PRELIMINARY STUDY ON THE FEEDING OF BLUEFIN TUNA (*THUNNUS THYNNUS)* IN THE MEDITERRANEAN AND THE STRAIT OF GIBRALTAR AREA

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SUMMARY

*The stomach contents of 595 specimens of bluefin tuna (*Thunnus thynnus *L.) caught with different fishing gears in the western Mediterranean and the Strait of Gibraltar area between 2008 and 2011 are analyzed. Significant differences were found in the diet of the analyzed specimens in terms of percentage composition by taxonomic groups according to the area, season, size and physiological state and origin of the tuna, together with the fishing gear with which they were caught. Important differences were found in the species composition of the stomach contents between the tuna caught in the Mediterranean Sea and those caught in the Strait of Gibraltar. By large taxonomic groups and for all the observed stomach contents, 66% was comprised of fish, whereas crustaceans amounted to 24%. Cephalopods represented 10%. These results confirm the opportunistic character of this species in terms of feeding strategy, as well as the high position it occupies in the food chain.*

RÉSUMÉ

Les contenus stomacaux de 595 spécimens de thon rouge (Thunnus thynnus L.) *capturées avec différents engins de pêche à l'Ouest de la Méditerranée et dans la zone du détroit de Gibraltar entre 2008 et 2011 sont analysés. Des différences notables sont apparues dans le régime alimentaire des spécimens analysés en termes de pourcentage de composition par groupes taxonomiques selon la zone, la saison, la taille, l'état physiologique et l'origine des thonidés, ainsi que selon l'engin de pêche avec lequel ils étaient capturés. Des différences importantes ont vu le jour dans la composition spécifique des contenus stomacaux entre les thonidés capturés dans la mer Méditerranée et ceux capturés dans le détroit de Gibraltar. Par grand groupes taxonomiques et pour tous les contenus stomacaux observés, 66% étaient composés de poissons, tandis que les crustacés représentaient 24%. Les céphalopodes représentaient 10%. Ces résultats confirment le caractère opportuniste de cette espèce en termes de stratégie trophique, ainsi que la position élevée qu'elle occupe dans la chaîne alimentaire.*

RESUMEN

*Se analizan los contenidos estomacales de 595 ejemplares de atún rojo (*Thunnus thynnus L.*) capturados con distintos artes en el Mediterráneo occidental y en el área del Estrecho de Gibraltar durante el período de 2008-2011. Se encontraron diferencias significativas en la dieta de los ejemplares analizados en la composición porcentual por grupos taxonómicos según el área, la época, el tamaño y estado fisiológico, asociado al arte de pesca con el que fueron capturados. Se identificaron 49 tipos de especies presa y se obtuvo la talla de 1.994 de ellas. Se observaron diferencias en la composición específica de los contenidos estomacales de los atunes capturados en el mar Mediterráneo y en el área del Estrecho de Gibraltar, respectivamente. Dentro del Estrecho y para la misma época se encontraron diferencias en la composición porcentual, por grandes taxones, en los contenidos estomacales según el tamaño-edad de los atunes rojos analizados. Por grandes grupos taxonómicos y para la totalidad de los contenidos estomacales observados, el 66 % estuvo compuesto por peces mientras que los crustáceos estuvieron representados en un 24%. Los cefalópodos significaron el 10%. Estos resultados reafirman el carácter generalista/oportunista de la estrategia alimenticia de esta especie y la alta posición que ocupa dentro de la cadena trófica.*

KEYWORDS

Bluefin tuna, stomach contentsl

1. Background

There are no comprehensive studies on the feeding of the bluefin tuna in the Strait of Gibraltar with the exception of the work carried out by Dr. Rodríguez Roda on tuna from Atlantic traps. It is well known that juveniles and adults are fed in an opportunistic way. Chase (2002) identified more than 20 fish species and 10 invertebrate species in bluefin tuna stomachs. Likewise, some differences were found between the feeding of juvenile and adult tuna. The former feed more on crustaceans, whereas the diet of adults contains a higher percentage of fish. (Eggleston and Bochenek, 1990; Ortiz de Zárate and Cort, 1986). A clear relationship between the prey size and the length of the tuna has not been established. However, Chase (2002) observed that the largest preys were only eaten by the giant tuna, with a fork length (LH) over 230 cm.

The goal of this study is to gain more knowledge on the trophic activity of bluefin tuna in order to explain the variability of this resource in terms of area/time distribution according to feeding grounds, seasons, tuna lengths, etc. Likewise, the results of this preliminary study could be applicable in order to explain the annual variability of the standardized abundance indexes according to the differences in the availability of feeding resources of this species by area or season and with an impact on the catchability by the different fishing gears. Several studies supply (Pinkas et al. 1991), Jock et al. indicate that interannual variations in the diet of bluefin tuna. Other study techniques were performed using stable isotope analysis (Estrada et al., 2005; Logan, 2009)

2. Material and methods

The methodology used includes the capture of stomachs from specimens caught by Spanish fleets in the Mediterranean and the Strait of Gibraltar with artisanal fishing systems: Processing and analysis of stomach contents **(Figure 8)**; weight of full and empty stomach (±1g); identification of prey taxa (in the case of fish and decapod crustaceans, the prey species is specified whenever possible), sampling of prey sizes and determination of their weight (g); separation, if applicable, of bait specimens; gathering and preservation of the hard parts of the preys (fish otoliths, cephalopod beaks, crustacean pincers, etc.) in ethylic alcohol for its subsequent identification; calculation of weight by species (g); qualitative degree of the digestion status of the prey (1 full or fresh, 2 partially digested, 3 largely digested); introduction of the obtained data in a specific software in order to perform the analysis on bluefin tuna feeding by area, season and length ranges. In addition, the technologies and fishing strategies used for obtaining the samples were taken into consideration, particularly the time (GMT) and fishing depth (m), as these factors have an impact on the specific percentage composition of the stomach contents for the same area, season and length range.

The stomach contents were compared in terms of length groups, areas, seasons and fishing gears, respectively.
The specimens were divided into two length categories according to their fork length (LH cm). The length groups analyzed were either smaller or bigger than 115 cm long. Therefore, the separation limit for both groups was set at 30 kg.

The analyzed and contrasted areas were the “western Mediterranean” and the “Strait of Gibraltar”, respectively.

The fishing gears included in the study are trolling lines (Troll-Spor) and surface longlines targeting bluefin tuna (LL), long-finned tuna (LLALB) and/or swordfish (LLHB), respectively, and whose activity is developed in the Mediterranean. The hand line (Hand) and the rod with live bait (BB) were used in the Strait of Gibraltar.

Considering the general asynchrony of some of the bluefin tuna fisheries, we established different seasons in which fishing activities may be active or not. Two main seasons separated by the reproduction period were established for the large specimens: pre-reproductive seasons and reproductive seasons (May, June and July) and post-reproductive season (August-September).

3. Results

Over the 2008-2010 period, a total number of 593 stomachs of bluefin tuna specimens were collected and processed, both from longline and recreational fisheries from the Mediterranean and from the artisanal hand line and live bait fisheries of the Strait of Gibraltar area in the framework of the On-board Observers Programme and the Information and Sampling Network of the IEO.

