Trophic partitioning among three mesopredatory shark species inhabiting the north-western Adriatic Sea

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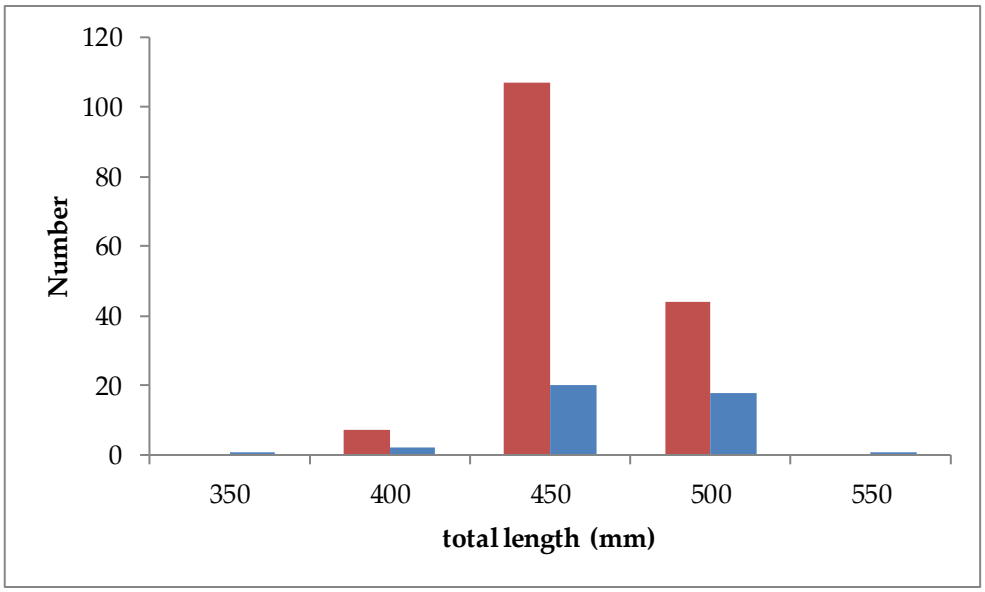
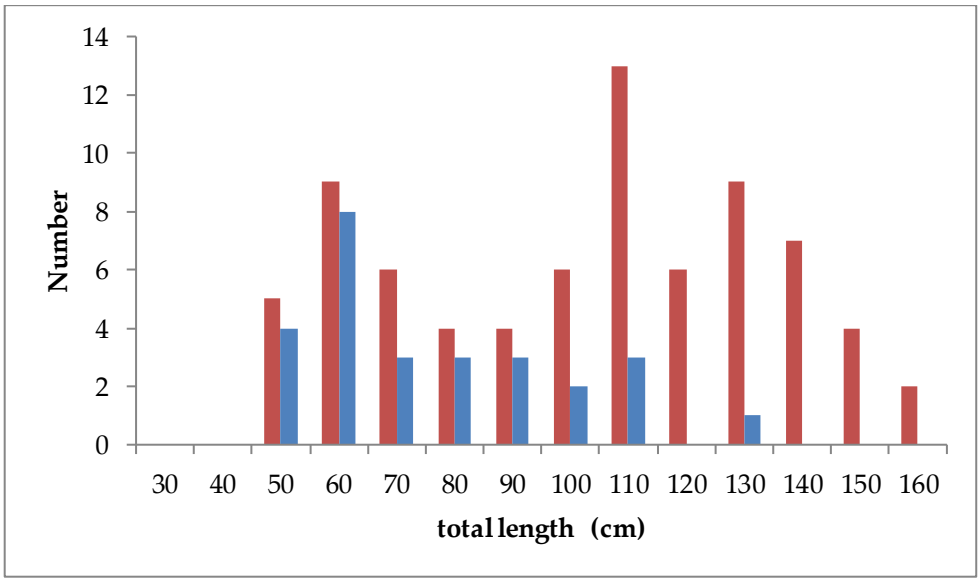
Figure S1 Length-frequency distributions of females (red bars) and males (blue bars) of (**a**) *Scyliorhinus canicula*, (**b**) *Mustelus mustelus*, and (**c**) *M. punctulatus* used for stomach content analysis (non-empty stomachs).



