

Diversifying fishing effort in Sicilian fisheries: the case of Fish Aggregating Devices (FADs)

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Abstract

In the Sicilian fisheries, the swordfish (*Xipbias gladius* Linnaeus, 1758), caught from March to December with several gears which vary according to season, represents one of the most important economic resources. The size composition changes depending on the gears used, the way it is operated, the fishing season. The gears used for swordfish fishing (longlines "for swordfish", drift nets, harpoons as operated by typical boats named "feluche") mainly catch adult specimens. From August to December, a high number of very young swordfish specimens (1.5 to 4.5 kg) is also caught as by-catch during the albacore fishing (*Thunnus alalunga* Bonnaterre, 1788) which is carried out by a special longline and hooks only 3 cm long. It was observed that in the same season, fishing areas and with boats of similar type, the fishing of dolphinfish (*Coryphaena hippurus* Linnaeus, 1758), using Fish Aggregating Devices (FADs) and purse seine is hardly practised in spite of the resource availability of swordfish. With the present work, which can be regarded as an initial approach to the problem of diversifying and managing fishing effort of swordfish, albacore and dolphinfish, their fisheries are examined and discussed, not overlooking the economic aspect, by considering whether a reallocation of fishing effort among the previously said resources might avert the risk of swordfish stock depletion.

Introduction

Many species fished are overexploited. The swordfish (*Xipbias gladius* Linnaeus, 1758) is one of the species with high commercial value and therefore fished in all seas of the world, throughout the year, and is also probably one of the most overexploited species.

Off Sicily, the swordfish is fished by fleets of almost all the ports: previously from the end of the winter (March) to the end of the summer (August), now, apart from the fishing ban period (45 days from 15 November), throughout the year (fig. 1). The gears mainly used are a longline for swordfish, drifting gillnet for swordfish (only for the period

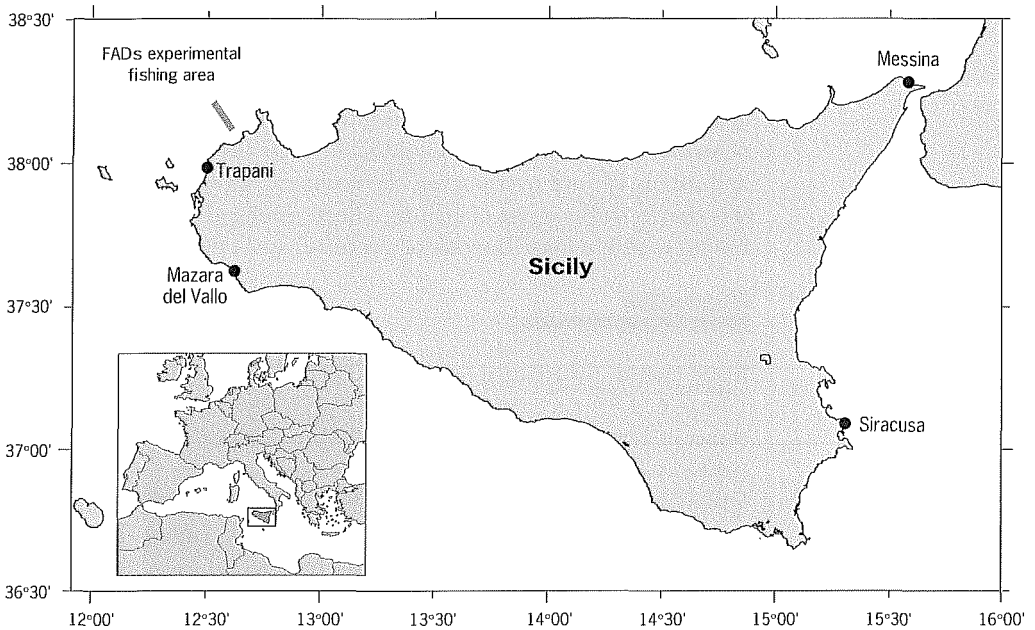
from May to July and, in any case, now being abolished definitively in Italy), and the harpoon used in the area of the Strait of Messina by special boats known as “feluche”. In recent years, the average size of swordfish catches has dropped year after year, indicating a depletion of the resource.

From September to December, the fleets of some Sicilian ports fish the albacore (*Thunnus alalunga* Bonnaterre, 1788), whose maximum size is generally around 15 kilogrammes. The gear normally used is a longline with hooks of just 3 cm, deadly for very young swordfish (specimens weighing between 1.5 and 4.5 kg) which are at times caught in greater numbers than the albacore itself. Despite the ban on the fishing and sale of such young swordfish, none of those unfortunate to be caught survive. Many fishing boats which fish albacore, generally until August, fish swordfish with longlines for swordfish or drifting gillnets.

In the same period, in many Sicilian ports, other fishing boats, some of which have fished swordfish until August, also fish the dolphinfish (*Coryphaena hippurus* Linnaeus, 1758) by means of Fish Aggregating Devices (FADs) and trawl nets. This latter activity contributes to deviating part of the fishing effort from swordfish and albacore towards dolphinfish.

