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Spatial and temporal community composition changes of Cumacea (Crustacea: Malacostraca: Peracarida) from the soft-sediment habitats of the Mediterranean coast of Israel

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Abstract

The present study provides a zoogeographic and faunistic update on the cumacean species that inhabit the soft substrate habitats of the Israeli waters of the Mediterranean Sea. Published and new unpublished cumacean records are both used to enable an overview of a 74-year period of species composition and distribution, providing a broad perspective of temporal faunistic changes. As a result, 43 cumacean species have now been recorded from the Mediterranean coast of Israel. Previously unpublished results, starting from 2013, were derived from intensified sampling of the continental shelf and slope as well as the bathyal plain, and revealed eight new species records for the eastern part of the Mediterranean Sea. The cumacean community included species primarily of the Mediterranean zoogeographic province with several Mediterranean-Atlantic examples. Three species, postulated to be of Indo-Pacific origin were also previously recorded on the continental shelf of the area. Finally, species composition and structure of the continental shelf indicated spatial and temporal changes between 2010 – 2021, partly due to different sampling methods as well as anthropogenic activities that took place in the area. The continental slope and the bathyal plain seem to remain as relatively stable environments.

Keywords: Cumacea; Eastern Mediterranean; Lessepsian migration; soft bottom; benthos.

Introduction

Marine Cumacea (Crustacea: Malacostraca: Peracarida) inhabit a variety of soft-substrate benthic habitats (Watling & Gerken, 2023). Though they have no planktonic stage − completing their entire life cycle on the bottom (Băcescu & Petrescu, 1999) − many of them are hyperbenthic species, i.e., they are swimming, bottom-dependent macrofaunal organisms, performing seasonal or diel vertical migrations into the water column (Brunel *et al*., 1978). Therefore, cumaceans have been investigated mostly as part of hyperbenthic communities on the continental slope of the Mediterranean Sea (e.g., Reyss, 1973; Cartes & Sorbe, 1993; 1996; 1997; Cartes *et al*., 2003; Mühlenhardt-Siegel, 2009), with a few similar studies performed on the continental shelf (e.g., Koulouri *et al*., 2013; Bakalem *et al*., 2021). Cumaceans have been described from the Egyptian shelf of the Mediterranean Sea and through the Suez Canal (Calman, 1927; Steuer, 1936; 1938). In addition, cumaceans recorded in the marine waters of Greece were documented in Koulouri *et al*. (2016), while several articles described cumacean communities along the Turkish waters (Bakir & Katagan, 2005; Sezgin *et al*., 2010; Ateş *et al*., 2014). As part of the benthic macrofauna, cumaceans are also reported in many environmental monitoring programmes (e.g., Corbera & Cardell, 1995) including the Mediterranean coast of Israel (Lubinevsky *et al*., 2017; 2019). To date, Cumacea along the Israeli waters of the Mediterranean have been described by Băcescu (1961), Corbera & Galil (2001), Corbera *et al*. (2012) and Corbera & Galil (2016). A striking biogeographic feature of this coast is Lessepsian migration, i.e., the introduction of species of Indo-Pacific origin into the Mediterranean Sea via the Suez Canal (Galil, 2006). Until now, three shelf cumacean species have been postulated to be of Indo-Pacific origin along the Israeli waters of the Mediterranean (Corbera & Galil, 2007). Increasing water temperatures have been observed along the Israeli coast, rendering this region a temperature "hot spot", which has been related to localised extinction of benthic species (Rilov, 2016; Ozer *et al*., 2017).

The Israeli waters of the Mediterranean have been intensively used for a variety of anthropogenic activities, including anchorage facilities, cooling of power stations, desalination plants, sewage disposal treatment, gas exploration and production, fisheries, recreation, and military activities. As a result of all these activities, environmental biotic monitoring in the framework of governmental programmes and a variety of compliance monitoring surveys were intermittently conducted from 1990 though more regularly and intensively since 2005. These activities covered the entire Israeli Mediterranean exclusive economic zone and territorial waters at a depth range of 4-1900 m.

The present article aims at updating those cumacean species inhabiting the soft substrate habitats of the Israeli waters of the Mediterranean Sea as well as their zoogeography, community composition and distribution depth ranges up to 2021, thus providing a broad perspective of temporal faunistic changes. The study is the second in a series of studies dealing with specific taxa of macrobenthic faunal communities inhabiting the Israeli waters of the Mediterranean. The first study described the tanaidacean (Crustacea, Malacostraca, Peracarida) communities of the Mediterranean Israeli continental shelf (Lubinevsky *et al*., 2022).

