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New record of *Alopias superciliosus* Lowe, 1841 in the North-Western Mediterranean and annotated review of the Mediterranean records

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On 9th September 2015 the head of a shark belonging to the genus Alopias, was landed at Camogli harbour in the Ligurian Sea (North Western Mediterranean). The specimen has been caught 16 miles far from the coast (44° 06' N, 008° 57' E) as by-catch of the mesopelagic swordfish longline, but only the head was recovered, due to the predatory/scavenging activity by other shark specimens. The specimen was a female of big-eye thresher shark Alopias superciliosus *a highly migratory species worldwide distributed in tropical and temperate waters but rarely caught in the Mediterranean Sea. The present record is the northenmost reported for this species in the Mediterranean area and the sixth in Italian waters*

Key words: *Alopias superciliosus*, Ligurian Sea, Mediterranean Sea, by catch, longline

INTRODUCTION

The bigeye thresher shark *Alopias superciliosus* Lowe, 1841 is a highly migratory species distributed in tropical and temperate waters (FROSE & PAULY, 2015), listed as "vulnerable" on the IUCN Red List due to the dangerous decline of the populations as a result of the unmanaged exploitation of this resource (AMORIM *et al.*, 2009). This species is mainly caught by longlines as an important part of the commercial by-catch of the professional fishery targeting swordfish and tunas in the Atlantic Ocean (AMORIM *et al.*, 2009). In the Mediterranean Sea incidental catches are also reported from artisanal fisheries (gill net, trammel net) (BAUCHOT, 1987), but the presence of this species in the area is scarcely documented and limited to sporadic records, maybe linked to possible misidentification with the common thresher *A. vulpinus* (CIGALA FULGOSI, 1983). This paper reports the first occurrence of the bigeye thresher in the northern part of the Mediterranean basin and a review of records known up to date in the Mediterranean area.

MATERIAL AND METHODS

The cephalic portion (including pectoral fins) of a specimen of *A. superciliosus* was landed at Camogli harbour (Ligurian Sea; Fig. 1) on 9th September 2015. It was caught 16 miles far from the coast (Longitude 44° 06'N,