Considering the particular structure of the fishing boats, their crew, generally consisting of two or three fishermen from the same family (father and sons, brothers, uncles and nephews), the fishing techniques and gear used, it can be said that the work of fishing the swordfish, albacore and dolphinfish off Sicily is an artisanal activity and that the boats should be classified as artisanal fishing fleets.

Figure 1
Sicilian fishing area.



With this work, which can be regarded as an initial approach to the problem of diversifying and managing the fishing effort of swordfish, albacore and dolphinfish, their fisheries are examined and discussed, without overlooking the economic aspect by considering whether a reallocation of the fishing effort among the previously mentioned resources might avert the risk of swordfish stock depletion.

Material and methods

A census has been done taken of all the fishing boats engaged in fishing swordfish, albacore and dolphinfish, operating from all Sicilian ports from January 1997 to December 1998. The catches and relevant fishing effort were also estimated.

Effort

Different approaches have been obviously developed (according to the type of fishing) to estimate the fishing effort. As far as the fishing of dolphinfish by FADs and purse seine net is concerned, the fishing effort has been estimated by means of the following formula:

$$\text{FADs fleet:} \quad E_k = N_b * N_f * N_h / 100 \quad [1]$$

with N_b the number of boats (fleet capacity), N_f the total number of FADs (gear capacity) and N_h the number of hauls carried out (activity). The effort E_k was divided by 100 for convenience.

With the swordfish and albacore specimens, we used two different formulas linked to the fleet:

$$\text{longline fleet:} \quad E_l = N_b * h * d / 1000 \quad [2]$$

$$\text{drifting gillnet fleet:} \quad E_g = N_b * l * d / 1000 \quad [3]$$

with h the average number of hooks per gear, d the number of fishing days and l the average length in metres of the net. Formula [2] was standardized in relation to a longline with 1 000 hooks, whereas formula [3] was standardized in relation to a 1 000 m long drifting gillnet. Formulas [2] and [3] cannot be compared to each other as they were obtained from different information.

Finally, the prices paid to the fishermen have been calculated on a weekly basis.

Results

Fishing fleet and fishing gear

Table 1 shows the swordfish, albacore and dolphinfish fishing fleet of all the ports in which at least one fishing boat is engaged in at least one of these activities. The fishing boats which use the longline for swordfish represent 48% (41% use the longline exclusively and 7% use the longline and drifting gillnet).

The drifting gillnets are to be banned completely by law in 2000 and 8% of the fishing boats which still use this tackle must convert. During the period from September to December, 16% of the fishing boats fish the albacore by means of a special longline known as "palangareddu" (small longline) and 27% fish the dolphinfish by means of FADs and trawl net. Finally, mention should be made of the nine fishing boats (the "feluche"), 1% of the fishing fleet, which operate in the Strait of Messina by means of a harpoon. This is the most typical and possibly the oldest way of fishing swordfish. The so-called "feluche" are boats about 15 m long, with a very high sighting mast and a long prow catwalk from where the fish are harpooned (Cavallaro *et al.*, 1988).

Table 1 - Average number of boats using longline for swordfish or albacore, drifting gillnet for swordfish and FADs in the last three years. *Boats using drifting FADs.

Port or landing place	Number of boats	Longline for swordfish	Longline for albacore	Gillnet	FAD	Longline and gillnet	Feluche
Augusta	27	15	5	4	3		
Catania	48	22	18	2	6		
Cefalu	33	3	9	5	13	3	
Gela	1	1					
Giardini Naxos	16	3	7	6			
Licata	22	6			16		
Lipari	48	27	12	4	5		
Marsala	44	44					
Mazara	17	17					
Messina	9						9
Ognina di Catania	25	20					
Porticello	103	34	18	7	44*		
Porto Empedocle	10	10					
Porto Palo di Capo Passero	55	23	1	5	26		
Pozzallo	10	3			7		
Pozzillo	96	31	22	3		40	
Riposto	29	9	13	7			
Sant'Agata	35	3	3	6	23		
Santa Maria La Scala	56	19	13	2		22	
San Vito Lo Capo	16	1			15		
Sciacca	12	9			3*		
Scoglitti	1	1					
Selinunte	5	2			3		
Syracuse	65	26	7	5	27		
Termini Imerese	22	3	6	2	11		
Trapani	22	6		2	14		
Tonnarella	23	10	2	1	10		
Falcone	14	7		3	4		
Capo di Orlando	6				6		
Total	870	355	136	69	236	65	9
Total %	100%	41%	16%	8%	27%	7%	1%

This fleet operates between June and September in the Strait of Messina or in the immediate vicinity. The catches generally consist of large swordfish. In recent years, there has been a drop both in the number of specimens caught and in their size. The reduction in catches and sizes has forced fishermen to consider the “tourism” aspect of this fishing profession and therefore, they often only have to allow a few tourists aboard and to capture just one swordfish in order to make both ends meet.

Drifting gillnet

This is a large net, commonly used until 1992, with a varying length of 12 to 16 km and a height of 15 metres. Since 1992, the longest net permitted by law is 2.5 kilometres. The characteristic feature of drifting gillnets for swordfish, compared to the other surface nets, is the extreme width of the meshes, which can reach 40 cm from knot to knot, making it the most treacherous for all average and large-sized marine species.

