FEEDING OF THE SWORDFISH, THE BLUEFIN AND OTHER PELAGIC NEKTON IN THE WESTERN LIGURIAN SEA

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Orsi Relini, L., F. Garibaldi, C. Cima, G. Palandri

Laboratori di Biologia Marina ed Ecologia Animale, Istituto di Zoologia, Università di Genova, Via Balbi 5, 16126 Genova, Italia

SUMMARY

The feeding of swordfish and bluefin tuna has been investigated in the western Ligurian Sea, where environmental conditions promote the richness and abundance of the mesopelagic fauna (a sampling by IKMT gives 40 species of fish, 16 species of cephalopods, and 13 species of crustacean decapods.

The biomass ingested by swordfish, reconstructed on the basis of stomach content analysis, consisted of 67.8% cephalopods, 30.7% fish, and 1.48% crustaceans, with a predominance of mesopelagic prey.

For bluefin, the major part of the stomach contents was comprised of anchovies. However, mesopelagic crustaceans and fish and ommastrephid cephalopods were also found to concur in the diet.

RESUME

L'alimentation de l'espadon et du thon rouge a été étudiée dans la partie occidentale de la mer Ligurienne, où les conditions d'environnement favorisent la richesse et l'abondance de la faune mésopélagique (un échantillonnage de l'IKMT donne 40 espèces de poissons, 16 de céphalopodes et 13 de crustacés décapodes).

La biomasse ingérée par l'espadon et reconstituée à partir de l'analyse du contenu stomacal était composée de 67,8% de céphalopodes, 30,7% de poissons et 1,48% de crustacés, avec une prédominance de proies mésopélagiques.

Quant au thon rouge, la majeure partie de son contenu stomacal est composée d'anchois. Toutefois, les céphalopodes ommastréphides, les poissons et les crustacés mésopélagiques font également partie de son alimentation.

RESUMEN

Se ha investigado la alimentación del pez espada y el atún rojo en el oeste del mar de Liguria, donde las condiciones del medio ambiente favorecen la riqueza y abundancia de la fauna mesopelágica (un muestreo por IKTM da 40 especies de peces, 16 de cefalópodos, 13 de crustáceos decápodos.

La biomasa ingerida por el pez espada, reconstruida por medio de análisis del contenido estomacal, consistía en un 67,8% de cefalópodos, 30,7% de peces y 1,48% de crustáceos, predominando las presas mesopelágicas.

Respecto al atún rojo, la mayor parte del contenido estomacal estaba compuesto por anchoas; sin embargo, los crustáceos mesopelágicos y los peces, y los cefalópodos *ommastrephidae*, también formaban parte de la dieta.

Introduction

In the Ligurian Sea swordfish and tuna fishing occur mainly in the western section, where the harbours of Imperia, Sanremo, Loano, Bordighera, Andora and Arma di Taggia accommodate 50% of the large pelagic fleet.

The marine environment is characterised by a narrow shelf, deep waters (2000-2500 m) very close to the coast and substantial primary production not limited to the coastal strip. In offshore waters a permanent geostrophic front runs parallel to the coast about 15-25 miles from it. This front gives rise to an upwelling. Other seasonal upwellings are linked to the winter formation of "deep water" i.e. to the sinking of surface waters which become cold and dense under the influence of northern winds.

