Feeding habits of stargazer (*Uranoscopus scaber* Linnaeus, 1758) in the southern Adriatic Sea (Croatia)

Prehrana bežmeka (Uranoscopus scaber Linnaeus, 1758) u južnom Jadranu (Hrvatska)

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Abstract

The feeding habits of the stargazer *Uranoscopus scaber* Linnaeus, 1758 were analysed using 360 stomachs of specimens collected in southern Adriatic Sea between October 2011 and September 2012. The total body length of the specimens ranged from 9.7 to 32.1 cm (18.89 ± 3.34 cm) and weight from 11.7 to 618.7 g (112.79 ± 63.17 g). In the sampled population there were 213 females (59.17%) and 147 males (40.83%). Stargazer is carnivorous fish and its diet in Adriatic Sea was composed of teleost fish, cephalopods and crustaceans. According to numerical abundance fish predominated followed by crustaceans, while according to the gravimetric composition fish predominated followed by cephalopods. Teleost fish were dominant prey in all seasons, and the principal prey were hake *Merluccius merluccius* and argentine *Argentina sphyraena*. Argentine was primary food in summer (*IRI* = 61.63), while hake occur in other seasons. In relation to the total body length teleost fish dominated in diet of stargazer whose total body length was < 25 cm. In size group I and II (TL < 20 cm) *A. sphyraena* was the main food, while *M. merluccius* was dominant prey in the size group III (TL = 20 – 25 cm). Vacuity index in the sampled population was relatively low (%*V* = 11.11%). During seasons the percentage of empty stomachs varied significantly with the highest value in winter (%*V* = 15.55%) and the lowest in spring (%*V* = 7.78%). In relation to the total body length the highest vacuity index was recorded for size group II (%*V* = 5.83) and the lowest for group VI (%*V* = 0).

KEY WORDS
fishes
Uranoscopus scaber
diet
Adriatic Sea

Sažetak

Prehrana bežmeka Uranoscopus scaber Linnaeus, 1758. analizirana je na temelju sadržaja 360 želudaca jedinki prikupljenih na području južnog Jadrana u razdoblju od listopada 2011. do rujna 2012. Raspon ukupne duljine tijela jedinki bio je od 9,7 do 32,1 cm (18,89 ± 3,34 cm), a mase od 11,7 do 618,7 g (112,79 ± 63,17 g). Uzorak se sastojao od 213 ženki (59,17%) i 147 mužjaka (40,83%). Bežmek je karnivorna vrsta i njegova prehrana u Jadranskom moru sastojala se od tri skupine plijena: ribe, glavonošci i rakovi. Prema brojnosti plijena prevladavaju ribe, a potom rakovi dok prema postotku mase prevladavaju ribe, a potom glavonošci. Ribe su imale najviše vrijednosti koeficijenta relativnog značaja tijekom svih sezona, a od riba neophodna i glavna hrana za bežmeka su bile vrste oslić Merluccius merluccius i srebrenjak Argentina sphyraena. Srebrenjak je bio glavna hrana tijekom ljetne sezone (IRI = 61,63), dok je u ostalim sezonama bio oslić. U prehrani bežmeka čija je ukupna duljina tijela < 25 cm dominiraju ribe. A. sphyraena bila je glavna hrana bežmecima čija je ukupna duljina tijela manja od 20 cm dok je M. merluccius dominirao kao plijen u želucima bežmeka čija je ukupna duljina tijela bila u rasponu od 20 do 25 cm. Koeficijent praznoće probavila u uzorku je bio relativno nizak (%V = 11,11%). Godišnje promjene koeficijenta praznoće probavila bile su statistički značajne. Najveća vrijednost ovog koeficijenta zabilježena je tijekom zime (%V = 15.55%), a najniža tijekom proljeća (%V = 7.78%). U odnosu na ukupnu duljinu tijela najviša vrijednost koeficijenta praznoće probavila zabilježena je za grupu II (%V = 5,83), a najniža za grupu VI (%V = 0).

