycatches and of their impact on affected populations (I.W.C., 1992, 1995).

This paper presents the results of a survey carried out on the Spanish driftnet boats during the 1992, 1993 and 1994 fishing seasons. This fleet stopped its activity in 1994.

The Spanish driftnet fleet operated on both the Atlantic and the Mediterranean sides of the Gibraltar Straits following the seasonal migration of the swordfish *Xiphias gladius*. From April to mid-June, their activities were concentrated in the Atlantic waters off the coasts of Morocco (Cape Espartel). From mid-June to mid-July, they operated on both sides of the Gibraltar Straits. From mid-July to the end of August operations were limited to the Mediterranean and from September to the beginning of November fishing took place in the Atlantic waters adjacent to the Gibraltar Straits. During the rest of the year, the boats were involved in other types of fishing. Our study focused on the main Mediterranean operation (i.e. from mid-July to the end of August), where preliminary information indicated that the conflict with dolphins was greatest.

In the Mediterranean, the main fishing grounds were located close to the Gibraltar Straits and its adjacent waters, mainly in the area known as 'La Tunara', which occupies the waters 5–20 km east of Point Europe (Fig. 1).

2. Methods

2.1. Observers' program

As the use of driftnets has been illegal in Spain since 1991, fishermen were contacted directly by researchers in 1992 and persuaded to place trained observers on board their vessels. On each fishing trip observers recorded data on three aspects: (1) data about the boat and the operational aspects of the fishing activity; (2) species, length, sex (only in cetaceans), condition (alive/dead), fate (used or discarded), and other details regarding the capture of both target and non-target organisms; and (3) location, species, school size, and behaviour of cetaceans sighted.

The 1992 survey was merely preliminary and as only 13 fishing sets were monitored in that year, accurate estimations could not be made. However, full data were obtained for 1993 and 1994 (Table 1).

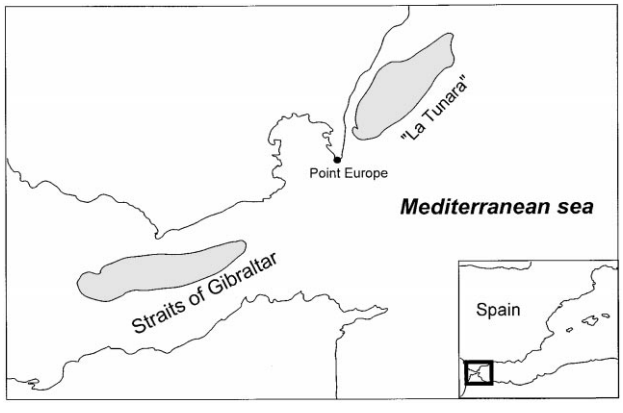

Fig. 1. Main fishing grounds (hatched areas) of the Spanish driftnet fleet on both the Atlantic and Mediterranean sides of the Gibraltar Straits.

2.2. Fishing effort

Again, given the unregulated nature of operations, no data on effort were available from the Spanish official fishing statistics. Therefore, the information about the activity of the fleet collected by the observers was used to estimate the total number of fishing operations carried out during the season. Taking into account that for 25% of the fishing season the fleet cannot operate due to adverse weather conditions, i.e. east winds blowing, the estimated number of sets (TS) was obtained as:

$$TS = \text{total number of effective fishing days} \times \text{total number of boats}$$

On the Mediterranean side of the Gibraltar Straits, the length of the net set is limited by the strong prevailing currents and the lack of space for setting nets in what is a vessel-crowded area. With these restraints, the fleet operations were largely homogeneous in terms of the gear used, and the total fishing effort deployed by the driftnet fleet each year (*TE*, expressed as km of net set) may be calculated from the fishing trips monitored by the observers as follows:

$$TE = \text{total number of sets} \times \text{mean length of the net}$$

2.3. Number of incidental catches

Estimates of incidental catches of dolphins were made following the ratio method (Scheaffer et al., 1986), a technique previously applied in the North Pacific