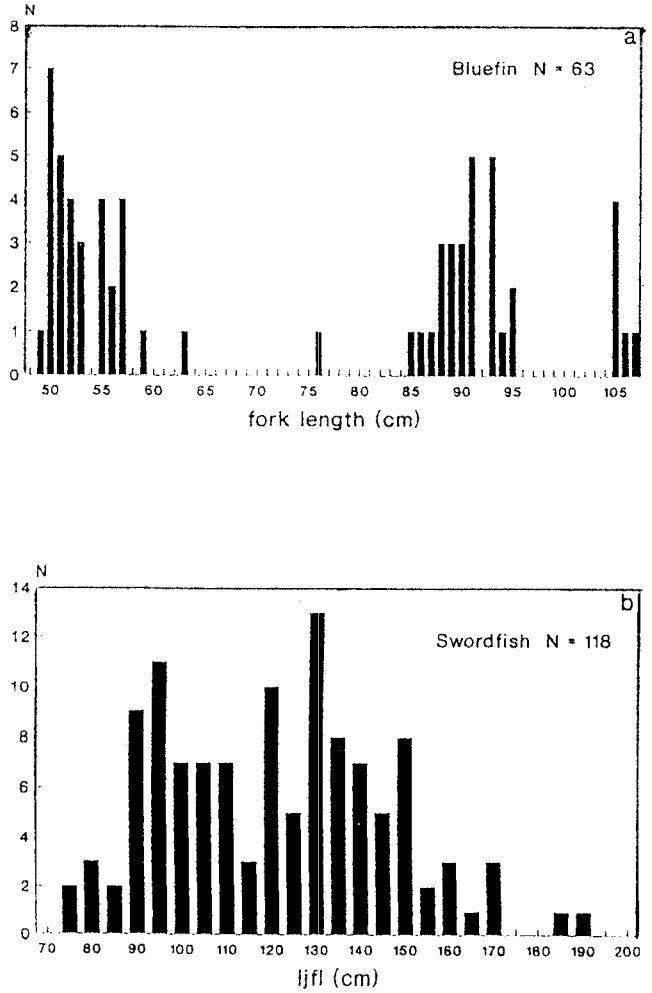
The food chains triggered by these oceanographic features have a key species in *Meganyctiphanes norvegica*, which is preyed upon by fish, cephalopods and large filterers. Baleen and toothed whales are more abundant in this area than elsewhere in the Mediterranean (Notarbartolo et al. 1993).

The study of feeding habits of bluefin, swordfish and marine mammals may explain the interaction between fishing and problems of conservation.

Material and methods

The stomach contents of 129 swordfish (11 empty) and 67 bluefin (4 empty) were sampled as a part of the "Characterisation of large pelagic stocks in the Mediterranean" programme, with the support of E.C.

Fig.1a and b. Length/frequency distribution of specimens for stomach content analysis



Swordfish lengths ranged from 78 cm to 192 cm ljfl (Kg 3.9-82.5); bluefin from 49 cm to 107 cm fl (Kg 2.8-18) (Fig. 1). Stomach contents were sorted into three main categories: fish, cephalopods and crustacean decapods. These were identified to the nearest taxon on the basis of ad hoc prepared collections of whole organisms or hard parts of them. The sampling covered mesopelagic fauna, and was carried out in twenty hauls using a 15-feet Isaacs Kidd Midwater Trawl (Table 1). The gastric contents were then studied using different methods for the bluefin and the swordfish. In the bluefin, contents are often monotonous and scarcely digested; these were weighted directly. In the swordfish prey items are numerous with a dominance of cephalopods whose remains are often limited to beaks. Ingested biomasses have been estimated on the basis of ad hoc relationships between hard parts (e.g. lower beaks, Clarke 1968) and the whole prey.

Results

The feeding of bluefin is illustrated in table 2. The largest share (93%) of ingested biomass is fish, among which Clupeiformes (Engraulidae, with *Engraulis encrasicholus* and Clupeidae with *Sardina pilchardus*) are dominant. This result is similar to that found in oceanic areas distant from the Mediterranean (main species *E. mordax* according Pinkas 1971). However, one also finds a certain use of mesopelagic organisms such as Paralepididae fish, Crustacean Decapods such as Pasiphaeidae and Sergestidae and especially Euphausiacea. With regard to this last group it should be pointed out that 1088 *M. norvegica* individuals, came from one single gastric content (a 10.6 Kg bluefin, caught 64 miles from the Ligurian coast). On that occasion tuna and whales found themselves together, probably attracted by a concentration of krill.

The diet of swordfish (Table 3) is based on cephalopods, fish and crustaceans with an approx. weight ratio of 52:23.5:1. Mesopelagic organisms are clearly dominant.

In term of weight the most important crustacean species is the penaeid shrimp *Funchalia woodwardi*, followed by *Pasiphaea multidentata*.

Among the cephalopods the Ommastrephidae with *Todarodes sagittatus* and *Ommastrephes bartramii* form almost 4/5 of the total. They are followed by the slight but numerous Cranchidae *Galiteuthis armata* and Histioteuthidae, especially with *Histioteuthis reversa*.

