Available online at www.sciencedirect.com
SCIENCE DIRECT®
Biological Conservation 121 (2005) 65–78
BIOLOGICAL CONSERVATION
www.elsevier.com/locate/biocon

Driftnet fishing and biodiversity conservation: the case study of the large-scale Moroccan driftnet fleet operating in the Alboran Sea (SW Mediterranean)

Sergi Tudela [a,*], Abdelouahed Kai Kai [b], Francesc Maynou [c], Mohamed El Andalossi [b], Paolo Guglielmi [d]

[a] *WWF Mediterranean Programme, Carrer Canuda 37, 3er, 08002 Barcelona, Spain*
[b] *Association AZIR, 48 Av. Hassan II, Al Hoceima, Morocco*
[c] *Institut de Ciències del Mar, CMIMA-CSIC, Psg. Marítim de la Barceloneta 37-49, 08003 Barcelona, Spain*
[d] *WWF Mediterranean Programme, Via Po, 25/c, 00198 Rome, Italy*

Received 17 December 2003; received in revised form 6 April 2004; accepted 8 April 2004

Abstract

Illegal, large-scale driftnets are still used in several Mediterranean areas. According to international official sources, Morocco harbors the bulk of this fleet in the Mediterranean. To ascertain its biodiversity impact, 369 fishing operations (worth 4140 km of driftnets set) made by the driftnet fleet targeting swordfish (*Xiphias gladius*) based in Al Hoceima (Alboran Sea) were monitored between December 2002 and September 2003. Parallel surveys were made in the main Mediterranean ports and in that of Tangiers, in the Gibraltar Straits, to estimate the total fishing effort. Results showed an active driftnet fleet conservatively estimated at 177 units. Estimated average net length ranges from 6.5 to 7.1 km, depending on the port, though actual figures are suspected to be much higher (12–14 km). Most boats perform driftnet fishing all year round, resulting in very high annual effort levels. A total of 237 dolphins (short-beaked common dolphin, *Delphinus delphis*, and striped dolphin, *Stenella coeruleoalba*), 498 blue sharks (*Prionace glauca*), 542 shortfin makos (*Isurus oxyrinchus*) and 464 thresher sharks (*Alopias vulpinus*) were killed by the boats monitored during the sampling period, during the peak of the swordfish fishery, along with 2990 swordfish. Loggerhead turtle (*Caretta caretta*) was also caught (46 individuals). Estimates for a 12-month period by the whole driftnet fleet yielded 3110–4184 dolphins (both species) and 20,262–25,610 pelagic sharks distributed in roughly equal proportions for *P. glauca*, *I. oxyrinchus* and *A. vulpinus*, in the Alboran Sea alone; further 11,589–15,127 dolphins and 62,393–92,601 sharks would be killed annually around the Straits of Gibraltar. Dolphins suffer from annual take rates exceeding 10% of their population sizes in the Alboran Sea; this unsustainable impact is particularly worrying for *D. delphis*, because its last remnant healthy population in the Mediterranean occurs in this area. Average catch rate for swordfish, the main target species, amounted to only 0.8 individuals/km net set. Pelagic sharks are actively targeted by a part of the fleet.

Keywords: Alboran Sea; Driftnets; Swordfish; Striped dolphin; Short-beaked common dolphin; Pelagic sharks

1. Introduction

Driftnets are defined by FAO as a fishing gear "consisting of a string of gillnets kept more or less vertical by floats on the upper line and weights on the lower line, drifting with the current, in general near the surface or in mid-water." (FAO, on-line Fisheries Global Information System – FIGIS). Worldwide, light synthetic fibers allow medium-scale and even small-scale boats to deploy driftnets many kilometers long. In the Mediterranean, driftnets have been used to capture several species of tuna and, currently, mostly swordfish.

Increasing scientific evidence in the 1980s and 1990s pointing to an intrinsically low selectivity of this gear with respect to non-target species crystallized in international binding legislation aiming at totally or partially eradicating these fisheries. Resolutions 44/225 and 46/

* Corresponding author.
E-mail address: studela@atw-wwf.org (S. Tudela).

0006-3207/$ - see front matter © 2004 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biocon.2004.04.010

215 adopted in 1989 and 1991 by the General Assembly of the United Nations recommended a moratorium on all large-scale pelagic driftnet fishing by 30 June 1992. In 1992 the European Community prohibited driftnet fishing in the Mediterranean with nets more than 2.5 km in length, as did the General Fisheries Commission for the Mediterranean (GFCM) in 1997 under a binding Resolution. A total ban on driftnet fishing on large pelagic species by the EU fleet in the Mediterranean entered into force from 1st January 2002; the same decision was adopted by ICCAT by means of a binding recommendation in November 2003. All fishing activities outside this legal framework qualify for IUU fishing (Illegal, Unregulated and Unreported) according to FAO (2001).

The use of driftnets in the Alboran Sea started in the 1980s; about 100 Spanish boats using driftnets targeting swordfish were active in the Alboran Sea in 1990. The activity of this fishery was permanently halted in August 1994. The remnant 27 boats entailed an incidental mortality of 366 dolphins in 1993 and 289 in 1994 (*Delphinus delphis* and *Stenella coeruleoalba* roughly in equal proportions; Silvani et al., 1999).

Another driftnet fishery quickly developed in Northern Morocco in the early 1990s involving the ports of Larache, Asilah, Tangiers, Al Hoceima and Nador (Fig. 1). The Universitat de Barcelona (1995) reported that the Moroccan driftnet fleet in the Alboran Sea in 1995 probably exceeded 200 vessels and that the length of the net used was known to often exceed 2.5 km. The authors concluded that "...the magnitude of the cetacean catches incidental to the activities of this fleet is unknown, but it is believed not to be lower than that observed for the Spanish fleet".

The swordfish fishery shows a marked seasonality as a consequence of the migratory nature of this species. Swordfish enters the Mediterranean Sea from April to June, returning westwards from August to November (de la Serna and Alot, 1990). This migratory behavior determines the seasonal mobility of the driftnet fleet around the Alboran Sea, the Gibraltar Straits and adjacent Atlantic grounds.

The Alboran Sea (Fig. 1) is an outstanding area for biodiversity in the Mediterranean, being a transitional zone between the Atlantic Ocean and the Mediterranean Sea (Lloris and Rucabado, 1998). The Alboran Sea is key for the migration of the internationally protected loggerhead turtle (*Caretta caretta*) from the Atlantic to the Western Mediterranean (Camiñas, 1997) and hosts a high diversity of cetacean species (Universidad Autónoma de Madrid and Alnitak, 2002). Among resident species, the short-beaked common dolphin (*D. delphis*) merits particular attention, because its population in the Alboran Sea is the healthiest in the Mediterranean, after a dramatic decline of the species in most of its Mediterranean range (Notarbartolo di Sciara, 2002).

This study arises as the first field assessment of the ecosystem impact of the Moroccan large-scale driftnet fleet operating in the Alboran Sea and nearby Straits of Gibraltar area, that currently accounts for the bulk of this illegal – though often 'tolerated' – fishing practice in the entire Mediterranean basin. It is the most comprehensive analysis of the impact of a large-scale driftnet fleet in the Mediterranean since the study by Di Natale et al. (1993) on the Italian case and addresses the issue of the compatibility of driftnet fisheries on large pelagic fish with biodiversity conservation in the region.