The first information on the fishing of swordfish by means of a drifting pelagic net is given by Oppiano (a Greek poet) in his five-volume work “Fishing” of 177 AD. From some notaries’ deeds of the fifteenth century we learn that in the Strait of Messina the so-called “*artem spidonis*” was exercised, i.e. fishing of swordfish with pelagic nets at night and with harpoons during the day. The fishing season started in April and ended in June, months in which maximum productivity was achieved. The boat used was generally the “*luntro nigrum*”, commonly known as “luntro”, a streamlined and fast craft measuring 6-7 m, propelled by eight rowers in four rows. The first news of overfishing of swordfish come from Lazzaro Spallanzani in 1793 who attributes the heavy drop in catches of swordfish with a harpoon, in the area of the Strait of Messina, to the excessive use of drifting pelagic nets. However, two centuries later and considering the description he makes of pelagic nets for swordfish of that time (long nets of more than 24 m, approximately 4 m high, and each boat may also use more than one), we can be certain that the causes for the decline were very different. In any case, Minasi, a historian, in one of his works dated 1889, says that the pelagic nets were introduced on a massive scale in the mideighteenth century. The first detailed information on the structure and size of nets is given in the early twentieth century, in documents of the chambers of commerce of Messina and Reggio Calabria. The nets, made in hemp, are between 800 and 1 000 m long, have a height of approximately 16 m and meshes with an opening of 34 centimetres.

Longlines for swordfish

These are made of a Nylon rope, twisted or otherwise, with a diameter that varies between 1.5 and 2.0 millimetres. The brackets, made from a double Nylon rope between 5 and 8 m long, are 30-35 m apart from each other and provided with 10 cm long hooks. The average length is about 50 km, for a total of 1 500 hooks. Frozen mackerel and squid are used as bait. With this gear large dolphinfish specimens are commonly caught from May to November (Potoschi *et al.*, 1993a,b).

Longlines for albacore

Another type of longline, also about 50 km long, is the one used for albacore fishing. The brackets, about 5 m long, are more or less 15 m apart from each other and the hooks are only 3 cm long. The fishing season for albacore starts in September and ends in December. Specimens caught in the Ionian Sea do not exceed 7 kg, whereas the ones caught in the Tyrrhenian Sea weigh 8 kg on average. Considering the simultaneous presence of young swordfish, using this equipment often allows a larger number of specimens to be caught, a considerable by-catch which heavily affects the stock of the species.

Fish Aggregating Devices (FADs)

FADs in the Mediterranean consist of a floating polystyrene foam surface, measuring about half a square metre and covered with a jute bag to which two palm branches are fastened. The framework is anchored to a block of concrete, weighing about half a quintal, by a Nylon cable. Dolphinfish tend to gather under the FADs and can easily be fished thanks to a special technique. The action consists of approaching the FADs while dragging a handline equipped with two hooks with a feather as bait. According to how fast the fish are biting and their number, the fishermen, thanks to their experience, are able to estimate the amount of fish under the FADs. In the case of a large number of dolphinfish, the handlines and the fish caught are dragged not too far from the FADs. This operation has an assembling and approaching effect on the other dolphinfish, creating the conditions for fast entrapment of the fish, away from any obstacles, using a special purse seine net (Bono *et al.*, 1997).

By-catch

Table 2 shows the species caught per tackle type. Most species are caught by a "spadara" net and therefore, despite the good catches of swordfish, mostly adult specimens, it was decided, as mentioned previously, to ban by law this very ancient fishing profession.

The by-catch of longlines for swordfish is formed by approximately 15 species. From the commercial viewpoint only about 50% of these species are of value. Amberjack (*Seriola dumerili* Risso, 1810) and Mediterranean spearfish (*Tetrapturus belone* Rafinesque, 1810) even if rarely caught, have high commercial value. The by-catch also includes some selachi of little or no commercial value and a few protected species such as *Caretta caretta* (Linnaeus, 1758) and leather-back (*Dermochelys coriacea* Vandelli, 1761) caught in more than 30% and around 10% of hauls respectively.

The longlines for albacore catch as a by-catch mainly very young specimens of swordfish with an average weight of around 2.5 kilogrammes. The remaining 8-9 species which usually make up the by-catch are of little or no commercial value or protected, such as loggerhead. The Sicilian waters mainly involved in the fishing of albacore are the Ionian area and the Southern Tyrrhenian. In this area the number of albacore,

swordfish, bluefin (*Thunnus thynnus* Linnaeus, 1758) and other species caught represent on average approximately 51%, 23%, 10% and 16% respectively of the total catch, while the percentage distribution by weight of the total catch is the following: 72%, 13%, 7% and 8% respectively.

Table 2 - By-catch for fishing net (B: by-catch; T: target).

