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Diet of *Tetrapturus belone* (Istiophoridae) in the central Mediterranean Sea

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The stomach contents of 69 Mediterranean spearfish Tetrapturus belone *collected in the Strait of Messina, central Mediterranean Sea were examined. Of the total specimens, caught by harpoon, only three stomachs were empty. Their diet consisted mainly of pelagic fish and cephalopods. The most important piscine prey belonged to the families of Belonidae, Clupeidae and Scomberesocidae. Cephalopods were mainly represented by* Tremoctopus violaceus *in terms of per cent weight and by* Illex coindetii *in terms of per cent frequency of occurrence.* Tetrapturus belone *is an active predator on epipelagic fast-moving prey and school-forming species. Its ecological role is similar to that of other large pelagic species which share the same environment.*

Keywords: billfish, diet, Mediterranean Sea, Strait of Messina, feeding habits, *Tetrapturus belone*

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INTRODUCTION

The Mediterranean spearfish *Tetrapturus belone* (Rafinesque) is a pelagic species belonging to the family Istiophoridae. It is considered a highly migratory species (Nakamura, 1985) whose distribution is limited to the Mediterranean Sea, although some specimens have been recorded from the Atlantic side of the Strait of Gibraltar (Di Natale *et al.*, 2005b). Like other billfish, this species probably swims in the upper 200 m water layer, generally above or within the thermocline (Nakamura, 1985). It is considerably abundant around Italy (Nakamura, 1985), particularly in the Tyrrhenian Sea, where it is caught as by-catch of large pelagic fisheries and in the Strait of Messina where it represents a target species (Di Natale *et al.*, 2003). There, the Mediterranean spearfish is fished at the surface by harpoons with traditional boats called 'feluche' or 'passerelle', typically used to catch swordfish, *Xiphias gladius* L., only from late spring to summer. After the crisis in swordfish fishery of the last years, worsened by the European ban of driftnets since 2002 (UE Regulation no. 1239/98), the interest for the Mediterranean spearfish fishery is increasing, despite its lower commercial value when compared to that of swordfish. In the last decades, the catches by harpoon of this species in the Strait of Messina showed an increasing trend, from 39 kg total weight in 1976 to 1221.5 kg in 2003 (Di Natale *et al.*, 2005a).

Although the importance of this species is rising on the market, scanty information on its biology and ecology is available. Robins & De Sylva (1960, 1963) and Spartà (1953, 1961) studied its eggs and larval development; Cavaliere (1962) and Potoschi (2000) reported a few data on the biology and fishery of the species in the Strait of Messina while catches from Italian seas are reported by Di Natale *et al.* (2003, 2005*a*, *b*). Some fishery and biological information are reported by De Sylva (1975) and by Nakamura (1985). Feeding ecology is an important aspect of the life-history strategy of fish and may be a precious tool for the comprehension of trophic dynamics and for the development of appropriate fishery management strategies. However, in the case of the Mediterranean spearfish, feeding ecology has been very poorly investigated. Based on the examination of stomach contents from a few specimens, a diet consisting of epipelagic organisms is reported (Spartà, 1961; Bini, 1968; Tortonese, 1975; Nakamura, 1985).

As information about feeding of *T. belone* is still based on feeble, sometimes doubtful observations, in this paper we aim at describing its feeding habits in order to increase the knowledge of the biology of this scarcely studied species.

MATERIALS AND METHODS

The study of feeding habits was carried out on the stomach contents of 69 Mediterranean spearfish, caught at the surface by harpoons. Samples were collected from 1995 to 2004 in the Strait of Messina (Figure 1) at day-time, during the fishing season for swordfish and Mediterranean spearfish by harpoon, from late spring to summer.