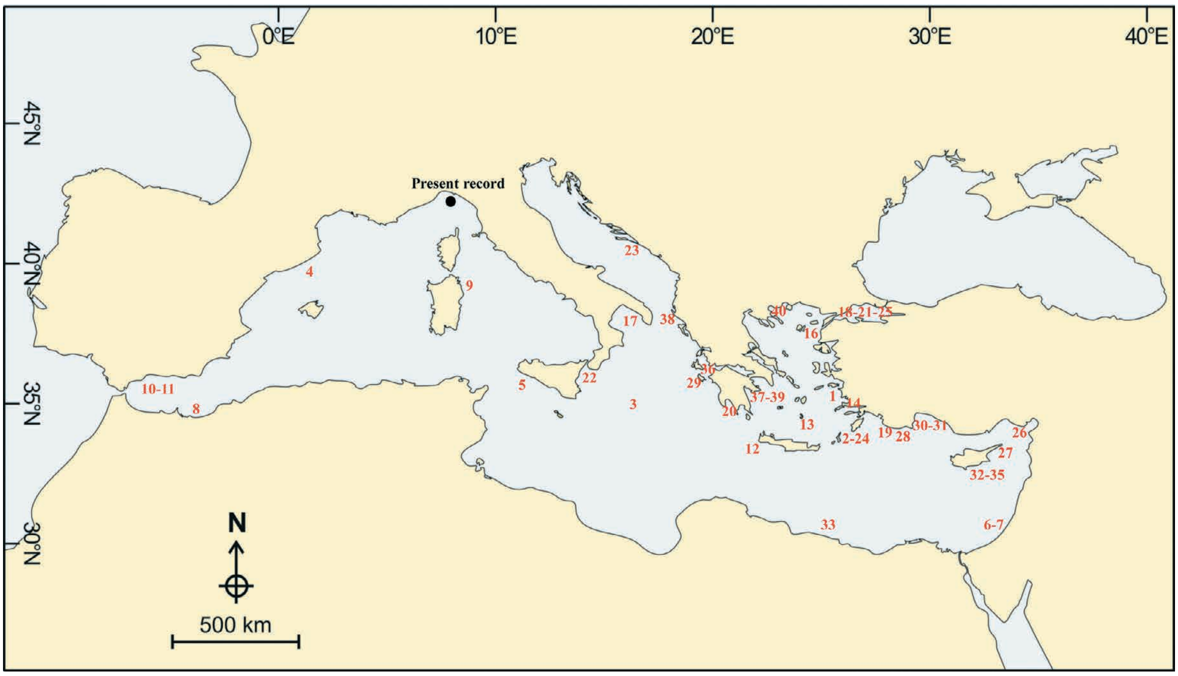

Fig. 1. Map of records of A. superciliosus *in the Mediterranean Sea*

Latitude 008° 57'E) by a mesopelagic swordfish longline (MESO SWOLL), which replaced the most commonly used surface swordfish long line (SWO LL) since 2010 (GARIBALDI, 2015a). Seventeen morphometric measures of the head and the pectoral fins were taken, in accordance with COMPAGNO (1984): head Length (HDL), prebranchial length (PGL), prepectoral fin length (PP1), pectoral fin length (P1L), pectoral fin height (P1H), pectoral-fin anterior margin (P1A), pectoral fin posterior margin (P1P), pectoral fin inner margin (P1I), preorbital length (POB), eye height (EYH), eye length (EYL), interorbital space (INO), prenarial length (PRN), internarial space (INW), preoral length (POR), mouth width (MOW), mouth length (MOL). All measures are reported in Table 1.

Nine of these measures (PP1, P1A, POB, EYH, EYL, INW, POR, MOW, MOL; dependent variables, y) allowed to estimate the hypothetical total length (TL; independent variable x) of the specimen by the mean of a length-length linear regression model (y = a + bx; Table 2) derived by the measures taken on 13 worldwide distributed specimens analysed by GRUBER & COMPAGNO (1981). Only the linear regression models showing a high Pearson's correlation coefficient (r>0.8) were considered correlated; the significance of each variable was tested by means of analysis of variance with the Fisher test (p-value = 0.05).

Table 1. Measurements (in cm) of the present specimen

Measures	Length (cm)
Head Length (HDL)	43.6
Prebranchial length (PGL)	31.6
Prepectoral fin length (PPL)	41.7
Pectoral fin length (P1L)	25.4
Pectoral fin heigth (P1H)	53.2
Pectoral-fin anterior margin (P1A)	54.4
Pectoral fin posterior margin (P1P)	50.6
Pectoral fin inner margin (P1I)	7.4
Preorbital length (POB)	11
Eye height (EYH)	7.4
Eye length (EYL)	4.7
Interorbital space (INO)	7.4
Prenarial length (PRN)	8.1
Internarial space (INW)	4.5
Preoral length (POR)	12.3
Mouth width (MOW)	10.4
Mouth length (MOL)	7.3

Table 2. Back-calculated FL and TL of the present specimen obtained on the basis of different sources.
x = TL; y=measures taken on the present specimen; 1= function used to convert CR in FL; 2 = function used to convert FL in TL

Measures (y) and Functions	Functions and VBGF parameters	Back calculated TL (cm)	Study
PP1	y = 0.1429x + 3.920 (n=13; r = 0.98; p<0.001)	264.4	Derived from Gruber & Compagno, 1981
P1A	y = 0.1798x + 4.475 (n=13; r = 0.97; p<0.001)	277.7	Derived from Gruber & Compagno, 1981
POB	y = 0.0309x + 3.841 (n=8; r = 0.76; p<0.05)	231.7	Derived from Gruber & Compagno, 1981
EYH	y = 0.0247x + 0.375 (n=10;r = 0.92; p<0.001)	284.4	Derived from Gruber & Compagno, 1981
EYL	y = 0.0099x + 2.407 (n=13; r = 0.85; p<0.001)	231.6	Derived from Gruber & Compagno, 1981
INW	y = 0.0131x + 0.688 (n=11; r = 0.98; p<0.001)	291.0	Derived from Gruber & Compagno, 1981
POR	y = 0.0321x + 4.293 (n=12; r = 0.83; p<0.001)	250.2	Derived from Gruber & Compagno, 1981
MOW	y = 0.0372x + 1.214 (n=12; r = 0.95; p<0.001)	246.9	Derived from Gruber & Compagno, 1981
MOL	y = 0.0277x - 0.481 (n=11; r = 0.93; p<0.001)	280.9	Derived from Gruber & Compagno, 1981
1	FL = 9.88CR + 48.88	296.4	Fernandez Carvalho *et al.* (2011)
VBGF	Linf = 293.0 FL; k = 0.06; L_0 = 111	306.2	Fernandez Carvalho *et al.* (2011)
VBGF	Linf = 284.2 FL; k = 0.06; L_0 = 109	298.3	Fernandez Carvalho *et al.* (2015a)
2	FL = 0.58TL + 4.83	-	Fernandez Carvalho *et al.* (2011)
Average		**271.6**	
SD		**26.1**	
Minimum		**231.6**	
Maximum		**306.2**	