Materials and Methods

Study area

The ≈190-km Israeli Mediterranean province is divided into a continental shelf (<100 m depth), continental slope (between 100-1000 m depth) and a bathyal plain (1000-2000 m depth), following Harris *et al.* (2014). Briefly, the sediment is generally sandy (>50%) up to a depth of ≈35 m, with gradually increasing silt and clay fractions between 35-80 m depth, and dominance of the clay fraction at levels deeper than those depths. The grain size mode in the muddy slope and bathyal plain ranges between 4.9-7.5 µm, decreasing towards the bathyal plain (Galil & Lewinsohn, 1981; Tom & Galil, 1991; Lubinevsky *et al*., 2017; 2019). The Israeli coast bathymetry and terrain are described in detail in Kanari *et al*. (2020) and references therein. The bottom surface terrain of the slope is divided into a northern canyon-rich steep region and a more moderate southern part. The deeper bathyal basin contains several characteristic regions: muddy waves and, folds, and channel system due to the prevailing currents which transfer the Nile's sediment supply into the region.

Collection efforts

The distribution of the Cumacea collections along the Israeli waters between 1949 to 2021 is presented in Figure 1, and is part of the macrofaunal sampling effort in the study area. The collection efforts can be classified into five spatio-temporal surveys: (1) the shelf sampling of 1949-1955 which was described in terms of sites, dates, and sampling devices by Holthuis & Gottlieb (1958). The applied sampling devices were: a 60 cm edge equilateral triangular dredge with 5 mm mesh size at the cod-end

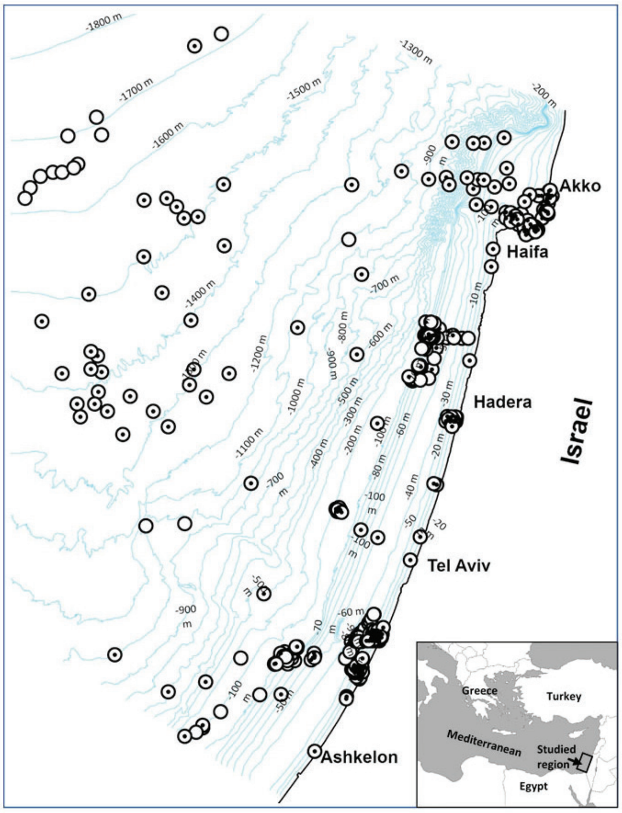

Fig. 1: Sites along the Mediterranean waters of Israel in which cumaceans were found during a series of biotic monitoring and research sampling efforts, between 1949 and 2021. Circles including black spots in their center indicate sites in which part or all cumaceans were identified to species-level. The gray areas include the sampling sites depicted in Băcescu (1961) with no exact coordinates.