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1. INTRODUCTION

Members of Uranoscopidae family are benthic predators that live at depths of up to 700 meters, and can grow up to 75 cm in length and 11 kg in weight [1]. The main characteristics of the family are an elongated and strong, laterally flattened body and a massive, square and bony head. Their eyes are located on the top of their heads while their mouths are vertical with a protractile appendix attached to the mandible. The teeth are small [1,2]. The stargazer, *Uranoscopus scaber* Linnaeus, 1758 is the only representative of the Uranoscopidae family in Mediterranean Sea and eastern Atlantic from the Bay of Biscay to Senegal [2]. In the Adriatic Sea it is recorded throughout the entire area except in the deep sea and shallow coves of the northern part [3]. The maximum reported total length of stargazer from the Adriatic Sea is 36 cm. The only larger specimen (TL=38 cm) in the entire area of its natural distribution was found in the records of the International Game Fishing Association [4]. The reproduction period of the stargazer ranges from March to September [5] and the length at first maturity is 11.76 cm for males 13.75 cm for females [6]. Although stargazer is not a commercially important species in fisheries, it is an important component of the food chain [5,7,8,9]. This benthic predatory species burrows into the muddy-sandy bottom and lure prey. When lunges out of the substrate it bends body between the head and trunk by more than 60° [1,10]. Stargazer does not use the electrical impulses to capture prey, but releases them during mechanical stimulation. The tissue that releases electrical impulses has lost the properties of ordinary muscle tissue, but still does not have the properties of electrical organs [11]. The diet of the stargazer is known from the few studies reported from different parts of the Mediterranean [7,12,13]. For the Adriatic Sea, only Jardas [2] noted that it feeds on fish, polychaetes and crustaceans. Information on diet composition of commercial and non-commercial species is crucial for implementing a multi-species approach to fisheries management [14] so this study aims to determine, for the first time, the diet and feeding habits of the stargazer from Adriatic Sea, by analysing variations in diet composition, taking into account factors such as seasonality and size groups.

2. MATERIAL AND METHODS

The 360 individuals of stargazer analysed in this study were collected monthly from October 2011 to September 2012 in the southern Adriatic Sea (Figure 1). This area is characterized by a seabed covered with muddy sediment [2]. The specimens were collected during day time hours at depths of 100 to 140 m using a commercial bottom trawl net. The net was 45 m long with 24 mm stretched mesh cod-end. The duration of each haul was about 3 h and the trawling speed fluctuated from 2.6 to 2.9 knots. After the catch the samples were stored on ice and transferred to the laboratory. There was no evidence of regurgitation. Total length (TL) of specimens was measured to the nearest 0.1 cm and weight (W) to the nearest 0.1 g per individual. Sex of fish was determined by eye examination of gonadal tissue. Stomachs were dissected and weighed to the nearest 0.001 g. The stomach contents and each individual prey

Figure 1 Sampling location in the southern Adriatic Sea (Croatia)

were also weighed. When possible, prey was determined to the lowest possible taxon depending on condition.

The analysis of changes in feeding habits was expressed as the vacuity index (%*V*) (%*V* = ratio of the number of empty stomachs x 100 and a total number of stomachs) and the fullness index (% *Jr*) (% *Jr* = (*Wp*/*W*) x100 where *Wp* is the mass of prey items calculated as the difference between the mass of an intact stomach and an empty stomach and *W* is total body mass) [15]. Student *t-test* was used to test the significance of the difference of vacuity index values between seasons [16]. Diet breadth was calculated oversize and season using the Shannon-Wiener diversity index: $H' = - \Sigma\, pi \times \ln pi$, where p*i* is the proportion of individuals belonging to a given species [17].

Three indices were used to describe diet composition: percentage frequency of occurrence (%*F* = ratio of stomachs that contained a given prey and the number of total non-empty stomachs x 100), percentage numerical abundance (%*N* = ratio of prey in a given taxonomic group and to the total number of prey in all groups x 100), and percentage gravimetric composition (%*W* = ratio of total weight of a particular taxonomic group and the total weight of prey in all groups found x 100) [15,18,19].

For more results about diet index of relative importance (*IRI* = (%*N* + %*W*) + %*F*), the main food index (*MFI* = [(%*N* + %*F*)/2] x *W*) and the coefficient of nutritiveness (*Q* = %*N* x %*W*) were calculated [19,20,21] for the whole sample, for each season separately and by sex.

3. RESULTS

Total body length of 360 individuals ranged from 9.7 to 32.1 cm (18.89 ± 3.34 cm) and weight from 11.7 to 618.7 g (112.79 ± 63.17 g). The sample was composed of 213 females (59.17%) and 147 males (40.83%). The total body length of females ranged from 12.8 to 32.1 cm (19.5 ± 2.93 cm) and that of males from 9.7 to 27.5 cm (18 ± 3.7 cm) (Figure 2).