Table 1
Operational traits of the fishing seasons surveyed

Year	Fishing season	Total fleet	Estimated number of sets	No. of monitored boats	No. of monitored sets
1993	22 July–31 August	27	830	4	27
1994	25 July–19 August	27	531	7	54

high seas driftnet fisheries (Hobbs and Jones, 1991). Confidence intervals for these estimates were calculated using the variance estimate ($\hat{V}$) of the ratio method:

$$\hat{V}(\hat{\tau}_y) = \hat{t}_x^2\left(\frac{1}{n}\right)\left(\frac{1}{x^2}\right) - \frac{\sum_{i=1}^{n}(y_i - rx_i)^2}{n-1}$$

with

$$r = \frac{\sum_{i=1}^{n} y_i}{\sum_{i=1}^{n} x_i}$$

where x is length (km) of net set, y is the number of dolphins caught, $\tau_x = TE$ and $\hat{\tau}_y = r\tau_x$

2.4. Composition of dolphin incidental catches

The length and sex of the dolphins caught incidentally were studied to determine which segment of the population was most heavily affected by the fishery. Given the sensitive nature of the dolphin captures, fishermen returned the carcasses to the sea almost immediately. Therefore, complete necropsies could not be carried out. Sex and length, however, were determined for all specimens caught, and these data were used to assign growth categories to the corpses examined.

Detailed information is available for on the length-related parameters of the western Mediterranean population of striped dolphins *Stenella coeruleoalba* (Aguilar, 1991; Calzada and Aguilar, 1995; Calzada et al., 1996). The length of neonates has been established at 95 cm, that of weaning at 165 cm, and that of attainment of sexual maturity at 187 cm for females and 190 cm for males.

Unfortunately, no comparable information is available for Mediterranean common dolphins *Delphinus delphis*. Because body length differs markedly between populations (Perrin, 1984), length-related parameters could not be extrapolated from conspecific populations. However, striped and common dolphins in the western Mediterranean have almost identical maximum body size (Calzada and Aguilar, 1995; Strandings database, University of Barcelona) which is closely related to other growth stages (Laws, 1956; Ohsumi, 1966), so the same length cutpoints were assumed to apply to common dolphins.

Thus, both common and striped dolphins smaller than 165 cm were considered to be calves, females between 165 and 187 cm long and males between 165 and 190 cm long to be juveniles, and females larger than 187 cm and males larger than 190 cm to be adults.

3. Results

3.1. Coverage of the observation program

During the 3 year period covered by the study, 10 observers monitored 94 fishing operations. Considering data from 1993 and 1994, an average of 0.75 operations per boat per day was estimated for the 2 years combined. Thus, c.3% of the operations in 1993 and 10.2% in 1994 were monitored by observers.

3.2. Fishing operation and fishing effort

During the period covered by the study, the fleet was composed of 27 vessels, whose lengths ranged from about 10 to 25 m and crews were composed of 5–8 persons. The gear consisted of a driftnet of 40 cm mesh size and c.32–40 m high. A single piece of net measured 72 m long and each boat set about 40–70 of these pieces, depending on the size of the boat. Thus, nets deployed by this fleet in the Mediterranean ranged from 2.9 to 5 km long (mean ± standard deviation 4.01 ± 0.50 in 1993, 3.64 ± 0.41 in 1994). Nets were set at sunset and hauled around midnight. Boats returned to harbour at *c*.0500–0700 each day. Table 2 shows that the total fishing effort deployed by the driftnet fleet during 1993 and 1994 ranged from about 3300 to 1900 km of net set. Differences between the two years were not significant.

3.3. Composition of incidental dolphin catches

For both species of dolphins the number of adults caught was small (19% for striped dolphins and 11% for common dolphins) (Fig. 2). Most common dolphins caught were extremely young calves, probably only a few months old, while most of the striped dolphins caught were juveniles, estimated to be already weaned. Further, 76% of the striped dolphins were males, which differs significantly from 50% (χ^2 $p < 0.01$). Indeed, all sexually mature individuals caught were males.