and a 0.1 m^2 Petersen grab, while results concerning benthic cumaceans were documented by Băcescu (1961); (2) the bathyal plain sampling of 1998-1999, in which a plankton net of 0.5 mm mesh size was applied, fitted to the upper part of an 8 m Marinovich-type deep-water trawl, enabling the collection of hyperbenthic cumaceans as well as individuals suspended by the ground rope of the trawl (Corbera & Galil, 2001). An additional deep-sea species, *Campylaspis laevigata* was collected by a 0.0625 m^2 box corer in 2011 (Corbera *et al*., 2012); (3) the shallow shelf sampling of 2005-2021 including a variety of biotic monitoring projects, in which a 0.11 m^2 Van-Veen grab (Kahlsico model W265/SS214) was applied, sampled macrobenthic cumaceans till 2012, documented by Corbera & Galil (2016), followed by sampling effort documented by this study for the period 2013-2021; (4) the slope and bathyal sampling of 2013-2019, documented here, in which two types of box corers were alternatively applied (Ocean Instruments, San Diego, USA; BX 700 Al and BX-650 of 0.0625 m^2 and 0.25 m^2, respectively); (5) biotic monitoring efforts ranging at depths between 34 and 1763 m, which were performed (following the requirements of the Israeli Ministry of Environmental Protection) between 2012-to date by commercial environmental survey companies hired by natural gas production consortia, using a 0.25 m^2 modified Gray-O'Hara box corer and a 0.1 m^2 Smith-McIntyre grab. The identifications carried out by these companies were done mostly above species level. The results of all the above-mentioned five sampling efforts were considered as adequate, for use in the long-term monitoring of cumaceans in the Israeli waters of the Mediterranean Sea described in the present study.

The samples of these efforts were processed on a 250-µm mesh size sieve, and the >250µm residue was preserved in 99% ethanol on board. In the laboratory, the samples were stained by means of an ethanol/Rose Bengal solution of ≈1 mg/ml or by a similar eosin solution and left for at least 24 h prior to further processing. The stained cumaceans were sorted out from the sediment under a stereoscope (Nikon SMZ 1000) for their further identification to species level. The scientific names of the cumaceans used throughout the article follow the designations of the World Register of Marine Species (WoRMS Editorial Board, 2023).

Results

Approximately 76,100 cumacean individuals were sampled along the Mediterranean Israeli waters. Of these, ca. 69,760 were identified to 43 species (ca. 47,800 of them during the present study, sampled between 2013 and 2021). The cumacean material data underlying our analysis can be downloaded from the recently established Israeli biotic database named ISRAMARBIO (https://experience.arcgis.com/experience/40e86605ff4d4e5096ed2c901fec2a2f) which may also be accessed through Tom *et al*. (2023), providing operational guidelines.

The general temporal and spatial distribution patterns of the various species are described in Table 1 and Figure 2, divided into groups which demonstrate similar distri-

Table 1. Presence of cumacean species along the Israeli coasts labelled by green rectangles. NR - new record for the Israeli waters of the Mediterranean Sea; ZO: Zoogeographic origin; M: Mediterranean; AM: Atlantic-Mediterranean; IP: Indo-Pacific; C: Cosmopolitan. Number of samples is presented between parentheses. Numbers with no standard deviation designate total sampled individuals.

Species	New records	1949 1955	1998 1999	2004 2007	2008 2011	2012 2016	2017 2021	Density [ind/m^2] or total number of individuals (samples)	ZO
Bodotriidae T. Scott, 1901									
Bodotria gibba (Sars, 1878)				🟩	🟩	🟩	🟩	26.8±29 (490)	M
Bodotria pulchella (Sars, 1878)				🟩	🟩	🟩	🟩	29.9±33.4 (431)	M
Bodotria scorpioides (Montagu, 1804)					🟩	🟩	🟩	41.5±45.5 (32)	AM
Cyclaspis longicaudata Sars, 1865			🟩			🟩		10.9±0 (≥2)	AM
Eocuma rosae Corbera & Galil, 2007				🟩	🟩	🟩	🟩	31.8±53.7 (97)	IP
Eocuma sarsii (Kossmann), 1880					🟩			21.8±24.3 (10)	IP
Iphinoe crassipes haifae Băcescu, 1961		🟩						4.0 (≥1)	C
Iphinoe douniae Ledoyer, 1965				🟩	🟩	🟩		21.0±27.4 (88)	M
Iphinoe armata Ledoyer, 1965					🟩	🟩		81.6±82.4 (48)	M
Iphinoe armata/douniae							🟩		M
Iphinoe serrata Norman, 1867		🟩						2.0 (≥1)	AM
Bathycuma brevirostre (Norman, 1879)			🟩					3.0 (≥1)	AM
Cumopsis goodsir (Van Beneden, 1861)				🟩	🟩	🟩		49.8±75.9 (46)	M
Vaunthompsonia cristata Bate, 1858		🟩		🟩			🟩	9.1±0 (7)	C