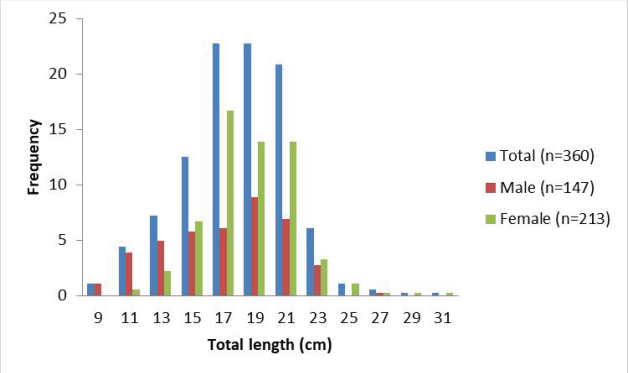

Figure 2 Length frequency distribution of *Uranoscopus scaber* population, Adriatic Sea

Of the 360 stomachs of stargazers 40 were completely empty so the vacuity index was relatively low (%*V* = 11.11%). Food that could be determined was found in 126 stomachs (35%), while completely digested gut content was found in 194 stomachs (53.89%). As a result the value of the fullness index of stargazer was relatively low (% *Jr* = 1.50%). Changes in the annual vacuity index were statistically significant (*t* = 4.90, *P* = 0.00). The highest number of empty stomachs and the highest index were found in winter (%*V* = 15.55%) and the lowest in spring (%*V* = 7.78%) (Table 1). For each season 90 stomachs were analysed. The diet of stargazer was also analysed according to different size groups. All individuals were divided into four total length groups: I <15 cm (n = 46), II = 15-20 cm (n = 170), III = 20-25 cm (n = 136) and VI >25 cm (n = 8). The highest vacuity index was recorded for size group II (% *V* = 5.83) and the lowest for group VI (Table 1). Shannon-Wiener diversity index (*H´*) values were highest in spring (3.65) and lowest in summer (1.88) while according to different size groups index was highest in group III (3.64) and lowest in group I (1.04) (Table 1).

Table 1 Values of Vacuity index (%*V*) and Shannon-Wiener diversity index (*H´*) of stargazer *Uranoscopus scaber* in the southern Adriatic Sea by seasons and total length groups

Seasons	%*V*	*H´*	TL group (cm)	%*V*	*H´*
Winter	15.55	2.10	<15 (n=46)	3.61	1.04
Spring	7.78	3.65	15-20 (n=170)	5.83	3.32
Summer	10	1.88	20-25 (n=136)	1.67	3.64
Autumn	11.11	2.65	>25 (n=8)	0	1.51

The diet of stargazers in the Adriatic Sea consisted of three main taxonomic groups: teleost fish, crustaceans and cephalopods (Table 2). By abundance and weight, the most important food was teleost fish (%*N* = 82.27; %*W* = 63.42), while cephalopods (%*N* = 14.58; %*W* = 17.42) and crustaceans (%*N* = 10.42; %*W* = 14.13) were additional food. The different groups of prey indicate a relatively diverse diet of the stargazer in the southern Adriatic

Teleost fish were the important and main food of stargazer in the southern Adriatic (*IRI* = 167.1; *MFI* = 508.02; *Q* = 805.17), while crustaceans (*MFI* = 86.35; *Q* = 141.56) and cephalopods (*MFI* = 74.88; *Q* = 120.92) represent additional food. The principal pray were hake *Merluccius merluccius* (*MFI* = 187.34; *Q* = 295.8) and argentine *Argentina sphyraena* (*MFI* = 182.81; *Q* = 291.44). All other fish species were occasional prey. Deepwater pink shrimp *Parapenaeus longirostris* (*MFI* = 38.66; *Q* = 65.65) and squid *Loligo vulgaris* (*MFI* = 63.22; *Q* = 102.51) were the most abundance alternative prey. Seasonal variation in diet was also analysed. Teleost were the dominant prey category in all seasons with the highest values recorded in winter (*IRI* = 187.29) (Table 3). *A. sphyraena* was the dominant food in summer, while *M. merluccius* was the dominant food in autumn, winter, and spring. Compared to the rest of the year during spring season abundance of cephalopods in diet decreased (*IRI* = 6.45), while for crustaceans increased (*IRI* = 66.41).