Species	Longline for swordfish	Longline for albacore	Drifting gillnet	FADs
<i>Alopias vulpinus</i>			B	
<i>Argonauta argo</i>			B	
<i>Auxis rochei</i>			B	
<i>Auxis thazard</i>			B	B
<i>Balistes carolinensis</i>	B		B	B
<i>Brama brama</i>	B		B	
<i>Brama raji</i>		B		
<i>Caetta caretta</i>	B	B	B	
<i>Cetorhinus maximus</i>			B	
<i>Coryphaena hippurus</i>	B		B	T
<i>Dasyatis centroura</i>		B		
<i>Dermochelys coriacea</i>	B			
<i>Dasyatis pastinaca</i>		B		
<i>Dasyatis violacea</i>	B	B	B	
<i>Euthynnus alletteratus</i>	B		B	
<i>Globicephala melaena</i>			B	
<i>Grampus griseus</i>			B	
<i>Illex coindetii</i>			B	
<i>Isurus oxyrinchus</i>	B			
<i>Lampris guttatus</i>			B	
<i>Luvarus imperialis</i>			B	
<i>Mobula mobular</i>			B	
<i>Mola mola</i>			B	
<i>Naucrates ductor</i>				T
<i>Polyprion americanus</i>		B	B	B
<i>Prionace glauca</i>	B	B		
<i>Ruvettus pretiosus</i>	B	B		
<i>Sarda sarda</i>	B	B		
<i>Schedophilus ovalis</i>		B	B	B
<i>Scomber japonicus</i>			B	
<i>Seriola dumerili</i>	B			T B
<i>Sphyrna zygaena</i>	B			
<i>Stenella coernalba</i>			B	
<i>Tetrapturus belone</i>	B		B	B
<i>Thunnus alalunga</i>	B	T	B	
<i>Thunnus thynnus</i>	B		B	
<i>Tursiops truncatus</i>			B	
<i>Ziphius cavirostris</i>			B	
<i>Xiphias gladius</i>	T	B	T	

Fishing by means of FADs and trawl net is the most selective of the four techniques considered. Dolphin fish is always the target species but another two species are considered targets according to the period of the trend in the catches of dolphin fish and the market. When the catch/price product of dolphin fish is considered good by fishermen, it is this species which is caught on an exclusive basis. Generally in the last weeks of August and the first of September the price/catch product is considered advantageous also for amberjack, so that both species are considered targets and, since the amberjack mixes in order to form a single shoal with pilotfish, the latter species becomes a by-catch. By the first half of October, the amberjack, leaves the FADs. Finally, when the dolphin fish starts to become scarce because the imminent winter causes the temperature of the water to drop below the threshold preferred by this species (around 18°C) and the amberjack has abandoned the FADs some time before, it is the pilotfish which becomes target species until the sea weather conditions destroy the FADs completely. The other species which make up the by-catch are caught rarely and by accident as shown in table 3, where the catches per species and per day of fishing carried out during an experimental fishing campaign on FADs by the Irma are reported.

Table 3 - Number of specimens, total weight, average weight and percentage of catch per species and fishing day.

Date	Species	Nb of specimens	Weight (g)	Average weight (g)	% catch
11-Sep	<i>Coryphaena hippurus</i>	62	19 015	307	42.30
	<i>Naucrates ductor</i>	119	25 550	215	57.00
	<i>Seriola dumerili</i>	2	300	150	0.70
16-Sep	<i>Coryphaena hippurus</i>	72	27 806	386	65.80
	<i>Naucrates ductor</i>	63	13 380	212	31.70
	<i>Seriola dumerili</i>	4	550	137	1.30
	<i>Polyprion americanus</i>	1	490	490	1.20
25-Sep	<i>Coryphaena hippurus</i>	134	57 123	426	87.30
	<i>Naucrates ductor</i>	25	6 397	256	9.80
	<i>Seriola dumerili</i>	16	1 900	119	2.90
30-Sep	<i>Coryphaena hippurus</i>	52	23 714	456	27.50
	<i>Naucrates ductor</i>	222	57 277	258	66.40
	<i>Seriola dumerili</i>	32	4 580	143	5.30
	<i>Schedophilus ovalis</i>	1	620	620	0.80
03-Oct	<i>Coryphaena hippurus</i>	231	115 258	499	93.50
	<i>Naucrates ductor</i>	22	5 361	244	4.30
	<i>Seriola dumerili</i>	17	2 600	153	2.10
21-Oct	<i>Coryphaena hippurus</i>	151	95 755	634	79.80
	<i>Naucrates ductor</i>	91	24 212	266	20.20
29-Oct	<i>Coryphaena hippurus</i>	34	27 935	822	77.20
	<i>Naucrates ductor</i>	30	8 227	274	22.80
06-Nov	<i>Coryphaena hippurus</i>	35	24 974	713	100
04-Dec	<i>Naucrates ductor</i>	150	39 115	260	99.30
	<i>Seriola dumerili</i>	4	279	70	0.70

A total of 9 fishing expeditions have been carried out on a series of 21 FADs between September and December 1996 in an area situated at around 14 miles north-west of Trapani (fig. 1). At least 94% of the catch have always been formed by dolphinfish and pilotfish (*Naurates ductor* Linnaeus, 1758). Only in the fishing expedition of 30 September were 32 specimens of amberjack caught for around 4.6 kg of total weight, corresponding to just over 5% of the total catch.

Catch, effort and CPUE

The catches and fishing effort at two ports, Syracuse and Mazara del Vallo, in 1997 and 1998, were examined. Syracuse, situated in the centre of the eastern coast of Sicily, houses a fleet of 65 fishing boats which on average use 26 longlines for swordfish, 7 longlines for albacore and 5 drifting pelagic nets for swordfish. 27 fishing boats used FADs and trawl nets. The 17 fishing boats of Mazara del Vallo, situated in the western part of the southern Sicilian coast, all use only the longline for swordfish.