In the analysis of stomach contents 49 species of fish were identified, crustaceans and cephalopods having obtained the height of 1994 specimens of prey species.

We observed that the "fishery" factor was significant for the results, as this catch represents a fraction of the bluefin tuna population which is more catchable for certain gears/tackles at a given moment due to its size, physiological state and other factors. The water depth is, amongst others, a significant factor which results in stomach contents which are largely made up of species representing a particular habitat.

In the case of the Strait of Gibraltar, considerable differences were found between the stomach contents of bluefin tuna caught with hand lines at high depths (>300 fathoms) and the tuna caught with string and live bait at less than 40 fathoms from the surface.

Tuna caught with hand lines belong to the group of fish which, after spawning in the Mediterranean, continue feeding for nearly one month at great depths on species whose capture implies, without a doubt, a lower energy expenditure. Likewise, the time spent in deeper and colder waters contributes to the after-spawning recovery of these specimens.

Similarly, stomach contents vary a great deal according to the different areas (Mediterranean and Strait of Gibraltar) and to length ranges and catch seasons.

Table 1 shows all the specimens from which stomach contents were obtained, classified by year, area, fishery and length range.

The relation taxa-prey found is very broad and varies according to the abovementioned factors **(Figure 1)**. **S**hows a general percentage list of all the stomach contents analyzed with the prey species grouped into large zoological groups (fish, mollusks and crustaceans) **(Figure 2)**.

This figure shows that, in terms of taxonomic categories, the highest percentage of prey species observed in the stomach contents of bluefin tuna in both areas corresponds to fish, followed by crustaceans and cephalopod mollusks in this order but with different proportions according to the area. It shows a list of the prey species found in the stomach contents of the 595 processed stomachs but considering both study areas in a separated way **(Table 2)**. The prey taxa which were more frequently observed in the stomach contents of bluefin tuna varied a great deal from the Mediterranean to the Strait of Gibraltar. Thus, the species which are mostly represented in the diet of the tuna caught in the Strait of Gibraltar belong to the taxonomic category of fish, "*Chauliodus sloani*", undetermined bony fish, *Auxis rochei*, undetermined Myctophoidei, *Lampanyctus crocodilus*, and *Scomber* spp., amongst others. Many different crustaceans were widely present in the diet, the most representative species being *Sergestes robustus, Pasiphaeidae* spp, *Acantephyra* spp, *Cirolana borealis*, Natantia spp. and *Pasiphaeidae* spp. As far as cephalopod mollusks are concerned, the most relevant ones were *Todarodes* spp., *Histioteuthis* spp., *Illex codetii, Alloteuthis* spp. and *Octopus* spp.

The most recurrent species found in the stomach contents of bluefin tuna caught in the Mediterranean area by artisanal fisheries were: undetermined bony fish, *Scomber* spp., *Engraulis encrasicolus*, undetermined Ammodytidae and *Trachurus trachurus* in fish. When it comes to crustaceans, the most relevant species (although with a lower presence) were *Polybius henslowii*, undetermined Euphausiacea and *Cirolana borealis*. Cephalopod mollusks are represented by *Todarodes* spp., *Allotteuthis* spp., *Illex coindetii* and *Octopus* spp.

When the presence percentages of the prey species found in the stomachs are represented by taxonomic categories for both study areas at the same time we can observe important differences in the proportion in which certain species are present **(Figures 3 to 5)**. Likewise, we can highlight a greater abundance of specimens for most of the species belonging to the three taxonomic categories of the Strait of Gibraltar. This circumstance would explain why bluefin tuna of all sizes remain in what certainly is (or may be) a recognized feeding area for this species. We must not forget that the stomach contents of bluefin tuna are usually made up of one or two species (Chase, 2002).

The development and completion of the analyses carried out with a specific software lead us to present the conclusions of this study, whose aim is to gain more knowledge about the trophic activity and the feeding parameters of the bluefin tuna by area, season and length ranges, so that we can know more about the factors conditioning the migratory patterns related with the results of electronic and conventional tagging.

The stomach contents of young and adult bluefin tuna specimens with fork lengths below and above 115 cm respectively were compared. Similarly, the stomach contents were compared for both study areas, namely, from tuna caught by trolling lines and surface longlines in the Mediterranean and from tuna caught with hand line and live bait in the Strait of Gibraltar. In the analysis of the stomach contents the taxonomic categories of preys (fish, crustaceans and cephalopods) have significantly different representations in the diet.

In young tuna specimens, the percentage representing the number of crustaceans is significantly higher (75%-90%) when compared to the percentage of fish (5%-24%) which is, in turn, higher than the percentage of cephalopod mollusks (0.88%-1.27%).

On the contrary, the percentage representing the number of fish increases notably in the stomach contents of adult bluefin tuna. Likewise, some differences can be observed according to the area and fishing gear **(Figure 6)**. To explain the observed differences in diet and feeding activity of the bluefin tuna caught in the Strait of Gibraltar with various arts, we obtained the condition indices of the same. It was noted that these rates are higher for all years, tuna bait, lower than the condition factor of tuna caught by hand line **(Figures 7** and **8)**.

4. Discussion

We observed significant differences in the percentage distribution of taxonomic categories in the stomach contents of tuna according to their lengths.

The percentage representation of crustaceans was comparatively higher in younger specimens than in adult ones. On the other hand, fish are the most representative category in the diet of adults, both in terms of volume and weight.

No significant differences were found in the percentage composition of stomach contents from young specimens by taxonomic categories. However, some differences were noted in their specific composition based on the area, which confirms the hypothesis that bluefin tuna is an opportunistic predator.

The prey species found in the stomach contents of bluefin tuna caught in the Mediterranean differ from those found in the Strait. Therefore, the “area factor” is considered determinant in the specific percentage composition of stomach contents.

A higher percentage of most of the common prey species was noted in the composition of the stomach contents in both areas, as well as a higher (degree of stomach filling) in the Strait of Gibraltar in general, which corroborates the fact that this area is a recognized feeding area where artisanal fisheries targeting bluefin tuna operate from July to March.

For the same reason, the stomach contents found in the Mediterranean bluefin tuna could imply a certain impoverishment of this sea when it comes to abundance and diversity of the different species which could potentially be the target of the trophic activity of the bluefin tuna.

Besides the length and the area, another factor to be taken into account when analyzing the trophic activity of bluefin tuna is the physiological state of the specimens in different seasons. This could evidently be related with the “season” factor. Thus, the stomach contents observed in adult tuna caught in the “revés” (feeding) stage over the July-August period in the Strait of Gibraltar, that is, shortly after post-spawning, are different from the stomach contents of adult tuna which go to the same area several weeks later. The former are caught at great depths with hand line and their stomachs contain bottom species, whereas the latter are caught closer to the surface (40 fathoms) with string and live bait and present a different specific composition in terms of stomach contents. These observed differences could be explained by the recovery of spawning tuna which, immediately after spawning, remain in deeper and cooler waters as well as by the catch of prey species demanding a lower energy expenditure. As we expected, differences were also noted in the "condition" factor in every year between each fraction of bluefin tuna caught with different gears in the same season. This could be related with population differences according to which, the bluefin tuna with a higher condition factor would have spawned previously and presented a higher recovery level. This reaffirms their status of residents in the Mediterranean which move to a different feeding area such as the Strait of Gibraltar. On the other hand, the contingent caught at great depths with hand line seems to constitute a fraction which enters the Mediterranean to spawn from the Atlantic and then returns to the Atlantic after one month approximately (IEO data bases on catches), recovering

in the Strait of Gibraltar and then continuing with its trophic migration through the Atlantic. This may be to the south, reaching the Cape Verde islands or to the north, up to Norwegian waters (De Metrio et. al. 1998).

