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BIODIVERSITY OF CRUSTACEAN ASSEMBLAGES IN THE IONIAN SEA: WHAT HAS CHANGED OVER THE PAST 30 YEARS?

BIODIVERSITÁ DEGLI ASSEMBLAGE DI CROSTACEI NEL MAR IONIO: CHE COSA È CAMBIATO NEL CORSO DI 30 ANNI?

Abstract - *The present study assessed the diversity and temporal variations of crustacean assemblages in the North-western Ionian Sea. A total of 92 taxa were recorded. Both univariate ecological indices and multivariate analyses were used to investigate temporal shifts in the community structure, revealing temporal variability in crustacean assemblages across the historical series. Distinct patterns emerged between shelf and slope communities, underscoring the key role of depth in structuring demersal assemblages. The long-term data series provided a robust framework for detecting and characterizing temporal variability in the status of demersal assemblages of the Ionian Sea.*

Keywords: *Demersal community, Mediterranean Sea, Spatial distribution, Temporal variations*

Introduction - Crustaceans represent one of the most diverse taxonomic groups within marine communities, even on soft bottoms traditionally affected by fishing activities. Decapods, in particular, play a key ecological role within the marine trophic network, and many species are important commercial resources. Therefore, the study of crustacean assemblages can be useful for understanding the dynamics of commercial species from an ecosystem-based perspective (Ciércoles *et al*., 2022). This study aims to assess the diversity of crustacean assemblages in the North-western Ionian Sea and their possible changes over thirty years.

Materials and methods - Data were collected annually from 1995 to 2024 within the framework of the MEDITS project (Spedicato et al., 2019), as part of the European Union's *Data Collection Framework* (DCF), during experimental bottom trawl surveys yearly conducted in the Geographical Sub-Area 19 (GSA 19) (North-western Ionian Sea). Sampling covered a bathymetric range between 10 and 800 meters, for a total of 2058 hauls. For each survey, density (N/km^2) and biomass (kg/km^2) standardized indices were calculated for the total faunistic category and for each species, across the full bathymetric range and within two macrostrata: the continental shelf (10–200 m) and the continental slope (200–800 m). For each taxon, the Frequency of Occurrence (F%) was calculated and the number of taxa by depth was presented by boxplots. Based on standardized biomass indices, biomass trends over the investigated period were tested using local polynomial regression fitting from the geom_smooth function of ggplot2 library, using R software (Wickham, 2016). Univariate ecological indices were calculated for each haul using standardized density indices (Margalef species richness, Simpson dominance and Pielou evenness) and potential temporal variations of the annual mean value were tested using linear regression. A multivariate analysis was performed using the PRIMERv7 software (Clarke & Gorley, 2015), to investigate the taxonomic composition of both macrostrata assemblages and assess differences in taxon abundance, using survey years as grouping factors. A fourth-root transformation was applied to minimize the influence of highly-abundant taxa. Based on the Bray-Curtis similarity index, similarity matrices were calculated and used to perform a Cluster analysis and non-metric multidimensional scaling (nMDS) ordination. The SIMPER analysis was carried out to investigate dissimilarities between year groups.

Results - A total of 92 crustacean taxa belonging to the orders Decapoda and Stomatopoda were collected from 1995 to 2024 (Tab. 1).

Tab. 1 – Identified taxa in the period 1995 – 2024 and their depth range of occurrence, sorted by F %.
Taxa identificati nel periodo 1995 – 2024 e relativo range batimetrico, ordinati in base alla F %.

