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Fishing activity and impacts along the main nesting area of loggerhead sea turtle *Caretta caretta* in Italy: overwhelming discrepancy with the official data

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SUMMARY: The southern coast of Ionian Calabria was recently recognized as the main nesting area of the loggerhead sea turtle *Caretta caretta* in Italy. The aim of this study was to characterize the fishing fleet in this area in terms of number of boats, economic situation, social aspects and impact on sea turtle specimens and target species. A multidisciplinary approach was essential to understand how the conservation problems of *C. caretta* are linked to various characteristics of the fishing fleet. Our data showed a vast discrepancy between the official census and the actual number of boats fishing in the area: 87% of the observed artisanal vessels lacked a required registration number, and thus were fishing illegally. This has caused serious social problems that worsened over the summer of 2007, when the presence of non-local registered vessels, using drift nets, generated a spatial conflict with the local artisanal fishermen. We identified 11 fishing gears used in the area and four of them were studied with on board observations: illegal drift nets, trammel nets, bottom longlines and longlines targeting swordfish. The total number of turtles caught during the summer in the area by longliners targeting swordfish was calculated to be 500 (±180 SE). In addition the presence of drift netters had a negative impact from an ecological and social point of view.

Keywords: *Caretta caretta*, fishing impact, by-catch, surface longline, drift nets, illegal fishing, artisanal fishing, IUU.

RESUMEN: Actividad pesquera e impacto en la principal área de nidificación de la tortuga boba *Caretta caretta* en Italia: diferencia abrumadora con los datos oficiales. – La costa sureste de la Calabria jónica ha sido identificada recientemente como el área principal de nidificación de la tortuga boba *Caretta caretta* en Italia. El objetivo del presente estudio fue caracterizar la flota pesquera en esta área cuantificando el número de barcos por tipología de pesca y describiendo la situación económica, los aspectos sociales y los impactos sobre individuos de tortugas marinas y de las especies objetivo. El enfoque multidisciplinario ha sido fundamental a la hora de entender como los problemas de conservación de *C. caretta* se relacionan con las varias características de la flota pesquera. Nuestros datos revelan una enorme discrepancia entre el censo oficial y el número real de barcos que faenan en esta área: el 87% de los barcos artesanales pesca ilegalmente, ya que no poseen la matrícula reglamentaria. Esto causa graves problemas sociales que empeoraron durante el verano 2007, cuando la presencia en el área de barcos matriculados, procedentes de otros lugares y que utilizaban las redes de deriva, provocó un serio conflicto espacial con los pescadores artesanales locales. Identificamos 11 artes de pesca empleadas en el área, cuatro de ellas estudiadas con observaciones a bordo: red de deriva ilegal, trasmallo, palangre de fondo y palangre para la captura del pez espada. El total de tortugas capturadas en verano en el área por los palangreros de pez espada fue estimado en 500 (±180 SE) y la presencia de rederos de deriva tuvo un impacto negativo desde un punto de vista ecológico y social.

Palabras clave: *Caretta caretta*, impacto de la pesca, capturas accidentales, palangre de superficie, redes de deriva, pesca ilegal, pesca artesanal, IUU.

INTRODUCTION

The loggerhead turtle *Caretta caretta* is included in the IUCN Red List of Threatened Species (http://www.redlist.org) and is protected by international conventions and European Union laws (Washington Convention, Appendix I CITES, Berne Convention, UE Dir. N. 206/22 1992, Appendix II, All. II). Habitat degradation, progressive destruction of nesting sites and increasing incidental mortality at sea are the most probable causes of the worldwide decline of the species (Lutcavage *et al*., 1997). In the Mediterranean, loggerhead nesting occurs almost exclusively in the eastern basin. The main nesting sites, in terms of nest number, are in Greece, Turkey, Cyprus and probably Libya (Margaritoulis *et al*., 2003).

One of the major threats for sea turtle conservation is the incidental capture by fishing gears, particularly by bottom trawling (Lewison and Crowder, 2007) and drifting longline (Lewison *et al*., 2004). In the Mediterranean, drifting longlines targeting albacore tuna (*Thunnus alalunga*) and swordfish (*Xiphias gladius*) are estimated to be responsible for at least 50000 sea turtle captures each year with an estimated mortality rate exceeding 30% (Casale, 2008). In Italy, the interaction between sea turtles and fisheries has been documented in the North Adriatic Sea, the Ionian Sea and surrounding the Straight of Sicily (Deflorio *et al*., 2005; Casale *et al.*, 2007, 2008).