As Froese (2006) suggests, after obtaining the length/weight relationships, the condition index (Kmean) was estimated for each type of gear and year, as follows: Kmean= $aLH^{(b-3)}$, where a and b are the parameters of the length/weight function and LH is the fork length.

Parameters of the length/weight relationship estimated for each year and the corresponding condition factor (Kmean) for tuna caught with live bait. The *a* and *b* parameters have been estimated in centimetres for lengths and in grams for weights, as recommended by Froese (2006) **(Table 3)**.

Parameters of the length/weight relationship estimated for each year and the corresponding condition factor (Kmean) for tuna caught with long line. The *a* and *b* parameters have been estimated in centimetres for lengths and in grams for weights, as recommended by Froese (2006) **(Table 4)**.

A t-Student test was carried out in order to check for any significant differences between Clark's condition indexes (Froese, 2006) for each year and between both gear types. It was observed that the interannual average of the condition index for tuna caught with the hand line (average= 1.6531) was significantly lower than the interannual average of the condition index for tuna caught with live bait gears (average= 1.726) (P= 0.046) (**Figures 7** and **8**, **Tables 3** and **4**).

It is noteworthy, finally, the upward trend in the condition index of tuna caught in the Strait of Gibraltar with both gear types **(Figure 8)** immediately after breeding, which could be related to a slight advancement and widespread annual spawning due to the widespread increase in sea temperature (global warming). The gonado-somatic index of the largest tuna caught with hand line depth in the Strait of Gibraltar have higher values in larger tunas (**Figure 9**, **Table 5**) probably due to the further development of the connective tissue of the gonads in the old tuna, among others.

Figures 10 to 13 set out the size ranges of prey species and sizes of predators bluefin tuna caught in the Mediterranean and the Strait of Gibraltar, manifesting themselves respectively match the low rates of species prey (of the 14 species observed only three common significant).

Bibliography

Chase, B.C. 2002, Differences in diet of Atlantic tuna (*Thunnus thynnus*) at five seasonal feeding grounds of the New England continental shelf. Fishery Bulletin 100, pp 168‑180.

Commisssion of European Communities (CEC). 1995, Characterization of large pelagic stocks (*Thunnus thynnus* L., *T. alalunga* Born., *Sarda sarda* Bloch, *Xiphias gladius* L.) in the Mediterranean Final Report, 1995.

Eggleston, D.B., and Bocherek, E.A. 1990, Stomach contents and parasite infestation of school bluefin tuna (*Thunnus thynnus*) collected from the Middle Atlantic Bight, Virginia. Fisheries Bulletin 88:389-395

Estrada, J.A., Lutcavage, M., Thorrold, S.R. 2005, Diet and trophic position of Atlantic bluefin tuna (*Thunnus thynnus*) inferred from stable carbon and nitrogen isotope analysis. Marine Biology. Volume: 147, Issue: 1, Pages: 37-45.

Logan, J. 2009, Tracking diet and movement of Atlantic bluefin tuna (*Thunnus thynnus*) using carbon and nitrogen stable isotopes. University of New Hampshire, 219 pages

Ortiz de Zárate, V., Cort, J.L.1986, Stomach contents study of immature bluefin tuna in the Bay of Biscay. ICES-CMH, 26:10 pp.

Pinkas, L., Oliphant, M.S. and Iverson, I.L.K. 1971, Food Habits of Albacore, Bluefin Tuna, and Bonito In California Waters. Scripps Institution of Oceanography Library, Fish Bulletin 152.

Rodriguez Roda, J. 1964, Biología del atún rojo *(Thunnus thynnus*) de la costa sudatlántica española. Inv. Pesq; 25:33-146.

Vignon, M., Dierking, J. 2011, Prey regurgitation and stomach vacuity among groupers and snappers. *Environmental Biology of Fishes.* 2011, 90 (4): 361-366.

Young, J.W., Lamb, T.D., Le, D., Bradford, R.W. and Whitelaw, A.W. 2003, Feeding ecology and interannual variations in diet of southern bluefin tuna, *Thunnus maccoyii*, in relation to coastal and oceanic waters off eastern Tasmania, Australia. Environmental Biology of Fishes Volume 50, Number 3, 275-291.

Table 1. Record of stomachs collected and processed during the period 2008-2010.

Periodo	*Area*	*Arte*	*Estómagos*
2008	MEDITERRANEO	PALANGRE	214
	ESTRECHO	ARTESANAL	28
2009	MEDITERRANEO	PALANGRE	104
	ESTRECHO	ARTESANAL	88
2010	MEDITERRANEO	PALANGRE	101
	ESTRECHO	ARTESANAL	60
Total 2008-2010	MEDITERRANEO	PALANGRE	419
	ESTRECHO	ARTESANAL	176

Table 2. List of species - prey observed in stomach contents.

Especies	*Estrecho*	*Mediterráneo*	*%Estrecho*	*%Mediterráneo*
Ammodytidae	0	14	0,00	3,34
Auxis rochei	19	6	10,80	1,43
Boops boops	6	1	3,41	0,24
Brama brama	2	0	1,14	0,00
Capros aper	0	2	0,00	0,48
Chauliodus sloani	61	2	34,66	0,48
Diplodus sargus	1	1	0,57	0,24
Engraulis encrasicolus	5	33	2,84	7,88
esparidos spp	5	1	2,84	0,24
Gobidae indeterminados	1	1	0,57	0,24
Lampanyctus crocodilus	9	3	5,11	0,72
Larva de pez	2	0	1,14	0,00
Lepidopus caudatus	8	1	4,55	0,24
Maurolicus muelleri	1	0	0,57	0,00
Merluccius merluccius	2	0	1,14	0,00
Myctophoidei indeterminados	9	6	5,11	1,43
Myctophum punctatum	2	2	1,14	0,48
Pagellus acarne	2	0	1,14	0,00
Pagelus erythrinus	1	0	0,57	0,00
Sardina pilchardus	0	48	0,00	11,46
Scomber japonicus	6	2	3,41	0,48
Scomber scombrus	2	7	1,14	1,67
Stomias boas	5	0	2,84	0,00
Teleosteo spp.	21	60	11,93	14,32
Tetragonurus cuuieri	4	0	2,27	0,00
Trachurus mediterraneus	1	2	0,57	0,48
Trachurus trachurus	5	12	2,84	2,86
Acantephyra	37	1	21,02	0,24
Aristeus antenatus	1	1	0,57	0,24
Cirolana borealis	31	8	17,61	1,91
Liocarcinus spp.	3	2	1,70	0,48
Euphausiacea indeterminados	0	30	0,00	7,16
Munida spp.	1	0	0,57	0,00
Natantia indeterminados	9	12	5,11	2,86
Pasiphaea multidentata	8	3	4,55	0,72
Pasiphaeidae spp.	42	1	23,86	0,24
Plesionika spp.	5	1	2,84	0,24
Polybius henslowii	8	30	4,55	7,16
Sergestes robustus	47	9	26,70	2,15
Alloteuthis spp.	5	13	2,84	3,10
Illex coindetii	4	8	2,27	1,91
Loligo vulgaris	1	0	0,57	0,00
Mollusca indeterminados	0	3	0,00	0,72
Octopus spp.	6	0	3,41	0,00
Histioteuthis sp	11	4	6,25	0,95
Sepia oficinalis	2	3	1,14	0,72
Todarodes spp.	17	27	9,66	6,44
Plasticos, Colillas y anzuelos	4	37	2,27	8,83

Table 3. Parameters of the length/weight relationship estimated for each year and the corresponding condition factor (Kmean) for tuna caught with Live Bait. The *a* and *b* parameters have been estimated in centimetres for lengths and in grams for weights, as recommended by Froese (2006).