(a)



(b)

(c)

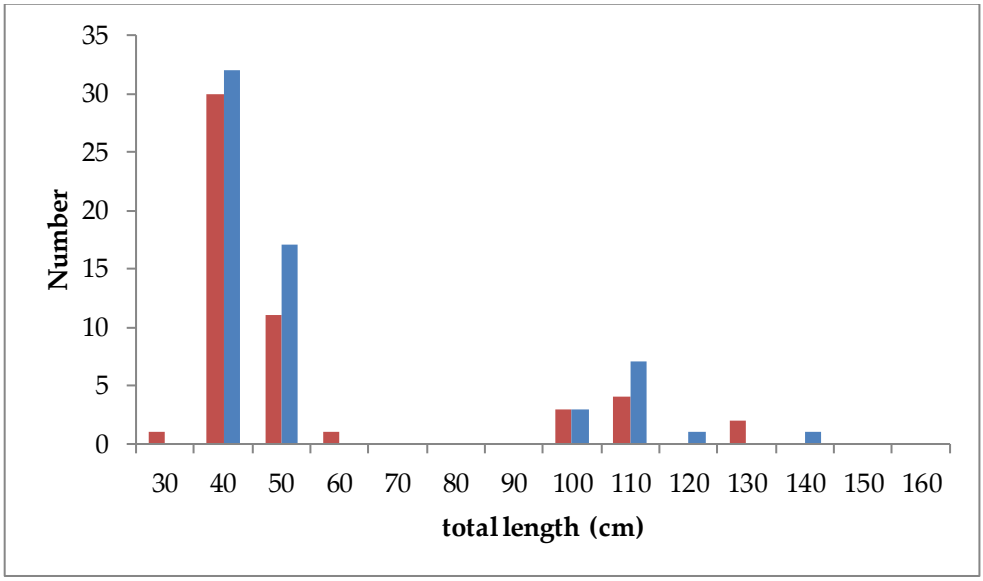

35
30
25
20
15
10
5
0
Number
30
40
50
60
70
80
90
100
110
120
130
140
150
160
total length (cm)

Table S1: List of all the prey categories identified in the diet of *S. canicula*, *M. mustelus*, and *M. punctulatus*, with the respective values of percent frequency of occurrence (%FOi), prey-specific abundance (%PNi), prey-specific weight (%PWi), and prey-specific index of relative importance (%PSIRIi). To perform multivariate analysis, prey categories were aggregated on the base of taxonomic criteria and %FOi<5%.

Aggregated prey categories	**Prey categories**	***Scyliorhinus canicula***				***Mustelus mustelus***				***Mustelus punctulatus***			
		%FO	**%PN**	**%PW**	**%PSIRI**	**%FO**	**%PN**	**%PW**	**%PSIRI**	**%FO**	**%PN**	**%PW**	**%PSIRI**
	Total TELEOSTS				**25.3**				**3.5**				**9.0**
Unid. Teleost	unidentified	47.5	27.7	23.7	12.2	22.5	0.2	16.6	2.6	29.2	0.2	16.7	5.1
Bento-demersal fishes	unid. Triglidae	1.0	25.0	30.9	0.3								
	Lepidotrigla cavillone	0.5	14.3	23.0	0.1								
	Callionymus sp.	0.5	8.7	5.1	0.0								
	Callionymus maculatus	0.5	12.5	39.3	0.1								
	Callionymus risso	0.5	12.5	19.5	0.1								
	Serranus hepatus	3.0	16.5	25.1	0.6								
Flatfishes	unid. flatfishes	1.5	26.1	31.4	0.4	2.0	0.3	27.8	0.5				
	unid. Pleuronectidae	0.5	14.3	53.9	0.2								
	Solea monochir	1.5	28.1	62.3	0.7								
	Arnoglossus sp.	6.0	23.4	35.3	1.8								
	Arnoglossus imperialis	1.0	19.6	20.9	0.2								
	Arnoglossus laterna	3.5	17.5	30.3	0.8								
Deltentosteus quadrimaculatus	*Deltentosteus quadrimaculatus*	12.0	25.0	30.8	3.3								
Cepola macrophthalma	*Cepola macrophthalma*	9.0	29.8	41.6	3.2								