The southern coast of Ionian Calabria (from Capo Bruzzano, 38°01'52"N, 16°08'38"E to Capo dell'Armi, 37°57'12"N, 15°40'50"E, 52 km long) was recently recognized as the most important Italian nesting area of the loggerhead turtle (Mingozzi *et al*., 2007), accounting for, on average (2003-2008), 11.2 ± 4.95 nests/years (range = 7-21), i.e. about 67% of the total number of nests documented in Italy (Mingozzi, unpubl.). This area thus represents a new nesting area in the Mediterranean, extending the regular loggerhead nesting range westward in the basin. The presence of this endangered species in this new area calls for the need to identify and quantify possible threats in order to implement sound conservation measures.

Since the summer of 2000, when the monitoring of nesting beaches along the southern Ionian coast of Calabria was initiated (Mingozzi *et al*., 2007), stranded sea turtles have been frequently found dead on beaches during the nesting season, with deaths attributed to injuries caused by fishing gears. In spite of the important role of southern Ionian Calabria in the reproduction of loggerhead turtles, no studies have quantified the impact of fishing activity on this species in this area. In the summer of 2007 we launched the first study to characterize fishing activities that were likely to affect the breeding individuals and the small and large juvenile specimens present in the study area. Long-term conservation of loggerhead turtles needs to promote fishing activities which are sustainable from a biological, social and economic point of view. Generally, an economically unsustainable fishery is the result of overexploitation of fish stocks, which leads first to a decrease in the economic benefits and then to negative values (Gordon, 1954). When this happens the exploited stocks are often on the edge of collapse and the ecosystem damaged.

Conservation and management measures should thus ensure the long-term sustainability of fishery resources at levels which promote the objective of their optimum utilization and maintain their availability for present and future generations (FAO, 1995).

The study area represents one of the least economically developed areas in Italy, where there are currently few alternatives to fishing. Developing sustainable fisheries activity should thus be an administrative priority from many points of view, in addition to the conservation of *C. caretta*.

To achieve this, we used a multidisciplinary approach designed to first characterize local fishing activities, then formulate a management initiative which balances the conservation of marine species with long-term sustainable fishing practices. The study was thus divided into four main objectives: 1) to identify and quantify the fishing effort in the Ionian waters adjacent to the main Italian nesting ground of *Caretta caretta,* measured as the number of active boats and fishing days; 2) to describe the economic, social and environmental aspects of the fishing activity; 3) to identify the impacts of fishing gears, in particular surface longlines, on the turtle specimens and on target species; and 4) to describe the current fishing-related social problems and identify possible future scenarios.

MATERIALS AND METHODS

Study area

The study area was divided into two sections: 1) the coastal zone between the port of "Saline Ioniche" (Montebello Ionico) (37º55'39"N 15º43'50"E) and Capo Bruzzano (43 km of coastline, including the main

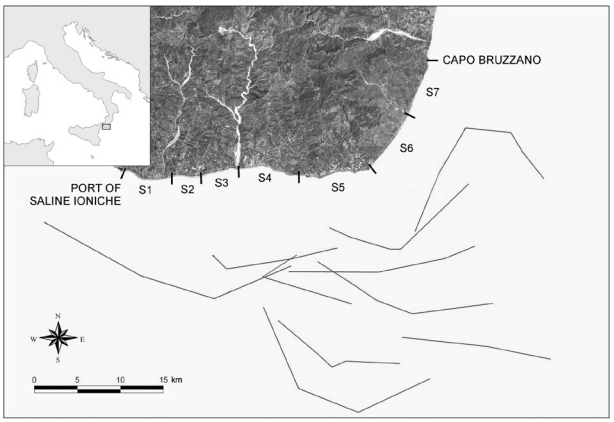

FIG. 1. – The study area, from the port of Saline Ioniche (SW) to Capo Bruzzano (NE) at the southernmost tip of the Italian peninsula. Figure shows the 7 coastline sectors (numbered S1-S7) used to census the vessel fleet, and the location (gray lines) of the fishing operations (n = 10, surface longlines) recorded on board a single commercial fishing vessel during the summer 2007.

nesting beaches on which fishing vessels were moored), and 2) its adjacent marine area, where on board observations of fishing activities were carried out.

The observation of the drift net operation was carried out 4 to 7 miles off-shore at 790-1200 m depths. The observations of trammel nets and bottom longlines were carried out at depths of 6 m and 543 m respectively. Finally, the observations of surface longline activities included a marine zone which was 3.5 to 17 miles from the coast, and between 200 and 2000 m depth (Fig. 1).