Year	*n*	R^2	*P*	*a*	*b*	K_{mean}
2006	54	0,941	<0,001	0,0551	2,7822	1,7167
2007	3194	0,916	<0,001	0,07155	2,7311	1,7063
2008	259	0,937	<0,001	0,0431	2,8299	1,7303
2010	128	0,958	<0,001	0,0399	2,8429	1,7467

Table 4. Parameters of the length/weight relationship estimated for each year and the corresponding condition factor (Kmean) for tuna caught with long line. The *a* and *b* parameters have been estimated in centimetres for lengths and in grams for weights, as recommended by Froese (2006).

Year	*n*	R^2	*P*	*a*	*b*	K_{mean}
2006	28	0,936	<0,001	0,015	3,0157	1,6324
2007	103	0,954	<0,001	0,013	3,0459	1,6552
2008	29	0,952	<0,001	0,025	2,9258	1,6737
2010	104	0,927	<0,001	0,0206	2,9616	1,6779

Table 5. They show different biological parameters and gonadosomatic index according to Kume and Joseph (1969) for tuna caught in both hand line (HAND), as bait (BB) during the months of August, the period studied, and over 150 cm size. Key: ISM gonadosomatic index by Kume and Joseph (1969).

	Talla (cm)	*RW (Kg)*	*Gónada (gr)*	*IGS*
HAND				
	204	156	1260	1.48
	220	167	2350	2.21
	221	163	1500	1.39
	221	182	2200	2.03
	215	161	1680	1.69
	215	162	1380	1.39
	224	188	1560	1.39
	187	110	1810	2.77
	211	154	1405	1.5
BB				
	185	118	1260	1.99
	180	94	730	1.25
	186	112	710	1.10
	192	123	860	1.22
	186	108	320	0.5
	154	69	380	1.04

Figure 1. Stomach contents of bluefin tuna captured in various fisheries in the Mediterranean and the Strait of Gibraltar.

Figure 1a. Stomach contents of bluefin tuna caught in the Strait of Gibraltar.

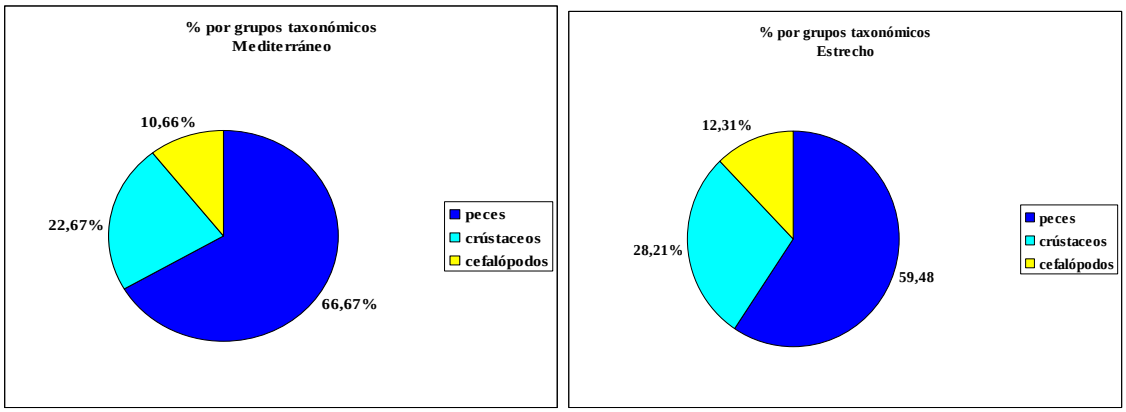


Figure 2. Percentages of occurrence of species, grouped into taxonomic categories (fish, crustaceans and cephalopods) in the stomach contents processed for the Mediterranean and the Strait of Gibraltar, respectively.

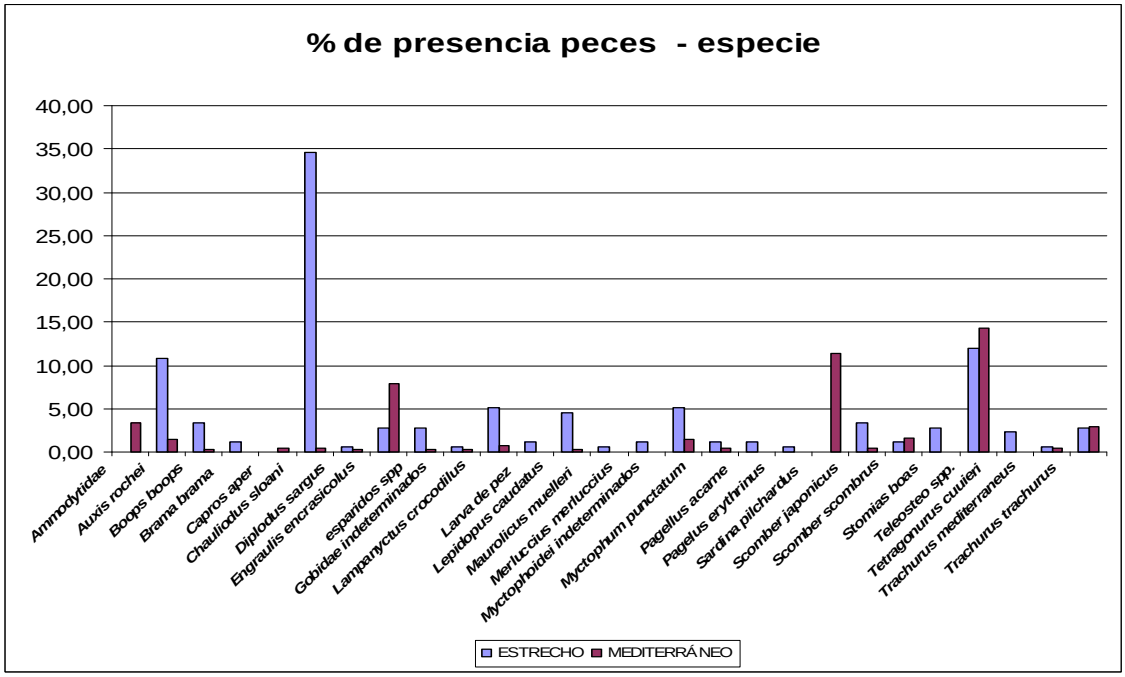


Figure 3. Relation of prey species (fish) observed in the stomach contents of bluefin tuna caught in the western Mediterranean and the Strait of Gibraltar.

