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Seasonal Diet and Feeding Strategy of Horse Mackerel *Trachurus mediterraneus* (Steindachner, 1868) (Perciformes: Carangidae) in the South-Western Black Sea

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Abstract: This study examined the diet composition of the Mediterranean horse mackerel *Trachurus mediterraneus* (Steindachner, 1868) along the Bulgarian Black Sea coast. In 2013-2015, the preferred prey groups were Polychaeta, Crustacea and Pisces. The horse mackerel had feeding strategies with different degrees of specialisation among seasons. In the spring, *T. mediterraneus* was mostly benthivorous, in the autumn it tended to prefer fish prey, whereas in the summer it fed on a mixed diet of zooplankton, benthos and fish. These dissimilarities between seasons were probably due to differences in prey availability and accessibility, depth allocation of the predator and varying nutritional needs of the horse mackerel during different seasons.

Key words: Black Sea, diet, feeding strategy, horse mackerel

Introduction

Food resources and forage time are critical factors for the survival of animals (Carvalho & Soares 2006). Detailed information of fish diet is very important for a better understanding of the functional role of fishes within the ecosystems (Blaber 1997). The study of diet and trophic ecology of commercially important fish species is greatly beneficial for the conservation and recovery of depleted fish stocks (Blaber 1997), as well as for studying marine food webs and ecosystems (Christensen & Pauly 1992). The investigation of the feeding biology of fish based on the analysis of stomach content has become a standard practice in fishery science and is required in order to provide relevant scientific advice for fisheries management (Hyslop 1980, Zacharia 2004).

The Mediterranean horse mackerel *Trachurus mediterraneus (*Steindachner, 1868) is a marine pelagic migratory fish distributed across the Mediterranean, Black, Azov and Marmara Seas (Stoyanov et al.1963, Karapetkova & Jivkov 2006, www.fishbase.org). Its wintering areas are situated along the coasts of the Crimea, Caucasus, Anatolia and parts of the Marmara Sea (Ivanov & Beverton 1985). The horse mackerel is a species of great commercial importance for the Black Sea fishery (Shlyakhov & Daskalov 2008). After the 1950s, the catches of *T. mediterraneus* gradually increased, reaching a maximum level of about 140,000 tons in the late 1980s (Prodanov et al. 1997). The next period (1990-2010) was marked by considerably lower catches (STEFC 2017). In recent years, the reported Black Sea catches fluctuate between 10,229 and 25,367 tons (STEFC 2017). The Bulgarian catches of horse mackerel are taken mainly during the spring and the autumn, when the species migrate along the coasts in a northern and a southern direction, respectively. In spring, *T. mediterraneus* appears in the Bulgarian coastal waters usually in mid-May. By mid-June, the majority of the schools migrate toward the north-western part of the Black Sea

for feeding and spawning. The autumn migration spans from mid-September to mid-December when the horse mackerel moves southwards, towards its wintering grounds (Stoyanov et al. 1963). In some years, part of the population of *T. mediterraneus* remains in the Bulgarian coastal waters during the summer months, (up to 30 m depth) for feeding and spawning (Zlatev 1986). The horse mackerel occupies a position in the middle of the trophic pyramid (trophic level 3.5, Ecopath with Ecosim, Daskalov et al. 2012, Daskalov 2013) that makes it important for the functioning of the ecosystem. The pelagic fish species in the mid-trophic levels exert both top-down control on their prey species and bottom-up control on their predators (the so-called wasp-waist control, Rice 1995). The horse mackerel diet has been studied in different parts of the Mediterranean region (Lipskaja 1966, Bini 1968, Tortonese 1975, Ben-Salem 1988, Kyrtatos 1998, Santic et al. 2003, 2004, Sever & Bayhan 1999, Bayhan et al. 2013); however, its feeding biology has not been sufficiently explored in the Bulgarian Black Sea waters (Stoyanov et al.1963, Stoikov 1978, Zlatev 1986, Yankova et al. 2007).

This study analyses the seasonal diet composition and feeding strategy (dietary specialisation) of *T. mediterraneus* along the Bulgarian Black Sea coast during 2013-2015. The data on the diet and feeding of horse mackerel will be used for the development of trophic models (Ecopath with Ecosim, Christensen & Pauly 1992).

Materials and Methods

Our study covers the southern Bulgarian Black Sea fishing area, including Bourgas Bay (Fig. 1). Random fish samples were collected weekly from commercial trawl catches and the artisanal fisheries during: May-June 2013 (273 specimens); September-November 2013 (159 specimens); May-July 2014 (279 specimens); September-November 2014 (341 specimens); June 2015 (155 specimens) and August 2015 (86 specimens).