Continued

Table 1 continued

Species	New records	1949 1955	1998 1999	2004 2007	2008 2011	2012 2016	2017 2021	Density [ind/m²] or total number of individuals (samples)	ZO
Diastylidae Bate, 1856									
Diastylis cornuta (Boeck, 1864)	NR					🟩	🟩	29.3±45.8 (7)	AM
Diastylis neapolitana Sars, 1879		🟩						7.0 (≥1)	M
Diastylis rugosa Sars, 1865					🟩	🟩	🟩	11.8±7.9 (46)	AM
Diastyloides biplicatus (Sars G.O., 1865)				🟩				11.4±4.5 (4)	AM
Diastyloides serratus (Sars G.O., 1865)				🟩		🟩	🟩	11.2±9.4 (19)	AM
Leptostylis sp.			🟩					5	
Makrokylindrus (Adiastylis) longipes (Sars, 1871)			🟩					5.0±0.7 (≥3)	AM
Leuconidae Sars, 1878									
Eudorella gottliebi Băcescu, 1961		🟩						15.0 (≥1)	M
Eudorella truncatula (Bate, 1856)		🟩		🟩		🟩	🟩	10.4±9.4 (19)	AM
Leucon (Crymoleucon) macrorhinus Fage, 1951	NR					🟩	🟩	9.7±10.4 (7)	AM
Leucon (Leucon) mediterraneus Sars, 1878	NR						🟩	18.7±11.3 (2)	M
Leucon (Epileucon) ensis (Bishop, 1981)			🟩			🟩	🟩	5.7±1.2 (9)	AM
Leucon (Leucon) affinis Fage, 1951	NR						🟩	6.4±2.9 (7)	M
Leucon (Macrauloleucon) siphonatus Calman, 1905						🟩	🟩	18.4±29.7 (33)	AM
Lampropidae Sars, 1878									
Platysympus typicus (Sars, 1870)			🟩					64.0 (≥1)	AM
Nannastacidae Bate, 1866									
Campylaspis glabra Sars, 1878		🟩		🟩	🟩	🟩	🟩	21.6±27.7 (419)	AM
Campylaspis laevigata Jones, 1974			🟩			🟩		3.0 (≥2)	AM
Campylaspis rostrata Calman, 1905	NR						🟩	4.0±0 (1)	C
Campylaspis sulcata Sars, 1870	NR						🟩	6.1±2.9 (2)	AM
Campylaspis vitrea Calman, 1906	NR						🟩	7.2±3.9 (2)	AM
Cumella (Cumella) limicola Sars, 1879				🟩	🟩	🟩	🟩	18.4±11.0 (22)	M
Cumella (Cumella) pygmaea G.O. Sars, 1865			🟩		🟩			9.1±0.0 (2)	AM
Procampylaspis armata Bonnier, 1896			🟩			🟩		5.5±0.0 (≥2)	M
Procampylaspis bonnieri Calman, 1906			🟩				🟩	7.2±3.7 (4)	AM
Procampylaspis mediterranea Ledoyer, 1988			🟩					3.0 (≥1)	M
Scherocumella gurneyi (Calman, 1927)				🟩	🟩	🟩	🟩	40.0±71.9 (57)	IP
Scherocumella longirostris (Sars, 1878)				🟩	🟩			18.2±15.7 (3)	M
Styloptocuma gracillimum (Calman, 1905)			🟩					35 (≥1)	AM
Pseudocumatidae Sars, 1878									
Pseudocuma (Pseudocuma) longicorne (Bate, 1858)		🟩		🟩	🟩	🟩	🟩	519.6±1716.3 (1115)	C
Pseudocuma (Pseudocuma) simile G.O. Sars, 1900	NR						🟩	28±15.3 (4)	M

bution characteristics (Table 2). Considering that sampling efforts have become relatively regular and intensive at the continental shelf since 2005, the species *Bodotria scorpioides*, *B. gibba*, *B. pulchella*, *Pseudocuma longicorne*, *Campylaspis glabra*, *Eocuma rosae*, *Iphinoe* spp., *Diastylis rugosa*, *Leucon (M.) siphonatus*, *Cumella limicola*, *Scherocumella gurneyi*, *S. longirostris* and *Vaunthompsonia cristata* seem to characterize this part of the study area. Several species with few individuals seem to prefer the deeper shelf such as *Campylaspis sulcata* and *Pseudocuma simile* as well as slope such as *Diastylis cornuta* and *Eudorella truncatula*.