Taxa	F%	Depth (m)
Parapenaeus longirostris (Lucas, 1846)	50,24	711-39
Polycheles typhlops (Heller, 1862)	49,03	779-216
Plesionika martia (A. Milne-Edwards, 1883)	47,18	779-115
Aristeus antennatus (Risso, 1816)	37,46	774-288
Aristaeomorpha foliacea (Risso, 1827)	37,07	779-243
Nephrops norvegicus (Linnaeus, 1758)	29,15	736-43
Pasiphaea sivado (Risso, 1816)	28,62	769-99
Pasiphaea multidentata (Esmark, 1866)	27,26	769-287
Solenocera membranacea (Risso, 1816)	27,16	741-48
Polybius depurator (Linnaeus, 1758)	23,76	764-12
Chlorotocus crassicornis (A. Costa, 1871)	21,77	736-85
Plesionika heterocarpus (A. Costa, 1871)	20,94	695-44
Macropipus tuberculatus (Roux, 1830)	20,41	729-18
Eusergestes arcticus (Krøyer, 1855)	17,98	769-213
Plesionika gigliolii (Senna, 1902)	17,44	684-151
Aegaeon lacazei (Gourret, 1887)	16,33	772-29
Plesionika acanthonotus (Smith, 1882)	16,18	764-235
Bathynectes maravigna (Prestandrea, 1839)	15,89	769-115
Robustosergia robusta (Smith, 1882)	15,35	772-232
Iridonida speciosa (von Martens, 1878)	13,90	736-89
Plesionika edwardsii (Brandt, 1851)	10,40	668-114
Processa canaliculata (Leach, 1815)	10,20	660-110
Monodaeus couchii (Couch, 1851)	10,16	764-25
Plesionika antigai (Zariquiey Álvarez, 1955)	9,77	648-107
Paromola cuvieri (Risso, 1816)	8,11	767-91
Calappa granulata (Linnaeus, 1758)	8,02	666-13
Squilla mantis (Linnaeus, 1758)	7,77	323-12
Goneplax rhomboides (Linnaeus, 1758)	7,63	720-12
Geryon longipes (A. Milne-Edwards, 1882)	7,48	774-271
Pontophilus spinosus (Leach, 1816)	5,88	734-13
Pagurus alatus (Fabricius, 1775)	5,73	720-14
Medorippe lanata (Linnaeus, 1767)	5,25	686-21
Dardanus arrosor (Herbst, 1796)	4,71	605-14
Plesionika narval (Fabricius, 1787)	4,57	656-52
Munida intermedia (A. Milne-Edwards & Bouvier, 1899)	4,23	725-267
Spinolambrus macrochelos (Herbst, 1790)	4,13	736-13
Pagurus spp.	3,98	764-20
Processa spp.	3,64	571-124
Aegaeon cataphractus (Olivi, 1792)	3,50	342-13
Rissoides pallidus (Giesbrecht, 1910)	3,45	615-25
Macropodia rostrata (Linnaeus, 1761)	3,35	651-20
Munida tenuimana (G.O. Sars, 1872)	2,19	631-259
Homola barbata (Fabricius, 1793)	2,14	593-23
Macropodia tenuirostris (Leach, 1814)	2,14	721-31
Inachus communissimus (Rizza, 1839)	1,99	156-12
Rissoides desmaresti (Risso, 1816)	1,94	531-142
Latreillia elegans (Roux, 1830)	1,75	711-39
Alpheus glaber (Olivi, 1792)	1,17	779-216
Anamathia rissoana (Roux, 1828)	1,02	779-115
Inachus dorsettensis (Pennant, 1777)	0,87	774-288
Munida spp.	0,83	779-243
Pseudosquillopsis cerisii (Roux, 1828)	0,68	736-43
Ligur ensiferus (Risso, 1816)	0,58	769-99
Philocheras echinulatus (M. Sars, 1862)	0,58	769-287
Acanthephyra eximia (Smith, 1884)	0,53	741-48
Munida rugosa (Fabricius, 1775)	0,53	764-12
Pisa armata (Latreille, 1803)	0,53	736-85
Acanthephyra pelagica (Risso, 1816)	0,49	695-44
Maja squinado (Herbst, 1788)	0,39	729-18
Penaeus kerathurus (Forskål, 1775)	0,29	769-213
Palinurus elephas (Fabricius, 1787)	0,24	684-151
Atelecyclus rotundatus (Olivi, 1792)	0,19	772-29
Pilumnus spinifer (H. Milne Edwards, 1834)	0,19	764-235
Scyllarus arctus (Linnaeus, 1758)	0,19	769-115
Maja crispata (Risso, 1827)	0,15	772-232
Pagurus prideaux (Leach, 1815)	0,15	736-89
Pasiphaea spp.	0,15	668-114
Pilumnus hirtellus (Linnaeus, 1761)	0,15	660-110
Plesionika spp.	0,15	764-25
Pontophilus norvegicus (M. Sars, 1861)	0,15	648-107
Scyllarides latus (Latreille, 1803)	0,15	767-91
Scyllarus pygmaeus (Spence Bate, 1888)	0,15	666-13
Ebalia nux (A. Milne-Edwards, 1883)	0,10	323-12
Erugosquilla massavensis (Kossmann, 1880)	0,10	720-12
Ethusa mascarone (Herbst, 1785)	0,10	774-271
Amalopenaeus elegans (Smith, 1882)	0,10	734-13
Inachus spp.	0,10	720-14
Neomaja goltziana (d'Oliveira, 1889)	0,10	686-21
Nematocarcinus exilis (Spence Bate, 1888)	0,10	605-14
Pisa nodipes (Leach, 1815)	0,10	656-52
Sicyonia carinata (Brünnich, 1768)	0,10	725-267
Acanthephyra spp.	0,05	736-13
Derilambrus angulifrons (Latreille, 1825)	0,05	764-20
Dromia personata (Linnaeus, 1758)	0,05	571-124
Eriphia verrucosa (Forskål, 1775)	0,05	342-13
Galathea intermedia (Lilljeborg, 1851)	0,05	615-25
Galathea strigosa (Linnaeus, 1761)	0,05	651-20
Homarus gammarus (Linnaeus, 1758)	0,05	631-259
Inachus thoracicus (Roux, 1830)	0,05	593-23
Palinurus spp.	0,05	721-31
Parthenopidae (MacLeay, 1838)	0,05	156-12
Achelous hastatus (Linnaeus, 1767)	0,05	531-142