Variation in diet composition was analysed in relation to the total body length. Evident is that the teleost fish dominated in diet in first three size groups. *A. sphyraena* was the main food for size group I (*IRI* = 66.24) and II (*IRI* = 38.32) while *M. merluccius* was for the size group III (*IRI* = 34.43) (Table 4). Both species were recorded in the stomachs of stargazer whose total body length is less than 25 cm. In size group IV dominant prey was *P. longirostris* (*IRI* = 62.21). *M. merluccius* was also recorded but *A. sphyraena* was not.

Table 2 Diet composition of stargazer *Uranoscopus scaber* in the southern Adriatic Sea (*%F* = frequency of occurrence, *%N* = numerical abundance, *%W* = gravimetric composition, *IRI* = index of relative importance, *MFI* = main food index, *Q* = coefficient of nutritiveness)

	%F	*%N*	*%W*	*IRI*	*MFI*	*Q*
Cephalopoda						
Loligo vulgaris	1.94	8.33	12.30	22.58	63.22	102.51
Sepiola sp.	0.28	1.04	0.35	1.67	0.23	0.37
Lolliguncula sp.	0.28	1.04	0.59	1.91	0.39	0.61
Cephalopoda indeterminata	1.11	4.17	4.18	9.46	11.04	17.43
Crustacea						
Parapenaeus longirostris	1.67	9.37	7	18.04	38.66	65.65
Solenocera membranacea	3.05	12.5	2.75	18.31	21.42	34.43
Alpheus sp.	0.28	1.04	0.07	1.39	0.05	0.08
Squilla sp.	0.55	2.08	0.42	3.06	0.55	0.87
Crustacea indeterminata	2.78	10.42	3.89	17.08	25.67	40.53
Pisces						
Engraulis encrasicolus	0.28	1.04	0.04	1.36	0.03	0.05
Argentina sphyraena	5.83	22.92	12.72	41.47	182.81	291.43
Gnathophis mystax	0.28	1.04	1.37	2.69	0.91	1.43
Merluccius merluccius	3.89	14.58	20.28	38.75	187.34	295.8
Merlangius merlangus	0.83	3.12	1.89	5.85	3.75	5.92
Micromesistius poutassou	0.28	1.04	0.95	2.27	0.63	0.99
Mullus barbatus	0.55	2.08	4.29	6.92	5.65	8.93
Centracanthus cirrus	0.28	1.04	1.26	2.58	0.83	1.31
Gobius sp.	0.83	4.17	1	6	2.52	4.2
Callionymus maculatus	1.11	4.17	3.61	8.89	9.53	15.05
Synchiropus phaeton	0.28	1.04	0.22	1.54	0.14	0.23
Blenius ocellaris	0.28	1.04	0.50	1.82	0.33	0.52
Aspitrigla cuculus	0.28	1.04	0.03	1.35	0.02	0.03
Lepidotrigla cavillone	0.28	1.04	0.82	2.14	0.54	0.86
Lepidorhombus whiffiagonis	1.11	4.17	4.96	10.24	13.10	20.69
Symphurus nigrescens	0.28	1.04	0.61	1.93	0.40	0.64
Teleostei indeterminata	4.72	17.70	8.87	31.30	99.49	157.09

Table 3 Seasonal variation in diet composition of stargazer *Uranoscopus scaber* in the southern Adriatic Sea (*IRI* = index of relative importance, *MFI* = main food index, *Q* = coefficient of nutritiveness)