Pelagic fishes	*Sardina pilchardus*									2.7	0.1	13.1	0.7
	Engraulis encrasicholus	3.5	26.5	43.4	1.2	2.9	0.2	15.1	0.5	8.8	0.3	27.9	3.1
	Total CRUSTACEANS				**59.6**				**95.3**				**66.2**
Unid. Crustacean	unidentified	31.0	32.8	21.1	8.4	25.5	0.3	25.9	4.9	35.4	0.3	30.5	10.9
Unid. Decapoda	unid. Decapoda	0.5	16.7	0.0	0.0	1.0	0.9	90.9	0.9				
Other Pleocyemata	unid. Stenopodidea	0.5	44.4	20.4	0.2								
	Upogebia tipica									2.7	0.3	29.2	0.6
	unid. Reptantia	2.0	9.2	27.0	0.4	1.0	0.1	6.3	0.0	4.4	0.2	21.1	1.4
Anomura	unid. Anomura	1.5	14.5	14.0	0.2	2.0	0.1	10.1	0.2	0.9	0.1	11.1	0.1
	Dardanus sp.					3.9	0.2	21.3	0.7	22.1	0.3	34.4	8.3
	Dardanus calidus					2.0	0.1	11.8	0.2	13.3	0.3	28.0	4.1
Other Brachiura	unid. Brachiura	18.0	25.9	37.9	5.7	20.6	0.3	31.9	6.5	16.8	0.2	18.1	4.0
	unid. Macropodia	0.5	20.0	1.7	0.1								
	Pilumnus hirtellus					1.0	0.1	6.7	0.2				
	Pilumnus villosissimus					1.0	0.1	11.1	0.2				
	unid. Parthenopidae					2.0	0.1	13.9	0.3	1.8	0.1	13.9	0.3
	Derilambrus angulifrons									0.9	0.1	6.7	0.1
	Corystes cassivelaunus									0.9	0.1	13.3	0.1
Ethusa mascarone	*Ethusa mascarone*	0.5	9.1	5.1	0.0	26.5	0.3	27.4	7.2	12.4	0.2	22.3	2.9
Portunidae	unid. Portunidae	16.5	29.2	49.3	6.5	28.4	0.4	38.4	10.2	5.3	0.3	29.9	1.8
	Liocarcinus sp.	13.0	35.5	44.6	5.2	17.6	0.4	36.8	6.5	6.2	0.3	28.9	2.0
	Liocarcinus depurator	21.0	36.9	70.3	11.3	35.3	0.4	43.6	16.6	6.2	0.5	49.0	3.6

	Liocarcinus vernalis	0.5	25.0	22.6	0.1	18.6	0.2	17.7	3.9				
	Carcinus aestuarii					12.7	0.3	33.1	5.0				
Unid. Caridea	unid. Caridea	30.0	37.5	19.5	8.6	9.8	0.3	29.3	2.6	17.7	0.3	25.0	5.5
Alpheus glaber	*Alpheus glaber*	10.5	23.1	23.5	2.4					0.9	0.1	14.3	0.2
Other Dendrobranchiata	unid. Solenoceridae	0.5	16.7	21.8	0.1								
	unid. Penaeidae	0.5	14.3	3.7	0.0	2.0	0.1	12.1	0.4				
Penaeus kerathurus	*Penaeus kerathurus*					8.8	0.2	17.7	1.6				
Processidae	unid. Processidae	13.0	26.9	12.3	2.6	16.7	0.3	32.9	3.0	42.5	0.6	56.0	17.8
	Processa edulis	3.0	44.6	27.2	1.1								
Other Stomatopoda	unid. Stomatopoda	2.5	22.2	25.4	0.6	15.7	0.2	16.0	2.7				
	Lysisquilla sp.	2.0	10.6	6.5	0.2								
	Platysquilla eusebia	1.0	13.4	2.6	0.1								
Squilla mantis	*Squilla mantis*	1.5	48.1	36.3	0.6	47.1	0.3	34.2	20.9	7.1	0.3	29.6	2.4
Rissoides desmaresti	*Rissoides desmaresti*	15.0	31.0	30.3	4.6	4.9	0.2	16.9	0.6	0.9	0.2	16.7	0.2
Isopoda	unid. Isopoda	3.5	19.1	1.9	0.4	2.0	0.2	15.5	0.2	0.9	0.3	25.0	0.2
	Sphaeroma serratum	1.5	22.2	30.0	0.4								
	Total POLYCHAETES				**4.7**				**0.6**				**14.1**
Polychaete	unid. Polychaete	27.0	22.4	11.6	4.6	5.9	0.2	17.2	0.6	60.2	0.2	22.4	12.3
	Polygordius triestinus	0.5	16.7	14.8	0.1								
	Arenicola marina									10.6	0.1	14.2	1.8
	Total MOLLUSCS				**9.7**				**0.5**				**9.0**
Unid. Cephalopods	unidentified	9.5	20.9	18.0	1.8					19.5	0.2	20.3	4.2