The samples were stored in 10% formaldehyde solution immediately after their capture and transported to the laboratory for further analysis. Total body length (TL, cm), weight (g) and stomach content weight (g) were measured to the nearest 0.01 unit (cm and g, respectively) of each specimen. The food items found in the stomachs were identified to the lowest possible taxonomic level, counted and weighed. The biomass of the prey species was expressed as weight in g (to the nearest 0.001 g). The importance of the various food items in the diet of *T. mediterraneus* was quantified using: (1) Frequency of Occurrence Index, $\%F=100n_i/n$, where n_i is the number of fish containing prey *i* and *n* is the number of fish whose stomachs contain food; (2) Numerical Abundance Index, %Cn – the percentage of the number of each food item divided by the total number of food items in all stomachs; (3) Gravimetric Composition Index, %Cw - the percentage of the wet weight of each prey item divided by the total weight of all stomach contents; (4) Index of Relative Importance, IRI = (%Cn + %Cw) * %F (Pinkas et al. 1971), modified on a percentage basis, %IRI = (IRI / ΣIRI)*100 (Cortese 1997). The %IRI evaluates the dietary importance (Hyslop 1980) and the relationship of the various food items found in the stomach (Zacharia & Abdurahiman 2004).

The feeding strategy (generalisation to specialisation) of *T. mediterraneus* was assessed using the modified Costello (1990) graphical method (Amundsen et al.1996), where the prey specific abundance %Pi (the percentage of a prey taxon out of all prey items in only those predators in whose stomachs it occurs) is plotted against the %F on a two-dimensional graph (Fig. 4a). The distribution of the points along the diagonals and the axes reflects the importance of the feeding strategy of the predator. Prey types positioned in the upper part of the graph indicate specialisation, whereas those positioned in the lower part have been eaten occasionally (generalisation). In a population with a high between-phenotype component (BPC, upper left corner), different individuals specialise on different resource types, whereas in populations with a high within-phenotype component (WPC, lower right corner), most of the individuals utilise various resource types simultaneously (Amundsen et al. 1996).

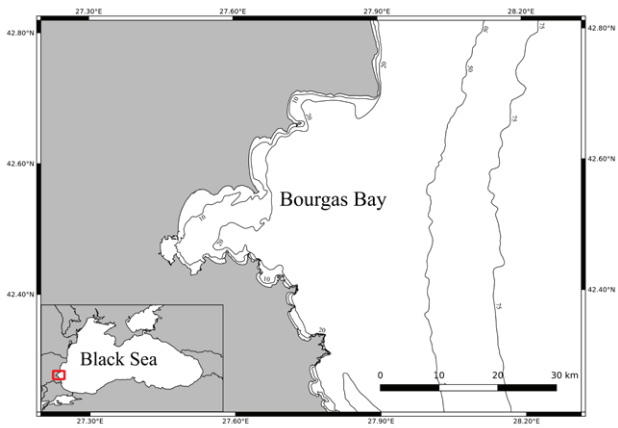

Fig. 1. Sampling area for *Trachurus mediterraneus* in the South-Western Bulgarian Black Sea (Bourgas Bay).

Results

Diet composition

Of the total 1293 stomachs examined, 652 were empty (50 %). The results of the diet composition analyses are summarised for spring (May-June), summer (July-August) and autumn (September-November; Figs. 3 and 4; Supplements 1, 2 and 3).

Spring: In May-June, 47% of the stomachs were empty. The diet of the horse mackerel consisted mostly of benthic invertebrates (Fig. 2). A total of 57 prey taxa belonging to seven major taxonomic groups, Polychaeta, Crustacea, Hydrozoa, Cephalochordata, Mollusca, Insecta and Pisces, were identified in the stomachs (Supplement 1). Polychaeta had the highest numeric and weight contributions (%Cn = 58; %Cw = 66), followed by Crustacea (%Cn = 38; %Cw = 20) and Pisces (%Cn = 4; %Cw = 13). The most important prey species were the metamorphosed reproductive heteronereid forms of the polychaetes *Neanthes fucata* (Savigny, 1822) (%IRI = 48) and *Platynereis dumerilii* (Audouin & Milne Edwards, 1833) (%IRI = 18). The larval stage of the decapod crustacean *Upogebia* spp. (%IRI = 3), as well as the isopod *Idotea balthica* (Pallas, 1772) (%IRI = 4) and the amphipod *Gammarus insensibilis* Stock, 1966 (%IRI = 3) were of a minor importance in the diet. The polychaetes were found in the stomachs of all size classes of fishes and had the highest biomass contribution to their diet (Fig. 3a). Crustaceans were also present in almost all size classes, with different biomass shares. The fish prey items had a relatively high biomass proportion in the small and medium size classes (range 10.5-14 cm TL) and were completely absent in the larger horse mackerel individuals. The biomass share of Polychaeta tended to increase with horse mackerel body length, while such trends were not found for the other prey groups.

Summer: In July and August, 39 % empty stomachs were registered in the studied fish. The diet of the horse mackerel included benthic invertebrates, fish and zooplankton (Fig. 2). A total of 33 prey taxa belonging to six major taxonomic groups, Crustacea, Polychaeta, Rotatoria, Mollusca, Insecta and Pisces, were found in the stomach content (Supplement 2). The dominant prey group was Crustacea (%Cn = 59; %Cw = 33), followed by Polychaeta (%Cn = 28; %Cw = 30) and Pisces (%Cn = 8; %Cw = 36). The most important food items were the larvae of Decapoda (%IRI = 39), the heteronereid form of *P. dumerilii* (%IRI = 18) and *Engraulis encrasicolus* (L., 1758) (%IRI = 16). *Neanthes fucata* (%IRI = 7), *I. balthica* (%IRI = 3) and the Lamellibranchia larvae (%IRI = 4) were less important in the diet. The share of the zooplankton components in the prey biomass increased in the large size classes, while the shares of the fish and the benthic invertebrates decreased (Fig. 3b).