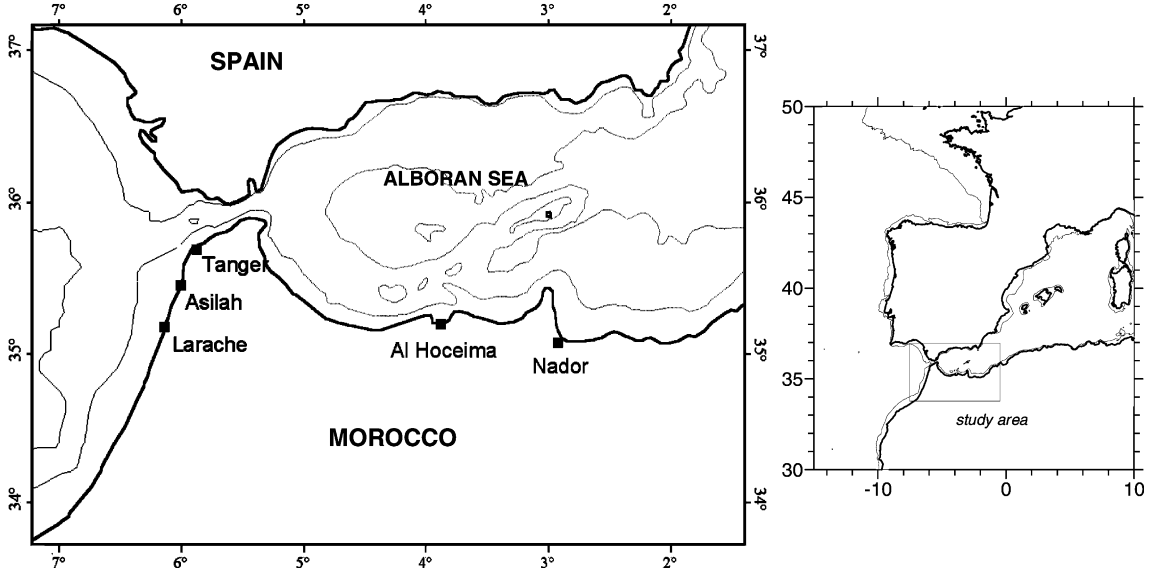

Fig. 1. Map of the study area. The isobaths of 200 and 1000 m are shown, as well as the major ports involved in driftnet fishing.

2. Methods

2.1. By-catch monitoring scheme

We monitored the daily fishing activity of four representative large-scale driftnet boats based at the port of Al Hoceima, one of the main fishing harbors of the Mediterranean Moroccan coast, for more than 8 complete months (December 2002–September 2003), encompassing the peak of driftnetting activity.

Given the reluctance of skippers to accept the boarding of observers alien to the fishing sector because of the illegal nature of the fishery and fiscal reasons, we worked with reliable crewmembers from the sampling boats, obtaining the daily data on catch composition on their arrival from the fishing operation. To secure stochastic independence of data, every collaborator was kept unaware of the existence of the others. All the collaborators were regularly paid a moderate sum in exchange for their cooperation and were not informed about the precise purpose of the project. The person in charge of data collection was native from Al Hoceima; he was familiar to the fishing harbor and a fluent speaker of the local tamazight language.

Selected by-catch species were purposely chosen according to both the magnitude of their by-catch and their conservation importance, the list of such priority species being refined on an adaptive way. It included 'swordfish' (*Xiphias gladius* and some sporadic billfish captures), 'marine turtles' (*C. caretta*), 'dolphins' (*D. delphis* and *S. coeruleoalba*), blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), thresher shark (*Alopias vulpinus*) and sunfish (*Mola mola*). Catch data were recorded as number of individuals per fishing operation. Information on effort was also obtained, as total length of net set per fishing operation and total net soaking time.

Figures on dolphin by-catches were initially taken for both species mixed; disaggregated information could be obtained from mid April 2003. Also, it was realized that 'swordfish' category included some sporadic captures of billfish, so from July on billfish captures were reported separately.

2.2. Estimation of total fishing effort

Surveys were conducted at the ports of Al Hoceima (January 2003), Tangiers (January and August 2003) and Nador (August 2003) to obtain information on the size, characteristics of the active driftnet fleets and seasonality of the fishing activity. A complete questionnaire was addressed in situ to the appropriate crewmen (usually the fisherman working as the 'keeper' of the driftnet boat), and information on all the active driftnet fleet based in these ports at the moment of the survey was obtained. An exploratory survey was also conducted on key fishing ports on the neighboring Atlantic façade (Asilah and Larache, June 2003).

2.3. Estimation of species-specific catch rates and total by-catch

The suitability of different measures of fishing effort to describe the catch rates of the different species was investigated, in order to find one or more CPUE measure(s) which could be used to extrapolate the data from the monitoring scheme to the entire fleet. Generalised Linear Models (GLM) were fitted to the original set of daily data, considering the following variables as estimators of catch rates (catch per unit effort; CPUE) for each species: (1) *number of individuals caught per fishing operation* (N/fishing operation), (2) *number of individuals caught per length unit of net set per fishing operation* (N/km) and (3) *number of individuals caught per length unit of net set and unit of soaking time per fishing operation* (N/km h). These analyses were carried out by considering the effect of the following factors: *month*, *boat*, *net length* and *net length* × *soaking time*.

GLM are an extension of linear models, where the distribution function of the response variable (catch rates) can be different from normal. GLM methods allow testing the contribution of several explanatory variables (factors: month and vessel, or quantitative variables: net length and net length × soaking time). The significance of each explanatory variable was assessed by the *F*-statistic at the 5% significance level. All statistical analyses were carried out in S-plus.

First, an estimate of captures was made for the Alboran sea, based on the data from Al Hoceima and Nador. The resultant figures are thought to be very reliable because the monitored boats were based in the former port and the coverage of fleet sampling there was particularly comprehensive. The behavior of the fleet based at Nador is very similar to that from Al Hoceima, including the occurrence of driftnet fishing all year round and in fishing grounds located exclusively in the Mediterranean, East of the Gibraltar Straits.

Based on the most adequate estimate of capture rate (and reference effort unit) for each species, the total capture during the 8-month sampling period was estimated by extrapolating the appropriate CPUE estimate to the estimate of total effort by the entire fleet. The extrapolation method used was the ratio method (Cochran, 1977), which provides also an estimate of the variance of the extrapolation, as it is a standard statistical method in the analysis of sea mammal by-catch rates (Hobbs and Jones, 1993). Annual catches were then estimated by increasing by a 3/2 factor the resultant 8-month estimates.

Then, the total capture by the driftnet fleet based in Tangiers was estimated by extrapolating to that fleet the catch rates obtained in the Al Hoceima monitoring,

using an estimate of annual fishing effort derived from accurate information on seasonal fleet activity recorded in Tangiers. The underlying assumption is that catch rates achieved in the Alboran fishing grounds by the Al Hoceima driftnet fleet are representative of those achieved by the fleet based in Tangiers, that operates around the Straits of Gibraltar and neighboring Atlantic waters, outside the Mediterranean Basin.

Given the exploratory nature of the survey carried out in Asilah and Larache and the lack of more detailed information, the driftnet fleet identified in those ports was not included in the total catch estimates, hence our estimates are conservative.

Table 1
Monitored driftnet boats based in the port of Al Hoceima

Code	Crew size (no. persons)	Engine power (HP)	No. driftnet units (unit length: 100 m)
ALH-1	12	170	65/120[a]
ALH-2	7	190	60
ALH-3	10	215	120 [60][b]
ALH-4	13	215	140 [63][b]
ALH-12	9	170	140 [70][b]

Codes aim at to preserve identity of boat owners.
[a] Net length nearly doubled from 16/7/2003 on, when this boat started using 120 units.
[b] Note the strong difference between the actual size of the driftnet as learnt from our daily monitoring of the fishing activity, and the size reported by the boat keeper during the Jan 2003 survey at the port (in brackets).

3. Results

3.1. Sampling coverage

The characteristics of the monitored boats are shown in Table 1. As detailed in Table 2, a total 369 fishing operations were monitored during the period ranging from 22nd December 2002 to 15th September 2003, with 4140 km of net deployed. This period covered the peak of the swordfish fishery, ranging approx. from March to June. All the fishing operations performed by the four monitored boats during the period of study were sampled. Boat ALH-2 stopped driftnetting on 9th May, due to a change in fishing gear. To replace this boat in the monitoring scheme, a new driftnetter (ALH-12), of similar characteristics, was monitored starting from 16th July.