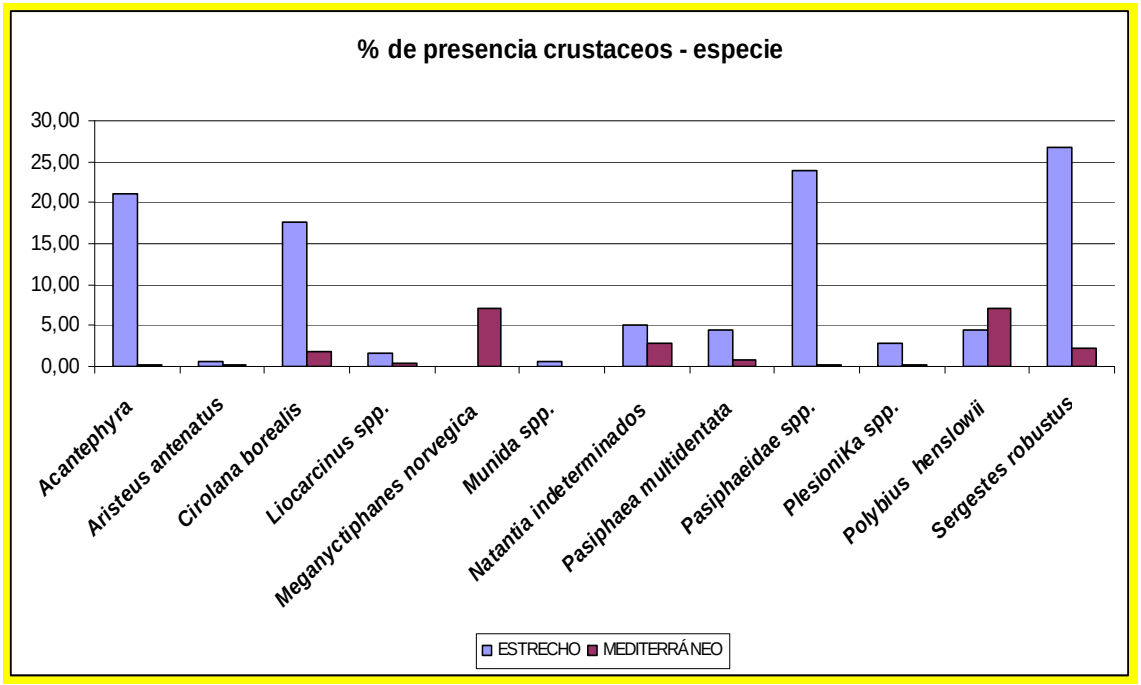


Figure 4. List of prey species (crustaceans) observed in the stomach contents of bluefin tuna caught in the western Mediterranean and the Strait of Gibraltar, respectively.

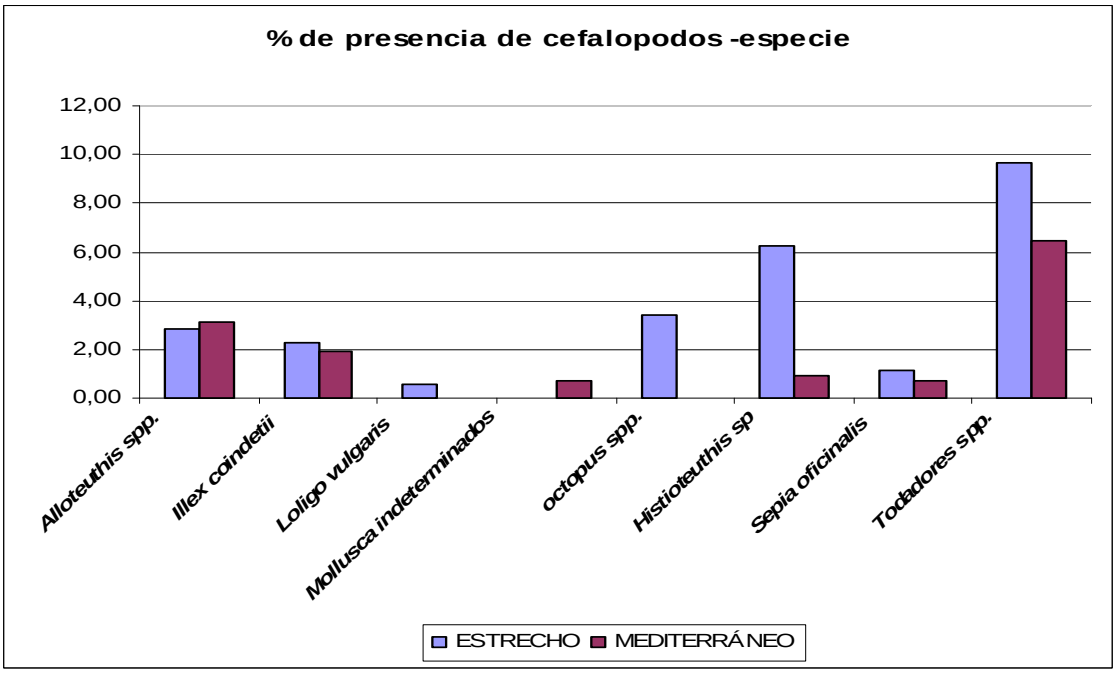


Figure 5. List of prey species (cephalopods) observed in the stomach contents of bluefin tuna caught in the western Mediterranean and the Strait of Gibraltar, respectively.

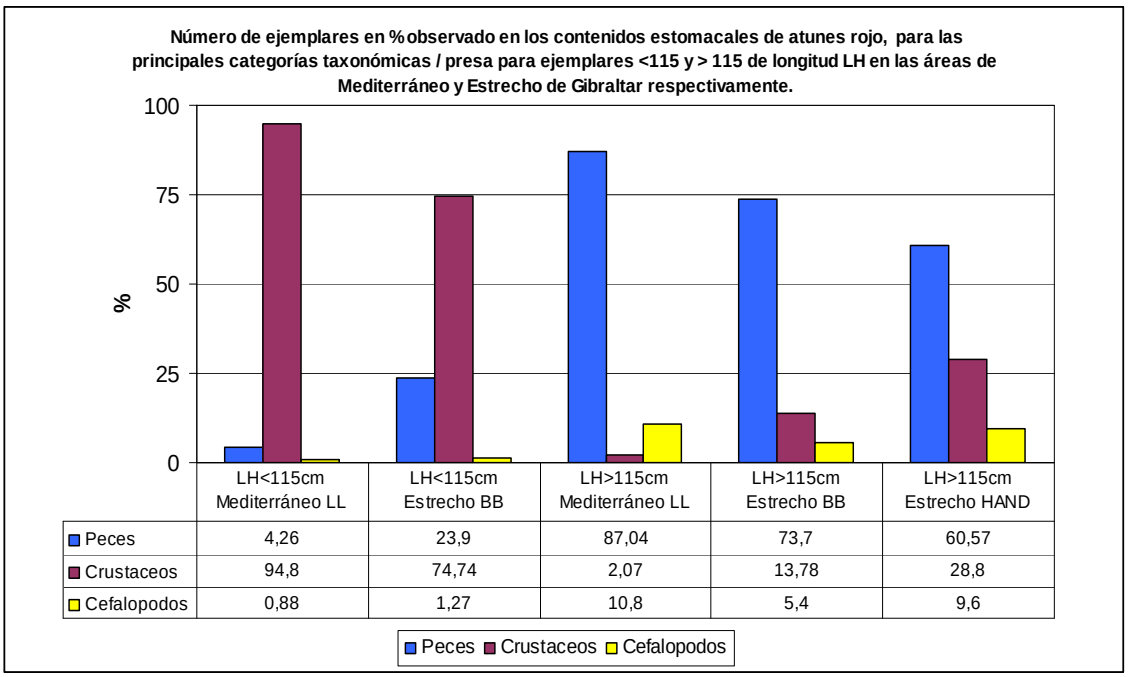


Figure 6. List of number of fish prey in percentage for the three most significant taxonomic categories according to size, area / gear.