3.4. Number of incidental catches

The species composition of the catch of the Spanish driftnet fleet in the Mediterranean Sea during the survey, expressed as the number of individuals of each species observed caught, is shown graphically in Fig. 3 and detailed in Table 3. Sunfish *Mola mola* constituted

Table 2
Estimated fishing effort (TE) deployed by the driftnet fleet in 1993 and 1994, expressed in km (± standard deviation) of net set

Year	Mean net length (km ± S.D.)	Total effort (km net set)
1993	4.01 ± 0.5	3329
1994	3.63 ± 0.41	1927

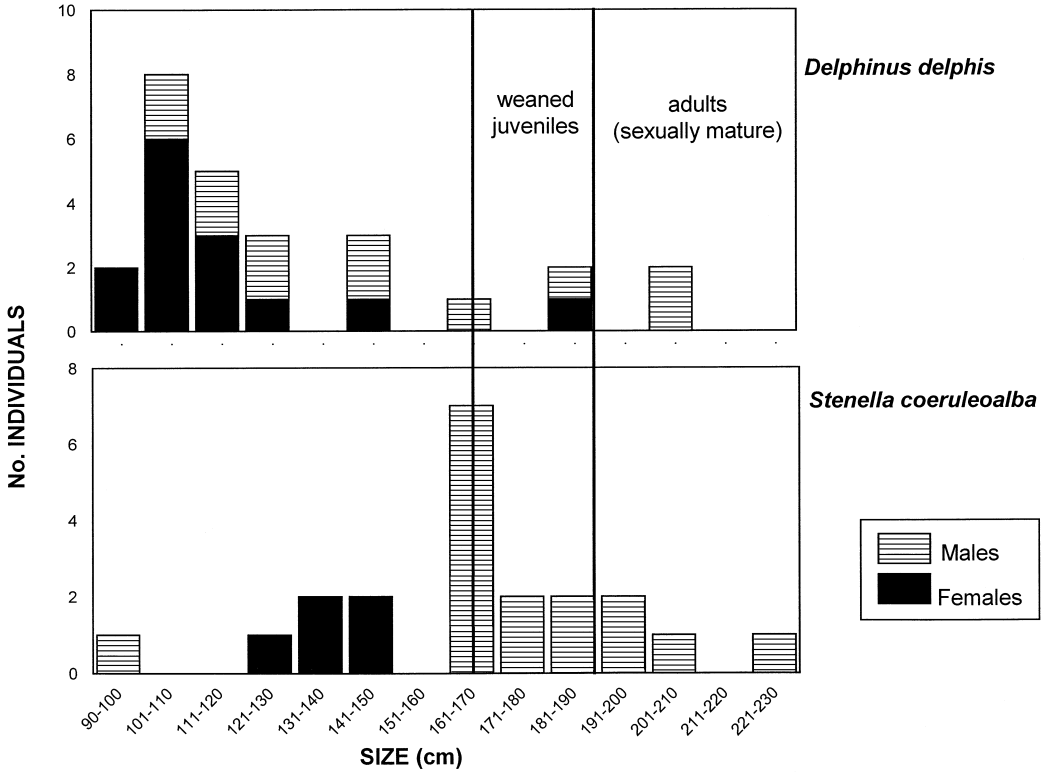

Fig. 2. Length distribution of the dolphins caught incidentally by species and sex.