Census of the fishing vessels moored along the study area

Data were collected from May to September 2007, which was the loggerhead turtle nesting season. Each vessel present on the shore in the study area was catalogued by length (the majority of boats were moored on beaches due to the lack of available ports). We divided the fleet into three sections, according to the indications of the General Fisheries Commission for the Mediterranean (GFCM) (www.gfcm.org) and Italian laws (Ministerial Order 26 July 1995 and Decree of President of Republic no 1639, 2 October 1968): 1) artisanal vessels: length <12 m and gross tonnage <10 t; 2) polyvalent vessels: length >12 m; and 3) recreational vessels: fishing occasionally and without an economic purpose. Using the methodology applied by Camiñas *et al*. (1986), the censused boats were grouped into 7 coastal sectors, according to the beach and municipality to which they belonged. Total length was directly measured for those vessels present on the shore (82.0% of the artisanal and 93.6% of the recreational vessels). For the remaining boats, which were anchored at sea and not along the shore, total lengths were visually gauged. Finally, our census was compared with the official records obtained from port authorities.

Technical and economic data of the fishing activity

To obtain technical and economic indicators that would allow us to describe our fleet and compare it with others (Franquesa *et al*., 2005), 50 boat-owners were interviewed to gather the following technical and economic data, concerning the fishing activity from autumn 2006 to summer 2007: a) technical data of the boat (length, gross tonnage, motor power, gears used and year of construction) and number of fishing days per month; b) cost data (fixed, variable and maintenance costs and investment typology); and c) total catch and profit data (monthly landings (kg) and landing price by species). The declared data on fish catches allowed us to estimate the total yearly catch and biomass extracted by the fleet in the study area.

We interviewed 37 artisanal, 6 polyvalent and 7 recreational boat-owners, corresponding to 17.5% (n=211), 60.0% (n=10) and 2.1% (n=326) of the total number of boats censused in these three categories respectively. Catch data from 18 interviews did not correspond with the data from on board observations or landings data. These data were filtered by comparing them with: i) production data declared by reliable boat-owners (known and trusted fisherman); ii) production data obtained from on board observations; and iii) literature on total catch in this area.

On board data collection

Fishing operations in the study area were analyzed through on board observation on vessels (n = 17) that were using a) illegal (8 km long, while the legal length is 2.5 km) drift nets "ferrettara" (n = 1), b) trammel nets (n = 2), c) bottom longlines (n = 4), and d) longlines targeting swordfish (n = 10). As stated by interviewees these gears are some of the most popular in the summer months when *C. caretta* nest in the area. For each fishing operation, the location of fishing gears at sea and their technical characteristics (main line and net length, mesh size, number and size of hooks) were recorded, and every specimen of each species caught was measured (total length to the lowest mm) and weighed (wet weight, g).

TABLE 1. – Technical features of the drifting surface longlines observed in the study area.

Features	Measures
Hook total length (cm) (standard J hook)	6.5-7.5
Number of hooks	450-860
Length of main line (km)	20.5-34.4
Diameter of main line (mm)	2
Length of branch line (m)	8
Diameter of branch line (mm)	1.7
Distance between branch line (m)	33-45
No. of branch lines between two floats	3-7
No. of floats	30-166
Distance between two floats (m)	132-360
Soaking time (h)	8-11.5
Bait	*Scomber scombrus, Illex argentinus*

With drifting longlines, observations were carried out on board a single commercial fishing vessel (8.9 m in length) to reduce data variability due to differences in fishing effort and efficiency among vessels (Camiñas *et al*., 2006). The CPUE (Catch Per Unit Effort) was calculated for the sea turtle by-catch. Two types of CPUE were calculated: 1) index R = no. incidental catches / no. hooks^{-3}, and 2) index F = no. incidental catches / no. fishing operations. A total of 5960 hooks were individually checked.

For each fishing operation, the following information was recorded using a GPS device (E-Trex - Garmin): a) the initial and final positions (e.g. soaking and retrieval of the gear), b) changes in tack during the operation, and c) the location where the sea turtles by-caught were found. For each turtle captured the curved carapace length notch-to-tip (CCLn-t) (Bolten, 1999) in cm was measured and the point of hook insertion in the body was recorded.

The technical characteristics of the surface longline gear observed in the study area are reported in Table 1.

RESULTS

Census of the fishing vessels moored along the study area

Fishing vessels belonged to two distinct categories: permanent vessels (local vessels that fish in the area all year) and seasonal vessels (non-local vessels that work in the area only in summer). The category of permanent vessels (n = 534) was composed of 206 artisanal, 2 polyvalent (mainly purse seiners for catching small pelagic species) and 326 recreational boats (Table 2). The category of seasonal vessels (n = 13) was composed of 5 artisanal (surface longliners) and 8 polyvalent boats (drift netters) (Table 3). For the seasonal vessels it was possible to identify the fishing gears used during the summer by observing daily the gears (drift nets and longlines) permanently located on board. For the permanent artisanal ves-

TABLE 2. – Total number of permanent vessels operating in the study area throughout the year.

