

Supporting Information

Supporting Information Table S1. Flatfish species recorded during the Mediterranean International Bottom Trawl Survey (MEDITS) in the North–Central Adriatic Sea (GSA17). For each species, the table reports family, scientific name, common English name, author and year of description, survey species code, and occurrence (%). Occurrence indicates the percentage of survey years in the analysed MEDITS time series (2002–2024) in which the species was captured at least once.

Family	Scientific name	Common name	Author, Year	Code	Occurrence
Bothidae	<i>Arnoglossus imperialis</i>	Imperial scaldfish	(Rafinesque, 1810)	ARNO IMP	5%
	<i>Arnoglossus laterna</i>	Mediterranean scaldfish	(Walbaum, 1792)	ARNO LAT	100%
	<i>Arnoglossus rueppelii</i>	Rüppell’s scaldback	(Cocco, 1844)	ARNO RUP	95%
	<i>Arnoglossus thori</i>	Thor’s scaldfish	Kyle, 1913	ARNO THO	100%
	<i>Bothus podas</i>	Wide-eyed flounder	(Delaroche, 1809)	BOTH POD	5%
Citharidae	<i>Citharus linguatula</i>	Spotted flounder	(Linnaeus, 1758)	CITH MAC	100%
Cynoglossidae	<i>Symphurus nigrescens</i>	Blackish tonguesole	Rafinesque, 1810	SYMP NIG	100%
Pleuronectidae	<i>Platichthys flesus</i>	European flounder	(Linnaeus, 1758)	PLAT FLE	65%
Scophthalmidae	<i>Lepidorhombus boscii</i>	Four-spot megrim	(Risso, 1810)	LEPM BOS	100%
	<i>Lepidorhombus whiffiagonis</i>	Megrim	(Walbaum, 1792)	LEPM WHS	100%
	<i>Psetta maxima</i>	Turbot	(Linnaeus, 1758)	PSET MAX	75%
	<i>Scophthalmus rhombus</i>	Brill	(Linnaeus, 1758)	SCOH RHO	95%
	<i>Zeugopterus regius</i>	Eckström’s topknot	(Bonnaterre, 1788)	PHRY REG	60%
Soleidae	<i>Buglossidium luteum</i>	Solenette	(Risso, 1810)	BUGL LUT	95%
	<i>Microchirus ocellatus</i>	Ocellated sole	(Linnaeus, 1758)	MICU OCE	55%
	<i>Microchirus variegatus</i>	Thickback sole	(Donovan, 1808)	MICU VAR	85%

Family	Scientific name	Common name	Author, Year	Code	Occurrence
	<i>Monochirus hispidus</i>	Whiskered sole	Rafinesque, 1814	MONO HIS	80%
	<i>Synapturichthys kleinii</i>	Klein's sole	(Risso, 1827)	SOLE KLE	75%
	<i>Solea lascaris</i>	Sand sole	(Risso, 1810)	SOLE LAS	30%
	<i>Solea solea</i>	Common sole	(Linnaeus, 1758)	SOLE VUL	100%

Supporting Information Table S2. Benthic invertebrate subcategories recorded in the haul-level dataset from the 2021, 2023 and 2024 MEDITS surveys in the North–Central Adriatic Sea (GSA17) before filtering. For each subcategory, the table reports the survey code, number of haul-level records (*N*), percentage of records relative to the full benthic dataset, and a brief taxonomic description. Subcategories retained for the multivariate analyses (occurring in $\geq 5\%$ of hauls) are shown in bold.

Code	<i>N</i>	Percent	Taxonomic group
B	867	27.30	Crustaceans (Decapoda)
Eec	634	20.00	Echinodermata
Etu	396	12.50	Tunicata (Ascidacea)
Esp	287	9.04	Porifera (sponges)
Ecn	245	7.72	Cnidaria
Emb	202	6.36	Mollusca Bivalvia
Emg	192	6.05	Mollusca Gastropoda
Bst	124	3.91	Stomatopoda
Emo	98	3.09	Mollusca Opisthobranchia
Ebr	45	1.42	Bryozoa
Epo	37	1.17	Polychaeta
G	35	1.10	Animal remains/products (shell debris, eggs, etc.)
Ehi	4	0.13	Hirudinea
V	3	0.09	Plantae (vegetal material)
Epr	2	0.06	Priapulida
Bci	1	0.03	Cirripedia
Ean	1	0.03	Annelida
Ech	1	0.03	Echiura
Ene	1	0.03	Nemertea

Supporting Information Table S3. Number of haul-level sampling stations included in the habitat-association analyses by survey year and MEDITS depth stratum. The table shows the distribution of the 323 hauls among the three survey years (2021, 2023 and 2024) and the six depth strata. Descriptions of the MEDITS depth stratum codes and their corresponding depth ranges are provided in Table 1 of the main text.