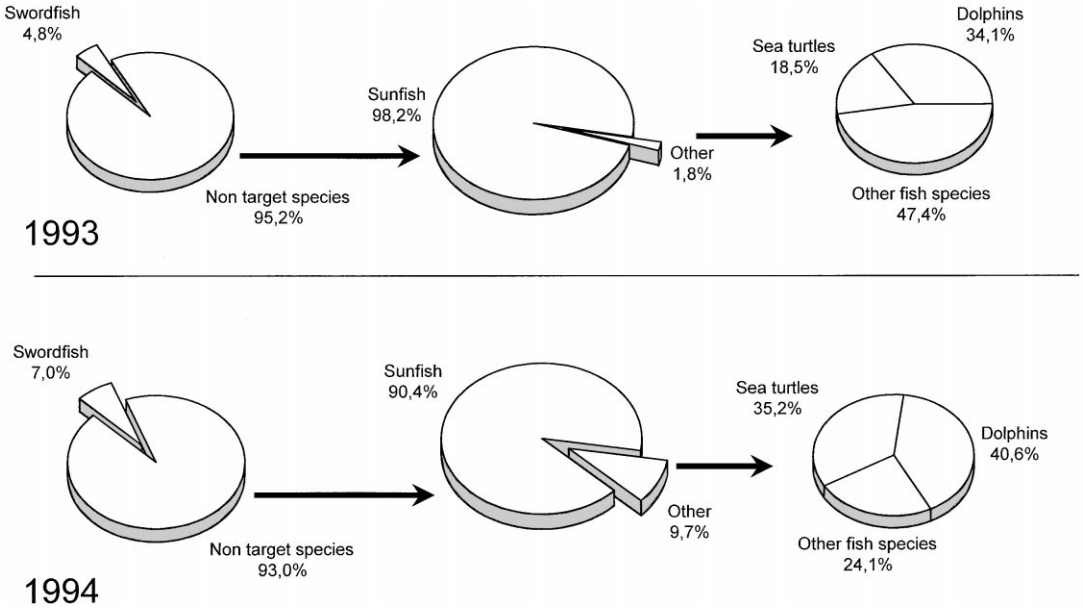

Fig. 3. Species composition of the incidental catch in the driftnet operations monitored in 1993 and 1994.

71% of the catch in 1992, 93% in 1993 and 90% in 1994, while swordfish, the target species, constituted only 7, 5 and 7% each year. No comparable data calculated in terms of biomass are available because of the impossibility of weighing the specimens caught individually, but body weight of sunfish ranged from 0.5 to 7 kg, while that of the swordfish ranged from 3 to 130 kg. Thus, it appears that the weight of the target species represented only a minor fraction of the biomass taken. It should be noted, however, that all sunfish examined by the observers were alive when taken on board and, when possible, fishermen returned them back to the sea still alive. No sunfish mortality data were collected during the 1993 season, but in 1994 observers found that

Table 3
Number of individuals of each species observed caught by the Spanish driftnet fleet in the Mediterranean

Species	1992[a]	1993[b]	1994[c]
Sun fish *Mola mola*	453	1737	2538
Swordfish *Xiphias gladius*	47	90	198
Bullet tuna *Auxis rochei*	108	2	1
Loggerhead turtle *Caretta caretta*	–	6	24
Common dolphin *Delphinus delphis*	6	5	15
Striped dolphin *Stenella coeruleoalba*	–	6	15
Skipjack tuna *Euthynnus pelamis*	9	–	1
Bluefin tuna *Thunnus thynnus*	3	1	1
Common dolphin-fish *Coryphaena hippurus*	1	3	–
Marbled electric ray *Torpedo marmorata*	–	3	–
Shortfin mako *Isurus oxyrhinchus*	2	2	3
Blue shark *Prionace glauca*	1	–	4
Leatherback turtle *Derimochelys coriacea*	–	–	2
Sphyrna zygaena	2	–	–
Myliobatis sp.	–	–	1
Chub mackerel *Scomber japonicus*	1	–	3
Dogtooth grouper *Polyprion arnericanus*	–	1	–
Atlantic mackerel *Scomber scombrus*	–	1	–
Derbio *Trachynotus* sp.	–	2	1
Sea arrow *Todarodes sagittatus*	–	–	1
Sand eel *Ammodytes* sp.	–	–	1

[a] Pilot sample of 13 sets.
[b] 27 sets.
[c] 54 sets.

only 6% of the sunfish captured in the nets died on board before being returned to sea.