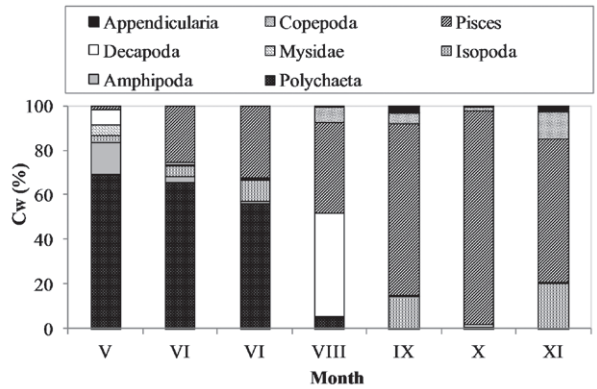

Fig. 2. Average gravimetric composition index (%Cw) of the main prey groups found in the horse mackerel stomachs by months, Bulgarian Black Sea landings (2013-2015).

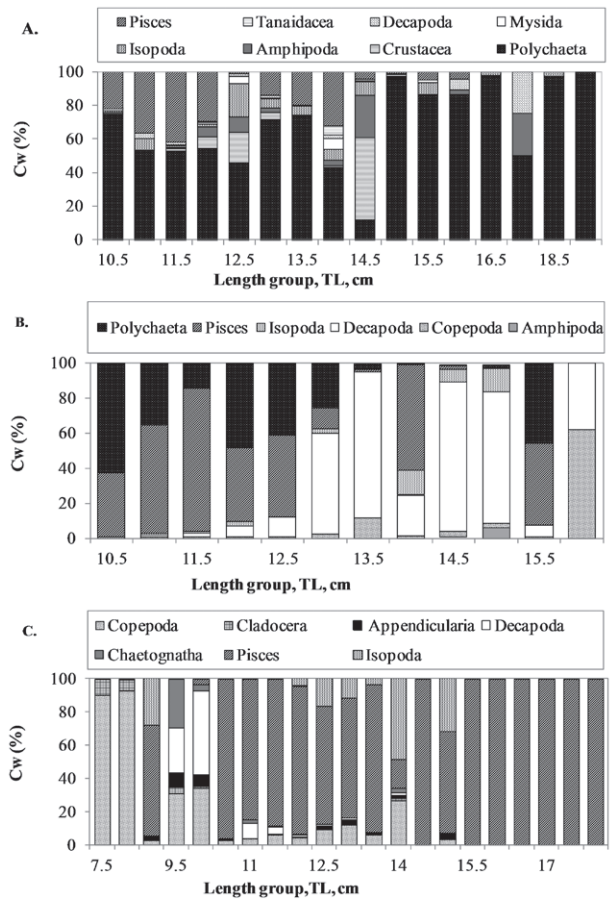

Fig. 3. Diet composition (%) expressed as average biomass of prey of *Trachurus mediterraneus* according to size class in 2013-2015 in the Bulgarian Black Sea: (A) spring (May-June), (B) summer (July-August), (C) and autumn (September-November).