Sampling efforts of the continental slope and the bathyal plain have been carried out on a regular basis

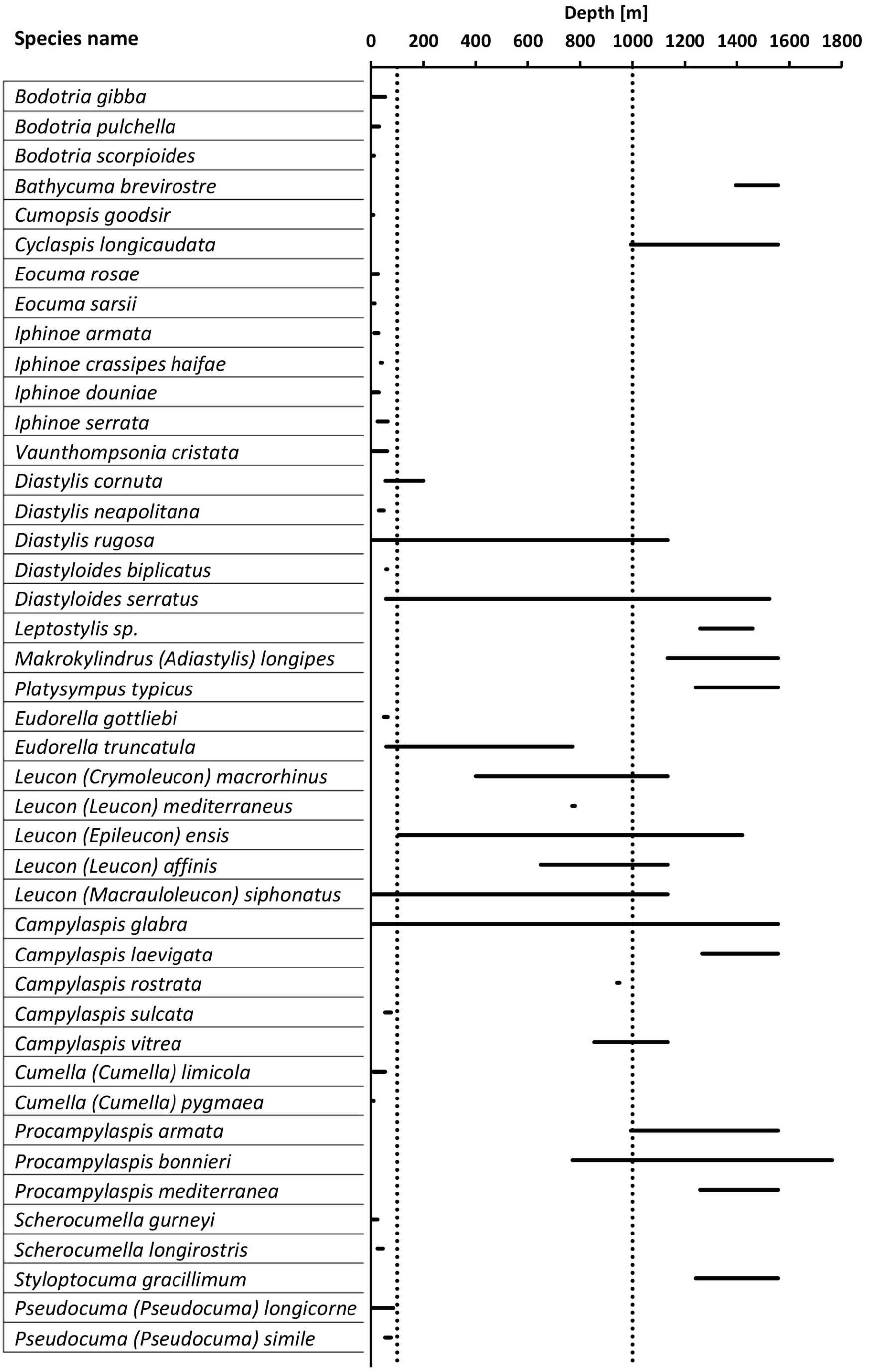

Fig. 2: Cumacean depth distribution. The vertical dotted lines designate the 100 and 1000 isobaths, respectively.

since 2013, revealing several species inhabiting these two stable environments, *Leucon (C.) macrorhinus*, *L. (L.) affinis*, *L. (E.) ensis* and *Procampylaspis bonnieri*. A few specimens of *Campylaspis rostrata* were found only on the slope of the study area, while *Macrokylindrus longipes* was found only on the bathyal plain. The species *Campylaspis glabra, Diastylis rugosa* and *Leucon (M.) siphonatus,* common on the continental shelf as well as *Diastyloides serratus* found on the deeper shelf, seem to have a broad distribution reaching the continental slope and bathyal plain.