P. longirostris, *P. typhlops*, and *P. martia* resulted the species with the highest F%. The biomass index of total crustaceans showed wide fluctuations, with no significant variations over time (Fig. 1). The relationship between the number of species (S) and depth showed a dome-shaped pattern, with the highest number of species distributed between 300 and 500 m depth (Fig. 2). Fluctuations in the different diversity indices were observed, with a statistically significant reduction over time ($p < 0,01$) of the evenness index in the slope assemblage (Fig. 3 and Fig. 4). In both macrostrata, the nMDS ordination showed differences in the structure of the assemblages between the early and last years of study. In the shelf assemblage, nMDS sorting and SIMPER analysis revealed six groups (Fig. 5a). The dissimilarity between groups was always higher than 40% with groups b and f, showing the greatest average dissimilarity of 58.47%. *P. depurator*, *P. heterocarpus*, and *P. longirostris* resulted the species best explaining the dissimilarity between the groups. Eight groups were identified in the slope assemblage (Fig. 5b), with a average internal dissimilarity that never exceeded 30%. Greatest dissimilarity was found between groups a and f, with an average dissimilarity of 28.74%. Five taxa most contributed to explain the differences between the two groups: *E. articus*, *A. foliacea*, *P. sivado*, *Processidae*, and *I. speciosa*.

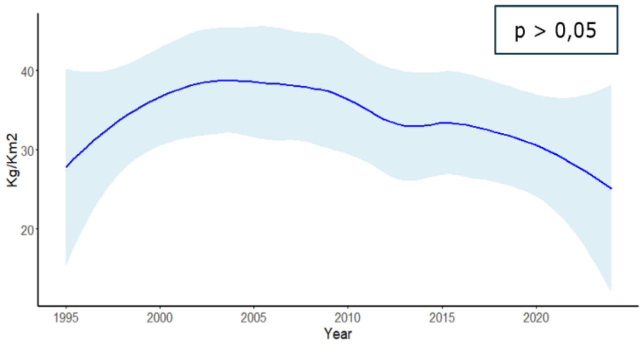

Fig. 1 - Trend of biomass index during the period 1995 - 2024.
Trend dell'indice di biomassa nel periodo 1995 - 2024.