Sex and sexual maturity were determined macroscopically by the direct observation of the small gonadal portion found on the residual part of the trunk.

In order to estimate age of the specimen, a total of 7 undamaged cephalic vertebrae were collected, measured (centrum radius, CR) and later on sectioned on the sagittal plan by the means of an Buehler Isomet Low Speed Saw, obtaining 0.8 mm thick sections. For the enhancement of growth bands, some sections were coloured using a staining Methylen Blue solution 0.1%. The vertebral sections were photographed and images digitalized. Age determination was performed counting the growth bands both on the whole vertebral centrum and sections. A supplementary estimate of the TL, starting to the fork length (FL), was performed by applying the von Bertalanffy growth function (VBGF): $Lt = L_{inf} - (L_{inf} - L_0)e^{-kt}$, where L_t = mean length (FL) at age t, L_{inf} = asymptotic maximum length (FL), k = the growth coefficient, L_0 = length at birth, and the relationship between CR and TL reported by FERNANDEZ-CARVALHO *et al.* (2011; 2015a) for the specimens of the Atlantic area (Table 2).

RESULTS

The particular morphology of the head (Fig. 2), with deep dorsal horizontal groove on each side and the vertical developed, large eyes allowed to distinguish *A. superciliosus* from the other two species belonging to the genus *Alopias*, the indigenous common thresher *A. vulpinus* and the pelagic thresher *A. pelagicus* (COMPAGNO, 1984).

The classification was also confirmed by jaw observation; teeth are similar in the upper and lower jaw, moderately large, showing slender, slightly curved cusps with smooth edges. No symphysial teeth are present. The dental formula (12-12/11-11; Fig. 3) corresponds to the commonest described in literature for the species (GRUBER & COMPAGNO, 1981).

The cranial portion of the specimen was cut and ripped behind the pectoral fins, showing teeth and bite marks, probably due to a predatory/scavenging activity of a large shark (Fig. 2). The marks were not evident enough to allow a clear identification of the possible shark species involved in this scavenging activity. It could be reasonably due to a large blue shark (*Prionace glauca*) given that it is the commonest pelagic shark species in the Mediterranean and some evidences of scavenging activity on cetaceans, birds and some large pelagics (i.e. Bluefin tuna) were observed as a result of the stomach contents analysis in the same area (GARIBALDI & ORSI RELINI, 2000).

The portion of gonadal tissue left inside the trunk after the scavenging activity was 28.3gr in weight. The presence of small oocytes, ranging in diameter between 0.5 mm and 2.08 mm allowed to determine it was a juvenile/subadult/immature female, also taking into account that studies demonstrated that *A. superciliosus* has a

Fig. 2. Head of the present specimen as found by fishermen (upper photo courtesy of Renato Cammarata)

Table 3. Records of A. superciliosus *in the Mediterranean Sea in chronological order. † = Not scientifically validated or unpublished data*