On a temporal scale, eight cumacean species are new records for the Israeli waters of the Mediterranean Sea: *Diastylis cornuta, Leucon (C.) macrorhinus, L. (L.) affinis, L. (L.) mediterraneus, Campylaspis rostrata, C. sulcata, C. vitrea* and *Pseudocuma simile*; only the last inhabits the shelf soft substrates (Fig. 2). The shelf species *Iphinoe crassipes haifae, I. serrata, Diastylis neapolitana* and *Eudorella gottliebi* were found only during the first sampling period of 1949-1955 at a depth range of 18- 64 m via a dredge and grab sampling devices. The bathyal plain species *Bathycuma brevirostre*, *Platysympus typicus*, *Procampylaspis mediterranea* and *Styloptocuma gracillimum* were sampled only within the framework of the second sampling period of 1998-1999, probably due to the application of a plankton net adjusted

Table 2. Groups of cumacean species that share similar spatial and temporal pattern in the study area.

Line	Species names	Characterization of spatial and/or temporal pattern
1	*P. longicorne, B. gibba, B. pulchella, B. scorpioides, E. rosae, C. limicola, S. gurneyi, V. cristata*	Species inhabiting only the shelf
2	*C. sulcata, P. simile*	Species inhabiting only deeper shelf
3	*D. cornuta, E. truncatula*	Species inhabiting both shelf and slope (broad distribution)
4	*L. macrorhinus, L. affinis, L. ensis, P. bonnieri, C. vitrea*	Species inhabiting both slope and bathyal plain (broad distribution)
5	*C. glabra, D. rugosa, L. siphonatus, D. serratus*	Species inhabiting shelf, slope, and the bathyal plain (broad distribution)
6	*C. rostrata, L. mediterraneus*	Species found only on the slope
7	*M. longipes*	Species found only on the bathyal plain
8	*I. crassipes haifae, D. neapolitana, E. gottliebi, I. serrata*	Shelf species, recorded only between 1949-55
9	*C. goodsir, E. sarsii, C. pygmaea, D. biplicatus*	Previously shallow shelf species, absent during the last 5-9 years
10	*D. cornuta, L. macrorhinus, L. affinis, C. rostrata, C. sulcata, P. simile*	Species found for the first time during the last 5-9 years, only the last inhabiting the shelf soft substrates
11	*B. brevirostre, P. typicus, P. mediterranea, S. gracillimum*	Bathyal species, collected only by a hyperbenthic net during 1998-9
12	*S. gurneyi, E. sarsii, E. rosae, I. crassipes haifae*	Species of postulated Indo-Pacific origin inhabiting only the shelf, the last found only between 1949-55 and doubtful as a possible introduction through the Suez Canal

Table 3. Distribution and density of cumacean Lessepsian immigrants now present in the study area. Number of samples in parentheses.

Species name	Habitat	Temporal range [year]	Density [Ind/m^2]
Eocuma rosae	HB	2005-21	33.5±56.0 (72)
Eocuma rosae	HH	2005-12	60.4±96.0 (25)
Eocuma rosae	SC	2020	9.1 (1)
Eocuma sarsii	HB	2008-11	21.8±24.3 (10)
Scherocumella gurneyi	HB	2006-17	52.9±90.4 (34)
Scherocumella gurneyi	HH	2005-15	32.3±42.7 (9)
Scherocumella gurneyi	SC	2012-17	26.1±23.5 (9)

HB – Haifa bay; HH – Haifa harbour; SC – southern coast (Lubinevsky *et al*., 2019).

to a bottom trawl. The shelf species *Cumopsis goodsir*, *Eocuma sarsii*, *Cumella pygmaea* and *Diastyloides biplicatus* were not recorded in the study area during the last 5-9 years. Table 3 and Figure 3 show the distribution and relatively high density of the species *Scherocumella gurneyi*, *Eocuma sarsii* and *Eocuma rosae* that were previously reported as having a putative Indo-Pacific origin (Corbera & Galil, 2007; 2016; WoRMS Editorial Board, 2023). The sub-species *Iphinoe crassipes haifae* was described by Băcescu (1961) from Israeli waters and was assumed to be an immigrant of Indo-Pacific origin. However, and despite the intensive sampling carried out during the last decades, the *haifae* subspecies has never been reported again. Therefore, and according to criteria referred to Zenetos *et al*. (2022), *Iphinoe crassipes haifae* should be considered as a “questionable” or “failed introduction” species.