Sector	Municipality	Beach/Port	Length of the beach (km)	Number of fishing vessels		
				Artisanal vessels	Polyvalent vessels	Recreational vessels
Sector 1	Montebello Iónico	Port of Saline Ioniche	-	34	2	9
Sector 1	Melito di Porto Salvo	Melito P. Salvo West	6.8	21	0	20
Sector 1	Melito di Porto Salvo	Melito P. Salvo East (Pilati di Melito beach)	2.6	10	0	27
Sector 2	Marina di S. Lorenzo	Marina di S. Lorenzo beach	3.1	17	0	42
Sector 3	Condofuri Marina	Condofuri Marina beach	4	5	0	55
Sector 4	Bova Marina	Fiumara Amendolea –Crisafi	5	23	0	64
Sector 4	Bova Marina	S. Pasquale	3.2	11	0	11
Sector 5	Palizzi Marina	Murrotto - Baia dei Gelsomini	2.4	25	0	19
Sector 5	Palizzi Marina	Spropoli West	0.35	13	0	1
Sector 6	Brancaleone Marina	Galati - Brancaleone West	6.6	39	0	48
Sector 7	Marinella di Bruzzano	Pantano Piccolo – Canalello	6.5	8	0	30
Total number of vessels between the port of Saline Ioniche and C. Bruzzano				206	2	326

TABLE 3. – Total number of vessels operating in the study area only in summer.

Sector	Municipality	Beach/port	Length of the beach (km)	Number of fishing vessels		
				Artisanal vessels	Polyvalent vessels	Recreational vessels
Sector 4	Bova Marina	Fiumara Amendolea –Crisafi	5	2	0	0
Sector 4	Bova Marina	S. Pasquale	3.2	1	0	0
Sector 5	Palizzi Marina	Murrotto – Baia dei Gelsomini	2.4	0	5	0
Sector 5	Palizzi Marina	Spropoli West	0.35	2	0	0
Sector 6	Brancaleone Marina	Galati - Brancaleone West	6.6	0	3	0
Total number of vessels between the port of Saline Ioniche and C. Bruzzano				5	8	0

TABLE 4. – Technical and economic indicators of the fleet studied (autumn 2006/summer 2007).

Indicators (average value)		Present study, SE Ionian Calabria		
		Artisanal	Polyvalent	Recreational
Technical indicators	Gross tonnage per boat (t)	3.53	16.46	0.71
	Yearly fishing days per boat (n)	212	246	107
	Vessels older than 26 years (%)	30.5	0	29
	Length of vessel (m)	6	15.8	4.9
Cost indicators	Yearly variable costs per boat (€)	6799	79974	1388
	Yearly gasoline costs per boat (€)	3271	37537	568
	Yearly maintenance costs per boat (€)	6513	34471	1126
Production and profitability indicators	Yearly catch per boat (t)	4.20	92.60	0.60
	Yearly catch per gross ton (t)	1.20	5.60	0.84
	Yearly income per boat (€)	42102	388600	-
	Yearly profit per boat (€)	4458	59352	-
	Gross estimated profit rate (%)	39.1	97.8	-

sels, such observations were not possible due to the general absence of gear on board and to the fact that multiple gears are used throughout the same season.

The artisanal sector was the most representative of the commercial fishing activity in the area in terms of the number of boats. However, almost all, 86.9% of the permanent artisanal vessels (n = 179, out of 206 total units), fished illegally without the required hull identification number and fishing licence. In contrast, all seasonal vessels had a hull registration number and fishing licence.

Technical and economic characterization of the fleet segments

Data from the interviews showed that the three fleet segments (artisanal, polyvalent and recreational boats) were different both in terms of their economic and technical characteristics (Table 4).

Fixed costs (administrative costs, such as fishing licence, mooring etc.) for artisanal and polyvalent boats were marginal due to the widespread illegality of the fishing activity in this area. Variable costs of the artisanal vessels were one order of magnitude lower than those of polyvalent boats, as was the profit from catches. Yearly maintenance costs included recovering the investments made into improving vessel conditions. Fishing gears represented the most frequent investment both for artisanal and polyvalent boats; however, these two fleet segments differed in the amount of capital invested due to differences in their fishing strategies and purchasing power. Artisanal vessels made their largest investments into motors, while nets were the largest investment for polyvalent vessels due to the high cost of illegal drift nets.