Fish are represented by surface species and mesopelagic species in a ratio of about 1:5. Among the latter, Trachipteridae (because of their size) and Paralepididae (because of their number) give rise to high biomass values.

The IRI index attenuates the difference between the three categories of prey, bringing especially cephalopods and fish closer together.

On the whole it is confirmed that also the Mediterranean swordfish is a mesopelagic hunter, as telemetric experiments have shown in specimens taken from the west coast of America (Carey e Robinson 1981), and that muscular cephalopods, which move around in a vertical space of about 1000 metres, play a fundamental role in diet (Stillwell e Kohler 1985, Bello 1991). Considering the Ligurian environment in particular, mesopelagic fauna is also of great importance for other predators. Thus the finwhale feeds exclusively on *M. norvegica* in

summer (Orsi Relini e Giordano 1992), the most numerous cetaceans in this area, that is striped dolphins *Stenella coeruleoalba*, consume mesopelagic fish and cephalopods as the swordfish (Orsi Relini et al 1994) and naturally a common use of deep cephalopods emerges from the scarce data based on "non-stranded" pilot whale *Globicephala melas* (Orsi e Garibaldi 1993) and Risso's dolphins *Grampus griseus* (in preparation).

Common use of offshore resources and common hunting grounds explain why there is conflict between the fishing of swordfish carried out using drift nets and the demands of conservation; given the particular density of cetaceans in the Ligurian area, from July 1990 the use of drift nets has been banned by decree of the Ministero della Marina Mercantile (Orsi Relini et al. 1992). Since August 1992, Italian fishermen are not allowed to use drift nets in the triangle formed by Cape Corse-Cape d'Antibes and Cape Corse-Punta del Mesco (Fig. 2). Since sword fishing is socially and economically important and must continue, it is to be hoped that Ligurian boats fitted with drift nets, instead of going to fish in distant waters, return to using traditional means, namely surface longlines.

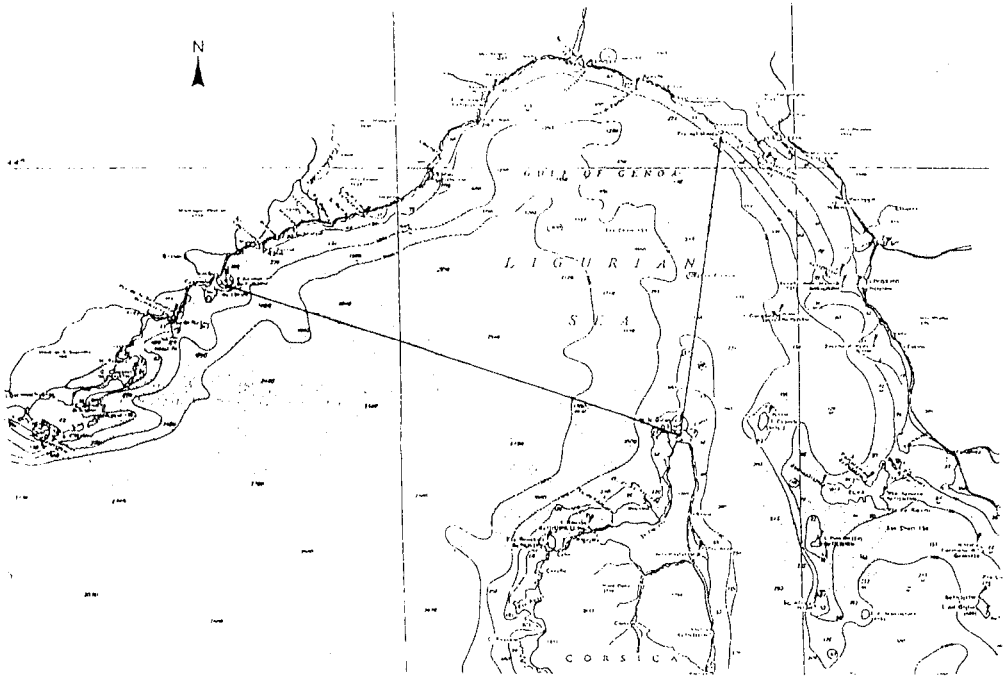


Fig. 2 Swordfish fishing areas (shadowed) and "Cetaceans sanctuary" (delimited by coastal line and two black lines) in the Ligurian Sea, i.e. the zone in which swordfish drifnet fishing is forbidden.