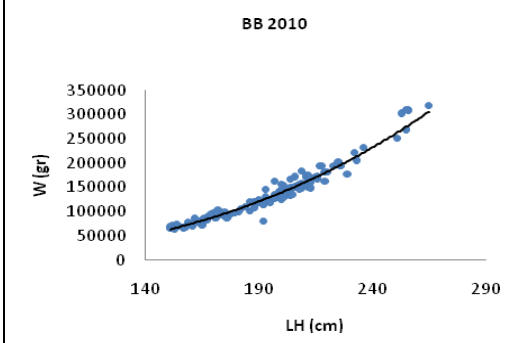
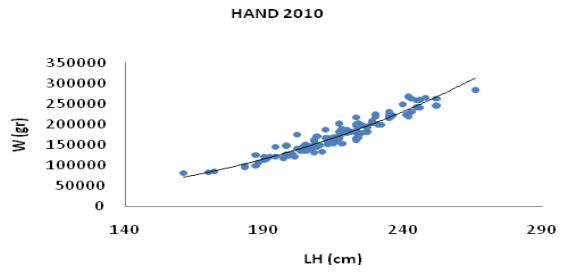
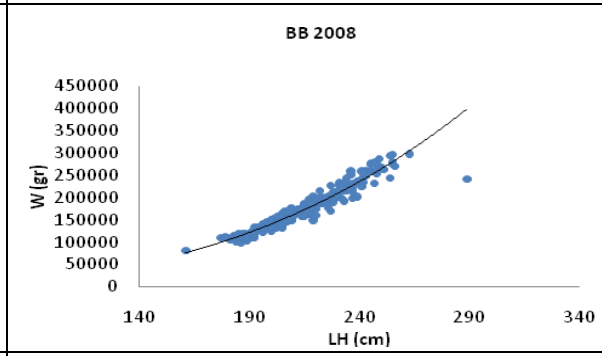
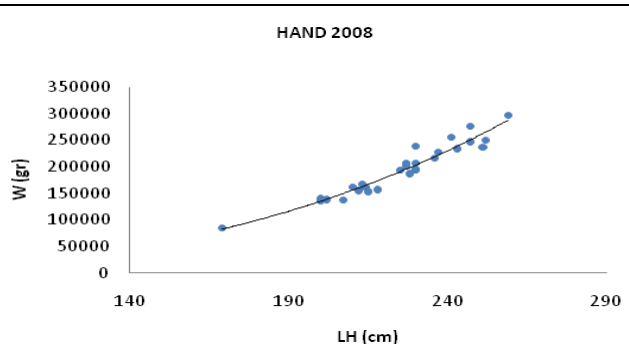
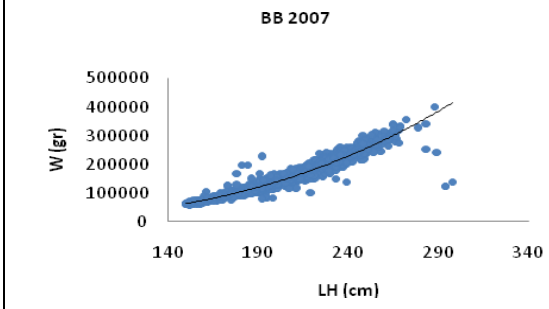
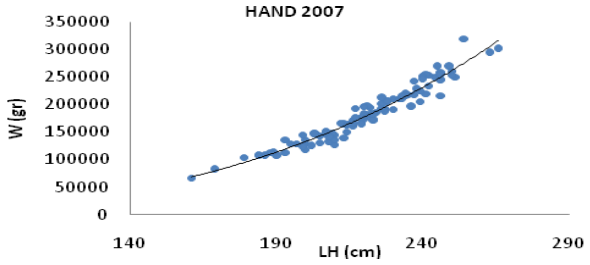
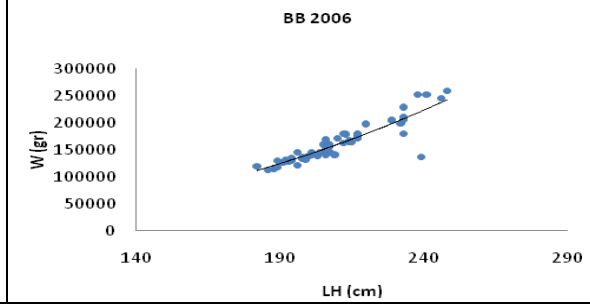
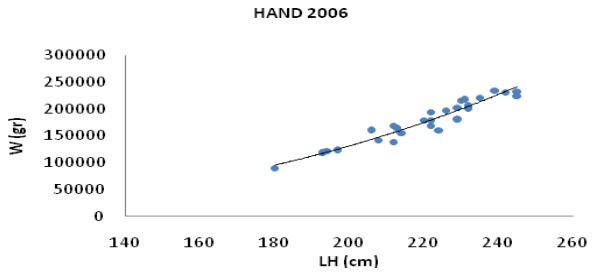
Year	*Live bait*	*Hand line*
2010		
2008		
2007		
2006		

Figure 7. Size (LH cm)-weight (RW) relationship of bluefin tuna caught by hand line and bait in the Strait of Gibraltar.

Condition indexes per year and gear.

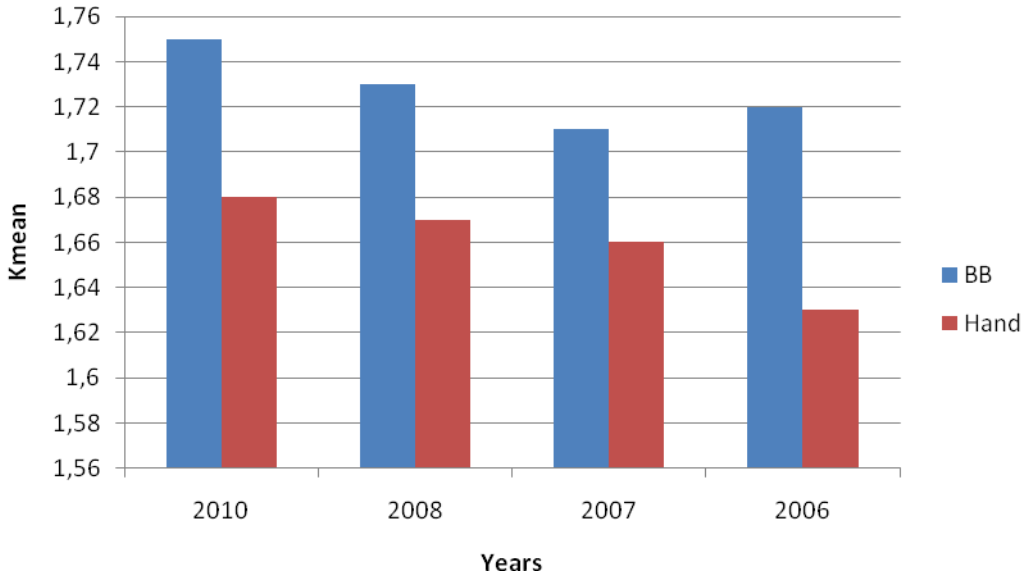


Figure 8. Condition indices of the bluefin tuna caught by hand line and bait, respectively, each year in the Strait of Gibraltar to the period 2006-2010.