A significant correlation between boat length (x) and yearly total catch (y) ($y = 1008.5 x - 1768$) was found for the artisanal sector ($R = 0.5$, $p = 0.001$). Applying this linear regression to the censused artisanal permanent vessels, we estimated a total yearly commercial biomass caught of 703 t. The total commercial catch for the remaining fleet segments was estimated by calculating the average catches of boats whose owners were interviewed, and then multiplying these by the total number of boats. For the polyvalent segment the estimated yearly commercial catch of the purse seiners was 255 t and summer commercial catch for the drift netters was 320 t. The summer commercial catch of the 5 longliners was also estimated as 22 t from on board observations. Finally, the yearly

TABLE 5. – Temporal patterns of use of the different fishing gears throughout the year for the boat-owners interviewed (percentage of the ship owners that use each fishing gear monthly: A = 80-100%, B = 60-80%, C = 40-60%, D = 20-40%, E = 0-20%) and *C. caretta* reproduction period (**main and *final nesting months) in the study area.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Drift net "mutualara"	D	D	E	E	E	E	E	E	B	A	B	C
Pot	B	B	C	D	D	D	C	C	D	C	B	B
Seine net	A	A	A	B	C	C	C	D	C	C	C	B
Line	D	D	E	E	D	C	D	B	A	A	C	D
Surface longline	D	E	D	D	C	B	B	C	C	C	D	D
Gillnet	A	A	B	B	B	B	B	B	A	A	A	A
Trammel net	B	A	B	B	B	B	B	B	C	B	B	B
Purse seine (small pelagic)	D	D	E	E	C	B	B	B	A	C	C	D
Bottom longline	C	C	C	B	B	A	A	B	A	B	C	C
Bottom drift net "bardasciuni"	E	E	E	E	C	A	A	B	C	E	E	E
Drift net "ferrettara"	E	E	C	A	A	A	A	A	A	D	E	E
C. caretta reproduction period						**	**	*				

catch of recreational vessels was estimated as 195 t. The annual total commercial biomass extracted from the study area by the studied fleet was estimated to be 1495 t. Combining the data from the interviews on the main fishing zone and the data from the on board observations, we found that the marine area in front of the nesting beaches (between the port of Saline Ioniche and C. Bruzzano) was the main fishing zone of the fleet studied. In particular, between 0 and 4 miles off the coast for the permanent artisanal vessels, between 4 and 12 miles for the purse seiners and drift netters; between 3.5 and 17 miles for the surface longliners targeting swordfish; and between 0 and 2 miles off-shore for the recreational vessels.

During the summer, fishing effort increased not only in terms of the number of boats (Table 3) but also, according to the interview data, the number of fishing days. In fact, compared to the spring of 2007, the number of fishing days increased by 46.3% in the summer for the artisanal vessels, by 27.4% for the polyvalent vessels and by 232.2% for the recreational vessels.

Information on changes in the gears used throughout the year was obtained from the interviews. A total of 11 fishing gears were used in the studied area (Table 5).

The main gears used during the loggerhead turtle nesting season included drift nets "ferrettara", set nets (gill and trammel nets) and longlines (bottom and surface). This information was used to direct on board observations.

The main impacts of fishing activity on the species caught

The soaking time of the illegal drift net "ferrettara" was 6 hours, from 8 p.m. to 2 a.m. The net was 8 km long, 30 m wide with a 160 mm mesh size. During the drift net survey a total of 7 species (n = 67 specimens) were caught: 26 albacore *Thunnus alalunga*, 24 little tunny *Euthynnus alletteratus*, 11 bluefin tuna *Thunnus thynnus*, 2 common dolphinfish *Coryphaena hippurus*, 2 common eagle ray *Myliobatis aquila*, 1 grouper *Epinephelus sp* and 1 swordfish *Xiphias gladius*. All samples in the catch were dead when loaded onto the boat. Of the total specimens caught, 64 (95.5%) were illegally caught, since they were species included in the Annex VIII of Council Regulation No 1239/98, and 10 specimens (90.9%) of the bluefin tuna caught were below the minimum legal size (1150 mm, EC No 41/2007).

The mean soaking time of trammel nets was 15 hours. Net length was nearly 1 km and 18 mm mesh size. The main target species for this gear was cuttlefish *Sepia officinalis* (n = 33 specimens, 60.4% of the total catch in weight) (Fig. 2). The average length of the specimens was 119.7 mm ± 23.02 SD (range = 90.0 - 193.0 mm) and no specimen was below the size of first sexual maturity (90 mm for females and 70 mm for males, Önsoy and Salman, 2005). The discarded specimens represented 5.9% (5 specimens) of the total catch; within this percentage, 20% were non-commercial species (*Torpedo sp*) and the remaining were commercial species which were discarded because of physical damage (completely damaged, only the skin and the skeleton remained). In the four observations of bottom longlines, the average length of the main line was 3.5 km, the average number of hooks ("J" shaped Mustad no. 3/0) was 700 (range = 500 to 900) and the soaking time was nearly 12 hours. The main target species for bottom longlines was European hake *Merluccius merluccius* (n = 56 specimens, 32.0% of the total