Specimens were measured to the nearest cm from the tip of the bill (upper jaw) to the posterior margin of the middle caudal rays (L_F); total weight (W) was also recorded to the nearest hectogram. The stomachs were removed and preserved in a 10% seawater–formalin solution for 24 h, and then transferred to 80% alcohol for subsequent analysis of contents. In the laboratory prey items were identified to the

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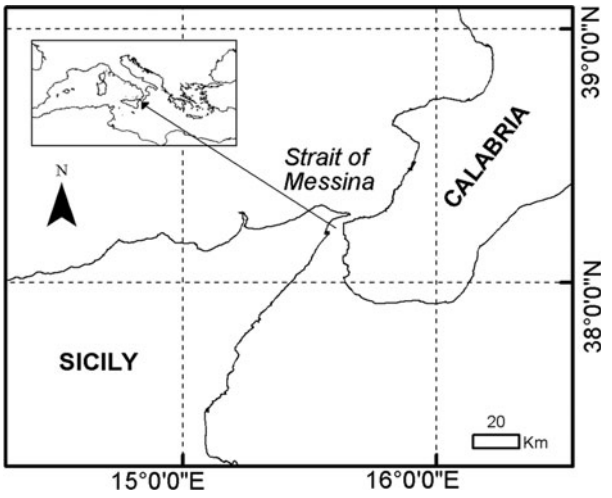

Fig. 1. Map showing the sampling area of *Tetrapturus belone* in the central Mediterranean Sea.

lowest possible taxonomic level, then counted and weighed to the nearest milligram. As hard parts resistant to digestion (i.e. cephalopod beaks) cumulate in the stomachs over more meals, leading to overestimation of the importance of prey they belong to, only prey bearing fleshy remains were considered for the analyses, as they were likely to have been recently eaten by the predator (see Santos *et al.*, 2001). Cephalopod beak lengths—the lower rostral length and the lower hood length in decapods and octopods respectively (Clarke, 1986)—were used to estimate mantle length of digested cephalopods and to reconstitute their weights, using relationships either in the literature (Clarke, 1986; Bello, 1991), or from measurements on specimens in our reference collection (ICRAM collection).

To assess the adequacy of the number of samples analysed, the cumulative number of new prey types against the cumulative number of non-empty stomachs were plotted (Ferry & Caillet, 1996). The PRIMER software was utilized to compute a prey species accumulation plot as an average of 999 curves based on different random orders of the stomachs. In order to assess whether the curve reached an asymptote, the logistic and linear regressions were calculated and their goodness of fit coefficients R^2 were compared: the sample size was considered sufficient if the R^2 for the logistic curve was higher than the R^2 for the linear relation (Castriota *et al.*, 2005).

The importance of the different prey items was evaluated by calculating the frequency of occurrence (%F = number of stomachs containing prey i/total number of stomachs containing prey * 100), abundance (%N = number of prey i/total number of prey * 100) and reconstituted weight (%W = weight of prey i/total weight of all prey * 100). These values were used to calculate the index of relative importance (I_{RI}) for each taxonomic category using mass instead of volume: $I_{RI} = (\%N + \%W) \times (\%F)$ (Hyslop, 1980; Hacunda, 1981). Fullness index (I_F = no. stomachs with food/ no. total stomachs) was also calculated.

The degree of diet specialization was given by the Levin's standardized index (Hurlbert, 1978; Krebs, 1989), $B_i = [(\Sigma_j p_{ij}^2)^{-1} - 1]\ (n - 1)^{-1}$ where:

B_i = Levin's standardized index for predator i;
p_{ij} = proportion of diet of predator i that is made up of prey j;
n = number of prey items.

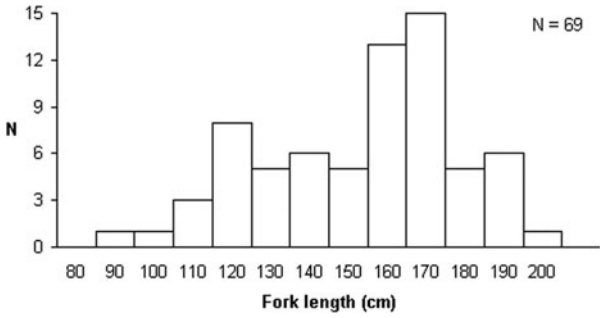

Fig. 2. Length–frequency distribution of *Tetrapturus belone* from the Strait of Messina sampled for stomach contents analysis.

This index ranges from 0 to 1; low values indicate diets dominated by few prey items (specialist predators), high values indicate generalist diets (Krebs, 1989).