• Syracuse

The season of fishing by means of FADs began in August, as per tradition, in both 1997 and 1998, although in the latter year it ended in November instead of December as it is usually the case. Despite the 1997 catch had been double compared to that of 1998, in the two years the CPUE was approximately equal: 50.6 in 1997 and 49.8 in 1998 (tab. 4, 5; fig. 2, 4). Therefore, the drop in catches is not to be found in the lack of availability of the resource but instead in a lack of interest by fishermen, evidently attracted by other activities which are obviously more profitable in the short-term.

The quantity of swordfish caught, with a longline for swordfish, is higher in 1998 than in 1997 for approximately 23 per cent. This increase is to be explained by the fact that in 1998 the swordfish fishing season by longline for swordfish began in January instead of March as always occurred previously and by the fact that the CPUE in 1998 increased for approximately 7% (tab. 4, 5; fig. 2, 4).

The swordfish catch using the longline for albacore in 1998 was less than in 1997 by around 13% while the CPUE decreased by approximately 30 per cent. This obviously indicates an increase in the fishing effort in 1998 which does not correspond to an increase in the catch: the effort in 1998 increased by around 24% compared to 1997 (tab. 4, 5, 6).

The quantity of swordfish caught by means of the drifting gillnet dropped in 1998 by around 30% compared to 1997, while the CPUE increased by approximately 15% and the effort dropped by approximately 39% (tab. 4, 5, 6).

Finally, the albacore catch increased in 1998 by approximately 17% and the CPUE grew by 3% approximately, yet the fishing effort expressed in kilogrammes recorded an increase of 14% (tab. 4, 5, 6).

Table 4 - Catch per month and per type of fishing gear in 1997 and 1998 at Syracuse.

Syracuse										
Year	FADs		Longline		Longline for albacore				Drifting gillnet	
	Catch (kg)		Catch (kg)		By-Catch (kg)		Catch (kg)		Catch (kg)	
	Dolphinfish		Swordfish		Swordfish		Albacore		Swordfish	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
January	-	-	-	3 315	-	-	-	-	-	-
February	-	-	-	780	-	-	-	-	-	-
March	-	-	2 145	1 560	-	-	-	-	-	-
April	-	-	11527	15643	-	-	-	-	-	-
May	-	-	15101	16359	-	-	-	-	2 915	2 376
June	-	-	24328	22212	0	0	14586	17017	2 622	659
July	-	-	9960	11067	0	0	33570	52884	3 418	3 241
August	15338	15273	7 110	1 580	-	-	-	-	-	-
September	63694	22291	4716	15327	-	-	-	-	-	-
October	76359	35469	1864	6990	3 788	3 062	0	0	-	-
November	4 534	1 004	147	98	4930	3985	33048	24786	-	-
December	308	-	-	-	5 720	5 473	3 920	4 704	-	-
Total	160 233	74037	76898	94931	14438	12520	85124	99391	8 955	6 276

Table 5 - CPUE per month and per type of fishing gear in 1997 and 1998 at Syracuse.

Syracuse										
Year	FADs		Longline		Longline for albacore				Drifting gillnet	
	CPUE (kg)		CPUE (kg)		CPUE (kg)		CPUE (kg)		CPUE (kg)	
	Dolphinfish		Swordfish		Swordfish		Albacore		Swordfish	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
January	-	-	-	20	-	-	-	-	-	-
February	-	-	-	20	-	-	-	-	-	-
March	-	-	18	11	-	-	-	-	-	-
April	-	-	43	46	-	-	-	-	-	-
May	-	-	27	28	-	-	-	-	14	17
June	-	-	42	39	0	0	48	43	14	6
July	-	-	17	16	0	0	108	142	7	11
August	27	30	31	33	-	-	-	-	-	-
September	48	53	54	73	-	-	-	-	-	-
October	68	67	26	46	58	39	0	0	-	-
November	36	43	26	47	33	24	137	127	-	-
December	91	-	-	-	63	41	39	39	-	-
Total	51	50	30	32	47	33	89	91	12	11

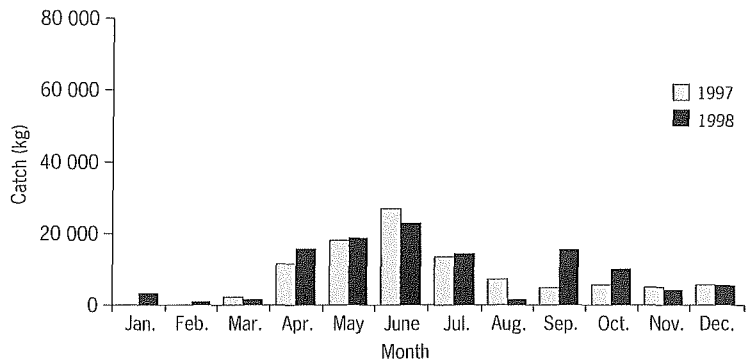
Figure 2
Catch per month of all gear types at Syracuse in 1997 and 1998.

Figure 3
Catch per month of longline
for swordfish at Mazara del
Vallo in 1997 and 1998.