3.2. Characteristics of the fishery

The height of the nets was estimated at 25–30 m. The number of net units used in the fishing operations ranged from 43 to 140 in Al Hoceima, 30 to 120 in Tangiers, 45 to 90 in Nador, 80 to 100 in Larache and 48 to 100 in

Table 2
Monthly account of the activity of the monitored boats during the study period

	ALH-1		ALH-2/ALH-12[a]		ALH-3		ALH-4	
	n	Effort (km net set)	*n*	Effort (km net set)	*n*	Effort (km net set)	*n*	Effort (km net set)
December 2002[b]	7	45.5	7	42	–	–	–	–
January 2003	11	71.5	13	78	13	152	14	196
February 2003	8	52	8	48	8	96	8	112
March 2003	9	58.5	8	48	11	132	11	154
April 2003	5[c]	45.5[c]	7	42	12	144	12	168
May 2003	7[d]	45.5[d]	5[e]	30[e]	11	132	11	154
June 2003	–	–	–	–	17	204	16	224
July 2003	12[f]	144[f]	12[e]	168[e]	18	216	19	266
August 2003	14	168	14	196	14	168	14	196
September 2003[g]	2	24	3	42	3	36	3	42
Total	75	654.5	77	694	107	1280	108	1512
Total monitored hauls = 369								
Total monitored km net = 4140.5								
Average fishing days per boat per month[h] = 10.0								

The total number of fishing operations conducted is shown (*n*), together with the total monthly effort. All fishing operations were monitored.
[a] Boat ALH-12 replaced boat ALH-2 from 16th July on in the monitoring scheme.
[b] Sampling started on Dec 22nd for ALH-1 and ALH-2 and on 1st January for ALH-3 and ALH-4.
[c] Including an exceptional fishing trip lasting three days.
[d] Monitoring was stopped the 9th May due to logistic constraints (boat under repairs).
[e] Monitoring of ALH-2 finalized the 9th May due to a change in fishing modality (from driftnets to fish traps); monitoring of ALH-12 started on 16th July.
[f] Monitoring was resumed on 16th July
[g] Monitoring was closed on 15th September.
[h] Estimated using only data from complete sampled months, including the period of inactivity of boat ALH-2.

Table 3
Average gear length and size of the active driftnet fleet identified and sampled in Moroccan ports (Mediterranean and adjacent Atlantic waters)

	Number of active driftnet boats	Mean net length (km ± SD)	Mean engine power (hp ± SD)
Al Hoceima (Jan 2003)	28	6.88 ± 3.0	149.28 ± 41.3
Tangiers (Jan 2003)	77	8.05 ± 1.7	190.64 ± 100.6
Tangiers (Aug 2003)[a]	53	5.86 ± 2.5	115.24 ± 76.8
Tangiers (Total)	130	7.15 ± 2.3	159.90 ± 98.6
Nador (Aug 2003)	19	6.57 ± 1.0	127.78 ± 34.9
Larache (Jun 2003)[b]	±30	8–10 (80–100 units)	–
Asilah (Jun 2003)[b]	±10	4.8–10 (48–100 units)	–

[a] only the new active units, not using driftnets during the previous Jan 2003 survey.
[b] Exploratory survey.

Asilah (Tables 1 and 3). Since the length of each single net unit is 100 m, the mean value of fishing gears deployed by the fleets based in Al Hoceima, Tangiers and Nador was estimated at, respectively, 6.8, 7.1 and 6.5 km.

These estimates, however, are likely underestimates; as it is stressed in Table 1, the length of the gear reported by the 'keeper' fishermen from boats ALH-3, ALH-4 and ALH-12 is near half the length reported by our crew collaborators from these same boats. Net length can vary throughout the fishing season, as it was the case of boat ALH-1 which increased the number of net units from 65 to 120 (6.5–12 km) at the peak of the fishing season. At the end of the monitoring period, the net length deployed by the 4 boats monitored ranged from 12 to 14 km.

Usually, the driftnet fishery takes place on a daily basis. Nets are set in the afternoon, from 14 to 19 h, and are recovered about 11–12 h later, approx. from 22 to 08 h. On especial occasions, though, fishing trips can last a few days.

3.3. Fleet size and activity

According to Table 3, only 28 driftnetters were active in Al Hoceima, contrasting with the range of 36–52 reported in official documents. The mismatch is even sharper regarding the fleets based in Nador and Tangiers.The figure of 357 active driftnetters submitted to ICCAT by official Moroccan sources in 2003 (document SCRS/2003/015) is much higher than the active fleet size identified by this study (a very conservative estimate of 177 units, excluding the fleet detected in Asilah and Larache).

Whilst the entire driftnet fleet based in Al Hoceima is active all year round, an important share of the fleet based in Tangiers only performs driftnetting during the high season of the swordfish fishery, from March to approximately October, whilst during November–February some units engage in other fisheries. Hence, we considered that the 77 active units identified in January 2003 are active as driftnetters all year round whilst the 53 new boats detected in the August 2003 survey were only operational as driftnetters during the spring-autumn period. According to Table 3, the latter use on average less powerful engines and smaller nets (Student's T test, $p < 0.001$).

As for Nador, 5 out of the 19 active boats identified are acting as purse seiners most of the year, only using driftnets the months of February, March and April. The remainder 14 units are driftnetters all year round.

The average number of driftnet fishing days per month in Al Hoceima amounts to a *conservative* figure of 10.0 active days per boat *per month* (see Table 2). As for the fleet based in Tangiers, the interviews conducted point to an average 15 fishing operations per boat *per month* during the period of activity. All four boats monitored were active in winter, when the abundance of swordfish in the area was at its lowest.

3.4. Overview of catches of target and incidental species

A total 5285 individuals were identified and recorded during the period of sampling, belonging to the selected target and incidental species (Table 4). Pelagic sharks were the main by-catch of the fishery, the combined catch of the topmost three species caught reached half the total swordfish capture in numbers (ratio 0.50:1). Sunfish (ratio 0.17:1) and dolphins (ratio 0.08:1) fol-

Table 4
Total catches achieved by the monitored boats during the period of sampling December 2002/January 2003 to September 2003 relative to the set of target and by-catch species selected for this study

Species	*n*
Swordfish[a] (*Xiphias gladius*)	2990
Dolphins (*D. delphis* and *S. coeruleoalba*)	237
Loggerhead turtle (*Caretta caretta*)	46
Blue shark (*Prionace glauca*)	498
Shortfin mako (*Isurus oxyrinchus*)	542
Thresher shark (*Alopias vulpinus*)	464
Sunfish[b] (*Mola mola*)	508

Data from 369 fishing operations – all of them carried out in the Mediterranean Sea – have been pooled.
[a] Including a small number (about 4%) of billfishes.
[b] Sunfish catches were monitored only from 2nd February in the case of boat ALH-1.