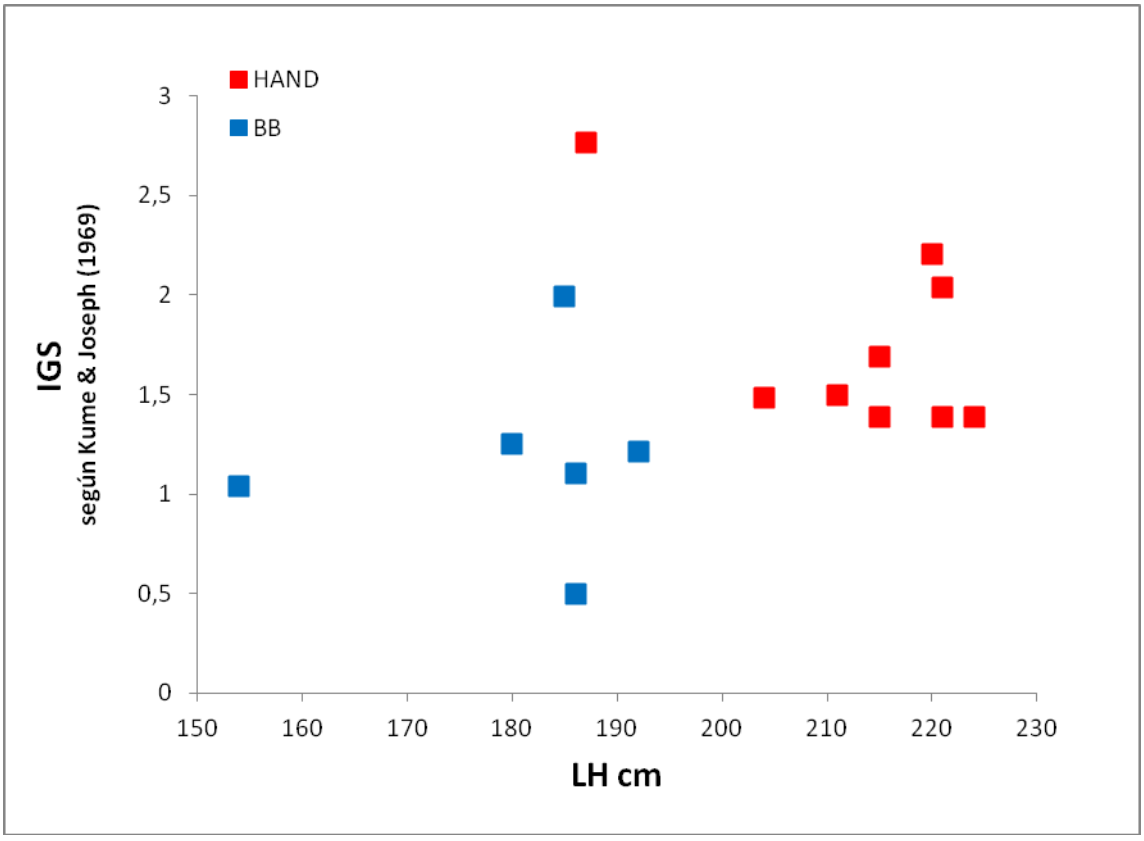


Figure 9. Gonadosomatic index of adult bluefin tuna caught in the Strait of Gibraltar during the month of August, post spawning season, by two fishing gears (hand line and baitboat).

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Mediterranean

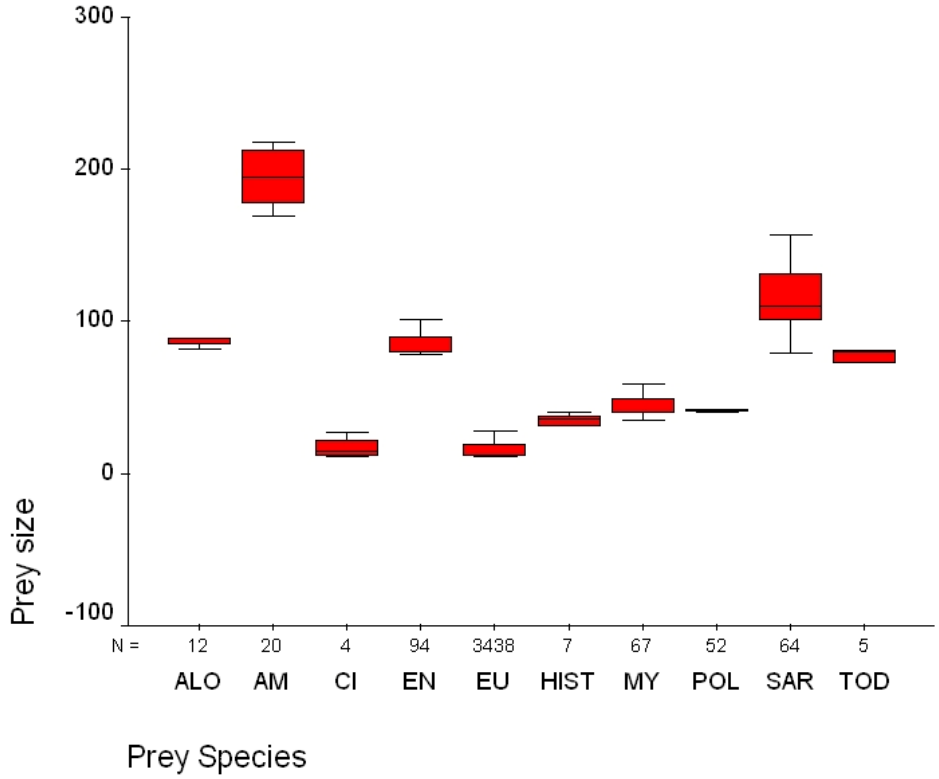

Figure 10. Prey size of bluefin tuna observed in the Mediterranean.