Discussion

The Israeli coast has been subjected to anthropogenic disturbances resulting from anchorage facilities, cooling of power stations, desalination plants, sewage disposal treatment, gas exploration and production, fisheries, recreation, and military activities. However, the species richness of cumaceans that inhabit the soft substrate habitats of the oligotrophic Israeli Mediterranean waters is revealed to be relatively high when compared with those lately recorded from other eastern Mediterranean areas (e.g., Sezgin *et al*., 2010; Koulouri *et al*., 2016). For example, the updated checklist of Cumacea of Hellenic waters in 2016 comprises 62 species, classified in 24 genera and 6 families, while 43 species, classified in 20 genera and 6 families have been identified in Israeli waters up to now. Furthermore, the faunistic composition of the continental slope and bathyal plain resembles that of the Catalan Sea (Cartes & Sorbe, 1993; Corbera & Galil, 2001).

The present study is similar to one that described

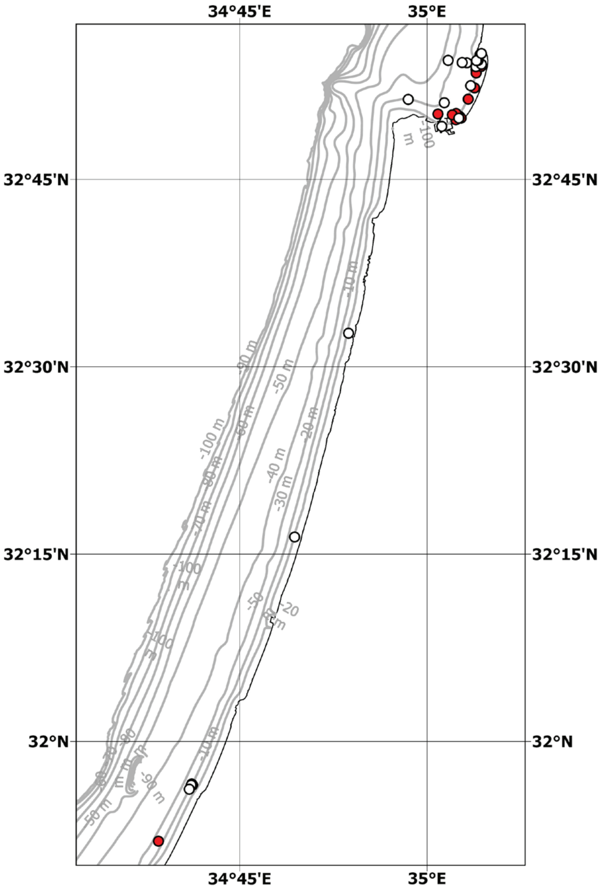

Fig. 3: Distribution patterns of the Indo-Pacific *Eocuma rosae* (red spots) and *Scherocumella gurneyi* (black outlined circles).

the temporal and spatial changes in tanaidacean species composition of the continental shelf of the study area which was based on an almost identical set of samples while covering the same period of time (Lubinevsky *et al*., 2022). A similar number of species was identified on the shelf for both orders, 28 and 27 for tanaids and cumacean, respectively. Both orders belong to the superorder Peracarida that comprises an important component of hyperbenthic (=suprabenthic) macrofauna that is usually sampled by using hyper- and epi- benthic sledges due to their swimming capacity and bottom dependence (Dauvin *et al*., 1995; Mees & Jones, 1997; Koulouri *et al*., 2003). However, benthic grabs and box corers are mostly used for environmental biotic monitoring surveys here, with a result of sub-optimal sampling of peracarids. Two cumacean community composition changes were observed in the shelf during the 74- year study period, the first being the apparent absence of several species that were recorded between 1949 and 1955 (Table 2, line 8), matching a similar change in the tanaidacean community composition. A technical reason for this apparent disappearance could be a combination of reduced sampling effort at the relevant depth range since 2005 and the additional use of a dredge during that period, apart from grabs that were and still are used in the continental shelf of the study area. Koulouri *et al*. (2003, 2013) has mentioned such differences due to relative efficiency of different sampling devices in collecting organisms characterized by different behaviour and distribution patterns. However, their actual disappearance cannot be ruled out. Moreover, the absence of several cumacean species, although found in the past, in the shelf of the study area during the last surveys (2012-2021, Table 2, line 9) and a new record of only one species (Table 2, line 10) despite the intensive (spatially and temporally) sampling effort could be attributed to the dramatic rise in surface temperature of 0.12°C per year over a period of 36 years across the entire eastern part of the Levantine basin (Ozer *et al*., 2017) and a rise of the summer peak from 29°C to 32°C during the same period of time in intertidal sites along the Mediterranean coast of Israel (Rilov, 2016). A decrease of organic carbon discharge from terrestrial anthropogenic sources at that time was reported by the Israeli Ministry of Environmental Protection.