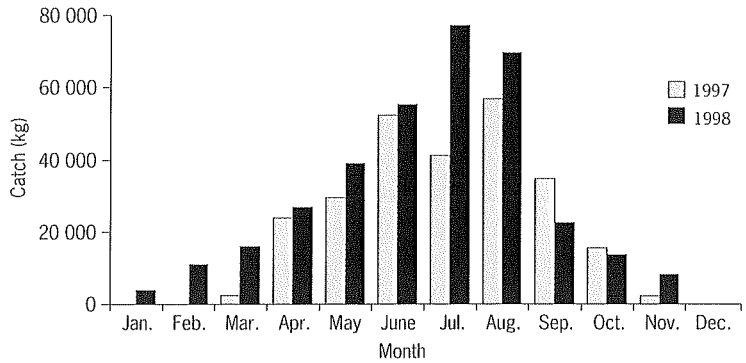


Table 6 - Fishing effort per month and per type of fishing gear in 1997 and 1998 at Syracuse.

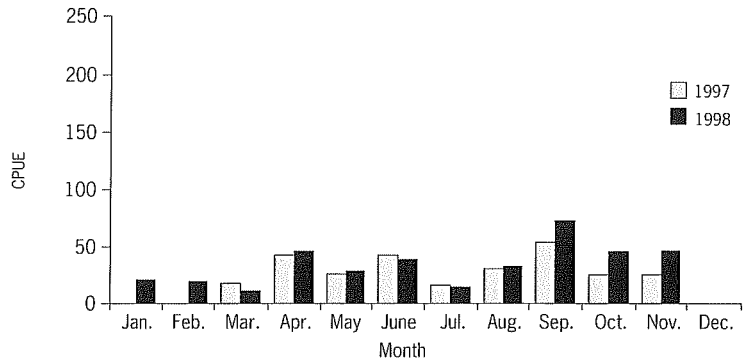
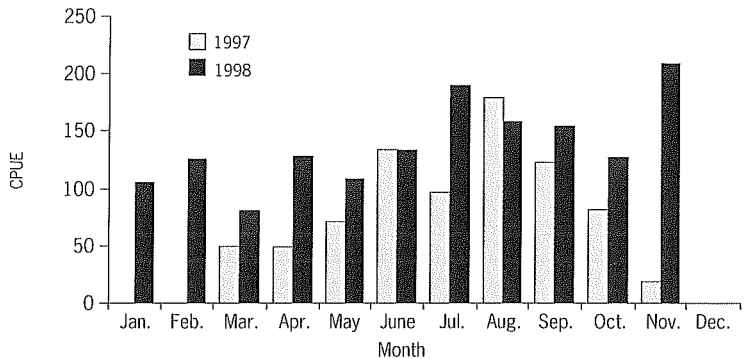
Year	Syracuse									
	FADs		Longline		Longline for albacore				Drifting gillnet	
	Effort (kg)		Effort (kg)		Effort (kg)		Effort (kg)		Effort (kg)	
	Dolphinfish		Swordfish		Swordfish	Albacore		Swordfish		
1997	1998	1997	1998	1997	1998	1997	1998	1997	1998	
January	-	-	-	169	-	-	-	-	-	-
February	-	-	-	38	-	-	-	-	-	-
March	-	-	121	146	-	-	-	-	-	-
April	-	-	269	342	-	-	-	-	-	-
May	-	-	562	575	-	-	-	-	210	140
June	-	-	586	567	0	0	306	399	189	115
July	-	-	585	672	0	0	310	372	480	280
August	558	513	228	48	-	-	-	-	-	-
September	1 327	424	88	209	-	-	-	-	-	-
October	1 131	526	72	153	65	80	0	0	-	-
November	124	23	28	21	151	168	240	195	-	-
December	3	-	-	-	90	133	99	120	-	-
Total	3 143	1 486	2 539	2 940	306	381	955	1 086	879	535

• Mazara del Vallo

The fishing areas of the fleet of Mazara del Vallo are relatively far from those of Syracuse, and in the former are only present fishing boats which use the swordfish longline with large hooks. The catch in 1998 increased over the previous year by approximately 32 per cent. Part of this increase, around 6%, is definitely due to the fact that in 1998 fishing began in January instead of March as it was traditionally the case (tab. 7). Another part appears due to the increase in the CPUE which in turn appears to be the result of a different allocation in time of the effort which, taking into account the extra two months (January and February) of fishing, did not increase in 1998 and was instead concentrated from March to August (fig. 3, 5). It is, in this period, that the best catches were recorded and when the larger-sized specimens were caught.

Table 7 - Catch, effort and CPUE per month in 1997 and in 1998 at Mazara del Vallo.

Mazara del Vallo Longline for swordfish						
Year	Catch (kg)	Catch (kg)	Effort	Effort	CPUE	CPUE
	1997	1998	1997	1998	1997	1998
January	-	3 462	-	33	-	105
February	-	10 854	-	86	-	126
March	2 368	15 647	47	192	51	81
April	23 687	26 463	124	253	72	104
May	29 204	38 400	185	353	82	109
June	51 475	54 563	188	406	125	134
July	40 673	75 872	278	399	20	190
August	56 032	68 560	312	431	180	159
September	34 200	22 545	382	146	97	155
October	15 315	13 798	406	108	135	128
November	2 424	8 047	418	38	128	210
December	-	-	-	-	-	-
Total	255 378	338 211	2 340	2 447	109	138

Figure 4
CPUE per month of longline
for swordfish at Syracuse
in 1997 and 1998.Figure 5
CPUE per month of longline
for swordfish at Mazara
del Vallo in 1997 and 1998.