N	Country	Area	Date (day/month/year)	n (TL - cm)	Weight (kg)	Sex	Gear	References
1	Greece	Leros Island	06/08/1952	1 (450)	-	M	-	Corsini-Foka & Sioulas, 2009
2	Greece	Rhodes Island	06/07/1954	1 (310)	-	M	-	Corsini-Foka & Sioulas, 2009
3	Italy	Jonian sea	02/12/1966	1 (460)	-	-	-	Gruber & Compagno, 1981
4	Spain	Catalan sea	August 1979	1 (-)	-	-	-	Barrul & Mate, 2002
5	Italy	Sicily Channel (Mazara del Vallo)	July-August (1979-82)	2 (95.5 – 206 SL) + 2 (-)	-	M - F	longlines	Cigala-Fulgosi, 1983
6	Israel	Israel	30/05/1986	1 (88)	-	embryos	longlines	Golani, 1996
7	Israel	Israel	15/05/1991	1 (86)	-	embryos	longlines	Golani, 1996
8	Spain	Gibraltar (Chafarinas island)	August 1991	1 (438)	-	F	longlines	Moreno, 1991
9	Italy	Sardinia (Tavolara island)	November 1994	1 (400) + 2 (40)	-	F + 2 embryos	-	Vacchi & Serena, 2000
10	Spain	Alboran Sea	November 2000	1 (200)	-	-	longlines	Barrul & Mate, 2002
11	Spain	Alboran Sea	1998-2000	6 (-)	-	-	longlines	Megalofonou *et al*., 2005
12	Crete	Western Crete	2000	1 (-)	-	-	-	Fergusson pers. comm. (in Clo *et al*., 2008)
13	Greece	Aegean Sea, Levantine basin	1998-2005	2 (151-360)	10-75 (gutted)	-	longlines	Damalas & Megalofonou, 2012
14	Turkey	Marmaris	April 2005	1 (350)	160	-	gill net	Clo *et al*., 2008
15	Turkey	Gökova	23/05/2005	1 (350)	150	-	shrimp net	Kabasakal & Karhan, 2007
16	Turkey	Sivrice coast (NE Aegean Sea)	21/05/2006	1 (400)	-	M	set net	Kabasakal *et al*., 2011
17	Italy	Porto Cesareo	26/06/2006	1 (-)	-	-	-	Clo *et al*., 2008
18	Turkey	Silivri coast (Marmara Sea)	23/02/2007	1 (450)	-	-	purse seine	Kabasakal & Karhan, 2007
19	Turkey	Fethiye coast	28/02/2011	1 (450)	300	F	trammel net	Kabasakal *et al*., 2011
20	Greece	Messiniakos Gulf	22/03/2011	1 (320)	-	-	-	Giovos pers. comm.
21	Turkey	Silivri coast (Marmara Sea)	02/07/2011	1 (250)	65	F	purse seine	Kabasakal *et al*., 2011
22	Italy	Pellaro	16/08/2011	1 (340)	-	F	stranding	Sperone pers. comm.
23	Montenegro	Island of Mamula	20/05/2012	1 (485)	285	-	-	Tsiamis *et al*., 2015
24	Greece	Rhodes	19/12/2012	1 (-)	200	-	longlines	Giovos pers. comm.
25 †	Turkey	Marmara sea	25/02/2013	1 (370)	250	-	-	sharkyear.com
26 †	Turkey	Yesilkoy	13/03/2013	1 (200)	110	-	-	sharkyear.com
27 †	Cyprus	Famagusta	12/05/2013	1 (500)	400	-	-	sharkyear.com
28 †	Turkey	Yediburunlar	15/07/2013	1 (500)	95	-	-	sharkyear.com
29	Greece	Kefalonia	27/03/2014	1 (400)	250	-	trammel net	Soldo A. & Troianos D. (CIESM Forum)
30	Turkey	Antalya	15/04/2015	1 (-)	-	-	-	Deval M.C. (CIESM Forum)
31	Turkey	Gulf of Antalya	05/05/2015	1 (293) + 2 (-)	57	-	trawler - longlines	Gokoglu M. (CIESM Forum)
32	Cyprus	South of Cyprus	28/04/2015	1 (160 FL) + 1 (-)	-	-	longlines	Kleitou *et al*., 2017
33	Egypt	Sedi-Abderahman	June 2015	1 (180)	-	-	longlines	Farrag, 2017
34	Italy	Camogli (Ligurian Sea)	09/09/2015	1 (272 estimated)	-	F	longlines	Present record
35	Cyprus	Southeast of Cyprus	24/09/2015	8 (-)	-	-	longlines	Kleitou *et al*., 2017
36	Greece	Killini	08/06/2016	1 (360)	-	-	trawler	Giovos pers. comm.
37	Greece	Argolikos gulf	28/01/2017	1 (260)	150	-	trammel net	Giovos pers. comm.
38	Albania	Dhërmi	22/02/2017	1 (308)	-	F	longlines	Giovos & Cakalli, 2017
39 †	Greece	Nea Kios	21/03/2017	1 (250)	120	-	-	sharkyear.com
40	Greece	Thracian sea, off Kavala Bay	28/06/2017	1 (360)	-	-	longlines	Giovos pers. comm.