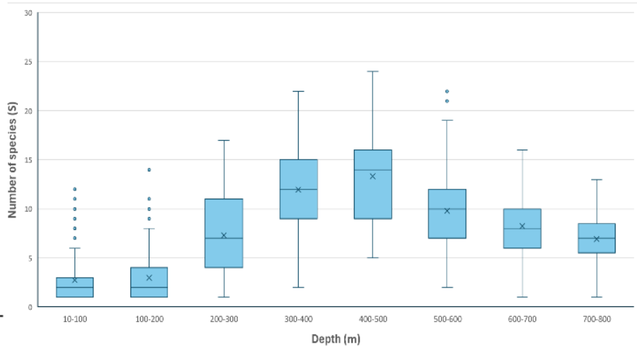

Fig. 2 - Relationship between number of species (S) and depth.
Relazione tra numero di specie (S) e profondità.

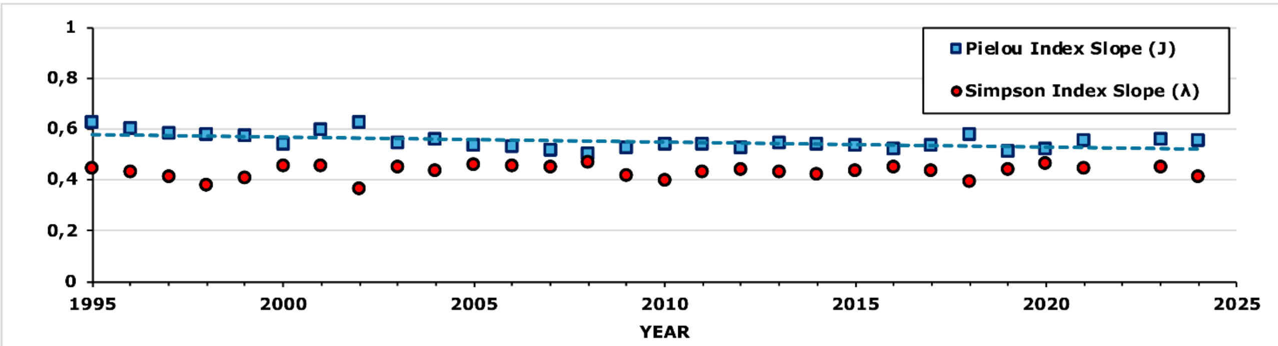

Fig. 3 - Trends of Pielou and Simpson indices on the continental slope assemblage during the study period.
Trend degli indici di Pielou e Simpson nella scarpata continentale nel periodo di studio.