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Tab. 1 - Mesopelagic fishes, crustaceans decapods, cephalopods caught by IKMT in the Ligurian sea and their occurence.

Osteichthyes		%	**Crustacea Decapoda**		%
Gonostomatidae	Cyclothone pygmaea	23.47	**Aristeidae**	Gennadas elegans	46.3
	Cyclothone braueri	70.02	**Penaeidae**	Funchalia villosa	0.13
	Gonostoma denudatum	+		Funchalia woodwardi	0.06
Photichthyidae	Ichthyococcus ovatus	0.02	**Sergestidae**	Sergestes arcticus	26
	Vinciguerria attenuata	0.02		Sergestes henseni	3.3
	Vinciguerria poweriae	0.05		Sergestes sargassi	2.6
Sternoptychidae	Argyropelecus hemigymnus	3.96		Sergestes viglax	2.9
	Maurolicus muelleri	+		Sergia robusta	2.7
Astronesthidae	Borostomias antarcticus	+	**Oplophoridae**	Acanthephyra pelagica	2.3
Melanostomiatidae	Bathophilus nigerrimus	0.01		Acanthephyra eximia	+
Stomiatidae	Stomias boa	0.02	**Pasiphaeidae**	Pasiphaea multidentata	9.3
Chauliodontidae	Chauliodus sloanei	0.37		Pasiphaea sivado	4.1
Paralepididae	Lestidiops jayakari		**Hippolytidae**	Ligur ensiferus	+
	Lestidiops sphyrenoides				
	Notolepis rissoi	0.28			
	Paralepis coregonoides		**Mollusca Cephalopoda**		
	Sudis hyalina				
Evermannellidae	Evermannella balbo	+	**Sepiolidae**	Heteroteuthis dispar	21.5
Myctophidae	Electrona rissoi	+		Stoloteuthis leucoptera	1.07
	Hygophum hygomii	+	**Enoploteuthidae**	Abralia veranyi	1.07
	Hygophum benoiti	0.32		Abraliopsis pfefferi	2.15
	Benthosema glaciale	0.42	**Onychoteuthidae**	Onychoteuthis banksi	1.07
	Myctophum punctatum	0.13		Ancistroteuthis lichtensteini	1.07
	Symbolophorus veranyi	0.07	**Histioteuthidae**	Histioteuthis bonnellii	5.4
	Lobianchia dofleini	0.02		Histioteuthis reversa	40.9
	Diaphus rafinesquei	0.02	**Ctenopterygidae**	Ctenopteryx sicula	5.4
	Diaphus holti	+	**Ommastrephidae**	Todarodes sagittatus	1.07
	Diaphus metopoclampus	+		Illex coindetii	1.07
	Lampanyctus crocodilus	0.37		Ommastrephes bartrami	1.07
	Lampanyctus pusillus	0.04	**Cranchiidae**	Galiteuthis armata	8.6
	Ceratoscopelus maderensis	0.27	**Octopodidae**	Pteroctopus tetracirrhus	1.07
	Notoscopelus kroeyerii	+		Octopus sp.	3.2
	Notoscopelus elongatus	+	**Chiroteuthidae**	Chiroteuthis veranyi	2.15
Argentinidae	Microstoma microstoma	+			
	Nansenia oblita	+	**n.e.i. Cephalopoda**		2.15
Nemichthyidae	Nemichthys scolopaceus	0.01			
Trachipteridae	Zu cristatus	+			
	Trachipterus trachypterus	+		Osteichthyes N = 26932	
Regalecidae	Regalecus glesne	+		Decapoda N = 7135	
Zoarcidae	Melanostigma atlanticum	+		Cephalopoda N = 93	

Tab. 2 Total prey items in 63 stomach contents of bluefin tuna from Western Ligurian Sea