Year	21101	21102	21106	21107	21108	21109	Total
2021	32	16	10	23	29	8	118
2023	32	17	8	17	20	8	102
2024	32	18	9	19	18	7	103
							323

Supporting Information Table S4. Summary of PERMANOVA results testing for differences in flatfish assemblage composition among bathymetric strata in the North–Central Adriatic Sea (GSA17). This analysis corresponds to the Principal Coordinates Analysis (PCoA) presented in Figure 3. The analysis was performed on Bray–Curtis dissimilarities of abundance (N km⁻²) data using 10 000 permutations. Degrees of freedom (*df*), sums of squares (SumOfSqs), coefficients of determination (*R*²), *F*-values, and significance levels (*p*) are reported.

Source	<i>df</i>	SumOfSqs	<i>R</i> ²	<i>F</i> Model	<i>p</i> (>F)
Model	5	15.01	0.73	63.20	< 0.001***
Residual	114	5.41	0.26	–	–
Total	119	20.42	1.00	–	–

Supporting Information Table S5A. Results of the permutation test for homogeneity of multivariate dispersions (PERMDISP) among MEDITS bathymetric strata for flatfish assemblages in the North–Central Adriatic Sea (GSA17). The analysis was based on the same Bray–Curtis dissimilarity matrix of fourth-root-transformed flatfish abundances (N km⁻²) used for the Principal Coordinates Analysis (PCoA) presented in Figure 3. Reported are the source of variation, degrees of freedom (*df*), sums of squares (SumOfSqs), mean squares (MeanSq), *F*-values, and permutation *p* values (*p*(>*F*)).

Source	<i>df</i>	SumOfSqs	MeanSq	<i>F</i> Model	<i>p</i> (> <i>F</i>)
Model	5	0.44	0.09	13.97	< 0.001
Residuals	114	0.72	0.01	–	–

Supporting Information Table S5B. Pairwise permutation tests for homogeneity of multivariate dispersions among MEDITS depth–area strata for flatfish assemblages in the North–Central Adriatic Sea (GSA17). The analyses were based on the same Bray–Curtis dissimilarity matrix of fourth-root-transformed flatfish abundances (N km⁻²) used for the Principal Coordinates Analysis (PCoA) presented in Figure 3. Tests were performed using *betadisper()* followed by *permutest()* in the R package *vegan* with 10 000 permutations. Reported are permutation *p*-values (not adjusted for multiple comparisons). The codes and definitions of the depth–area strata are provided in Table 1 of the main text.

Stratum 1	Stratum 2	<i>p</i> -value
21101	21102	0.0658
21101	21106	< 0.001
21101	21107	0.0425
21101	21108	0.6624
21101	21109	0.6406
21102	21106	< 0.001
21102	21107	0.9442
21102	21108	0.1608
21102	21109	0.3112
21106	21107	< 0.001
21106	21108	< 0.001
21106	21109	< 0.001
21107	21108	0.1247
21107	21109	0.2758
21108	21109	0.8953

Supporting Information Table S6. Complete results of the envfit analysis projecting flatfish species onto the Principal Coordinates Analysis ordination of long-term assemblage composition (Figure 3 of the main text) across MEDITS bathymetric strata in the North–Central Adriatic Sea (GSA17). For each species, the table reports vector coordinates on the first two PCoA axes (PCoA1, PCoA2), squared correlation coefficients (r^2) between species and ordination scores, and permutation p -values (999 permutations). Abundances were fourth-root-transformed ($N\ km^{-2}$) prior to computation of Bray–Curtis dissimilarities. Species codes are provided in Supporting Information Table S1.

Species	PCoA1	PCoA2	r^2
LEPM BOS	0.80	0.00	0.81
ARNO THO	-0.42	-0.67	0.78
CITH MAC	-0.37	-0.69	0.77
LEPM WHS	0.72	-0.22	0.71
ARNO RUP	0.71	0.12	0.65
MICU VAR	-0.25	-0.64	0.60
SYMP NIG	0.46	-0.49	0.56
ARNO LAT	-0.60	0.29	0.56
SOLE VUL	-0.61	-0.02	0.47
SCOH RHO	-0.52	0.13	0.36
BUGL LUT	-0.39	-0.24	0.27
SOLE KLE	-0.30	-0.28	0.21
MONO HIS	-0.30	-0.23	0.18
PHRY REG	-0.23	-0.30	0.18
PLAT FLE	-0.31	-0.16	0.16

Species	PCoA1	PCoA2	r^2
PSET MAX	-0.31	-0.05	0.12

Supporting Information Table S7. Permutational multivariate analysis of variance (PERMANOVA) testing for differences in haul-level flatfish assemblage composition among bathymetric strata in the North–Central Adriatic Sea (GSA17). This analysis corresponds to the Principal Coordinates Analysis (PCoA) presented in Figure 4. The analysis is based on Bray–Curtis dissimilarities of fourth root-transformed abundances (N km⁻²), with 10 000 permutations. degrees of freedom (*df*), sums of squares (SumOfSqs), coefficients of determination (R^2), *F*-values and *p*-values are reported.