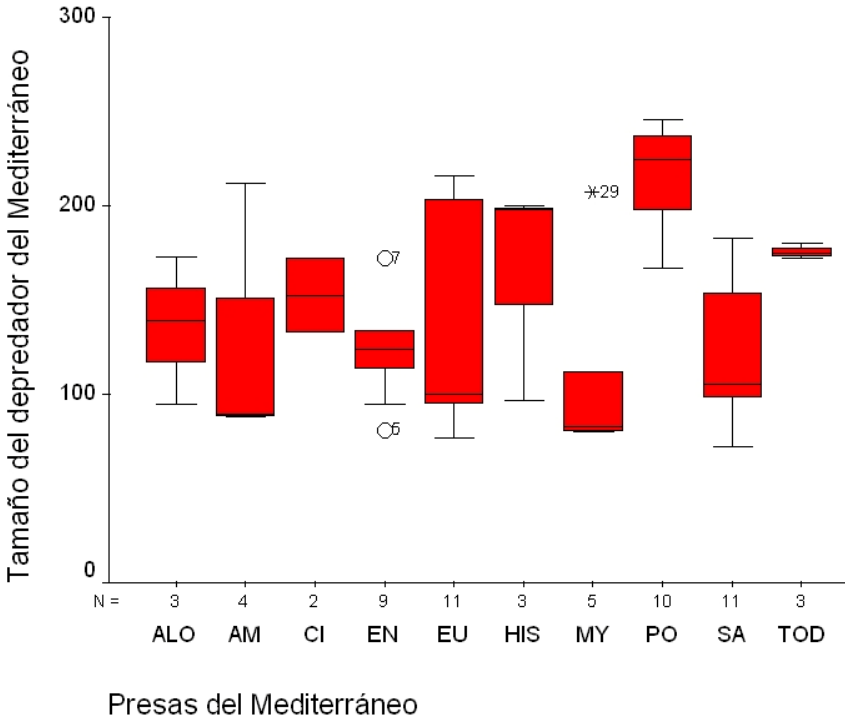

Figure 11. Size of the predator (red tuna) in relation to prey observed in the Mediterranean.

Strait of Gibraltar

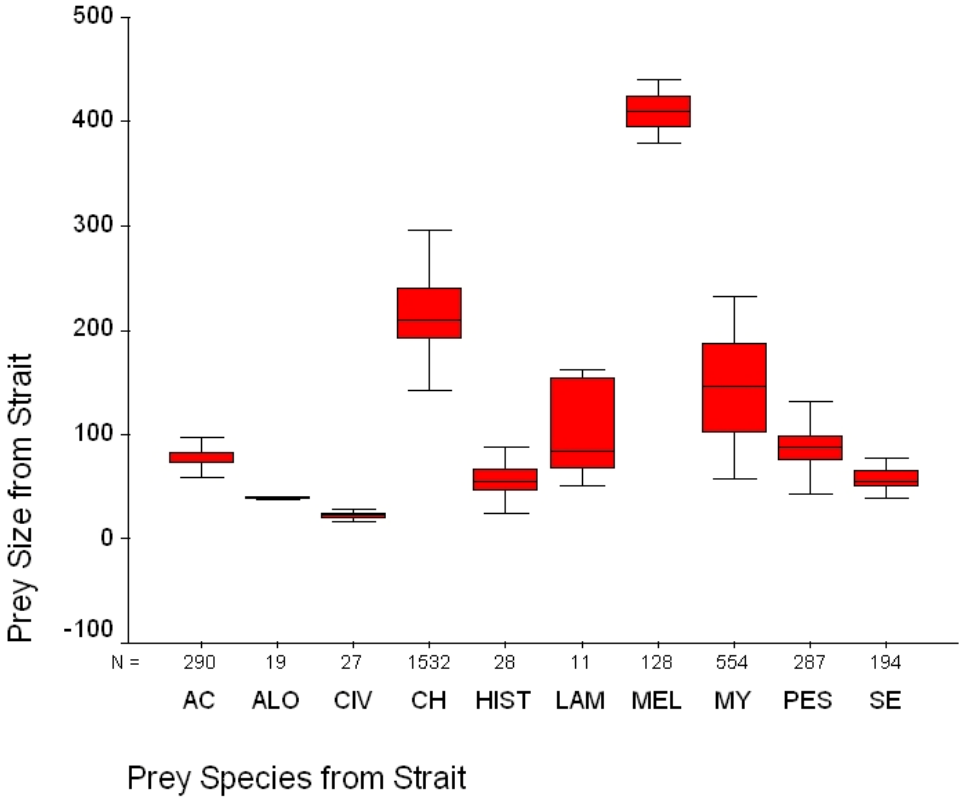

Figure 12. Bluefin tuna prey size observed in the Strait of Gibraltar.

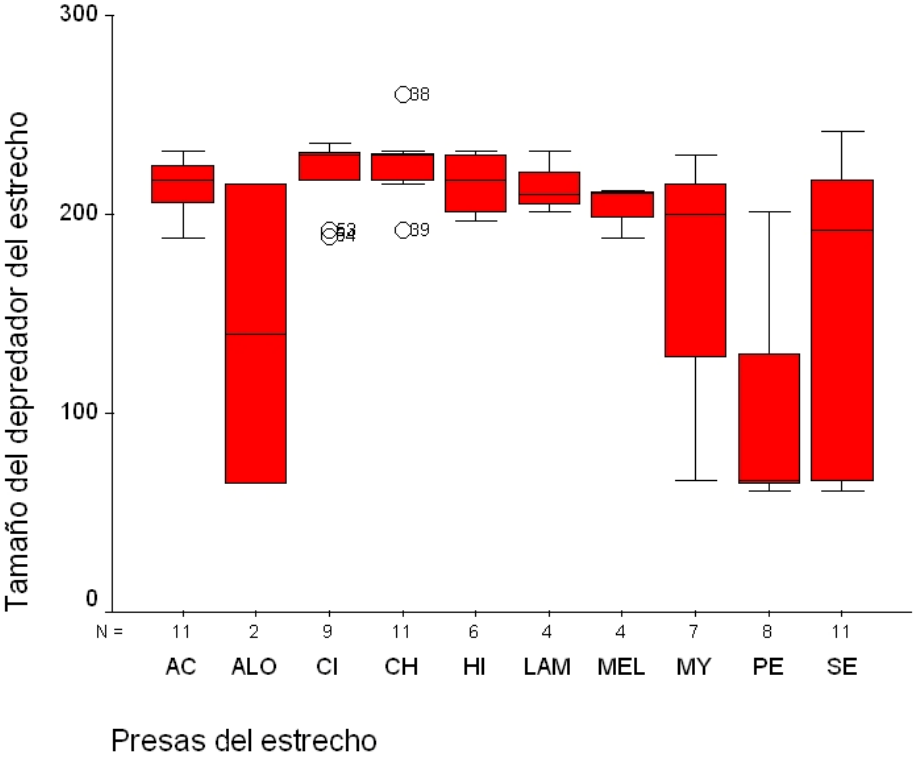

Figure 13. Size of the predator (red tuna) in relation to the prey species observed in the Strait of Gibraltar.

Species codes used in previous analysis.

ALO	*Alloteuthis spp.*
AM	*Ammodytidae*
CI	*Cirolana borealis*
EN	*Engraulis encrasicolus*
EU	*Euphausiacea indeterminados*
HIST	*Histioteuthis sp*
MY	*Myctophoidei indeterminados*
POL	*Polybius henslowii*
SAR	*Sardina pilchardus*
TOD	*Todarodes spp.*
AC	*Acantephyra*
CH	*Chauliodus sloani*
LAM	*Lampanyctus crocodilus*
MED	*Auxis rochei*
PES	*Pasiphaeidae spp.*
SE	*Sergestes robustus*