The binomial test was applied on the frequency of occurrence values of each prey category to select prevailing items in the diet of *Tetrapturus belone*: a prey category was considered as rare if its frequency of occurrence was significantly less than 5%, for $P < 0.05$. The binomial test was also repeated on the abundance values of each prey category.

RESULTS

Mediterranean spearfish caught had an average total weight of 11.0 kg (range 2.8–22.0 kg) and an average fork length of 149 cm (range 89–191 cm). Of the total stomachs examined only three were empty, thus the fullness index was 0.96. Figure 2 shows the length–frequency distribution of the 69 specimens used for the stomach contents analysis.

The cumulative prey types curve (Figure 3) for the entire data set resulted as fitting better with a logistic curve ($R^2 = 0.97$; $F_{(1,64)} = 1627.2$, $P < 0.001$) than with a linear relation ($R^2 = 0.92$, $F_{(1,64)} = 734.2$; $P < 0.001$); therefore the sample size was considered sufficient to describe the diet of *Tetrapturus belone*.

The analysis of the stomach contents led to the identification of 27 prey items (Table 1), belonging to two main taxa: Pisces and Cephalopoda. A total of 421 fish, 59 cephalopods and 8 other invertebrates were found in the stomachs analysed, with a mean of 7.4 prey individuals (± 0.6 SE) per stomach.

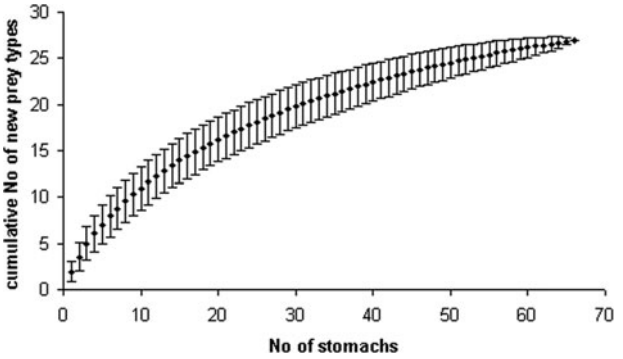

Fig. 3. Prey species accumulation plot as an average of 999 curves based on different random orders of the stomachs extracted (number of stomachs = 66). Vertical bars represent standard deviation.

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Table 1. Percent frequency of occurrence (%F), percent of total number (%N), percent of total weight (%W), index of relative importance (I_{RI}) and percent index of relative importance (%I_{RI}) for food items of *Tetrapturus belone*.

Prey Categories	%F	%N	%W	I_{RI}	%I_{RI}
Pisces unid.	43.9	30.7	4.3	1538.6	36.8
Belonidae					
Belonidae unid.	6.1	3.3	1.3	27.6	0.7
Belone belone	33.3	21.1	20.5	1388.4	33.2
Belone svetovidovi	1.5	0.2	0.1	0.4	<0.1
Carangidae					
Seriola dumerili juv.	1.5	0.2	0.2	0.6	<0.1
Trachurus sp.	3.0	1.2	0.5	5.2	0.1
Centriscidae					
Macroramphosus scolopax juv.	6.1	4.5	0.1	27.9	0.7
Clupeidae					
Clupeidae unid.	4.5	4.7	0.6	24.4	0.6
Alosa sp.	4.5	1.0	0.8	8.3	0.2
Sardina pilchardus	1.5	0.2	<0.1	0.3	<0.1
Sardinella aurita	16.7	6.4	12.3	310.4	7.4
Coryphaenidae					
Coryphaena hippurus juv.	1.5	0.2	0.6	1.2	<0.1
Engraulididae					
Engraulis encrasicolus	3.0	1.0	0.1	3.5	0.1
Gobiidae	1.5	0.8	<0.1	1.3	<0.1
Scomberesocidae					
Scomberesox saurus	18.2	9.8	10.6	372.3	8.9
Scombridae	3.0	0.6	0.1	2.0	<0.1
Sparidae					
Oblada melanura	1.5	0.2	0.1	0.5	<0.1
TOTAL PISCES	**97.0**	**86.3**	**52.2**	**13435.1**	**87.1**
Cephalopoda unid.	10.6	3.7	0.2	41.0	1.0
Octopoda	1.5	0.2	<0.1	0.3	<0.1
Tremoctopus violaceus	7.6	2.7	43.7	351.3	8.4
Teuthoidea					
Ancistrocheirus lesueuri	4.5	0.8	0.9	7.9	0.2
Histioteuthis bonnellii	4.5	1.0	0.3	5.9	0.1
Illex coindetii	10.6	3.1	1.7	50.7	1.2
Todarodes sagittatus	3.0	0.6	1.0	4.7	0.1
TOTAL CEPHALOPODS	**33.3**	**12.1**	**47.7**	**1992.3**	**12.9**
Invertebrates unid.	3.0	0.4	<0.1	1.3	<0.1
Tunicata Salpida	1.5	0.2	<0.1	0.3	<0.1
Siphonophora Diphyidae	1.5	1.0	<0.1	1.6	<0.1