Eledone spp.	*Eledone* sp.	0.5	33.3	18.5	0.1					2.7	0.1	13.8	0.4
	unid. Sepiidae	3.5	22.0	21.9	0.8								
Sepiidae	*Sepia officinalis*	1.5	17.6	58.8	0.6								
	Sepia elegans	1.0	23.8	71.9	0.5								
	unid. Sepiolidae	19.0	25.7	15.2	3.9					14.2	0.2	23.8	3.8
Sepiolidae	*Sepietta oweniana*	3.0	17.4	26.6	0.7								
	Sepiola rondeleti	1.0	9.5	22.3	0.2								
	unid. Teuthida	2.5	24.2	22.0	0.6	1.0	0.1	14.3	0.1	0.9	0.1	10.0	0.3
Teuthida	*Alloteuthis media*	1.0	16.7	39.5	0.3								
	Alloteuthis subulata	0.5	20.0	33.6	0.1								
	unid. Bivalvia	1.0	25.0	1.0	0.1	2.9	0.1	7.5	0.1	2.7	0.1	11.6	0.2
	Mussels					2.9	0.2	18.1	0.3				
Bivalvia	*Tapes* sp.					2.0	0.0	4.2	0.1				
	unid. Solenoidae									0.9	0.2	16.7	0.1
	unid. Veneridae	0.5	25.0	0.0	0.1								
	unid. Sipunculidae	1.5	15.1	1.2	0.1								
	Sipunculus nudus									5.3	0.3	27.1	1.5
Other	unid. Holothuroidea	2.5	22.5	19.2	0.5								
	unid. Nemertea	0.5	25.0	4.7	0.1								
	Suberites domuncula									0.9	0.1	14.3	0.1

Table S2: Results of the similarity percentage (SIMPER) analysis reporting the average biomass and percentage contribution of the different prey categories to the difference observed between the combination of sex*size comparisons in the diet of *M. mustelus*. Only prey categories contributing at least with 4% to the difference were included in the table.

Average dissimilarity (%)	Prey category	Average biomass	Average biomass	Contribution (%)
		Small Females	**Small Males**	
75.80	*Squilla mantis*	1.95	0.67	24.48
	Portunidae	1.36	1.44	20.50
	Ethusa mascarone	0.84	0.87	13.07
	other Brachiura	0.28	0.56	8.91
	unid. crustacea	0.42	0.34	7.02
	other Stomatopoda	0.22	0.22	4.33
		Small Females	**Big Females**	
75.92	Portunidae	1.36	6.13	41.07
	Squilla mantis	1.95	2.50	21.04
	other Brachiura	0.28	0.69	6.56
	Ethusa mascarone	0.84	0.00	6.53
	unid. crustacea	0.42	0.28	4.36
	other Stomatopoda	0.22	0.39	4.29
		Small Males	**Big Females**	
79.88	Portunidae	1.44	6.13	41.42
	Squilla mantis	0.67	2.50	19.79
	other Brachiura	0.56	0.69	8.42
	Ethusa mascarone	0.87	0.00	6.69
	other Stomatopoda	0.22	0.39	4.42
	unid. crustacea	0.34	0.28	4.33
		Small Females	**Big Males**	
73.55	*Squilla mantis*	1.95	3.33	27.29
	Portunidae	1.36	3.51	25.82
	other Dendrobranchiata	0.00	1.53	9.24
	other Brachiura	0.28	0.70	7.43
	Ethusa mascarone	0.84	0.00	7.41