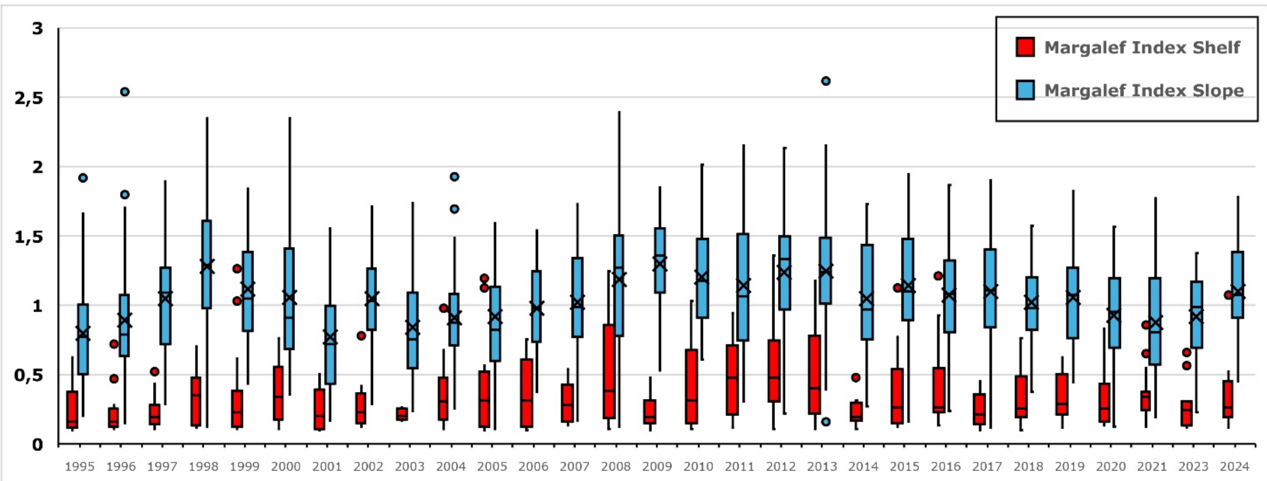

Fig. 4 – Box plots of Margalef index, computed on the continental shelf and slope during the study period.
Box plot degli indici di Margalef, calcolati su piattaforma e scarpata durante il periodo di studio.

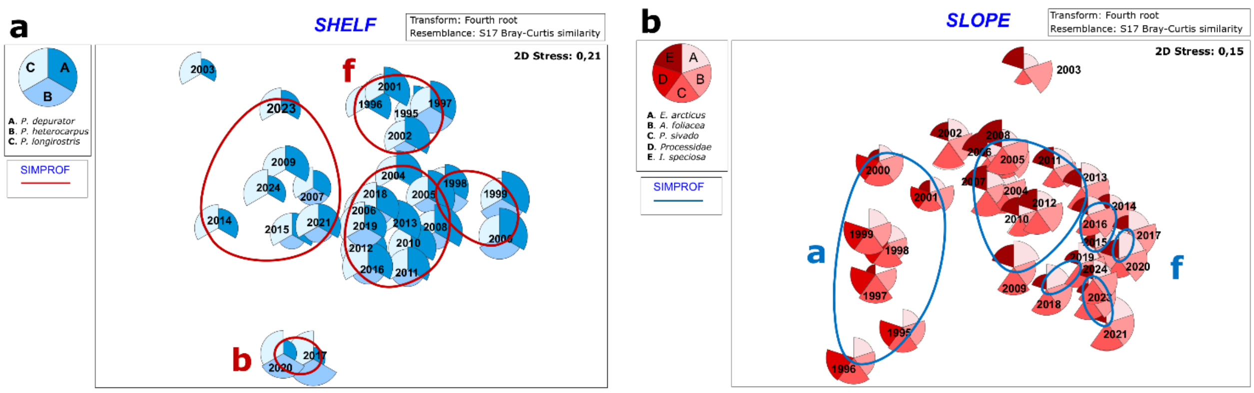

Fig. 5 - (a) Results from nMDS ordination for the continental shelf assemblage; (b) Results from nMDS ordination for the continental slope assemblage.

(a) Risultati dell'ordinamento nMDS per l'assemblage di piattaforma continentale; (b) risultati dell'ordinamento nMDS per l'assemblage di scarpata continentale.

Conclusions - This study, carried out on a long time series of data, allowed a preliminary analysis of the main temporal dynamics of the demersal crustacean assemblages in the Ionian Sea. The different patterns observed on the shelf and slope confirm the main role of the depth in the characterization of demersal communities. The assemblages analysed show overall stability over the period 1995–2024, despite the differences in their structure between the early and last years documented by the nMDS. The shelf assemblage showed a heterogeneous composition, with low values in the species richness. In contrast, the slope assemblage exhibited greater species richness and overall stability in structure, despite a significant reduction in the Pielou's evenness index, probably indicative of an unbalanced relative distribution of some taxa, with no influence on the Simpson's dominance. The decrease of fishing effort and the increase of the sea-bottom temperature in the last decades, documented in the North-western Ionian sea (Maiorano *et al.,* 2022a), could have affected the changes in both community structure and species abundance over time, as already observed for commercial resources, such as *A. foliacea* and *P. longirostris* (Sbrana *et al*., 2019; Maiorano *et al.,* 2022b). Further integrated analyses will be essential to assess the cumulative effect of potential environmental and anthropogenic drivers on the demersal associations.

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