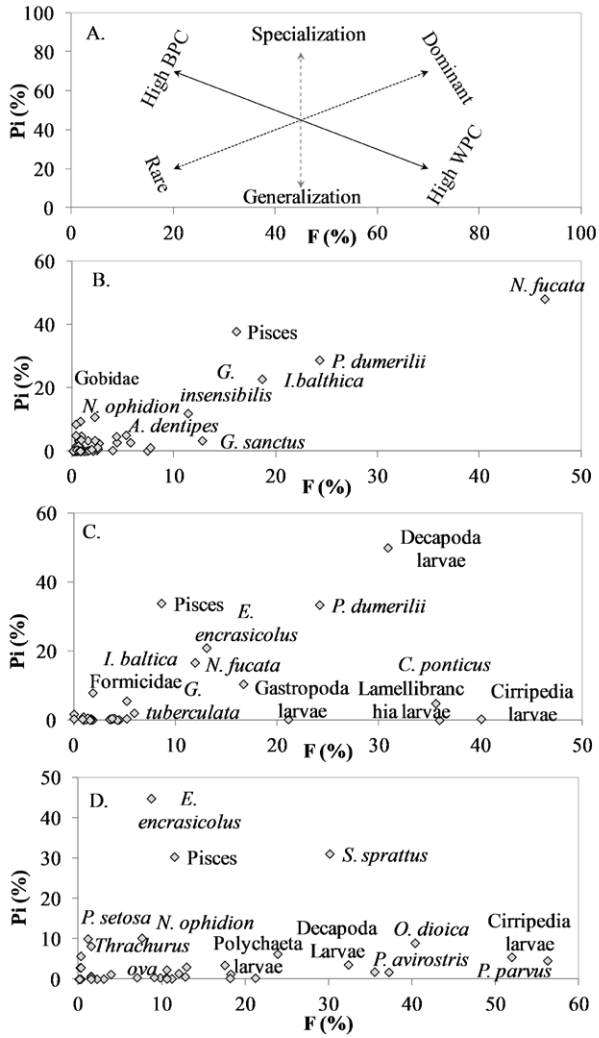

Fig. 4. Modified Costello (1990) diagram (Amudsen et al., 1996) representing: (A) Feeding strategy (black line), niche width contribution (grey dashed line) and prey importance (black dash line); (B) Feeding strategy of *Trachurus mediterraneus* in spring (May-June); (C) Feeding strategy of *T. mediterraneus* in summer (July-August); (D) Feeding strategy of *T. mediterraneus* in autumn (September-November), Bulgarian Black Sea, 2013-2015.

Autumn: We found that 59 % of the stomachs were empty. There was a prevalence of pelagic components in the diet of the horse mackerel (Fig.2). A total of 27 prey taxa belonging to nine major taxonomic groups, Crustacea, Appendicularia, Ctenophora, Mollusca, Chaetognatha, Foraminifera, Scyphozoa, Polychaeta and Pisces, were identified in the stomach content (Supplement 3). The predominant prey groups were the zooplanktonic crustaceans (% Cn = 33; %Cw = 20) and Pisces (%Cn = 24; %Cw = 78). The group Appendicularia was also relatively abundant but had a low gravimetric contribution. The highest IRI values were calculated for *Oikopleura dioica* Fol, 1872 (%IRI = 30), *Sprattus sprattus* (L., 1758) (%IRI = 24), *Paracalanus parvus* (Claus, 1863) (%IRI = 11) and *E. encrasicolus* (%IRI =9). The calanoid copepod *Centropages ponticus* Karavaev, 1895 (%IRI = 4), the larval stages of Cirripedia (%IRI = 4) and the pelagic chaetognath *Parasagitta setosa* (J. Müller, 1847) (%IRI = 3) had only a minor importance in the horse mackerel's diet. Only zooplankton components were found in the stomach contents of the small size classes (7.5-8 and 9.5-10 cm TL) of *T. mediterraneus*, whereas only fishes where found in the stomachs of the large size classes (range 14.5-18 cm, TL; Fig. 3c).

Feeding strategy

In 2013-2015, the horse mackerel demonstrated a mixed feeding strategy, with varying degrees of specialisation and generalisation on different prey types. In May-June, the majority of the prey points were located in the lower left part of the diagram (Fig. 4b), which indicates a generalised feeding of the horse mackerel on those items. These food components were eaten more rarely or occasionally and were classified as unimportant in the diet. *Neanthes fucata* was the dominant prey during this time of the year and its location on the graph (upper right part) indicated that it was a preferred prey. Pisces (non-identified), *P. dumerillii* and *I. balthica* were consumed up to 15-25% that suggested certain preference for these food items. In spring, neither high within- (WPC) nor between-phenotype (BPC) contributions to the niche width were observed, and the niche width was generally quite narrow.

In summer, the WPC was higher (the points were positioned further to the lower right of the graph) and the trophic niche was relatively wide (indicated by a high %F and a low %Pi, Fig. 4c). In summer, 25-30% of the population of horse mackerel fed upon the dominant prey items - the larval stages of Decapoda and *P. dumerilii*. The location of Pisces (n.i.) showed some degree of individual specialisation (9%) on this prey group. The rest of the food items were occasional victims and were either consumed by a considerable part of the predator's population (but only in small quantities) or constituted a small portion of the diet of a few horse mackerel specimens (generalised feeding strategy). In autumn, the high positions of *E. encrasicolus,* Pisces (n.i.) and *S. sprattus* on the graph indicated an individual positive selection of fish as a food (Fig. 4d). The majority of the prey items were situated along the x-axis and in the lower right part of the diagram, which indicated a high WPC to the niche width: most individuals had a relatively large trophic niche and generalised diets.