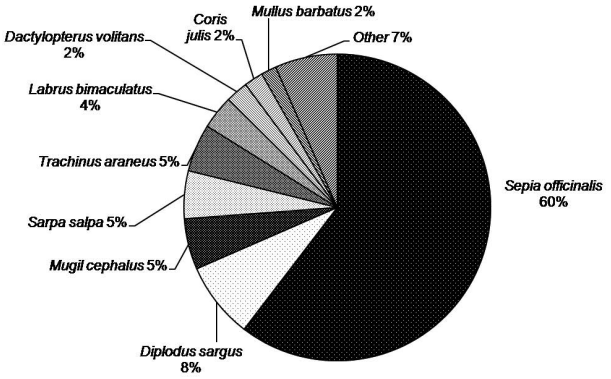

FIG. 2. – Catch composition of trammel nets (weight) sampled in the study area during the summer of 2007.

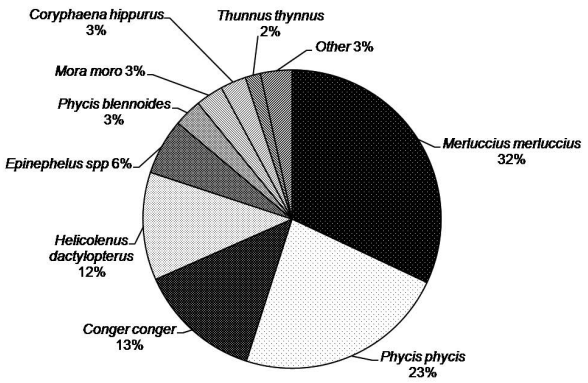

FIG. 3. – Catch composition of bottom longlines (weight) sampled in the study area during the summer of 2007.

catch in weight) (Fig. 3). The average length of the specimens was 469.4 mm ± 82.36 SD (range = 210.0 to 720.0 mm) and all of them were above the minimum legal size (TL, total length = 200 mm). The discarded specimens represented 7% (22 specimens) of the total catch number; within this percentage 36% were non-commercial species (*Mustelus sp*) and the rest were commercial species discarded because of physical damage (the eyes, the gills and part or all of the belly area were damaged).

From the observations of the surface longlines targeting swordfish, 17 (36.9%) out of 46 specimens caught were loggerhead turtles, while the remaining specimens belonged to 5 different species of fish: swordfish (n = 19, 41.3%), bluefin tuna (n = 5, 10.9%), common dolphinfish (n = 2, 4.3%), ocean sunfish *Mola mola* (n = 2, 4.3%) and the Mediterranean spearfish *Tetrapturus belone* (n = 1, 2.2%). The average length of the swordfish in the catch was 1212 mm ± 260.3 SD (range = 750.0 - 1760.0 mm) and 57.9% (n = 11) of them were below the minimum legal size (1200 mm).

An increasing trend in the R index of *C. caretta* by-catch was observed from June to August (Table 6). Out of 17 sea turtles captured, 16 (94.1%) were hooked to squid baited hooks attached to attracting lights. Of the 16 turtles that were brought on board, 7 (43.8%) were found hooked on the lower palate, 6 (37.5%) deep in the digestive track and 3 (18.8%) on the higher oesophagus. All of the sea turtles caught were found alive. On average, CCLn-t (curved carapace length) for turtles was 52.67 cm ± 8.07 SD (range: 40.0 - 66.0 cm); one of the turtles caught was an adult female (66.0 cm CCLn-t).

The total sea turtle by-catch of the longline gear was estimated for the study area from the following information: a) average value of the index F (1.67), b) total number of vessels using the same gear (n = 5), and c) the average number of fishing days per boat for each summer month (June, July and August 2007) (n = 20). For longline vessels, a total of 100 sea turtles by-caught per vessel (1.67 * 20 * 3) was estimated and a total of n = 500 (± 180 SE) turtles was calculated for the whole fleet over the summer.

DISCUSSION

Fishing fleet typologies and features

The fleet studied was divided into three main segments: polyvalent, artisanal, and recreational. The polyvalent vessels were primarily composed of drift netters. This type of net should be consid-

TABLE 6. – Indicators of observed fishing effort (drifting surface longlines targeting swordfish *Xiphias gladius*) and incidence of *C. caretta* by-catch in the southern Ionian Sea during the summer of 2007.

Indicators	June	July	August
Fishing sets (total n = 10)	3	4	3
Number of turtles caught (total n = 17)	1	8	8
Fishing effort observed (x 1000 hooks) (total n = 5.96)	1.75	2.35	1.86
Number of turtles caught/ number of hooks^{-3} (R) (average = 2.76)	0.57	3.40	4.30
Number of turtles caught / fishing sets (F) (average = 1.67)	0.33	2.00	2.67

ered illegal, not only because it is generally longer than the maximum length allowed by Italian law, as demonstrated by our on board observation, but also according to the definition of Illegal, Unreported and Unregulated Fishing (IUU) made by FAO (2001). In this document illegal fishing refers to activities conducted by vessels flying the flag of states that are parties to a relevant regional fisheries management organization (Italy is part of GFCM and ICCAT) but operate in contravention of the conservation and management measures adopted by that organization and by which the states are bound. One of the conservation measures adopted by GFCM (2005) is the recommendation by ICCAT in relation to Mediterranean swordfish that the contracting parties should prohibit the use of drift nets for fisheries of large pelagics in the Mediterranean.