Family	Numbers			Occurrence			Weight	
	N°	%N°	%N°t	F	%F	%Ft	g	%
OSTEICHTHYES								
Engraulidae	1818	97.6	56.55	47	78.33	74.6		
Clupeidae	8	0.43	0.25	3	5	4.76		
Belonidae	9	0.48	0.28	6	10	9.5		
Scomberesocidae	3	0.16	0.09	3	5	4.76		
Paralepididae	14	0.75	0.44	4	6.66	6.35		
n. c. i.	10	0.54	0.31	10	16.66	15.9		
Total	1863	99.96	57.92	-	-	-	3960.98	92.88
CRUSTACEA								
Pasiphaeidae	6	0.46	0.19	4	36.36	6.35		
Sergestidae	1	0.08	0.03	1	9.1	1.59		
Euphausiacea	1282	98.39	39.88	6	54.54	9.52		
Mysidacea	1	0.08	0.03	1	9.1	1.59		
Phronimidae	9	0.69	0.28	4	36.36	6.35		
Copepoda	1	0.08	0.03	1	9.1	1.59		
n. c. i.	3	0.23	0.09	3	27.27	4.76		
Total	1303	100	40.53	-	-	-	256.94	6.03
CEPHALOPODA								
Ommastrephidae	28	75.68	0.87	10	58.82	15.9		
Argonautidae	3	8.11	0.09	2	11.76	3.17		
n. c. i.	6	16.22	0.19	6	35.29	9.52		
Total	37	100	1.15	-	-		40.13	0.94
SIPHONOPHORA	13	100	0.40	6	100	9.52	5.4	0.13
THALIACEA								
Pyrosomida	2	100	0.06	2	100	3.17	1.11	0.26
TOTAL	3218	-	-	-	-	-	4264.56	-

Tab. 3 - Total prey items in 126 swordfish stomach contents from Western Ligurian Sea and IRI index*.

Family	Numbers		Occurrence		Estimated weights		IRI
	N°	%	F	%	g	%	
CRUSTACEANS							
EUPHAUSIACEA	477	28.2	22	17.5	238.5	0.3	498.8
AMPHIPODA							
- Phronimidae	95	5.6	13	10.3	95	0.1	58.7
DECAPODA							
- Peneidae	75	4.4	9	7.1	750	1.0	38.3
- Pasiphaeidae	3	0.2	2	1.6	30	0.04	0.4
- Sergestidae	1	0.1	1	0.8	8	0.01	0.1
Unidentified shrimps	4	0.2	4	3.2	20	0.03	0.7
TOT. CRUSTACEANS	651	38.5	50	39.7	1141.5	1.5	1588
CEPHALOPODS							
Ommastrephidae	105	6.2	46	36.5	39236.3	51.0	2087.8
Cranchiidae	115	6.8	49	38.9	7093.4	9.2	622.4
Sepiolidae	64	3.8	20	15.9	270.5	0.4	66.8
Argonautidae	30	1.8	18	14.3	1770	2.3	58.6
Onychoteuthidae	30	1.8	16	12.7	1185.3	1.5	41.9
Histioteuthidae	9	0.5	9	7.1	2452	3.2	26.3
Chiroteuthidae	1	0.1	1	0.8	99.2	0.1	0.2
Octopodidae	2	0.1	2	1.6	-	-	-
Tremoctopodidae	1	0.1	1	0.8	30	0.03	0.1
TOT. CEPHALOPODS	357	21.1	95	75.4	52136.7	67.8	6703.1
FISHES							
Paralepididae	423	25.0	34	27.0	7434	9.7	936.9
Trachypteroidea	18	1.1	18	14.3	9960	12.9	200.2
Engraulidae	115	6.8	15	11.9	862.5	1.1	94.0
Scomberesocidae	45	2.7	18	14.3	2925	3.8	93.0
Myctophidae	28	1.7	16	12.7	500	0.6	29.2
Bramidae	14	0.8	2	1.6	210	0.3	1.8
Carangidae	2	0.1	1	0.8	600	0.8	0.7
Squalidae	1	0.1	1	0.8	400	0.5	0.5
Sparidae	1	0.1	1	0.8	200	0.3	0.3
Belonidae	1	0.1	1	0.8	50	0.1	0.2
Unidentified fish	34	2.0	26	20.6	510	0.7	55.6
TOT. FISHES	682	40.4	95	75.4	23651.5	30.7	5360.9
TOTALS	1690	100.0	-	-	76929.7	100.0	-

***IRI** = (% number + % estimated biomass) x % frequency of occurrence