Discussion

Several authors (Fortunatova, 1948; Briskina, 1954; Stoianov et al. 1963) have reported that the diet of the horse mackerel in the Black Sea is dominated by benthic crustaceans (Mysidacea, Caridea, Amphipoda), fishes (gobies, anchovy, big scale sand smelt), polychaetes (mostly heteronereid forms) and zooplankton (Decapoda larvae, Copepoda**,**). In the Bulgarian Black Sea, Stoikov (1978) and Zlatev (1986) found that in spring and summer, the horse mackerel mainly feeds on zooplanktonic crustaceans (Decapoda larvae) and polychaete worms, while in autumn – on fish (anchovy and sprat). Yankova et al. (2007) described a similar seasonal diet composed of zooplankton (Copepoda, Cladocera), teleosts (sprat and anchovy) and polychaetes. Despite the similarities between these studies, the authors reported different biomass contributions of the prey groups comprising the diet. These variations might be explained by the different sampling regions, accessibility of the prey, depth distribution of the schools (Fortunatova 1948, Briskina 1954) and the alimentary needs of the horse mackerel. Our results showed that the diet composition of the horse mackerel was more diverse in the spring than in summer and autumn. The reproductive season of the horse mackerel in the Black Sea spans between May and August (Stoianov et al. 1963, Karapetkova & Jivkov 2006), with a maximum in July (Stoikov 1978). The higher diversity of preys in the diet in May-June may be due to the increased food demand necessary for reproduction (Gkenas et al. 2011). The benthic fauna in the stomachs confirmed the fact that during its spring migration, the horse mackerel being tolerant to warm water keeps close to the shore (up to 8-10 m of depth) and where it can easily find accessible food (Stoikov 1978). Since the horse mackerel is not a strict benthivore, it probably consumes also plankton crustaceans during their diel vertical migrations in the water column. The spring and summer months are also the reproductive season of the polychaetes, when the latter leave the bottom in large numbers to swim and broadcast their gametes in the water (JGU 2008). The intake of the heteronereid forms of polychaetes is important since their rich caloric contents are essential for gonad development in the horse mackerel (Stoikov 1978, Gkenas et al. 2011). This combination of easy accessibility and high nutritional value of the worms is what makes them the preferred food items of the horse mackerel in May-July. This could also explain the higher biomass contribution of Polychaeta in the stomachs of the large-sized specimens - fish in prespawning or spawning condition. After the breeding season, the polychaetes die or burrow again in the sediment and became, therefore, inaccessible as prey of the horse mackerel (JGU 2008). In summer, with the warming of sea water, the horse mackerel moves to the deeper parts of the basin, while in autumn, its population is distributed in the area of about 10 miles from the shore (up to 55 m depth, Zlatev 1986). Also, in the summer and autumn months, the zooplankton and fish communities have their peak production (Valiela, 1995). This could explain the significant contribution of zooplankton (in August) and fish (in September-November) components to the diet of the horse mackerel. The zooplankton is numerically important in the diet but usually has a low contribution in weight. In autumn, the horse mackerel accumulates high amounts of body fats (Stoikov 1978, Zlatev 1986), to which contributes the high consumption of fish preys in this season. The fattening is necessary for subsisting during the winter months - a period characterised by low temperatures, reduced abundance of prey, minimum rates of predation and low physiological activity (Ambroz 1954, Briskina 1954, Santic et al. 2003, 2004, Garrido & Murta 2011).

We established that the food habits of the horse mackerel were changing relative to individual size. The majority of the identified prey groups were found in the smallest and medium-sized classes. As the fish grew, the diversity of the consumed taxa decreased (Fig. 3a, b, c) and mainly polychaetes and fish (the largest preys detected) were found in large-sized specimens (16.5-19 cm, TL). An increased importance of fish prey in the diet in larger horse mackerel has been reported by Zlatev (1986), Cabral & Murta (2002), Santic et al. (2003) and Yankova et al. (2007). According to the optimal foraging theory, with the increase in predator size, the mean prey size is due to increase (Schoener 1979) and the larger fish can only sustain growth by feeding on large prey (Valiela 1995). This is the metabolic basis behind the size-dependent selection in the feeding behaviour of the majority of the animals (Valiela 1995). However, the smaller-sized preys, such as zooplankton, could also be important due to their high encounter rates, greater abundance and a high probability of capture (Scharf et al. 2000). Compared with the summer and autumn months, the observed narrow niche width in the spring indicated that the benthic zone provided a rich food supply for the horse mackerel. In the pelagic zone, the encounter of larger prey was rare, and thus the predator consumed its most important prey items in small quantities. Although a significant number of prey taxa were found in the horse mackerel stomachs, the majority of them were classified as rare food (generalised diet). The feeding strategy indicated a

relative specialisation on only few prey items such as polychaetes, larvae of Decapoda and fish. The mixed feeding strategy of the horse mackerel means that it forages efficiently on the most readily available and abundant trophic resources. The diet of the species reflects the seasonal composition of the prey community in the ecosystem (Stevens et al. 2007). Fish usually eat the most suitable prey available within the size range they can ingest (Link et al. 2005, Stevens et al. 2007). In our study, the higher abundance and availability of prey, such as polychaetes (in spring), decapods (in summer) and fish (in autumn), most probably caused the comparatively specialised foraging of these prey groups (Stevens et al. 2007). In nature, a given predator may easily and rapidly change its trophic niche, therefore changing the whole configuration of the trophic web, to adapt to differences in prey abundance and availability (Garrido &Murta 2011). Such a switch of trophic niche by a predator may also change its trophic level (Garrido & Murta 2011). This alteration should be taken into account in the analysis of long-term trends and in food web modelling (Persson 1999). Hence, dietary data from different regions and periods should be implemented in the construction of a stock-representative diet matrix.

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Supplement 1. Average values of the Numerical Abundance Index (% Cn), Gravimetric Composition Index (% Cw) and Index of Relative Importance (%IRI) for prey items found in the stomachs of *Trachurus mediterraneus* in the Bulgarian Black Sea in May-June, 2013-2015.