Regarding the artisanal segment, 86.9% of the artisanal permanent vessels lacked a required registration number. According to the IUU definition, these vessels are illegal because their fishing activity is conducted by national vessels in waters under the jurisdiction of a state, without the permission of that state. They are also unreported, because these vessels have not been reported to the relevant national authority, in contravention of national laws and regulations. This study quantified, for the first time in Italy, the degree of illegal fishing that takes place in a specific region for a multiple-gear fleet, in terms of the actual number of boats and the use of banned fishing gears. While a few studies have tried to quantify the illegal use of specific fishing gears, such as the purse seine for bluefin tuna (ATRT, 2008) or drift nets for large pelagics (Cornax *et al*., 2006), these studies aimed to understand the illegal fishing which exploits highly valued species, such as tuna and swordfish in (at least) southern Italy. Our research takes this one step further by extending the dimension of illegality to the artisanal fishery sector and reveals that IUU fishing activity represents the core of the Calabrian fisheries. In other European countries, such as Spain (Atlantic region) or Scotland, the amount of illegal fishing is much lower than what we found in Calabria (Otero *et al*., 2005; Young *et al*., 2006).

Technical and economic features of fleets

The conflict between artisanal and polyvalent segments arises due to economic and political factors surrounding the use of illegal drift nets, which constitute the largest economic gain of polyvalent fishing. Both the artisanal and polyvalent vessels exploited marine resources for economic gains, even though the costs and profits differed. Revenues of polyvalent vessels were much higher than for artisanal vessels, since illegal drift netters used nets that were several kilometres long, which allowed larger catches. As a result, incomes differed by an order of magnitude between the two fleet segments. This difference gave rise to social conflict which worsened over the summer season when the local artisanal boats were increasingly competing with the illegal drift netters for space. However, since many of the artisanal fishermen were illegal they could not openly oppose the illegal drift nets used by the polyvalent competitors.

The technical and production indicators of the fleet were compared with the 2002 official information (Irepa, 2003) for the Calabrian fleet. Comparisons with more recent data were not possible because, as of 2003, Irepa has adopted a different fleet segmentation protocol. The comparison of our data with Irepa data of 2002 shows differences in technical characteristics and in production and profitability values. For the polyvalent segment, the gross tonnage per boat in the Irepa data of 2002 was 13.7 tons, the annual average fishing days per boat was 166.7, the annual catch per boat averaged 23.7 tons and the annual incomes per boat were 96940 €. These indicators were much lower compared to the data obtained in this study, which could be due to the different periods compared, or the different composition of the fishing segments, since in our study the polyvalent vessels are exclusively drift netters and purse seiners for small pelagics. For the artisanal segment ("small scale fishery" in Irepa's reports) the gross tonnage per boat was 2.4 tons, the annual fishing days per boat were 184.3, the annual catch per boat was 5.4 tons and the annual incomes per boat were 27510 €. In this case the differences with our data could be due not only to the different periods compared but also to the exclusion of a large number of fishing vessels from the official statistics. In our study 87% of the permanent artisanal vessels fished illegally. This worrying reality, although obtained for only a specific area of the Ionian coast of Calabria (43 km long), may reflect what is happening on a much wider scale, at least along the entire Calabrian Ionian coast in the province of Reggio Calabria. In fact, qualitative observations were made of other beaches along the Ionian coast in the province of Reggio Calabria (beaches of Bianco, Ardore,

Bovalino, Locri, Siderno) between the years 2005 and 2007, and these confirmed the presence of a large number of fishing boats without hull identification numbers. Officially, the Calabrian fishing fleet constitutes a small proportion (6.4%, n = 912) of the total national units (Irepa, 2007), in spite of the great extent of the regional coastline (780 km, 10.4% of Italian extent). Our data questions the reliability of the Calabrian official information on fishing activity, in terms of a real census of boats and, possibly, in terms of technical and economic indicators. In addition, the reliability of the official information regarding fishing activity throughout Italy should also consider the reliability of official regional statistics.