Prey	Autumn			Winter			Spring			Summer		
	IRI	*MFI*	*Q*	*IRI*	*MFI*	*Q*	*IRI*	*MFI*	*Q*	*IRI*	*MFI*	*Q*
Cephalopoda	34.88	83.57	154.69	49.30	199.56	384.19	6.45	5.2	9.52	51.8	326.85	619.3
Loligo vulgaris	25.48	79.95	147.98	-	-	-	6.45	5.20	9.52	52.07	326.85	619.30
Sepiola sp.	4.95	2.29	4.23	-	-	-	-	-	-	-	-	-
Lolliguncula sp.	-	-	-	9.96	9.41	18.12	-	-	-	-	-	-
Cephalopoda indeterminate	4.44	1.33	116.63	39.34	190.15	366.07	-	-	-	-	-	-
Crustacea	51.51	77.72	143.85	54.59	127.76	245.96	66.41	168.9	321.91	33.99	47.16	89.36
Parapenaeus longirostris	15.84	31.24	57.83	17.76	21.66	41.7	32.88	135.12	247.54	-	-	-
Solenocera membranacea	22.3	34.22	63.34	-	-	-	18.20	32.96	60.2	17.95	16.79	31.8
Alpheus sp.	-	-	-	-	-	-	3.61	0.51	0.93	-	-	-
Squilla sp.	-	-	-	-	-	-	8.36	5.76	10.55	-	-	-
Crustacea indeterminate	13.37	12.25	22.68	36.83	106.1	204.26	4.20	1.47	2.69	16.31	30.37	57.55
Pisces	143.57	607.3	1118.08	187.29	785.55	1512.29	143.06	300.26	551.82	146.78	662.44	1255.16
Engraulis encrasicolus	-	-	-	-	-	-	3.50	0.31	0.57	-	-	-
Argentina sphyraena	33.30	133.31	240.56	20.42	41.43	79.76	26.67	67.74	124.10	61.63	456.01	864.02
Gnathophis mystax	-	-	-	-	-	-	9.04	9.48	17.36	-	-	-
Merluccius merluccius	55.97	375.72	695.42	43.47	236.07	454.47	32.34	126.42	231.61	9.44	11	20.85
Merlangius merlangus	-	-	-	-	-	-	17.82	39.21	71.83	-	-	-
Micromesistius poutassou	-	-	-	-	-	-	-	-		9.22	10.42	19.74
Mullus barbatus	-	-	-	8.66	4.59	8.84	19.98	27.57	50.51	-	-	-
Centracanthus cirrus	-	-	-	12.84	20.12	38.73	-	-	-	-	-	-
Gobius sp.	8.23	2.9	5.37	18.21	25.03	48.19	-	-	-	-	-	-
Callionymus maculatus	-	-	-	-	-	-	3.40	0.15	0.28	30.76	118.22	223.99
Synchiropus phaeton	-	-	-	8.36	3.5	6.74	-	-	-	-	-	-
Blenius ocellaris	-	-	-	-	-	-	5.39	3.44	6.3	-	-	-
Aspitrigla cuculus	-	-	-	-	-	-	3.43	0.2	0.37	-	-	-
Lepidotrigla cavillone	-	-	-	10.95	13.09	25.2	-	-	-	-	-	-
Lepidorhombus whiffiagonis	15.09	28.48	52.71	-	-	-	10.86	12.50	22.9	9.27	10.54	19.96
Symphurus nigrescens	5.86	3.98	7.37	-	-	-	-	-	-	-	-	-
Teleostei indeterminate	25.39	63.01	116.63	64.36	441.7	850.34	10.9	14.18	25.98	26.44	56.26	106.60

Table 4 Variation in diet composition in relation to the total body length of stargazer *Uranoscopus scaber* in the southern Adriatic Sea (*IRI* = index of relative importance)

Total length	< 15 cm	15-20 cm	20-25 cm	> 25 cm
Prey	IRI	IRI	IRI	IRI
Cephalopoda				
Loligo vulgaris	-	24.58	7	-
Sepiola sp.	-	2.94	-	-
Lolliguncula sp.	-	-	3.38	-
Crustacea				
Parapenaeus longirostris	-	5.86	10.62	62.21
Solenocera membranacea	-	10.93	19.23	24.55
Alpheus sp.	-	-	3.03	-
Squilla sp.	-	2.9	3.06	-
Pisces				
Engraulis encrasicolus	-	2.69	-	-
Argentina sphyraena	66.24	38.32	19.9	-
Gnathophis mystax	-	3.76	-	-
Merluccius merluccius	27.88	9.77	34.43	20.59
Merlangius merlangus	13.86	3.9	3.13	-
Micromesistius poutassou	-	-	3.63	-
Mullus barbatus	-	8.75	-	-
Centracanthus cirrus	-	-	-	16.83
Gobius sp.	-	11.44	-	-
Callionymus maculatus	12.97	3.83	7.41	-
Synchiropus phaeton	-	-	3.13	-
Blenius ocellaris	-	3.06	-	-
Aspitrigla cuculus	-	-	-	11.52
Lepidotrigla cavillone	-	-	3.54	-
Lepidorhombus whiffiagonis	-	7.25	7.7	-
Symphurus nigrescens	-	-	3.40	-