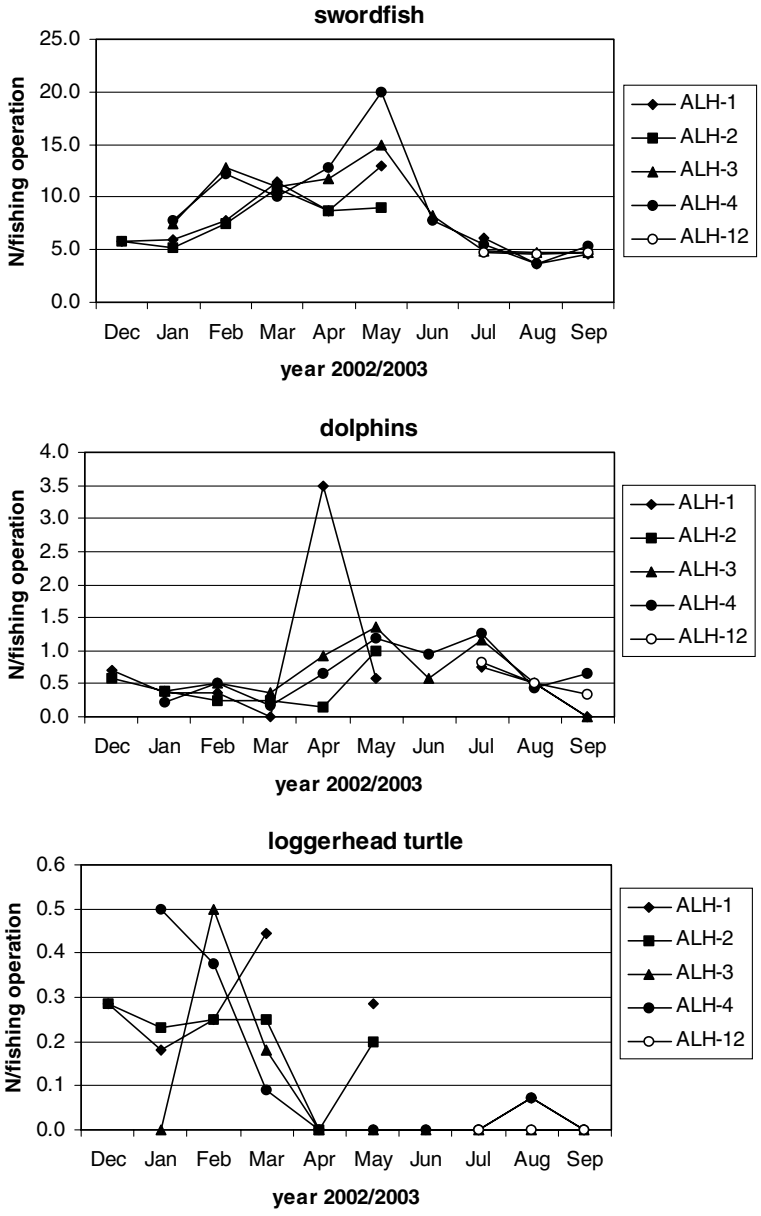

Fig. 2. Evolution of the monthly average catch per fishing operation by the monitored boats relative to swordfish and the major by-catch groups analyzed. Note the different scales. (Note, dolphins = *Delphinus* + *Stenella*).

lowed in the ranking of by-catch importance. Fig. 2 shows the monthly evolution of daily capture per boat for the different species selected and the different boats monitored.

3.5. GLM analysis of CPUE measures and by-catch estimations

In the case of N/fishing operation, the distribution function was found to follow a Poisson distribution (as in other studies: Hobbs and Jones, 1993; Silvani et al., 1999), while the two other catch rate measures were log-normal. The results of the analyses of the three CPUE measures tested showed that in many cases any of the three measures was in general adequate, but the month or vessel factors were significant for some species (see Table 5).

For swordfish and dolphins (total and both species) any of the three measures was an appropriate measure of catch rates, affected only by the month of the year. Thus to estimate the total by-catch of dolphins by the combined fleet from Al Hoceima and Nador, month-by-month estimates using the ratio method were produced for the 8 month sampling period using CPUE 1 (N/fishing operation) and CPUE 2 (N/km net set). The total was then extrapolated to the entire year.

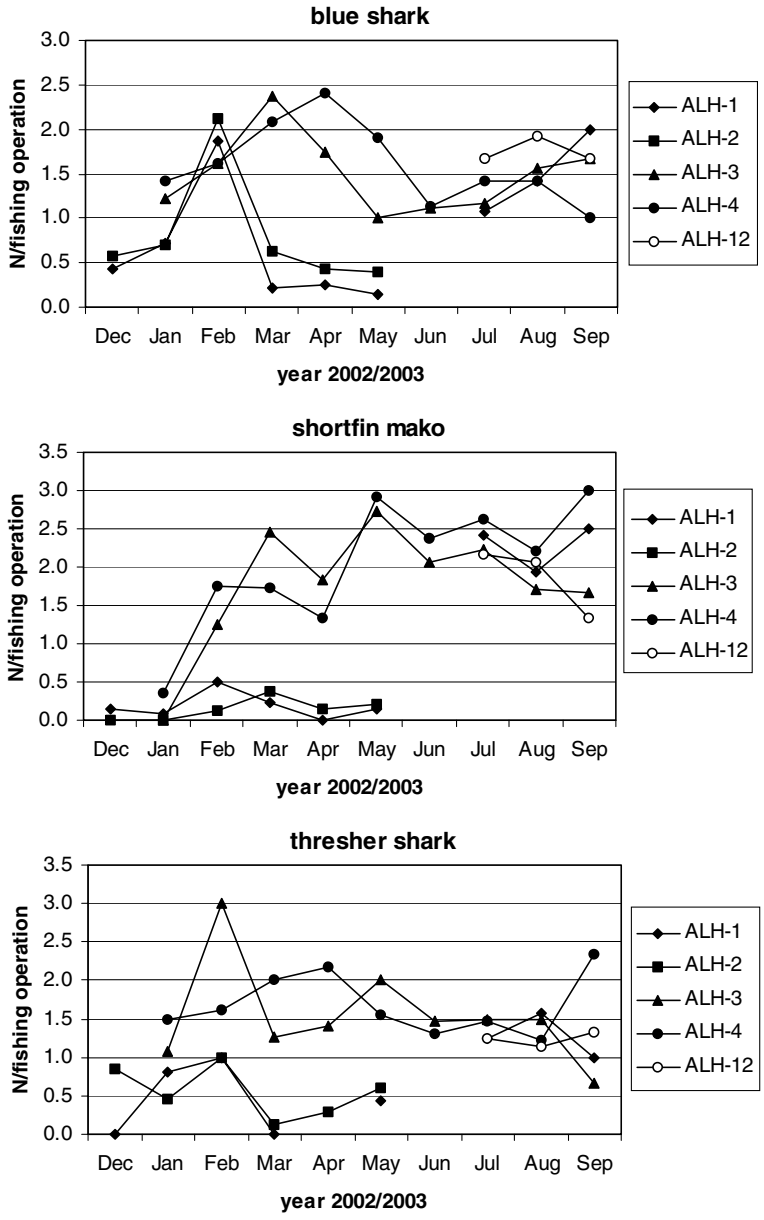

Fig. 2. (*continued*)

Table 5
Significant factors in the GLM analysis with respect to the three measures of CPUE considered (NS: none of the factors were significant)

	Variables		
	N/fishing operation	N/km net set	N/km net × soaking time
Swordfish	Month $p(F) < 0.0001$	Month $p(F) < 0.0001$	Month $p(F) < 0.0001$
Dolphins	Month $p(F) = 0.00074$	Month $p(F) = 0.0016$	Month $p(F) = 0.0045$
Turtles	Month $p(F) < 0.0001$, vessel $p(F) < 0.0001$	Month $p(F) < 0.0001$, vessel $p(F) < 0.0001$	Month $p(F) < 0.0001$, vessel $p(F) < 0.0001$
P. glauca	Vessel $p(F) = 0.0007$, net length $p(F) = 0.0026$	NS	NS
I. oxyrinchus	Month $p(F) < 0.0001$, vessel $p(F) < 0.0001$	Month $p(F) < 0.0001$, vessel $p(F) = 0.0019$	Month $p(F) < 0.0001$, vessel $p(F) = 0.0036$
A. vulpinus	Vessel $p(F) = 0.0020$, net length $p(F) = 0.0079$	NS	NS

For pelagic sharks (three species) the type of vessel was a significant variable determining catch rates along with the length of the net (in *P. glauca* and *A. vulpinus*), which is usually related to the vessel. A *post-hoc* analysis of the GLM results indicated that vessels ALH-1 and ALH-2 had significantly lower catch rates than the other three vessels, suggesting two different fishing patterns with respect to sharks: a passive truly 'by-catch' scheme and a possible 'target fishery' one. Thus to estimate the total by-catch for sharks in the Al Hoceima-Nador area 2 separate estimates using CPUE 1 and CPUE 2 were made: one considering that 2/5 of the fleet have ''low'' shark catch rates and the other considering that 3/5 of the fleet have 'high' shark catch rates (possible target fishery). The total catch estimates of the two 'types' of fleet were then combined. Sharks did not show any significant seasonality; the significance of the variable 'month' detected in *I. oxyrinchus* disappeared after grouping the information according to the two types of fleet. Due to the statistical significance of net length, by-catch estimates using CPUE 1 are considered more reliable than those based on CPUE 2 (except in the case of *Isurus*, for which the effect of net length was not significant).