Source	<i>df</i>	SumOfSqs	R^2	<i>F</i> Model	<i>p</i> (> <i>F</i>)
Model	5	28.53	0.32	29.70	< 0.001
Residual	317	60.90	0.68	–	–
Total	322	89.44	1.00	–	–

Supporting Information Table S8. Results of the envfit analyses and substrate centroids for the haul-level Principal Coordinates Analysis ordination of flatfish assemblages (Figure 4 of the main text) in the North–Central Adriatic Sea (GSA17). For flatfish species and benthic invertebrate subcategories, PCoA1 and PCoA2 give the coordinates of fitted vectors, r^2 is the squared correlation with ordination scores, and p is the permutation p -value (999 permutations). Substrate types are represented by centroids, computed as mean PCoA scores of hauls assigned to each EMODnet sediment class (M = mud, SM = sandy mud, MS = muddy sand, S = sand), and therefore have no associated r^2 or p . Bottom temperature was fitted as a continuous environmental variable and is reported as an envfit vector. Flatfish species codes are provided in Supporting Information Table S1, and benthic invertebrate subcategory codes are provided in Supporting Information Table S2.

CATEGORY	CODE	PCoA1	PCoA2	r^2	p
<i>Flatfish</i>	CITH MAC	0.60	-0.53	0.76	0.001
	ARNO LAT	-0.65	-0.47	0.76	0.001
	LEPM BOS	-0.02	0.80	0.58	0.001
	LEPM WHS	0.08	0.79	0.32	0.001
<i>Benthos</i>	Esp	0.95	-0.29	0.16	0.001
	Eec	0.92	-0.39	0.11	0.001
	Etu	0.99	-0.07	0.14	0.001
	B	-0.30	-0.95	0.07	0.001
	Emg	-0.99	0.16	0.06	0.001
<i>Temperature (°C)</i>	T	-0.23	-0.44	0.11	0.001
<i>Substrate type</i>	M	-0.11	-0.01	—	—
	MS	0.13	-0.06	—	—
	S	0.30	-0.01	—	—

CATEGORY	CODE	PCoA1	PCoA2	r^2	p
	SM	-0.07	0.07	—	—

Supporting information Table S9A. Environmental collinearity diagnostics for the sensitivity analysis of flatfish habitat associations. Pearson (r) and Spearman (ρ) correlation coefficients quantify the linear and monotonic association, respectively, between bottom depth and bottom temperature across the 323 haul-level sampling stations included in the habitat-association analysis (2021, 2023 and 2024 MEDITS surveys). Variance inflation factors (VIFs) were calculated from the full distance-based redundancy analysis (dbRDA) including depth, bottom temperature and substrate type as explanatory variables. For substrate type, the maximum VIF among dummy variables is reported.

Variables	Statistic
Depth vs Bottom temperature (Pearson r)	−0.53
Depth vs Bottom temperature (Spearman ρ)	−0.79
VIF – Depth	1.47
VIF – Bottom temperature	1.43
VIF – Substrate (maximum dummy variable)	1.21

Supporting information Table S9B. Variation partitioning of flatfish assemblage composition among bottom depth, bottom temperature, and substrate type based on distance-based redundancy analysis (dbRDA). The full dbRDA model was fitted to the Bray–Curtis dissimilarity matrix calculated from fourth-root-transformed flatfish abundances, with a square-root correction applied to the dissimilarities. Adjusted R^2 values were obtained from variation partitioning of the full dbRDA model. The significance of the unique fractions was subsequently assessed using partial dbRDA models with the remaining predictors included as conditioning variables and 9 999 permutations restricted within survey year. Pseudo- F statistics and permutation-based p -values are reported only for the unique fractions. Shared fractions were not tested statistically. Negative shared fractions resulting from adjusted R^2 estimation were interpreted as zero.

Fraction	Adjusted R^2	Pseudo- F	p
Unique depth	0.062	24.78	<0.001
Unique bottom temperature	0.034	13.89	<0.001
Unique substrate	0.068	9.62	<0.001
Shared depth–temperature	0.013	—	—
Shared depth–substrate	0.004	—	—
Shared temperature–substrate	≈ 0	—	—
Shared all variables	≈ 0	—	—
Residual	0.822	—	—

Supporting Information Table S10. Summary statistics of the symmetric Procrustes analysis (PROTEST) comparing Principal Coordinates Analysis configurations of flatfish assemblages based on year-by-depth stratum averaged abundances (Figure 3 of the main text) versus haul-level data from the 2021, 2023, and 2024 surveys (Figure 4 of the main text). Reported are the Procrustes sum of squares (m^2), symmetric Procrustes correlation (r), permutation p -value, and number of permutations (n_{perm}).

Metric	Value
Procrustes sum of squares (m^2)	0.404
Symmetric Procrustes correlation (r)	0.772
p -value	0.054
n_{perm}	719