Thirty loggerhead turtles *Caretta caretta* and two leatherback turtles *Dermochelys coriacea* were observed caught. All except one were alive when the net was brought on board and, after disentanglement, they were released alive to the sea. Data on incidental catches of sea turtles in 1993 were insufficient to allow for a robust application of the ratio method; in 1994 the estimate of loggerhead turtles caught was 236 animals (95% confidence intervals 117–354).

The cetacean catch was composed solely of the striped and common dolphins, the latter making up 55% of the overall catch. Dolphins were invariably already dead when brought on board, apart from one common dolphin caught in 1993 which was released still alive. Overall, 15.4% of monitored operations in 1992, 37% in 1993 and 35% in 1994 produced incidental catches of dolphins. When this occurred, usually only one animal was entangled in the net; the only exceptions were two sets in 1994 in both of which four dolphins were found entangled together on both occasions. Once on board, fishermen disentangled the animals, an operation that in most cases involved the cutting of flippers, the dorsal fin or the tail, and returned the corpses to the sea.

The lower number of catches in 1994 compared with 1993 (Table 4) is due to the shorter fishing season (4 weeks)

Table 4
Estimates of the number of dolphins caught incidentally by the Spanish driftnet fleet in Mediterranean waters. From these, it is estimated that 50% correspond to striped dolphins and 50% to common dolphins

Year	Bycatch rate (dolphins/km net)	Total estimate	Confidence intervals (95%)
1993	0.11	366	(268–464)
1994	0.15	289	(238–340)

since the activity of the fleet was stopped by the Spanish fishing authorities before the end of the season.

No difference in cetacean catches was observed between nets set in inshore or in offshore waters. Indeed, the geographical distribution of dolphin catches matches that of the fishing grounds. However, when nets were set in the Straits of Gibraltar, the incidence of dolphin catches of cetaceans appeared to be lower, although sampling in this area was quite limited (only five in the 2 years, resulting in 1 dolphin caught), and therefore this conclusion should be taken cautiously.

There was no correlation between swordfish and cetacean catches ($r = 0.091$). To study the relationship between net length and dolphin bycatch we fitted a General Linear Model (GLM, SAS, 1990). Results showed that there was a relationship in both years (1993, $p = 0.0908$; 1994, $p = 0.099$).

Moreover no correlation was observed ($r = 0.014$) between dolphin catch rate and the height of the net used, apparently because dolphins almost invariably became entangled in the upper part of the net.

4. Discussion

Swordfish driftnets were introduced in the Mediterranean in the 1980s (De la Serna and Alot, 1990). In the Alboran Sea, driftnet fishing initially targeted various tuna species, but during the mid-1980s attention was turned to swordfish. After 1988 the number of vessels dedicated to this fishery increased markedly because of the high revenues obtained. In 1990, about 100 Spanish boats based in the harbours of La Línea de la Concepción, Algeciras, Tarifa and Barbate (all located in southwestern Spain), were operating in the Atlantic and Mediterranean waters adjacent to the Gibraltar Straits.

The EC Council regulation 345/92 provides that EC boats may not use driftnets exceeding a length of 2.5 km (DOCE, LO42, pp15, 18 February 1992). However, Spanish legislation is more restrictive and, since 1991, explicitly prohibited the use of driftnets in Spanish territorial waters, with the exception of those used in fishing bonito *Sarda sarda*, frigate mackerel *Auxis rochei* and similar species, which should not measure more

than 1.5 km (OM 22 October 1990, BOE no. 255, 24 October 1990). In spite of this prohibition, an unregulated fleet of about 30 vessels continued operating in the area from 1991 until August 1994, when their activity was finally halted. The number of dolphins washed ashore with marks such as cuts in the flippers or in the flukes showing that they had been killed in a fishing interaction, increased markedly. For example, a survey along the southern coast in Spain in 1990 showed that 20% of dolphins found washed ashore on the beach had markings attributable to a fishing conflict (Aguilar et al., 1990).