The catch rates for turtles were not usable for extrapolation as the incidence of by-catch on this species was low.

As for the estimation of by-catch by the fleet based in Tangiers, the ratio method was applied on specific effort data in a way similar as detailed above for Al Hoceima-Nador.

Table 6 shows by-catch estimates for dolphins and pelagic sharks in the Alboran Sea, by the fleets based in Al Hoceima and Nador. Table 7 contains *orientative* by-catch estimates for the fleet from Tangiers, subject to the validity of the assumption that catch rates there are as in the Alboran Sea. Average catch rates for swordfish and incidentally caught species are detailed in Table 8.

Table 7
Estimates of total catch of cetaceans and pelagic sharks by driftnetters from Tangiers based on the ratio method and using as a CPUE unit the daily catch per boat

	Estimates for 12-month period	
	Total catch	95% CI
Dolphins	*13358.30*	*1768.61*
Prionace	*26110.16*	*4274.05*
Isurus	*26944.76*	*6712.94*
Alopias	*24441.69*	*4116.95*

Category 'dolphins' includes equal proportion (50%) of *D. delphis* and *S. coeruleoalba* specimens. Estimates are in number of individuals (N). These estimates should be regarded with caution since they rely on the assumption that by-catch rates by the Al Hoceima fleet are applicable in Tangiers.

3.6. Catch rates and estimation of total catch of by-caught species

X. gladius accounted for 96% of the individuals reported under the category 'swordfish', the remainder 4% being occasional billfish specimens (540 and 23 individuals, respectively). Swordfish captures occurred in 99.4% of all sets monitored. The highest capture per fishing operation recorded amounts to 31 individuals. Swordfish catch rates presented a marked seasonality, with strong monthly variation. Average catch rates during the sampling period are roughly estimated at 8.1 individuals per fishing operation and 0.8 individuals per km of net set (Table 8).

A total by-catch of 46 loggerhead turtles was recorded, which originated in 8.4% of the monitored sets. The highest capture in a single fishing set was recorded at three individuals. A strong seasonality and a significant effect of the vessel factor on catch rates were detected (Table 5).

The capture of dolphins, either *D. delphis* or *S. coeruleoalba*, was verified in 38.9% of all fishing sets monitored. Total dolphin by-catch by the 5 boats

Table 6
Estimates (in number of individuals) of total catch of cetaceans and pelagic sharks by driftnetters from Al Hoceima and Nador based on the ratio method and different measures of catch per unit effort (CPUE)

	Estimates of the 8-month sampling period				Extrapolation to 12-month sampling period			
	CPUE 1		CPUE 2		CPUE 1		CPUE 2	
	Total catch	95% CI	Total catch	95% CI	Total catch	95% CI	Total catch	95% CI
Dolphins	2431.25	357.87	2431.25	329.10	3646.88	536.81	3646.88	493.65
Prionace	5041.40	548.40	*4755.45*	*161.43*	7562.09	822.62	*7133.11*	*242.15*
Isurus	5457.90	698.44	5288.25	205.41	8186.94	1047.67	7932.38	308.10
Alopias	4791.20	535.81	*4466.65*	*161.99*	7186.82	803.71	*6699.98*	*243.00*

CPUE 1: daily catch per boat (N/fishing operation); CPUE 2: daily catch per km net set per boat (N/km net set).

Category 'dolphins' includes equal proportion (50%) of *D. delphis* and *S. coeruleoalba* specimens. Estimates are in number of individuals (N). Estimation of by-catch of *P. glauca* and *A. vulpinus* using CPUE 2 (in italics) is not fully adequate since GLM analyses show a significant effect of net length in the catch of both species.

Table 8
Catch rate estimates (CPUE) for swordfish and the major by-catch species considered

	Period	Capture per fishing operation (N/fishing operation)	Capture per km net set (N/km)
Swordfish[a]	December–September	8.102	0.810
Loggerhead turtle[a]	December–May	0.211	0.026
Dolphins[a,b]	December–September	0.642	0.060
Prionace (low)	December–September	0.872	0.117
Prionace (high)	December–September	1.594	0.121
Isurus (low)	December–September	0.608	0.059
Isurus (high)	December–September	1.909	0.145
Alopias (low)	December–September	0.728	0.092
Alopias (high)	December–September	1.528	0.117

Two different scenarios are presented for pelagic sharks ('low' and 'high'), attributable to the by-catch capture pattern (approx. 2/5 of the fleet) and to the target fishing pattern (approx. 3/5 of the fleet) revealed by GLM analyses (see text).

[a] Catch rates presented are just for comparative purposes, since GLM analyses revealed a strong seasonality; in the case of loggerhead turtle, rates are only estimated for the period of the bulk of by-catches.

[b] Both species pooled.

monitored in this study amounted to 237 specimens, all of them taken in Mediterranean fishing grounds in the Alboran Sea. The highest by-catch figure recorded was 11 individuals, captured on 21st April by boat ALH-1 after deploying 'only' 6.5 km of net. The ratio swordfish/dolphin was 12.6:1 in number of individuals. A strong seasonality is detected in the incidence of by-catch with the month factor being highly significant. Higher catch rates in numbers per fishing operation were recorded approx. from April to July (Fig. 2).

As shown in Table 9, the disaggregated information available points to the short-beaked common dolphin accounting for 45.6% of the dolphin catch, whilst the remaining 54.3% corresponds to the striped dolphin. These data do not differ significantly from 50% (χ^2 test, $p = 0.27$), as estimated by Silvani et al. (1999) for the by-catch by the former Spanish driftnet fleet operating in the Alboran area.

Table 6 shows the total estimates of dolphin by-catch by the fleet operating in the Alboran Sea using two measures of catch rates: N/fishing operation and N/km of net. For a 12-month period, 3647 individuals are estimated to have been caught (±537; 95% CI, note that CI is conservative because the variable did not follow normal distribution, cf. Hobbs and Jones, 1993), in equal proportions of 1555–2092 *D. delphis* and 1555–2092 *S. coeruleoalba*.

Table 9
By-catch of dolphins per species

	ALH-1, ALH-3, ALH-4 and ALH-12	
	Delphinus delphis (N)	*Stenella coeruleoalba* (N)
April 2003[a]	7	8
May 2003	13	15
June 2003	8	17
July 2003	32	32
August 2003	14	13
September 2003	0	3
Total	74	88

Data (in number of individuals) have been pooled on a monthly basis for boats ALH-3 and ALH-4 (from April 2003) and ALH-1 and ALH-12 (from July 2003).

[a] Disaggregated data are available only from 12th April.

The estimate of annual dolphin by-catch by the fleet based in Tangiers amounts to 11,590–15,127 individuals (both species pooled), under the hypothesis of same by-catch rates as in the Alboran Sea (see Table 7). This by-catch would be occurring in the vicinity of the Straits of Gibraltar, mainly outside the Mediterranean Basin.

Blue shark, shortfin mako and thresher shark occurred in, respectively, 54.4%, 58.8% and 49.3% of the fishing operations monitored. Maximum catch figures per set range from 11 specimens in *P. glauca*, 6 in *I. oxyrinchus* and 9 in the case of *A. vulpinus*. According to total by-catch numbers shown in Table 4, the three species are, though slightly, unevenly represented in the catch (χ^2 test, $p < 0.05$).