Fish were the dominant group according to all numerical indicators and were mostly composed of pelagic species. Ten families were identified among them, with the dominance of Belonidae which represented 41.2% of the total preyed fish in terms of %I_{RI}. The families Clupeidae and Scomberesocidae were also well represented (%I_{RI} = 12.9 and 8.7 of the total preyed fish respectively). The species *Belone belone* (L.), *Scomberesox saurus* (Walbaum) and *Sardinella aurita* Valenciennes played the major role in the feeding of Mediterranean spearfish (Table 1).

Cephalopods occurred in 33.3% of the stomachs analysed and accounted for 12.1% in number, and 47.7% in weight of the total preyed organisms. Cephalopod remains were attributed to 5 species, all pelagic. *Tremoctopus violaceus* Delle Chiaje was the most important species among them in terms of %*W*, while *Illex coindetii* (Verany) was the most represented in terms of %*F*.

Levin's standardized index, calculated for the evaluation of diet breadth, was 0.2 for the numerical abundance and 0.1 for the biomass of the prey items.

The results of the binomial test indicated Belonidae, Clupeidae, Scomberesocidae and Teuthoidea as the significantly non-rare prey categories in terms of frequency of occurrence. The same results were obtained in terms of abundance except for Teuthoidea which were at the limit of significance ($P = 0.05$).

DISCUSSION

Very few studies have been carried out on the biology of the Mediterranean spearfish and none on its feeding habits. Based on examination of stomach contents from a few specimens, some authors propose that it probably feeds on pelagic fish, such as sardines (Clupeidae), flyingfish (Exocoetidae), carangids, scombrids, dolphinfish (Coriphaenidae) and, around Sicily, Atlantic sauries, sardine-like fish, needlefish and pilotfish (Bini, 1968; De Sylva, 1975; Tortonese, 1975; Nakamura, 1985). Partial teuthophagy is also reported in the Ligurian Sea (Garibaldi & Orsi Relini, 2005). Diet preference of *Tetrapturus belone* for pelagic fish would justify occasionally catches with surrounding nets used for the fishery of the Atlantic saury in the Strait of Messina (Cavaliere, 1962; Spartà, 1961; Tortonese 1975).

Our results confirmed fish as the main prey of the Mediterranean spearfish, although cephalopods were also well represented in terms of frequency of occurrence and reconstituted weight (Figure 4). If we also consider the large numbers of accumulated beaks in most stomachs examined, the frequency of occurrence of cephalopods increases from 33.3% to 58.2% and their abundance rises to 41.8%, confirming their important role in the diet of *T. belone*. Looking at the diets of other pelagic predators, cephalopods seem to play a most important part as food of the Atlantic white marlin *T. albidus* Poey, a very close congener of *T. belone*, also known from the Mediterranean Sea (Nakamura, 1985). They are also preyed upon by large predacious fish such as tunas, swordfish, sharks and other billfish (Roper *et al.*, 1984; Bello, 1990, 1991, 1999; Abitía-Cárdenas *et al.*, 2002; Rosas-Alayola *et al.*, 2002; Vaske *et al.*, 2004).