Fig. 3. Jaws of the present specimen of A. superciliosus

size-at-first maturity (L_{50}) between 332 and 350 cm TL, at about 12-13 years of age (STILLWELI & CASEY, 1976; MORENO & MORON, 1992; CHEN *et al.*, 1997; FERNANDEZ CARVALHO *et al.*, 2015a; b). The analysis of annual growth bands has led to an estimated age of 8 years (Fig. 4).

On the basis of all the above collected parameters, following the different methods reported in Table 2 was possible to estimate that the size of the specimen could be between 231.6 cm and 306.2 cm TL, an average size of 271.6 cm TL (st. dev. 26.1) (Table 2).

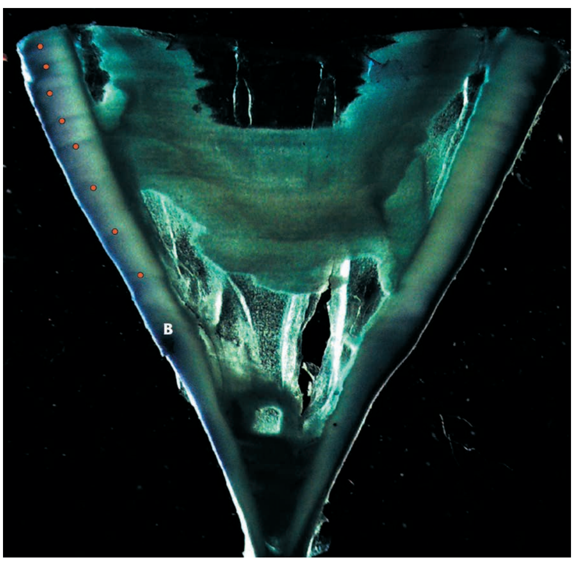

Fig. 4. Vertebral section. B = birth band. Red dots= growth rings

Considering the linear regression models obtained from nine measures of the head and fins derived by GRUBER & COMPAGNO (1981) the average estimated size was 262.1 cm TL (SD=22.8).

On the basis of the vertebral ring radius measure (average of 12.7 mm; SD=0.33) the size should correspond to an individual of 174.7 cm FL (296.4 cm TL; Table 2).

Considering the two VBGF reported for the Atlantic ocean by FERNANDEZ-CARVALHO *et al.* (2011; 2015a) an eight years old female should correspond to a specimen ranging form 175.8 and 180.4 cm FL (i.e. 298.3-306.2 cm TL) (Table 2).

DISCUSSION

The present record is the most northerly reported for this species in the Mediterranean and the sixth in Italian waters (CIGALA FULGOSI, 1983; VACCHI & SERENA, 2000; CLÒ *et al.*, 2008; SPERONE pers.comm.) (Table 3). The area comprising Ligurian and North Tyrrhenian sea is the bulk of the Pelagos Sanctuary, established for the protection of its ecosystem and cetaceans, officially recognized as Specially Protected Areas of Mediterranean Interest (SPAMI). It is often described as a "small ocean" for its oceanographic and biological characteristics and is a well known feeding area for many large apex predators, such as cetaceans (Mysticeti and Odontoceti), tunas, swordfish, billfishes and pelagic sharks, mainly from families Lamnidae, Alopiidae, Carcharinidae (ORSI RELINI *et al.*, 1999; GARIBALDI & ORSI RELINI, 2000), due to the presence of a permanent geostrophic frontal area and *upwelling* processes, sustaining a complex food web (GASPARINI *et al.*, 1999). The presence of "alien" or non indigenous large pelagic species were recorded in the past as documented by the catches of a black marlin *Makaira indica* (ORSI RELINI & COSTA, 1987) and a great hammerhead *Sphyrna mokarran* (BOERO & CARLI, 1977), which are so far the only records for the Mediterranean Sea, and more recently of a silky shark, *Carcharhinus falciformis* (GARIBALDI & ORSI RELINI, 2012).