However, the Moroccan fleet, apparently composed of about 120 boats, continued operating in the region. Moreover, from about 1992, some Italian driftnet boats, with nets reportedly exceeding EC limitations (Di Natale and Notarbartolo-di-Sciara, 1994), started operating around the Balearic Islands and the northern limits of the Alboran Sea.

The boats used in Gibraltar Straits fishery are smaller (10–25 m long) and used shorter nets (3–5 km) than those commonly used by the Italian driftnet fleet (Di Natale and Notarbartolo-di-Sciara, 1994). No precise data are available from the Moroccan driftnetters, but opportunistic observations in the Alboran Sea and in the local Moroccan ports by the observers suggest that they use smaller boats and shorter nets.

Whenever fishermen acted promptly to disentangle and release incidental catch, suchs as sunfish and turtles, the impact of the fishery on these two species can be assumed to be limited. The large proportion of immature cetaceans caught has been commonly observed in incidental catches associated with gillnets (Goujon et al., 1993; Gearin et al., 1994; Kinze, 1994), and suggests that young animals may be less skillful at avoiding nets. However, the catch of striped dolphins was dominated by juvenile males, while that of common dolphins presented an even sex ratio and calves were proportionally more abundant. The reason for these apparent differences in the length/age- and sex composition of the catch between the two species is unclear; it may be related to the segregation of different components of the population in the fishing grounds or to differences in the behaviour displayed when approaching the gear.

Because of the illegal nature of this fishery in Spain, no official data about the total fishing effort or about the landed catches were available. Therefore, to estimate the total fishing effort we have assumed that the fleet was operating in an homogeneous way and that the coverage of our study was a good representation of the overall operation. This may have introduced some bias in the calculations, although the small size of the fleet (only 27 vessels), the small dimensions of the fishing grounds, and the limited length of the fishing season meant observers could collect information, either directly or indirectly, from nearly all the vessels involved. We therefore assume that the estimates obtained here are representative of the overall operation.

Driftnets have long been recognized as an important cause of mortality for cetaceans, and concern has been expressed that some cetacean populations in the Mediterranean sea may be unable to sustain current levels of removal. In particular, the International Whaling Commission (I.W.C., 1994) expressed its concern as to whether the striped dolphin could sustain the current level of incidental catches, and the International Union for the Conservation of Nature (IUCN) included the common dolphin in a list of populations at risk, in part because of the impact of fishing (Perrin, 1989).

The populations of striped and common dolphin in the Alboran sea have been estimated at 17 728 ($SE = \pm 5850$) and 14 736 ($SE = \pm 5894$) individuals, respectively (Forcada, 1996). These figures would in principle suggest a healthy, dense population. However, there is evidence that the common dolphin has suffered a sharp reduction in its distribution range in the western Mediterranean, at least in the western side of the basin (Aguilar et al., 1994), and that the striped dolphin has seen its numbers greatly reduced by the epizootic that afflicted the species in the Mediterranean sea during 1990–1992 (Aguilar and Raga, 1993). The exchange rate of the two Mediterranean species with their counterparts in the Atlantic is unknown, although reported differences in coloration (Fraser and Noble, 1970; Sylvestre, 1985) and maximum body size (Calzada and Aguilar, 1995; Di Méglio et al., 1996) suggest some degree of isolation. If this is correct, the estimated catches by the Spanish fleet alone (Table 4) would represent a mortality rate of about 1% of the population per year. Given that the relatively small Spanish fleet alone was able to generate this level of mortality, and bearing in mind the ongoing activities of the Moroccan fleet (about four times more numerous but apparently operating with smaller boats) and the Italian fleet (of unknown number but working with substantially longer nets), it is reasonable to fear that populations may be unable to cope with the mortality produced by incidental fishing. Further information is urgently needed on the number of boats and the pattern of operation of the Moroccan and Italian driftnet fleets, as well as their associated catches.

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