The most represented fish species in the diet of *T. belone* (i.e. *Belone belone*, *Scomberesox saurus* and *Sardinella aurita*) are widely distributed in the Strait of Messina (Spartà, 1961); they used to form large schools that would allow the Mediterranean spearfish to maximize the efficiency of predation. Billfish require large amounts of energy to survive and coming across schools of fish or cephalopods

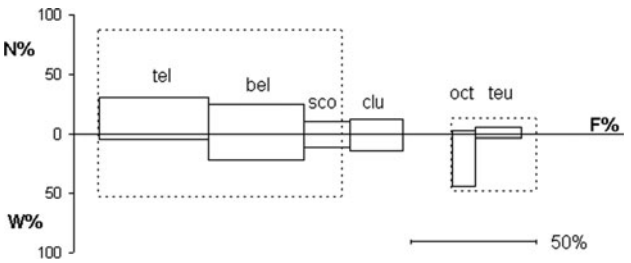

Fig. 4. Frequency of occurrence (%*F*), abundance (%*N*) and biomass (%*W*) of main prey categories (tel = unidentified teleosts; bel = Belonidae; sco = Scomberesocidae; clu = Clupeidae; oct = Octopoda; teu = Teuthoidea) in the diet of *Tetrapturus belone* from the Strait of Messina. Dashed lines refer to total fish (left) and total cephalopods (right).

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helps them in providing the large rations necessary to support their high metabolic demands. This chasing strategy has been also observed in other billfish as well as in other pelagic predators (Abitía-Cárdenas *et al.*, 2002).

Other prey found in the stomachs of *T. belone*, such as juvenile *Macroramphosus scolopax* (L.), carangids, juvenile dolphinfish, sparids, juvenile scombrids, juvenile gobiids and European anchovies, may be considered as secondary or accidental prey, at least in the sampling period; all grouped, they accounted for only 1.7% in weight and 8.8% in number. All preyed specimens were epipelagic organisms, also including juveniles of demersal or benthic fish which spend their early life stages in the upper waters.

Overall, according to the prey species composition found, *T. belone* pursues epipelagic prey. As confirmed by the low Levin's index, few species accounted for most of the prey consumed, indicating specialist feeding at least in the sampling period, which was limited to summer months. This result is atypical for billfish which are usually referred to as generalists (Somvanshi & Varghese, 2001; Abitía-Cárdenas *et al.*, 2002; Vaske *et al.*, 2004). Resource composition and prey turn-over in the area over the short sampling period may explain this result. Some species such as *Coryphaena hippurus* L. and *Naucrates ductor* (L.), which are reported as prey of *T. belone* (Nakamura, 1985), were scarcely represented or absent in the stomachs of the Mediterranean spearfish from the Strait of Messina. These two species do increase in abundance in Sicilian waters from August to December (Andaloro *et al.*, 2003), when the swordfish fishing season by harpoon is about to finish.

According to De Sylva (1975), the Mediterranean spearfish, like other billfish, is typically a clear-water species, requiring high transparency waters for its feeding which is largely visual. Diurnal feeding is also reported for other istiophorids, albeit it may extend till night-time depending on moon phases (Trias *et al.*, 1996). However, in the stomachs of *T. belone* from the Strait of Messina, we have found highly digested bodies and hard part remains of cephalopods. These organisms are known to undergo diel vertical migrations, wherein they commonly inhabit deep water during the day, then ascend towards the surface at night (Roper, 1974). Hence, their high occurrence and abundance and the condition of their remains in the stomachs of specimens caught at day-time suggest that they were probably ingested the night before the Mediterranean spearfish capture, thus revealing potential nocturnal predatory behaviour. As cephalopods are predators upon mesopelagic organisms (Sanchez, 1982; Marabello *et al.*, 1996), they represent, in terms of trophic webs and energetic fluxes, a major link between mesopelagic and epipelagic environments.

Generally, *T. belone* is presumed to feed upon organisms whose distribution is closely determined by oceanographic and trophic conditions: organisms concentrated at or just above the thermocline (De Sylva, 1975) as well as those moving upward for trophic reasons should be expected to attract this predator for feeding purposes. In the Strait of Messina, *T. belone* shares the habitat with other large pelagic predators, mainly the bluefin tuna *Thunnus thynnus* (L.), the swordfish *X. gladius* and the dolphinfish *C. hippurus* (Romeo *et al.*, 2001), as confirmed by catch records by harpoon fishery over about three decades, from 1976 to 2003 (Di Natale *et al.*, 2005a). Their concentration in this area, as well as that of *T. belone*, is possibly due to the considerable upwelling of food and nutrients into the upper layers of the Strait. Thus, they may be considered potential competitors for food, although they possibly adopt different strategies for exploiting the same environment (Dagorn *et al.*, 2000).