4. DISCUSSION

The stargazer is carnivorous fish and although three groups of prey: teleost fish, crustaceans and cephalopods were recorded, a significant dominance of teleost fish in the stomachs was confirmed. This can be explained by the state of prey populations on the seabed in the sampling area, which is confirmed by commercial fishing catches and indirectly by examining the stomachs of the researched species. The dominant species in the stomachs were *A. sphyraena* (*IRI* = 41.47) and *M. merluccius* (*IRI* = 38.75). Booth species in the Adriatic Sea generally lives at depths between 100 and 200 m and during recruitment the highest density of booth species are found at depths of 100 to 150 m where the stargazer in this research was sampled. However, Sanz [12] in his investigation on diet reported *M. merluccius* as prey for stargazer in the Balearic Sea, but not as a primary food. Principal pray were fish, primarily *Callioymus maculatus* and *Trachurus trachurus*. *C. maculatus* was also recorded in this study, but with a lower percentage of occurrence. In the Egyptian Mediterranean waters, the dominant prey recorded in the stomachs of stargazer was also fish, *Spicara smaris* [13], which was not the case in our research. This can be explained also by the depth during sampling because *S. smaris* in the Adriatic Sea usually lives at depths of 10 to 40 m [2]. Species recorded in the diet of the stargazer in the Black Sea [7] *Merlangius merlangus* and *Gobius* sp. were also recorded in this study, but with a lower percentage of occurrence.

Loligo vulgaris the most numerous and important cephalopod species in this study (*IRI* = 22.58) was also the only cephalopod species recorded in the stomachs of stargazers from the Balearic Sea [12]. The most abundant and important crustacean species was *Solenocera membranacea* (*IRI* = 18.31) and in the Adriatic Sea, the highest abundance of this species was found at depths between 50 and 100 m [22]. In the stomachs of stargazers from the Balearic Sea this species was the second most abundant crustacean [12]. The abundance of species on which the stargazer feeds depends primarily on locality. The availability of each species also depends on its seasonal occurrence. According to the highest *IRI* values, *A. sphyraena* was the primary food for stargazer in the Adriatic Sea in summer while *M. merluccius* was primary food throughout the rest of the year. *M. merluccius* spawns almost all year round with peaks in winter and summer [23,24] suggesting an abundant food supply for stargazers. In relation to the total body length teleost fish dominated in diet in size group I, II and III. In group IV dominant prey was *P. longirostris* but this group had the smallest number of samples (n = 8), and this difference in important prey could be result of limited samples. The important prey in group I and II was *A. sphyraena* while in group III was *M. merluccius*.

The values of vacuity index for the whole sample was relatively low (%V = 11.11%) suggesting that the stargazer is an active feeder. The abundance of available prey in the environment may have a major influence on the lower values of empty stomachs of demersal fishes from Adriatic Sea [25]. A notable higher percentage of empty stomachs for the whole sample have been reported for the coast of Egypt (34.8%) [13] and the Black Sea (35.4%) [7].

In this research the changes in vacuity index were statistically significant. The highest vacuity index was in winter and the

lowest in spring which coincides with the spawning season from March to September with a peak in May [5]. Feeding intensity was increased before spawning. Rizkalla and Philips [13] also recorded the highest value of vacuity index in winter and the lowest in spring. Related to size the highest vacuity index for the stargazer from Adriatic Sea was recorded in group II and the lowest in group VI (no empty stomachs were recorded).

The most diverse diet was recorded in the spring season (H´=3.65) and feeding on high number of prey items was recorded for the size group III (H´= 3.64). Stargazer is predator that feeds by bending the body trunk when lunges out of the substrate which causes the prey to be sucked in [10].

Feeding habits in all researched areas primarily depends on ecological conditions that will at certain moments enable the abundance of certain species of prey. The species that we found in the stomachs of stargazer tell us about the situation with the populations of organisms on the seabed of the researched area. As a predator who passively waits on the seabed and whose nutrition depends on the movement of its prey the qualitative and quantitative development of its population depends on the richness of the populations in the researched area. Seasonal fluctuations of the population of prey as well as the presence throughout the year determine the dominant pray which in our research was teleost fish, mostly these two species, *M. merluccius* and *A. sphyraena*. Both of them spatially overlap with stargazer. The spawning season and the available amount of fry of these two species certainly favour the maintenance of the stargazer population in this water area, which is proven by the contents of the stomachs throughout the researched period. Such a conclusion certainly depends on the level of human activity in the researched area because increased fishing effort can significantly disrupt the relationships between the populations of organisms mentioned in the research. Certainly, these results show the current situation which may change in the future where the causes may be different but human activity, as one of them, is certainly not negligible.

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