Overall, our data point to a ratio swordfish/sharks of 1.9:1 in number of individuals. Incidental catches of blue shark, shortfin mako and thresher shark in a 12-month period are estimated at about 7000–8000 individuals each in the Alboran Sea (Table 6). Orientative estimates of the yearly by-catch by the Tangiers fleet, mostly occurring in the Straits of Gibraltar and nearby Atlantic waters, ranges from 24,000 to 27,000 individuals for each one of these three species (Table 7).

4. Discussion

4.1. Main features of the fleet

According to this study all the Moroccan driftnet fleet employs nets largely exceeding 2.5 km long, qualifying as IUU according to the FAO definition. Moroccan driftnets appear to be longer than those deployed by

Table 10
By-catch estimates and catch rates of sea turtles caught by driftnet fleets operating in the Mediterranean

Species	Area/fishery	Year	By-catch estimate	Catch rate	Reference
Caretta caretta	Alboran Sea	1994	236 (117–354)	0.45 N/haul	1
Caretta caretta	Gibraltar Straits[a]	1989–90	–	0.78 N/haul	2
Caretta caretta	Ligurian Sea	1990–91	–	0.057 N/haul	3
Caretta caretta	Tyrrhenian Sea	1990–91	–	0.046 N/haul	3
Caretta caretta	Ionian Sea	1980s	16000[b]	–	4
This study					
Caretta caretta	Alboran Sea	2003	–	0.21 N/haul[c]	

References: 1 – Silvani et al. (1999); 2 – Estimated from Camiñas (1997); 3 – Di Natale (1995); 4 – De Metrio and Megalofonou (1988).
[a] Both sides.
[b] Annual catch.
[c] Period December–May.

the former Spanish fleet in the Alboran Sea, which was using nets of 4 km and 3.6 km on average the years 1993 and 1994, respectively (Silvani et al., 1999).

The high activity of the fleet recorded (10–15 days per month, in many cases all year round) contrasts with the range of 32–44 days of activity *per year* estimated for the Italian *spadara* driftnet boats in 1991 (SGFEN/STECF, 2001) and the average of 21 days of activity per boat *per year* (with a range from 2 to 37 days) attributable to the French *thonnaille* fleet in 2000 (Imbert et al., 2001, in SGFEN/STECF, 2001). This extended fishing season by the Moroccan driftnet fleet largely increases the incidence of by-catch.

The relative capture of swordfish ranged between 1.25 and 2 swordfish per km of net set for May being considerably lower in other periods of the year (with an average of 0.8 individuals/km of net set for the period considered). These results show that the eventual compliance with the former maximum legal length of the gear (2.5 km) would yield at best a few fish per boat, supporting the thesis that truly small-scale driftnet fleets targeting swordfish in the Mediterranean are not economically viable.

4.2. Impact on by-catch species

4.2.1. Turtles

Though all captures of marine turtles recorded by this study belonged to the species *C. caretta*, fishermen from Larache report the frequent capture of leatherback turtles (*Dermochelys coriacea*) in their driftnets, as reported by Camiñas (1995) and Silvani et al. (1999) for the former Spanish driftnet fleet in the Alboran Sea.

Turtles are released alive whenever possible due to a superstitious belief, which points to an effective fishing-induced mortality much lower than by-catch figures reported in this study. This, however, contrasts with the high numbers of dead turtles reported to be washed ashore in the city of Ceuta (N Africa), some of them with symptoms of net entanglement (Ocaña and García de los Ríos, 2002).

The occurrence of the loggerhead turtle in the captures shows a marked seasonality. Whereas in the first months of the year turtles were commonly by-caught, they became rare from April to May onwards. It has been reported that the Alboran Sea is a crucial area for the two-way migration of the species between the Mediterranean and the Atlantic throughout the Gibraltar Straits (Camiñas, 1995, 1997). Winter catches by the Moroccan driftnet fleet in the Alboran Sea might reflect the presence of a local wintering population of loggerhead turtle in the Southern Alboran Sea which might be reinforced with a migration of individuals from the Western Mediterranean to the Atlantic (prevailing currents in the fishing area are westward).

As shown in Table 10, the by-catch rate of loggerhead turtle by driftnets in the Alboran Sea (0.21–0.78 N/haul; including this study) is much higher than that reported for the Italian driftnet fleet (0.04–0.05 N/haul), probably due to a much higher turtle density in Alboran waters linked to the strategic role of this sea in the Atlantic/Mediterranean exchanges.

4.2.2. Cetaceans

Even though the driftnet fleet based in Morocco entails the by-catch of a diversity of cetacean species (including minke whale *Balaenoptera acutorostrata*, fin whale *Balaenoptera physalus*, sperm whale *Physeter macrocephalus*, pilot whale *Globicephala melas* and bottlenose dolphin *Tursiops truncatus*; Association AZIR, unpublished data), during the period of sampling only the capture of striped and short-beaked common dolphin (*S. coeruleoalba* and *D. delphis*, respectively) by the boats monitored was recorded.

As for the conservation situation of *D. delphis*, the Mediterranean population of this species has been given in 2003 the status *Endangered* in the IUCN Red List of Threatened Species. This population is regarded as a conservation priority by the IUCN 2002–2010 Conservation Action Plan for the World's Cetaceans (Reeves et al., 2003). Both species, the short-beaked common dolphin and the striped dolphin are listed in Appendix II

Table 11
By-catch estimates (no. ind.), catch rates and take rates (by-catch/population size) of dolphins caught by driftnet fleets operating in the Mediterranean

Species	Area/fishery	Year	By-catch estimate	Catch rate	Take rate as %	Reference
D. delphis and *S. coeruleoalba*	Alboran Sea	1993	366[a](268-464)	0.11 N/km net[a]	1.2[b]	1
D. delphis and *S. coeruleoalba*	Alboran Sea	1994	289[a] (238–340)	0.15 N/km net[a]	1.2[b]	1
S. coeruleoalba	Ligurian-Provençal Basin	2000	326 (180-472)	0.34 N/haul	1.3	2
S. coeruleoalba	Ligurian Sea	1990	–	0.455 N/haul	–	3
S. coeruleoalba	Ligurian Sea	1991	–	0.125 N/haul	–	3
S. coeruleoalba	Central Mediterranean	1990	–	0.052 N/haul	–	3
S. coeruleoalba	Central Mediterranean	1991	–	0.087 N/haul	–	3
S. coeruleoalba	Italian driftnet fishery	1990	1149	–	–	4
S. coeruleoalba	Italian driftnet fishery	1991	1363	–	–	4
This study						
D. delphis and *S. coeruleoalba*	Alboran Sea	2003	3647[a] (3110-4184)	0.642 N/haul[a], 0.06 N/km net[a]		
D. delphis	Alboran Sea	2003	see above	see above	12.3[c]	
S. coeruleoalba	Alboran Sea	2003	see above	see above	10.2[c]	
D. delphis and *S. coeruleoalba*	Gibraltar Straits and nearby Atlantic area	2003	*13358*[a,d] (*11,590–15,126*)	–	–	

References: 1 – Silvani et al., 1999); 2 – Imbert et al., 2001, in: SGFEN/STECF, 2001; 3 – Di Natale et al., 1993; 4 – Di Natale, 1995.
Take rates in the first three rows are from SGFEN/STECF (2001).
[a] Each species accounting for 50% of this total; see Table 7.
[b] Attributable to each one of the species, separately.
[c] Under the hypothesis of separated demographic units in the Alboran sea.
[d] Orientative data (see main text and Table 7).

of the Bern Convention, in Appendix II of the Bonn Convention, in Appendix II of the Washington Convention and in Annex IV of the EU Habitats Directive. The IUCN status of *S. coeruleoalba* is: *Lower risk (Conservation dependant)*. The only available estimate of the population size of both striped dolphin and short-beaked common dolphin in the Alboran Sea dates back to the period 1991–1992, when it amounted to 17728 (SE = ±5850) and 14736 (SE = ±5894) individuals, respectively (Forcada, 1996). The figure for striped dolphin should be regarded with caution since it was obtained at a moment when the species was suffering an important epizootic in the Mediterranean that induced a significant mortality on the population.