Revenues

The total gross revenues of fishing with the longline for swordfish at Syracuse was 680,362 euro in 1997 and 838,582 euro in 1998. The drifting gillnet made 61,941 and 99,001 euro in 1997 and 1998 respectively.

Finally, the small swordfish caught as by-catch of the longline for albacore made 89,479 euro in 1997 and 77,592 euro in 1998. As regards the albacore, it contributed 210,010 euro to the 1997 revenues and 238,132 euro to those of 1998. Dolphinfinh finally brought 760,741 euro in 1997 and approximately half in 1998. All the approximately 38 fishing boats which in the two considered years were engaged in fishing swordfish at Syracuse had a much lower yield than the 17 fishing boats of Mazara del Vallo which only used the longline for swordfish with large hooks. Although adding the albacore fishing yield, the Syracuse fleets yielded less and caught a large quantity of very young swordfish. If we consider that a one-year-old swordfish weighs on average between 10 and 15 kg, i.e. from 4 to 6 times the average at which they are caught by the treacherous longline for albacore in the period from September to December, and that the commercial value of swordfish of legal sizes is at least double, we become aware of the damage (tab. 8).

Table 8 - Revenues (in euro) per fleet at Syracuse and Mazara del Vallo in 1997 and 1998.

	Syracuse	Mazara del Vallo	Syracuse	Mazara del Vallo
Fleet	1997	1997	1998	1998
Swordfish longline	680,362	2,242,159	838,582	2,969,414
Swordfish gillnet	61,941	-	99,001	-
Swordfish small longline	89,479	-	77,592	-
Total swordfish	831,783	2,242,159	1,015,175	2,969,414
Albacore longline	210,010	-	238,132	-
Dolphinfinh (FADs)	760,741	-	335,373	-
Total	1,802,533	2,242,159	1,588,680	2,969,414

The dolphinfinh, although paid to fishermen at low prices, at an average of between 3 and 4 euro, has a good yield which could improve considerably with targeted schemes, even simply of an advertising nature. The dolphinfinh revenues should be added to those from amberjack and pilotfish which we have not considered here for the sake of brevity. We shall only add that the amberjack obtained a price paid to the fishermen in August of around 12.5 euro and in September of around 6 euro, while the pilotfish obtained a price of approximately 2.5 euro throughout the season of fishing with FADs.

As regards, costs we can add that the longline always needs a bait and staff for baiting the hooks on every fishing expedition. In order to bait 1 500 hooks, 1 500 fish are required which are normally frozen mackerel bought at a low price but which in any case have a cost of around 350 euro. The initial investment for buying or building a longline is not less than that of a trawl net for dolphinfinh. The cost of the FADs is low, around 50 euro per FAD, which will last the whole fishing season from August to December.

Discussion

The fishing effort exerted on the stock of swordfish, when it affects the recruits, appears excessive. The drifting gillnets used for thousand years, although only catching adult specimens, are to be banned in Italy by 2000 due to the assumed by-catch (unfortunately there are no reliable quantity data). The list of species which make up the by-catch is only qualitative and the same species often make up the longline by-catch both for swordfish and albacore (tab. 2).

In the fishing areas of the Mazara fleet, where the longline is not used for albacore, which is deadly for young swordfish (the weight of the specimens caught varies from a minimum of 1.5 kg to a maximum of 4.5 kg with an average of around 2.5 kg), the catches of swordfish by longline are more abundant compared to those of the fishing areas of Syracuse.

Fishing by means of FADs and purse seine has virtually no by-catch. The catch consists solely of young specimens born in June-July. The stock of reproducing adults is not involved in any fishing activity. However, the adults form a by-catch in fishing with longline for swordfish and albacore and the drifting gillnet.

In the four years from 1995 to 1998, all the Sicilian fishing fleets have always captured less than 100 specimens of adult dolphinfish aged over a year and weighing more than five kilogrammes. It appears therefore that the high rate of growth, the low vulnerability of the reproducers and the relatively short fishing season, in that the specimens in late December no longer visit the FADs, are sufficient for ensuring stock continuity. The specimens of pilotfish, which in quantity terms is the species most caught after dolphinfish, are generally always adult; only at the end of October, it is possible to catch very young specimens born a few months earlier. In any case, the fishermen are not very interested in catching pilotfish as it has low commercial value and mainly because it is the combination of the FADs plus pilotfish which attracts the dolphinfish and possibly the amberjack too. In fact, the first species to colonise the FADs is the pilotfish, followed by the amberjack and dolphinfish. When all the specimens of pilotfish are caught together with the other species, and the FADs are deserted, around 10 days are required for the FADs to be repopulated by pilotfish and to attract dolphinfish. It appears that more the FAD is attractive to dolphinfish the more it is populated with other species, mainly pilotfish. The FADs plus pilotfish system as an attraction for dolphinfish is not yet wholly clear and to date there is no research aimed at solving the mystery.