General fishing impacts

The four fishing gears analyzed were characterized by the different levels of size-selectivity of the target species and different discard rates. Trammel nets and bottom longlines appeared to be the most size-selective of the studied fishing gears. However, the drift net appeared to be a non-selective fishing gear at least for bluefin tuna, an overexploited species and at risk of collapse (ICCAT, 2008). Moreover, 95.5% of the total specimens caught were illegal catches as they belong to highly migratory species (Council Regulation No 1239/98).

Drifting surface longlines targeting swordfish appear to be a non-selective fishing gear that catches a high percentage of the swordfish specimens below the minimum legal size (57.9%). The discard rate (in numbers) of the total catch was 41.3%, due exclusively to the non-commercial species by-catch. 89% of this by-catch were loggerhead sea turtles.

A fishery using size and species selective fishing gears is more sustainable in the long-run than one using less selective fishing gears (FAO, 1995; FAO, 2005-2009).

Incidental captures of marine turtles

Our on board observations in bottom longline and trammel net vessels did not report sea turtle by-catch, although some studies have highlighted an interaction between sea turtles and these fishing gears (e.g. Delaugerre, 1987).

No sea turtles were caught during the on board observation on the illegal drift net vessel. However, it is known that this gear has a negative impact on sea turtle specimens, as demonstrated by literature on the subject, which stresses the high number of sea turtles caught with drift nets in the Ionian Sea (De Metrio and Megalofonou, 1988).

Drifting surface longlines targeting swordfish also showed negative impacts on the loggerhead turtle specimens due to the high relative number of sea turtles in the catch species composition and to the internal and external injuries caused by this gear, which can affect the feeding activity of the turtles and could be responsible for their subsequent mortality. These conclusions are based on the following observations: a) *C. caretta* was the second species in number of individuals caught, after the target species *X. gladius*; b) the CPUE estimated for the loggerhead turtle by direct observations during July and August was higher than that calculated by Deflorio *et al*. (2005) for Sicilian longliners targeting swordfish in the northern Ionian Sea during the summer of 1999 (for a significance level of 10%); c) the average size (CCLn-t) of loggerhead turtles caught in our samplings corresponded to large juveniles closer to sexual maturity than those reported by Deflorio *et al*. (2005), and therefore they are more important for the conservation of the species in terms of demographic contribution (UNEP-RAC/SPA, 2000); moreover, one sea turtle caught during the on board observations was an adult female. Our data show that the area studied could include an important feeding ground for *C. caretta*. Furthermore, as this area is located off the most important reproduction site for the species in Italy, the risk of accidentally capturing nesting females is high.

Based on the results of Casale *et al.* (2008) on sea turtle survival rates as a function of the location of the hook in the animal's body, the mortality after release could be about 46.5% (n = 232 ± 84 SE) for the loggerhead turtles captured by the surface longliners fishing in front of the Calabrian nesting beaches.

Limitations of the study

The limitations of this study can be summarized as:

1) The fleet studied does not include vessels which may occasionally fish in the area during the year (e.g. bottom trawlers or purse seiners from other fishing ports). The catch of these occasional fishing operations could significantly increase the quantity of total biomass fished annually in the study area to an excess of 1500 tonnes.

2) The observed fishing gears are limited to the summer season and to 4 of the 11 total fishing gears used in the area. Future research should consider the possible impacts on *C. caretta* and other target and non-target species of all the fishing gears used throughout the year in this region.

Possible scenarios

Possible scenarios for this area at the short to medium term include:

1) The situation remains as is without any administrative intervention. The possible consequences could be a decrease in the numbers of female sea turtles nesting in Calabria and a reduction in juvenile specimens present in the area and possibly those born at other beaches of the Mediterranean or Atlantic, thus nullifying part of the conservation efforts promoted by other Mediterranean and non-Mediterranean countries. The overexploitation of some target stocks could be another consequence, supported by the current increase in the number of artisanal vessels. This fleet's expansion is possibly a consequence of the positive profits of the artisanal segment, as proved by the Gordon-Schaefer bio-economic static model (Gordon, 1954; Schaefer, 1954; Seijo *et al*., 1997), and by its extensive illegality that facilitates the incorporation of new illegal vessels into the fishery.

2) Regional and national institutions know the existence of an illegal artisanal fleet and implement a management plan along with a substantial reduction in the number of illegal fishing units in the medium term. This reduction could be compensated by the development of alternative economically profitable activities connected with the eco-tourism industry or others. New activities could be realistic and possible over the medium to long term if they assume a structural change of the local economy. In the meantime any management initiative should include the improvement of the selectivity of the fleets by modifying the gear design components (hooks, line length, etc.) and/or operation (e.g. not using attracting lights, using alternative baits which are less attractive for turtles, or testing circle hooks) and by using alternative more selective fishing gears to reduce the capture of immature species and non-target species. Setting up spatial and seasonal protection zones and the eradication of the illegal drift nets (a practice that directly sustains a small number of families) should be prioritized.

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