According to Universidad Autónoma de Madrid and Alnitak (2002), the conservation of the healthy population of *D. delphis* in the Alboran Sea might be the only hope for the species to expand towards the Mediterranean Sea and to recover from the population decline that took place in only a few decades throughout the Mediterranean in a Northeast-Southwest sense, leaving only a few relic populations in the Central and Eastern Mediterranean basins (Bearzi et al., 2003).

According to the International Whaling Commission the anthropogenic removal rate of any cetacean population should not exceed half the maximum net growth rate of the population (IWC, 1995). This organism advises that an estimated annual anthropogenic removal of 2% of the best available population estimate may cause the population to decline and requires immediate action to reduce by-catch (Hobbs and Jones, 1993; López et al., 2003). As shown in Table 11, the results of our research point to a by-catch of *Stenella* and *Delphinus* in the Alboran Sea conservatively estimated to be higher than 10% of the population estimates respectively available for these species in the area (taken from Forcada, 1996). These results are one order of magnitude higher than take rates achieved by other Mediterranean driftnet fisheries that are available in the scientific literature (see Table 11). In fact, the total figures of dolphin by-catch by the Moroccan driftnet fleet in the Alboran Sea are extraordinarily high if compared to other by-catch estimates in the Mediterranean region (see also Table 11) or other areas, such as the Pacific (Hobbs and Jones, 1993) or NE Atlantic (Tregenza, 1999). The fact that this mortality is inflicted on a very small area of the Mediterranean adds further importance to the issue. Also from Table 11, it can be drawn that catch rates by the Moroccan driftnet fleet are within the range of those reported by other driftnet fisheries in the Mediterranean. The key difference explaining the high total catch figures lies in the long nets used and the enormous annual fishing effort deployed as a result of the extended fishing season.

It is difficult to understand how such a dramatic mortality on dolphin populations on a sustained way for 15 year of existence of the fishery could have been compatible with the maintenance of their populations.

Indeed, the very persistence of the short-beaked common dolphin in the Alboran Sea, demographically isolated from the rest of the Mediterranean, could be explained by a significant flow of individuals from the Atlantic, in the context of a strong population occurring in the contiguous Atlantic waters (which in turn would suffer an enormous mortality by the driftnet fleet based in Tangiers). Another alternative or complementary hypothesis would be the presence of an important *D. delphis* population in the North of Africa, East of the Alboran Sea.

A recent genetic study by the Universidad Autónoma de Madrid and Alnitak (2002) on the short-beaked common dolphin (*D. delphis*) suggested a higher genetic flow between the Alboran Sea and the populations inhabiting the adjacent Atlantic waters than between the Alboran Sea population and those found in the rest of the Mediterranean (including Italy and Greece). The genetic continuity between populations on both sides of the Straits of Gibraltar is complemented by the occurrence of important densities of short-beaked common dolphin in the middle of the Gibraltar Straits and in the adjacent Atlantic area of the Gulf of Cadiz, reported in the same study. These evidences might suggest the existence of a single demographic unit on both sides of the Gibraltar Straits, with strong implications for the conservation of the species. Indeed, if it were the case, the take rates (as % of the total population) attributable to the Moroccan driftnet fleet presented here should be recalculated by accounting for the total mortality inflicted by the fleet (including the one based in Tangiers) and considering the size of the whole demographic unit of *D. delphis* inhabiting the Alboran Sea and neighboring Atlantic waters. Though unfortunately no information is available on the latter, it is quite unlikely that it will be of the order necessary to successfully cope with the combined mortality estimated for the fleet from Al Hoceima and Nador, on one hand, and the fleet from Tangiers, on the other (a total figure of about 8500 individuals for each species).

Clearly, driftnet fishing is posing a severe threat to the survival of the *D. delphis* and *S. coeruleoalba* populations in the Alboran Sea. As recently summarized by Bearzi (2002) in a review of the interactions between cetacean populations and fisheries in the Mediterranean, during the peak of driftnet fisheries in the Mediterranean (in late 80s–early 90s, prior to the legislative measures banning totally or partially driftnet fishing) the total cetacean by-catch was estimated at more than 8000 individuals in the Italian seas alone (Di Natale and Notarbartolo di Sciara, 1994), and up to 10,000 individuals in the whole Mediterranean (IWC, 1994). This suggests that the impact of the current large-scale Moroccan driftnet fleet on dolphin populations is similar to that achieved by the former Italian driftnet fleet in the peak of its activity, in the whole area harvested by this fleet. The striking differences are that the latter fleet was fivefold the size of the Moroccan fleet and the area harvested by them was much more extended.

4.2.3. Pelagic sharks

In spite of the overwhelming predominance of *P. glauca*, *I. oxyrinchus* and *A. vulpinus* in the catches, other shark species – mainly from the Carcharhinidae family – are known to be landed in Al Hoceima port on an occasional basis.

Even though sharks are by-catch species or at best a secondary target in the Moroccan swordfish fishery, sometimes – obeying to the scarcity of the target species – some boats deploy the driftnets less offshore, at only 1–2 miles from the coast, where the chances of capturing some pelagic sharks (especially the thresher shark) are higher. According to catch rates for the two types of driftnetters shown in Table 8, *I. oxyrinchus* is the species most affected by the change from the by-catch scheme to the target fishery. Indeed, the catch rate per fishing operation for shortfin mako is near three times higher in those boats apparently behaving as active shark fishers (from 0.6 to 1.9 N/fishing operation) and the catch per km net follows a similar difference (from 0.06 to 0.14).

The high catch figures of sharks presented in this study sharply contrast with the information available on the activity of the former Spanish driftnet fleet in the Alboran Sea. Indeed, Silvani et al. (1999) reported only an anecdotic occurrence of shortfin mako and blue shark in the catch (i.e. 3 and 4 individuals in 1994, from a total 54 fishing operations monitored) and did not report any capture of thresher shark. Conversely, Valeiras et al. (2003) reported that the Alboran Sea is the area of the Western Mediterranean where Spanish fleets targeting swordfish using surface longlines achieve the higher by-catch rates of pelagic sharks (between 78% and 92% of the total by-catch in weight). According to this source the shark species involved in this by-catch are, in this order, *P. glauca*, *I. oxyrinchus* and *A. vulpinus*.

Blue shark was given the status *Lower Risk (Near Threatened)* in the 2000 IUCN Red List Global Assessment. It is also listed in Annex III ('species whose exploitation is regulated') of the Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean (SPA) of Barcelona Convention. Shortfin mako (*I. oxyrinchus*) is listed as *Lower Risk* (*Near Threatened*) in the 2000 IUCN Red List Global Assessment. According to Stevens (2000) and Goldman (2000), shortfin mako and thresher shark are very sensitive to depletion by fisheries, as pointed out by the heavy population declines driven by the California driftnet fishery between the 1970s and early 1990s.

The vulnerability of pelagic shark species in the area of study is best exemplified by the evolution of captures by the Spanish surface longline fleet in the Mediterra-

nean (including the Alboran Sea) from 1984 to 1994 (Camiñas, 1998). As a result of a change in the target of the fishery, that expanded from only swordfish to also encompassing pelagic sharks, the annual capture of blue shark increased from 5557 to 14,935 individuals, whilst those of shortfin mako and thresher shark dropped, respectively, from 1225 to only 122 and 176 to 93. In addition, the mean weight of all shark species decreased. These findings pointed to a fishing pressure on shortfin mako and thresher shark well beyond the reproductive capacity of these species and suggest the likely dramatic impact that the massive by-catch by the Moroccan driftnet fleet on these same species reported here (about 23,000 individuals by the fleet from Al Hoceima and Nador and further 77,500 by the one from Tangiers, distributed in roughly equal proportions for the three species) is entailing on their Alboran Sea and adjacent Atlantic populations.