Group	Food item	%Cn	%Cw	%IRI
Polychaeta				
	Polychaeta (not identified)	2.48	3.18	2.29
Polynoidae	Polynoinae (not identified)	5.28	1.82	6.29
	Harmothoe reticulata (Claparède, 1870)	0.18	0.03	0.02
	Harmothoe imbricata (Linnaeus, 1767)	0.31	0.15	0.17
Phyllodocidae	Phyllodocidae (not identified)	0.14	0.04	0.02
	Eumida sanguinea (Örsted, 1843)	0.03	<0.01	<0.01
	Eulalia sp.	0.24	0.02	0.03
	Phyllodoce mucosa Örsted, 1843	0.01	<0.01	<0.01
	Genetyllis tuberculata (Bobretzky, 1868)	0.33	0.49	0.10
	Nephtys cirrosa Ehlers, 1868	0.01	<0.01	<0.01
Syllidae	*Exogone naidina* Örsted, 1843	0.10	<0.01	<0.01
	Syllidae (not identified)	0.01	<0.01	<0.01
Glyceridae	*Glycera tridactyla* Schmarda, 1861	0.10	0.22	0.02
Nereididae	*Platynereis dumerilii* (Audouin & Milne Edwards, 1833) (heteronereid form)	10.97	19.17	17.94
	Nereididae (not identified)	1.42	1.65	0.67
	Neanthes fucata (Savigny, 1822) (heteronereid form)	31.36	37.26	48.36
	Alitta succinea (Leuckart, 1847)	0.12	1.92	0.28
Spionidae	Spionidae (not identified)	3.31	0.17	1.08
	Prionospio cirrifera Wirén, 1883	0.79	0.06	0.32
Dorvilleidae	*Protodorvillea kefersteini* (McIntosh, 1869)	0.04	<0.01	<0.01
	Schistomeringos rudolphi (Delle Chiaje, 1828)	0.01	<0.01	<0.01
Opheliidae	*Polyophthalmus pictus* (Dujardin, 1839)	0.68	0.03	0.20

Supplement 1. Continuation.

Group	Food item	%Cn	%Cw	%IRI
Terebellidae	*Polycirrus* sp.	0.01	<0.01	<0.01
Crustacea	Crustacea (not identified)	1.71	1.52	1.12
Amphipoda	*Hyale* sp.	0.53	0.16	0.18
	Hyale pontica Rathke, 1847	0.57	0.02	0.18
	Melita palmata (Montagu, 1804)	0.08	0.09	0.02
	Microprotopus maculatus Norman, 1867	1.66	0.21	0.44
	Microdeutopus gryllotalpa Costa, 1853	1.38	0.04	0.51
	Apherusa sp.	0.12	0.01	0.01
	Ampithoe sp.	0.03	0.01	<0.01
	Ampithoe helleri Karaman, 1975	0.13	0.01	0.01
	Monocorophium acherusicum (Costa, 1853)	0.04	<0.01	<0.01
	Caprella acanthifera Leach, 1814	0.02	<0.01	<0.01
	Phtisica marina Slabber, 1769	0.10	<0.01	<0.01
Gammaridae	Gammaridae (not identified)	3.46	0.83	1.36
	Ampelisca diadema (Costa, 1853)	0.16	0.18	0.03
	Stenothoe monoculoides (Montagu, 1815)	0.65	0.06	0.05
	Nototropis guttatus Costa, 1853	0.57	0.03	0.14
	Dexamine spinosa (Montagu, 1813)	0.57	0.46	0.12
	Gammarus insensibilis Stock, 1966	4.16	5.99	2.86
Isopoda	*Stenosoma capito* (Rathke, 1837)	0.57	0.04	0.04
	Dynamene bidentata (Adams, 1800)	0.20	0.01	0.02
	Idotea balthica (Pallas, 1772)	7.28	3.09	4.34
	Idotea ostroumovi Sowinsky, 1895	0.11	0.24	0.02
	Eurydice pontica (Czerniavsky, 1868)	0.03	0.01	<0.01
	Eurydice dollfusi Monod, 1930	0.09	0.04	0.02
	Eurydice spinigera Hansen, 1890	1.96	0.62	0.86
	Elaphognathia bacescoi (Kussakin, 1969)	0.04	<0.01	<0.01
	Isopoda (not identified)	0.11	0.01	0.02
Mysidae	*Gastrosaccus sanctus* (Van Beneden, 1861)	2.50	1.84	1.03
	Siriella jaltensis Czerniavsky, 1868	0.08	0.27	0.04
	Siriella clausi G.O. Sars, 1877	0.08	0.17	0.03
	Mesopodopsis slabberi (Van Beneden, 1861)	0.06	0.02	<0.01
	Mysidacea (not identified)	0.16	0.06	0.02
Maxillopoda	*Athanas nitescens* (Leach, 1813 [in Leach, 1813-1814])	1.06	0.26	0.71
Decapoda	*Alpheus dentipes* Guérin, 1832	1.85	1.35	0.66
	Processa edulis (Risso, 1816)	0.77	0.03	0.14
	Decapoda larvae	0.01	<0.01	<0.01
	Upogebia spp. larvae	3.63	0.21	3.14
Anomura	*Pisidia longimana* (Risso, 1816) larvae	0.02	<0.01	<0.01
	Porcellanidae larvae	0.01	<0.01	<0.01
Tanaidacea	*Chondrochelia savingyi* (Kroyer, 1842)	0.38	2.19	0.30
	Tanaidacea (not identified)	0.25	0.01	0.04
Cumacea	Cumacea (not identified)	0.24	0.10	0.02
	Iphinoe sp.	0.01	<0.01	<0.01
	Iphinoe maeotica Sowinskyi, 1893	0.12	0.03	0.01
Copepoda	Copepoda (not identified)	0.08	0.04	0.01
Hydrozoa	Leptohelia Lindner, Cairns & Zibrowius, 2014	0.17	0.01	0.02
Cephalochordata	*Branchiostoma lanceolatum* (Pallas, 1774)	0.05	0.08	0.01
Bivalvia	*Mytilaster lineatus* (Gmelin, 1791)	0.12	0.01	0.01
Insecta	Insecta imago	0.07	<0.01	0.01
Osteichthyes	Pisces (not identified)	2.65	5.40	1.61
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	0.01	2.94	0.24
Clupeidae	*Sprattus sprattus* (Linnaeus, 1758)	0.32	1.66	0.68
Syngnathidae	*Nerophis ophidion* (Linnaeus, 1758)	0.01	0.42	0.01
Gobiidae	Gobiidae (not identified)	1.07	2.97	1.14