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REFERENCES

Abitía-Cárdenas L.A., Muhlia-Melo A., Cruz-Escalona V. and Galván-Magaña F. (2002) Trophic dynamics and seasonal energetics of striped marlin *Tetrapturus audax* in the southern Gulf of California, Mexico. *Fisheries Research* 57, 287–295.

Andaloro F., Campo D., Sinopoli M., Castriota L. and Campagnuolo S. (2003) Pelagic fish community associated with FADs off the Sicilian coast (Southern Tyrrhenian Sea). In M.Â.A. Pinheiro de Carvalho *et al.* (eds) *Island ecosystems conservation and molecular approach I symposium*. Madeira: CCBG, pp. 131–138.

Bello G. (1990) Cephalopod remains from blue sharks, *Prionace glauca*, caught in the Gulf of Taranto. *Rapports de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 32, 242.

Bello G. (1991) The role of cephalopods in the diet of the swordfish, *Xiphias gladius*, from the Eastern Mediterranean Sea. *Bulletin of Marine Science* 49, 312–324.

Bello G. (1999) Cephalopods in the diet of albacore, *Thunnus alalunga*, from the Adriatic Sea. *Journal of Molluscan Studies* 65, 233–240.

Bini G. (1968) *Atlante dei pesci delle coste italiane. Vol. VI*. Roma: Mondo Sommerso.

Castriota L., Scarabello M.P., Finoia M.G., Sinopoli M. and Andaloro F. (2005) Food and feeding habits of pearly razorfish, *Xyrichtys novacula* (Linnaeus, 1758), in the southern Tyrrhenian Sea: variation by sex and size. *Environmental Biology of Fishes* 72, 123–133.

Cavaliere A. (1962) Notizie su biologia e pesca di *Tetrapturus belone* Raf., cenni sull'adulto e descrizione di un suo rarissimo stadio giovanile. *Bollettino di Pesca e Idrobiologia* 15, 171–176.

Clarke M.R. (1986) *A handbook for the identification of cephalopods beaks*. Oxford: Clarendon Press.

Dagorn L., Menczer F., Bach P. and Olson R.J. (2000) Co-evolution of movement behaviours by tropical pelagic predatory fishes in response to prey environment: a simulation model. *Ecological Modelling* 134, 325–341.

De Sylva D.P. (1975) Synopsis of biological data on the Mediterranean spearfish, *Tetrapturus belone* Rafinesque. *NOAA Technical Report NMFS SSRF-675*, Part 3, 121–131.

Di Natale A., Mangano A., Celona A., Navarra E. and Valastro M. (2003) Size frequency composition of the Mediterranean spearfish catches in the Tyrrhenian Sea and in the Strait of Messina in the period 1994–2002. *Collective Volume of Scientific Papers ICCAT* 55, 692–709.

Di Natale A., Celona A. and Mangano A. (2005*a*) A series of catch records by the harpoon fishery in the Strait of Messina from 1976 to 2003. *Collective Volume of Scientific Papers ICCAT* 58, 1348–1359.

Di Natale A., Mangano A., Celona A. and Valastro M. (2005*b*) Size frequency composition of the Mediterranean spearfish (*Tetrapturus belone*, Rafinesque) catches in the Tyrrhenian Sea and in the Strait of Messina in 2003. *Collective Volume of Scientific Papers ICCAT* 58, 589–595.

Ferry L.A. and Caillet G.M. (1996) Sample size and data analysis: are we characterizing and comparing diet properly? In (eds. D. MacKinlay and K. Shearer) *Feeding ecology and nutrition in fish, symposium proceedings*. San Francisco: American Fisheries Society, pp. 71–80.

Garibaldi F. and Orsi Relini L. (2005) Teutophagous cetaceans of the Ligurian Sea: feeding strategies, niche breadth and possible competition with other top predators. In *19th Annual Conference of the European Cetacean Society and Associated Workshops*, La Rochelle, France, 2–7 April 2005, Abstract Book, 84.