Regarding the deep-water cumaceans, the single study published on the eastern Mediterranean included only the continental slopes of the Ionian and Aegean Seas (Reyss, 1973). Recently, Mühlenhardt-Siegel (2009) investigated cumaceans in the deep Ionian Sea and Levantine basin from the Gulf of Taranto to the coast of Israel (45-4391 m) revealing 29 species. Deep-water cumaceans of the Levantine Sea were studied for the first time in the survey that took place between 1998 and 1999, revealing 12 species (Corbera & Galil, 2001). During that study, a plankton net was fitted to a deep-water trawl, collecting bathy-pelagial fauna and also individuals suspended by the trawl's bottom sweeping rope. Since 2013, regular sampling of the slope and bathyal plain of the study area using box corers has revealed new records of the species *Diastylis cornuta, Leucon (Crymoleucon) macrorhinus, Leucon (Leucon) affinis, Leucon (Leucon) mediterraneus, Campylaspis rostrata, Campylaspis sulcata, Campylaspis vitrea*. However, several bathyal species of the study area observed during the sampling period of 1998-9 were absent from those sampling surveys which followed (Table 2, line 11), probably due to the relative efficiency of different sampling devices in collecting organisms characterized by different behaviour and distribution patterns (Koulouri *et al*., 2003). The sparse density of the eastern Mediterranean slope and bathyal plain macrofauna may also lead to under-sampling and even missed collection of certain species (Lubinevsky *et al*., 2017). No temporal series can be provided yet for these communities.

In zoogeographical terms, most of the recorded cumacean species are of Atlantic-Mediterranean and endemic origin, although three species of Indo-Pacific origin were described by Corbera & Galil (2007, 2016). *Eocuma rosae* was identified as a new species from individuals sampled in the eastern Mediterranean and indirectly assumed to have an Indo-Pacific origin due to morphological similarities with various Indo-Pacific *Eocuma* species. *Scherocumella gurneyi* was reported by Corbera & Galil (2007), and previously recorded from the Suez Canal by Calman (1927) as *Nannastacus gurneyi*. Although long established in the north-western Mediterranean, *Eocuma sarsii* was considered as a non-indigenous species in the Mediterranean Sea by Macquart-Moulin (1991) and Corbera & Galil (2016). The individuals from the Israeli coast identified by Băcescu (1961) as new sub-species, *Iphinoe crassipes haifae,* were the fourth suspected Lessepsian migrant. However, the lack of subsequent observations leads us to consider it a "questionable" species according to the criteria referring to by Zenetos *et al*. (2022).

The three first Lessepsian migrants *Eocuma sarsii*, *E. rosae* and *Scherocumella gurneyi* demonstrated similar temporal and spatial distribution patterns with the Indo-Pacific tanaidacean *Cristapseudes omercooperi*, exhibiting high densities in Haifa Bay and harbour habitats (Lubinevsky *et al*., 2022). These patterns could be attributed to the relatively high organic carbon level sites (Lubinevsky *et al*., 2019; 2022). Furthermore, several studies have demonstrated that marinas and semi-enclosed water bodies (e.g., bays) impacted by anthropogenic stressors function as hubs for the stepping-stone transfer of marine non-indigenous species (Corbera & Galil, 2016; Ulman *et al*., 2017). Temporally, *Iphinoe crassipes* and *Scherocumella gurneyi* have not been sampled since 1955 and 2018, respectively.

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