Supplement 2. Average values of the Numerical Abundance Index (%Cn), Gravimetric Composition Index (%Cw) and Index of Relative Importance (%IRI) for prey items found in the stomachs of *Trachurus meditarraneus* in the Bulgarian Black Sea in July-August, 2013-2015.

Group	Food item	%Cn	%CW	%IRI
Polychaeta	Polychaeta (not identified)	1.70	4.03	0.92
	Polychaeta larvae	0.08	0.00	0.01
Phyllodocidae	Phyllodocidae (not identified)	0.21	0.04	0.03
	Phyllodoce mucosa Örsted, 1843	0.14	0.09	0.02
	Phyllodoce sp.	0.02	0.01	0.00
	Genetyllis tuberculata (Bobretzky, 1868)	0.47	1.31	0.30
Syllidae	Syllidae (not identified)	0.07	0.01	0.01
Glyceridae	*Glycera tridactyla* Schmarda, 1861	0.02	0.01	<0.01
	Glycera sp.	0.19	0.11	0.03
Nereididae	*Platynereis dumerilii* Audouin & Milne Edwards, 1833) (heteronereid form)	9.32	15.28	18.43
	Nereididae (not identified)	0.95	0.80	0.19
	Neanthes fucata (Savigny, 1822) (heteronereid form)	4.14	8.32	7.39
Dorvilleidae	*Protodorvillea kefersteini* McIntosh, 1869)	0.42	0.03	0.14
Opheliidae	*Polyophthalmus pictus* (Dujardin, 1839)	0.49	0.02	0.07
Eunicidae	*Lysidice ninetta* Audouin & H Milne Edwards, 1833	0.02	0.01	<0.01
Crustacea	Crustacea (not identified)	0.07	0.15	0.03
Amphipoda	*Melita palmata* (Montagu, 1804)	0.05	0.01	<0.01
	Microprotopus maculatus Norman, 1867	0.12	0.01	0.01
	Microdeutopus gryllotalpa Costa, 1853	0.19	0.01	0.02
Gamaridae	Gammaridae (not identified)	0.71	0.07	0.18
	Nototropis guttatus Costa, 1853	0.02	0.01	<0.01
	Gammarus insensibilis Stock, 1966	0.42	0.27	0.13
Isopoda	*Dynamene bidentata* (Adams, 1800)	0.33	0.07	0.05
	Idotea balthica (Pallas, 1772)	6.63	3.54	3.15
	Eurydice pontica (Czerniavsky, 1868)	0.78	1.14	0.60
	Eurydice dollfusi Monod, 1930	0.05	0.01	0.01
	Elaphognathia bacescoi (Kussakin, 1969)	0.19	0.03	0.02
	Isopoda (not identified)	0.04	0.01	<0.01
Mysidae	*Gastrosaccus sanctus* (Van Beneden, 1861)	0.76	0.06	0.08
	Siriella jaltensis Czerniavsky, 1868	0.19	0.01	0.02
Maxillopoda	*Athanas nitescens* (Leach, 1813 [in Leach, 1813-1814])	0.45	0.04	0.10
Decapoda	Decapoda larvae	35.96	23.76	38.71
Cumacea	Cumacea larvae	4.51	0.11	0.95
	Cumacea (not identified)	0.05	0.01	0.01
Copepoda	Copepoda (not identified)	0.12	0.02	0.01
	Acartia sp.	0.03	0.01	<0.01
Calanoida	*Centropages ponticus* Karavaev, 1895	7.28	3.56	5.04
Harpaticoida	Harpacticoida sp.	0.04	0.01	<0.01
Cladocera	*Penilia avirostris* Dana, 1849	0.02	<0.01	<0.01
	Pseudevadne tergestina (Claus, 1877)	0.11	<0.01	0.01
Cirripedia	Cirripedia larvae	1.30	0.20	0.49
Gastropoda	Gastropoda larvae	1.45	0.07	0.79
Bivalvia	Lamellibranchia larvae	4.47	0.01	3.67
Rotatoria	*Notholca* sp.	6.50	0.01	0.50
Bivalvia	*Mytilaster lineatus* (Gmelin, 1791)	0.69	0.01	0.05
Insecta	Formicidae (not identified)	0.49	0.51	0.15
Osteichthyes	Pisces (not identified)	0.73	21.94	2.12
	Pisces larvae	0.04	0.26	0.02
	Pisces ova	0.03	0.12	<0.01
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	6.94	13.87	15.51