As regards the amberjack, the quantities caught, although they are very young specimens, are minimal and not such as to jeopardise the integrity of the stock. In the same period, artisanal fishing with trammel net and gillnet catches very young amberjack in quantities higher by at least one order of magnitude compared to those caught under the FADs.

Conclusion

It appears useful and appropriate to transfer fishing effort from swordfish and albacore towards dolphinfish, above all the fisheries which fish albacore by longline with small hooks. The simplest way appears that stimulating demand for dolphinfish in order to raise the price paid to the fishermen and encourage them to take up fishing using FADs and trawl net. Currently, the only markets for dolphinfish are Malta, Sicily, Tunisia and the Balearics. A Maltese firm, specialised in the processing and preservation of fish products, has produced and marketed, mainly in Italy, as from 1996, frozen slices of dolphinfish (20 000 kg in 1997) with peeled tomatoes, celery, olives and capers, ready for fast cooking in the oven, and filets of smoked dolphinfish (4 000 kg in 1998). Activities of this type, in addition to being desirable in that they give fish products considerable added value and make them available throughout the year and not only during the fishing season, could in the short to medium terms encourage the hope for transfer of fishing effort from swordfish to dolphinfish. Valorisation and expansion of the dolphinfish market must not entail a depreciation of swordfish but, instead, it must be the greater availability of the dolphinfish resource which attracts fishing effort.

The lower the fishing effort on swordfish in the period from September to December, the better the catches from March to August of the following year will be. As mortality of recruits decreases, the number of swordfish which reach first sexual maturity will increase and, by reproducing, will contribute to reinstating the stock.

Bibliographic references

- Andreoli M.G., Levi D., Cannizzaro L., Garofalo G., Sinacori G., 1994. Sampling statistics of southern Sicily trawl fisheries (Minipestat): Methods. NTR-ITPP, 46(1).
- Andreoli M.G., Campanella N., Cannizzaro L., Garofalo G., Giusto G.B., Jereb P., Levi D., Norrito G., Ragonese S., Rizzo P., Sinacori G., 1995. Sampling statistics of southern Sicily trawl fisheries (Minipestat): Data Report. NTR-ITPP, Spec. Publ., 4(2).
- Bono G., Cannizzaro L., Gancitano S., Rizzo P., 1997. La pesca sui cannizzati aspetti quali-quantitativi. Biol. Mar. Mediterr., 5(1), 661-664.
- Cannizzaro L., D'Andrea F., Potoschi A., Scalisi M., 1999. Economic aspects of the fishing of dolphinfish in Sicily. Scientia Marina, 63(3-4), 459-464.
- Cannizzaro L., D'Andrea F., Pizzicori P., Norrito G., 1997. Aspetti economici della pesca della lampuga (*Coryphaena hippurus* Linnaeus, 1758) alle Pelagie. Biol. Mar. Mediterr., 5(1), 768-771.

- Cannizzaro L., Potoschi A., Scalisi M., D'Andrea F., Romeo T., 1997. Bio-economic aspects of swordfish and dolphinfish fisheries in Sicily. Proceedings of the third international conference on the Mediterranean coastal environment, Medcoast 97, 1, 97-107.
- Cavallaro G., Cefali A., Faranda M., Potoschi A., Sotiriadis S., 1988. Rilevazioni e studi biologici per la valutazione dello stock di pescespada (*Xipbias gladius* L., 1758) nei mari meridionali italiani. Atti seminari delle unità responsabili dei progetti di ricerca promossi nell'ambito dello schema preliminare di piano per la pesca e l'acquacoltura. Ministero della Marina Mercantile, Roma, CNR-UO, 4(1), 259-270.
- De Metrio G., Potoschi A., Sion L., Cacucci M., Sturiale P., 1996. Catches of juvenile bluefin tuna (*Thunnus thynnus* L.) and swordfish (*Xipbias gladius* L.) in the Italian seas during the albacore fishing season. Tuna Symposium, 10-18 Giugno 1996, Azores, ICCAT.
- Morales-Nin B., Oliver P., Castro J.J., Cannizzaro L., Potoschi A., Pla C., 1995. Biology and fishery of dolphinfish in the Western Mediterranean and Canary Islands area. Institut Mediterrani d'Estudis Avançats, Palma de Mallorca. Final Rep., contract UE, 94/031.
- Morales-Nin B., Oliver P., Castro J.J., Cannizzaro L., Potoschi A., Pla C., 1998. Dolphinfish biological and fishing data in the Western Mediterranean. Final Rep., contract UE, 95/073.
- Potoschi A., Cavallaro G., Sturiale P., Pisciotta G., Granatae A., Mellini B., 1993a. The swordfish (*Xipbias gladius* L., 1758) surface longline fishing practised in the fisheries of Eastern Sicily. ICCAT, SCRS/92/26, XL(1), 327-330.
- Potoschi A., Cavallaro G., Sturiale P., Lo Duca G., 1993b. Valutazione degli stocks di pescespada, tonno ed alalunga nel Mar Ionio relativamente alle marinerie siciliane? Rapporto finale anni attività 1990-1992, Ministero Marina Mercantile, 125.