Acknowledgements

The field component of this study was possible thanks to a grant from the WWF Project Across the Waters to AZIR. The authors are indebted to the Moroccan fishermen from Al Hoceima who participated in the data collection.

References

Bearzi, G., 2002. Interactions between cetacean and fisheries in the Mediterranean Sea. In: Notarbartolo di Sciara, G. (Ed.), Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies. In: A Report to the ACCOBAMS Secretariat, Monaco, February. Section 9, 20p.

Bearzi, G., Reeves, R.R., Notarbartolo di Sciara, G., Politi, E., Cañadas, A., Frantzis, A., Mussi, B., 2003. Ecology, status and conservation of short-beaked common dolphins (*Delphinus delphis*) in the Mediterranean Sea. Mammal Review 33 (3), 224–252.

Camiñas, J.A., 1995. The Loggerhead *Caretta caretta* (Linnaeus, 1758) pelagic movements through the Gibraltar Strait. Rapport et Procès-Verbaux des Reunions. Commision Internationale pour l'exploration scientifique de la Mer Méditerranée, vol. 34, p. 238.

Camiñas, J.A., 1997. Relación entre las poblaciones de la tortuga boba (*Caretta caretta* Linnaeus 1758) procedentes del Atlántico y del Mediterráneo en la región del Estrecho de Gibraltar y áreas adyacentes. Revista Española de Herpetología 11, 91–98.

Camiñas, J.A., 1998. El Futuro de los Caladeros. Perspectivas de la Pesca en el Mediterráneo Occidental. In: Encuentro Medioambiental Almeriense: En Busca de Soluciones. Universidad de Almería, Almería, Spain.

Cochran, W.G., 1977. Sampling Techniques. Wiley, New York.

de la Serna, J.M, Alot, E., 1990. Consideraciones relativas a los desplazamientos efectuados por el pez espada (*Xiphias gladius* L.) en el área del Estrecho de Gibraltar y otras observaciones relacionadas con la biología de la reproducción. ICCAT, Collective Volume of Scientific Papers XXXII (2), 205–212.

De Metrio, G., Megalofonou, P., 1988. Mortality of Marine Turtles *Caretta caretta* L. and *Dermochelys coriacea* (L.) consequent to accidental capture in the Gulf of Taranto. Rapport et Procès-Verbaux des Reunions. Commision Internationale pour l'exploration scientifique de la Mer Méditerranée, vol 31.

Di Natale, A., 1995. Driftnet impact on protected species: observers data from the Italian fleet and proposal for a model to assess the number of cetaceans in the by-catch. ICCAT Collective Volume of Scientific Papers 44, 255–263.

Di Natale, A., Labanchi, L., Mangano, A., Maurizi, A., Montaldo L., Montebello O., Navarra E., Pederzoli A., Pinca S., Placenti V., Schimmenti G., Sieni E., Torchia E., Valastro M., 1993. Gli attrezzi pelagici derivanti utilizzati per la cattura del pescespada (*Xiphias gladius*) adulto: valutazione comparata della funzionalità della capacità di cattura, dell'impatto globale e della economia dei sistemi e della riconversione. Report to Ministero della Marina Mercantile, 300p.

Di Natale, A., Notarbartolo di Sciara, G., 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean Sea and of cetacean bycatch. Report of the International Whaling Commission, Special Issue 15, pp. 189–202.

FAO (2001). International Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing. Rome, 24p.

Forcada, J., 1996. Abundance of common and striped dolphins in the southwestern Mediterranean. In: Evans, P.G.H., Nice, H. (Eds.), European Research on Cetaceans, vol. 9, pp. 153–155.

Goldman, K.J., 2000. Common thresher shark *Alopias vulpinus* (Bonnaterre, 1788). In: Fowler, S.L., Camhi, M., Burgess, G.H., Cailliet, G., Fordham, S.V., Cavanagh, R.D., Simpfendorfer, C.A., Musick, J.A. (Eds.), Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes. IUCN SSC Shark Specialist Group, IUCN, Gland and Cambridge, pp. 50–52.

Hobbs, R.C., Jones, L.L., 1993. Impacts of high seas driftnet fisheries on marine mammal populations in the North Pacific. International North Pacific Fisheries Commission Bulletin 53, 409–434.

IWC, 1994. Report of the workshop on mortality of cetaceans in passive fishing nets and traps. Report of the International Whaling Commission, Special Issue 15, pp. 6–57.

IWC, 1995. Report of the Scientic Committee. Annex G. Report of the sub-committee on small cetaceans. Report of the International Whaling Commission 45, pp. 165–186.

Lloris, D., Rucabado, J., 1998. Guide FAO d'identification des espèces pour les besoins de la pêche. In: Guide d'Identification des Ressources Marines Vivantes du Maroc. FAO, Rome. 263p.

López, A., Pierce, G.J., Santos, M.B., Gracia, J., Guerra, A., 2003. Fishery by-catches of marine mammals in Galician waters: results from on-board observations and an interview survey of fishermen. Biological Conservation 111, 25–40.

Notarbartolo di Sciara, G., 2002. Cetacean Species occurring in the Mediterranean and Black Seas cetacean species occurring in the Mediterranean and Black Seas. In: Notarbartolo di Sciara, G. (Ed.), Cetaceans of the Mediterranean and Black Seas: State of Knowledge and Conservation Strategies. In: A Report to the ACCOBAMS Secretariat, Monaco. Section 7, 17p.

Ocaña, O., García de los Ríos, A., 2002. Las poblaciones de tortugas marinas y cetáceos de la región de Ceuta y áreas próximas. Instituto de Estudios Ceutíes, Ceuta. 172p.

Reeves, R.R., Smith, B.D., Crespo, E.A., Notarbartolo di Sciara, G. (compilers), 2003. Dolphins, Whales and Porpoises: 2002–2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC Cetacean Specialist Group, IUCN, Gland. ix+139p.

SGFEN/STECF, 2001. Incidental catches of small cetaceans. Working Paper of the Subgroup on Fishery and Environment (SGFEN) of the Scientific, Technical and Economic Committee for Fisheries (STECF) of the EC. Document SEC(2002) 376, Brussels, 81pp.

Silvani, L., Gazo, M., Aguilar, A., 1999. Spanish driftnet fishing and incidental catches in the western Mediterranean. Biological Conservation 90, 79–85.

Stevens, J.D., 2000. Shortfin mako *Isurus oxyrinchus* (Rafinesque, 1810). Sharks, rays and chimaeras: the status of the chondrichthyan

fishes. In: Fowler, S.L., Camhi, M., Burgess, G.H., Cailliet, G., Fordham, S.V., Cavanagh, R.D., Simpfendorfer, C.A., Musick, J.A. (Eds.), Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes. IUCN SSC Shark Specialist Group, IUCN, Gland and Cambridge, pp. 59–61.

Tregenza, N.J.C., 1999. Fishing and cetacean bycatch. In: Kaiser, M.J., de Groot, S.J. (Eds.), Effects of Fishing on Non-Target Species and Habitats. Blackwell, Oxford, pp. 269–280.

Universidad Autónoma de Madrid and Alnitak, 2002. Proyecto de Identificación de las áreas de especial interés para la conservación de los cetáceos en el Mediterráneo español. Final Report. Sector Sur. vol. IV. Ministerio de Medio Ambiente, Madrid.

Universitat de Barcelona, 1995. Project Suroeste. A survey of interactions between marine mammals and fisheries in the south-western waters of the EEC. Final Report, Brussels.

Valeiras, J., de la Serna, J.M., Alot, E., 2003. Nuevos datos científicos sobre desembarco de especies asociadas realizados por la flota española de palangre de superficie en el Mediterráneo en 1999 y 2000. ICCAT, Collective Volume of Scientific Papers 55, pp. 149–153.