	unid. teleosts	0.24	0.59	5.91
		Small Males	**Big Males**	
82.64	*Squilla mantis*	0.67	3.33	30.59
	Portunidae	1.44	3.51	24.08
	other Brachiura	0.56	0.70	9.24
	other Dendrobranchiata	0.00	1.53	8.70
	Ethusa mascarone	0.87	0.00	7.15
	unid. teleosts	0.11	0.59	4.94
		Big Females	**Big Males**	
63.91	Portunidae	6.13	3.51	38.06
	Squilla mantis	2.50	3.33	25.05
	other Brachiura	0.69	0.70	8.96
	other Dendrobranchiata	0.00	1.53	8.72
	unid. teleosts	0.33	0.59	5.11
	Penaeus kerathurus	0.35	0.48	4.43

Table S3. Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes ratios (mean ± std.dev.) and estimated trophic level of *S. canicula*, *M. mustelus*, and *M. punctulatus*. Data are presented divided for sex and size.

Species		Females			Males		
		$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	trophic level	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	trophic level
M.mustelus	**small**	-17.24 ± 0.67	13.04 ± 0.19	4.1	-17.37 ± 1.64	13.50 ± 0.35	4.1
	big	-13.31 ± 1.75	13.97 ± 0.78	4.0	-13.95 ± 1.74	13.23 ± 0.38	4.0
M. punctulatus	**small**	-16.69 ± 2.16	12.59 ± 0.60	3.7	-17.60 ± 1.74	12.09 ± 1.40	3.7
	big	-15.12 ± 1.87	13.45 ± 1.09	4.2	-13.55 ± 2.80	13.58 ± 0.78	4.2
S. canicula	**big**	-17.99 ± 0.75	13.58 ± 0.34	4.2	-17.71 ± 1.12	13.45 ± 0.62	4.1

Table S4. Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes ratios (mean ± std.dev.) and estimated trophic value of the main prey items of the three studied shark species.

Taxon	**Prey**	**$\delta^{13}C$ (‰)**	**$\delta^{15}N$ (‰)**	**trophic level**
Fish	*Serranus hepatus*	-17.84 ± 0.05	12.05 ± 0.59	3.7
	Arnoglossus laterna	-17.96 ± 0.67	11.45 ± 0.37	3.5
	Monochirus hispidus	-18.34 ± 0.37	11.18 ± 0.53	3.4
	Deltentosteus quadrimaculatus	-16.51± 1.45	11.75 ± 0.91	3.6
	Pomatoschistus minutus	-17.15 ± 0.95	12.81 ± 0.16	3.9
Crustacean	*Liocarcinus depurator*	-16.00 ± 0.36	10.77 ± 0.63	3.3
	Processidae	-15.76 ± 0.32	11.25 ± 0.73	3.5
	Squilla mantis	-17.40 ± 0.63	10.90 ± 0.60	3.4
Molluscs	*Aequipecten opercularis*	-19.20 ± 1.56	5.09 ± 0.45	1.7

Analysis of the diets of *Mustelus mustelus* and *M. punctulatus* including only animals attributed to the small size group.

PERMANOVA analysis highlighted a significant difference in the diet between the two species (Figure S2 and Table S5). The average diet similarity was 25.0% within *M. mustelus* and 22.5% within *M. punctulatus*. The average dissimilarity was 90.7% (Table S6).

Table S5. Results of permutational multivariate analysis of variance (PERMANOVA) on the dietary composition by biomass of small sized *M. mustelus* and *M. punctulatus*. Bold values highlight statistical significance.

PERMANOVA						
Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Species	1	70548	70548	22.44	**0.001**	999
Residual	139	4.37E5	3143.9			
Total	140	5.08E5				

Figure S2. Non-metric multidimensional scaling (nMDS) ordination of dietary composition by biomass of *M. mustelus* (Mm, blue ■) and *M. punctulatus* (Mp, green ●).