Unlike what observed for the common thresher, *A. vulpinus*, that more frequently is present in epipelagic water (CARTAMIL *et al.*, 2010; CAO *et al.*, 2011), the bigeye thresher shark is a species with strong diel vertical migration, diving over 900 m depth (COELHO *et al.*, 2015). It spends the most of the daytime in deeper and cold mesopelagic waters between 300-500 m and the night-time in epipelagic waters between 10-100 m depth (WENG & BLOCK, 2004; COELHO *et al.*, 2015). This habit was confirmed by this catch; in fact the fishermen estimated by the counting of hooks that the specimen was caught with the MESOSWOLL at a depth around 300 m, over a water column of 1000 m depth. In the Ligurian Sea over the last seven years the introduction of this gear completely changed the fishing pattern. Before 2010, with the traditional surface SWOLL the elasmobranchs by-catch represented more than 48% in numbers of the total catch with a massive presence of the pelagic stingray, *Pteroplatytrigon violacea,* (43,7%), followed by the blue shark *P. glauca*, the shortfin mako *Isurus oxyrinchus,* the porbeagle shark *Lamna nasus*, the common thresher *A. vulpinus* and certain species belonging to the family Carcharhinidae (*Carcharhinus plumbeus* and *C. falciformis*) were recorded in the area. On the contrary, using MESO SWOLL elasmobranch by-catch of the swordfish fishery is normally composed only by *P. glauca*, the little sleeper shark *Somniosus rostratus* and, at a smaller extent, by the pelagic stingray, with a strong reduction of discards and commercial by-catch of elasmobranchs species, which is at present less than 10% in numbers of the total catch (GARIBALDI, 2015b). The differences between the two gears are referred to timing of fishing operations (SWO LL 8-10 hours, MESO SWOLL 24-36 hours), but mainly to the depth of displacement (SWO LL 0-20 m depth, MESO SWO LL 100-600 m depth) (GARIBALDI, 2015a).

Despite the increase of the fishing effort recorded for the MESO SWOLL in the Ligurian sea and generally in all the Western Mediterranean area, with a consequent major overlap with the main habitat of the *A. superciliosus* (COELHO *et al.*, 2015), the documented catches by longlines of this species in the Mediterranean are not increasing over the last 15 years (Table 3), suggesting that it can be considered rare in the area. In the last decades the majority of the records for this species in the Mediterranean have been reported from the south eastern basin (Greek and Turkish waters), as confirmed by the numerous catches reported by longlines fleet of Cyprus (KLEITOU *et al*., 2017) and some more recent records not yet reported in the scientific literature (Fig. 1; Table 3). This could be linked to environmental factors influencing shark movements and migrations (SCHLAFF *et al.,* 2014), such as temperature, salinity, water depth, bottom topography and food availability (WENG & BLOCK, 2004, PRETI *et al*., 2008; CAO *et al*., 2011; COELHO *et al*., 2015).

A possible source of bias could be related to other factors, such as the misidentification or its low commercial value, if compared with the common thresher *A. vulpinus* and, in past, frequently discarded onboard (CIGALA FULGOSI, 1983; AMORIM *et al.*, 2015). Nevertheless, with the introduction of the recent EC Regulation which have forbidden the retaining onboard or the landing of *A. superciliosus* (Council Reg. 2017/127 of 28/01/2017), fishermen are also inclined to reject the specimens at sea, avoiding possible sanctions. For the future, in order to improve the knowledge on the distribution of this species in the Mediterranean, it would be useful to encourage fishermen to report and take documentation (*i.e.* photographs) of any catches, before releasing the specimens caught.

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Novi nalaz velikookog psa lisice, *Alopias superciliosus* Lowe, 1841, u sjeverozapadnom Sredozemlju s pregledom svih dosadašnjih nalaza u Sredozemlju

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SAŽETAK

Dana 9. rujna 2015. godine pronađena je glava morskog psa roda Alopias u luci Camogli na Ligurskom moru (sjeverozapadni Mediteran). Primjerak glave je ulovljen 16 milja daleko od obale (44 ° 06 'N, 008 ° 57' E) tijekom lova na sabljarke mezopelagičnim parangalom, te je zbog grabežljivosti i uklanjanja drugih primjeraka morskih pasa, utvrđena samo glava. Primjerak glave je pripadao ženki morskog psa *Alopias superciliosus*, koji spada u visoko migratorne vrste rasprostranjene širom svijeta u tropskim i umjerenim vodama, no rijetko su ulovljene u Sredozemnom moru.

Ovaj je nalaz najsjeverniji za ovu vrstu u Sredozemlju i ujedno je šesti nalaz za talijanske vode.

Ključne riječi: *Alopias superciliosus*, Ligusko more, Sredozemno more, prilov, parangal