Hacunda J.S. (1981) Trophic relationships among demersal fishes in a coastal area of the Gulf of Maine. *Fishery Bulletin* 79, 775–788.

Hurlbert S.H. (1978) The measurement of niche overlap and some relatives. *Ecology* 59, 67–77.

Hyslop E.J. (1980) Stomach content analysis—a review of methods and their application. *Journal of Fish Biology* 17, 411–429.

Krebs C.J. (1989) *Ecological methodology*. New York: Harper Collins Publishers.

Marabello F., Guglielmo L., Granata A. and Sidoti O. (1996) Studi preliminari sulle abitudini alimentari di *Todarodes sagittatus* (Cephalopoda) nel Tirreno meridionale. In G. Albertelli *et al.* (Eds) *Atti dell'11° Congresso dell'Associazione Italiana di Oceanologia e Limnologia*. Genova: AIOL, pp. 271–278.

Nakamura I. (1985) Billfishes of the world. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. *FAO Fisheries Synopsis* 125, 65 p.

Potoschi A. (2000) Biological aspects of *Tetrapturus belone* (Raf., 1810) in the Straits of Messina. *Biologia Marina Mediterranea* 7, 819–824.

Robins C.R. and De Sylva D.P. (1960) Description and relationships of the longbill spearfish, *Tetrapturus belone*, based on western North Atlantic specimens. *Bulletin of Marine Science of the Gulf and Caribbean* 10, 383–413.

Robins C.R. and De Sylva D.P. (1963) A new western Atlantic spearfish, *Tetrapturus pfluegeri*, with a redescription of the Mediterranean spearfish *Tetrapturus belone*. *Bulletin of Marine Science of the Gulf and Caribbean* 13, 84–122.

Romeo T., Ancora S., Manganaro A., Andaloro F. and Fossi C. (2001) The swordfish fishing by harpoon in the Strait of Messina. *Rapports de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée* 36, 318.

Roper C.F.E. (1974) Vertical and seasonal distribution of pelagic cephalopods in the Mediterranean Sea. Preliminary report. *Bulletin of the American Malacological Union* 27–30.

Roper C.F.E., Sweeney M.J. and Nauen C.E. (1984) FAO species catalogue. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO Fisheries Synopsis* 125, 277 p.

Rosas-Alayola J., Hernandez-Herrera A., Galvan-Magana F., Abitia-Cardenas L.A. and Muhlia-Melo A.F. (2002) Diet composition of sailfish (*Istiophorus platypterus*) from the southern Gulf of California, Mexico. *Fisheries Research* 57, 185–195.

Sanchez P. (1982) Régimen alimentario de *Illex coindetii* (Verany, 1837) en el Mar Catalàn. *Investigación Pesquera* 46, 443–449.

Santos M.B., Clarke M.R. and Pierce G.J. (2001) Assessing the importance of cephalopods in the diets of marine mammals and other top predators: problems and solutions. *Fisheries Research* 52, 121–139.

Somvanshi V.S. and Varghese S. (2001) Distribution, abundance indices and some biological characteristics of the Indo-Pacific sailfish, *Istiophorus platypterus* (Shaw and Nodder, 1792) in the North western Indian EEZ. *Indian Ocean Tuna Commission Proceedings* 4, 164–168.

Spartà A. (1953) Uova e larve di *Tetrapturus belone* Raf. (Aguglia imperiale). *Bollettino di Pesca, Piscicoltura e Idrobiologia* 8, 58–62.

Spartà A. (1961) Biologia e pesca di *Tetrapturus belone* Raf. e sue forme post-larvali. *Bollettino di Pesca, Piscicoltura e Idrobiologia* 15, 20–24.

Tortonese E. (1975) *Osteichthyes. Fauna d'Italia*. Vol XI, 636p. Bologna: Calderini.

Trias C., Marcano L.A. and Alio J.J. (1996) Alimentacion de peces istioforidos de la region nororiental y central de Venezuela. *Collective Volume of Scientific Papers ICCAT* 45, 288–294.

and

Vaske T. Jr., Vooren C.M. and Lessa R.P. (2004) Feeding habits of four species of Istiophoridae (Pisces: Perciformes) from northeastern Brazil. *Environmental Biology of Fishes* 70, 293–304.

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