Supplement 3. Average values of the Numerical Abundance Index (%Cn), Gravimetric Composition Index (%Cw) and Index of Relative Importance (%IRI) for prey items found in the stomachs of *Trachurus meditarraneus* in the Bulgarian Black Sea in September-November, 2013-2015.

Food item		Cn%	CW%	%IRI
Crustacea				
Tanaidacea		<0.01	<0.01	<0.01
Cumacea	Cumacea (not identified)	<0.01	0.02	<0.01
Isopoda	Isopoda (not identified)	0.04	11.33	1.32
	Isopoda larvae	<0.01	<0.01	<0.01
Copepoda	*Acartia (Acartiura) clausi* Giesbrecht, 1889	1.46	0.47	1.35
	Acartia sp.	0.06	0.01	0.01
	Acartia larvae	0.18	0.02	0.07
	Copepoda (not identified)	2.15	0.24	1.62
	Copepoda larvae	0.15	0.01	0.03
Calanoida	*Centropages ponticus* Karavaev, 1895	3.75	0.91	3.93
	Centropages ponticus Karavaev, 1895 larvae	1.19	0.26	0.66
	Calanus euxinus Hulsemann, 1991	0.18	0.59	0.16
	Calanus sp.	0.01	0.14	0.01
	Calanus larvae	0.30	1.69	0.55
	Paracalanus parvus (Claus, 1863) larvae	0.41	0.02	0.05
	Paracalanus parvus (Claus, 1863)	10.80	1.73	10.94
	Pseudocalanus elongatus (Boeck, 1865) larvae	0.12	0.01	0.02
	Pseudocalanus elongatus (Boeck, 1865)	0.19	0.15	0.12
Cyclopoida	Cyclopoida sp.	0.01	<0.01	<0.01
	Oithona similis Claus, 1866	0.01	<0.01	<0.01
Harpaticoida	Harpacticoida sp.	0.06	0.01	0.03
Monstrilloida	Montstrilla sp.	0.01	<0.01	<0.01
Cladocera	*Evadne* sp.	0.51	0.02	0.45
	Evadne nordmanni Lovén, 1836	0.15	<0.01	0.06
	Evadne spinifera P.E.Müller, 1867	0.98	0.03	0.86
	Penilia avirostris Dana, 1849	1.34	0.52	1.37
	Pleopis polyphemoides(Leuckart, 1859)	0.01	<0.01	<0.01
	Pseudevadne tergestina (Claus, 1877)	0.50	0.01	0.37
Cirripedia	Cirripedia larvae	4.60	0.37	3.62
Deacapoda	Decapoda larvae	4.08	0.95	3.07
	Decapoda (not identified)	<0.01	<0.01	<0.01
Appendicularia	*Oikopleura (Vexillaria) dioica* Fol, 1872	35.63	1.82	30.32
Ctenophora	Pleurobrachia larvae	0.01	<0.01	<0.01
Foraminifera		<0.01	<0.01	<0.01
Mollusca				
Gastropoda	Gastropoda larvae	0.38	0.01	0.13
Bivalvia	Lamellibranchia larvae	0.53	0.00	0.14
Chaetognatha	*Parasagitta setosa* (J. Müller, 1847)	5.45	0.17	3.24
Scyphozoa	*Aurelia* larvae	0.01	0.00	0.00
Polychaeta	Polychaeta larvae	0.12	0.05	0.06
Osteichthyes	Pisces (not identified)	0.26	6.53	0.99
Engraulidae	*Engraulis encrasicolus* (Linnaeus, 1758)	3.03	41.50	9.14
Clupeidae	*Sprattus sprattus* (Linnaeus, 1758)	20.97	24.43	23.79
Gobiidae		0.09	0.07	0.01
	Mesogobius batrachocephalus (Pallas, 1814)	0.05	0.07	0.01
Carangidae	*Trachurus* ova	<0.01	0.01	<0.01
Syngnathidae	*Nerophis ophidion* (Linnaeus, 1758)	0.03	4.42	0.96
	Pisces larvae	0.05	0.40	0.11
	Pisces ova	0.13	1.01	0.45