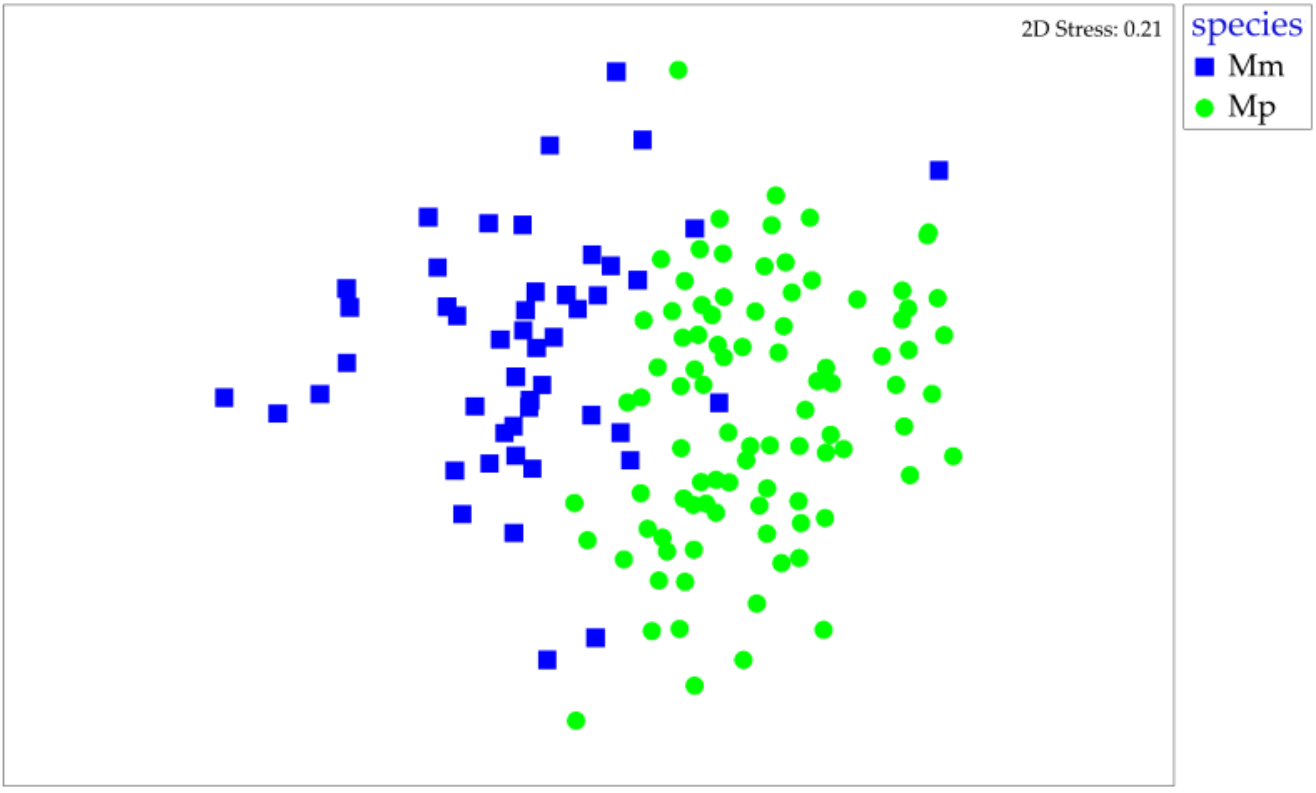


Table S6. Results of the similarity percentage (SIMPER) analysis reporting the average biomass and percentage contribution of the different prey categories to the difference observed in the diet between *M. mustelus* and *M. punctulatus*. Only prey categories contributing at least with 4% to the difference were included in the table

Prey category	**Average biomass**	**Average biomass**	**Contribution (%)**
	M. mustelus	***M. punctulatus***	
Portunidae	1.39	0.04	18.24
Squilla mantis	1.40	0.02	17.28
Ethusa mascarone	0.85	0.13	11.42
other Brachiura	0.40	0.20	7.49
unid. crustacea	0.39	0.27	6.93
Processidae	0.18	0.36	5.57
Anomura	0.11	0.35	5.55
Polychaete	0.06	0.40	5.46
other Caridea	0.16	0.18	4.25