SIXTH FRAMEWORK PROGRAMME
PRIORITY 6.3
GLOBAL CHANGE AND ECOSYSTEMS

IASON

Biodiversity, hazards and threats to the stability of the SES ecosystem

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SES – The “miner’s canary”

The Mediterranean and the Black Sea, due to their small size, are sooner affected by stresses than the world ocean. It is important to gain better knowledge that will enable prediction of possible scenarios of the state of the two seas, not only for better management of SES, but also since they can be used as a model for the impacts of global change.

Biodiversity is understood as more than the number of species in an area, a conglomeration including genetic variability, species interactions and ecosystem processes: the CBD defines biodiversity as “the variability among living organisms from all sources… and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.”

Ecosystem stability is perceived as one of the advantages deriving from conservation, so to have a constant flow of benefits from the protected environment. The concept of stability, however, has been challenged.

Non-equilibrium ecology recognizes that ***intermediate disturbance*** has a positive impact, preventing few successful and highly competitive species from monopolizing communities.

Hazards and threats

Land sourced pollution

Eutrophication deriving from untreated or partially treated sewage and agricultural run offs and wastes. A recent issue is the discharge of ***antibiotics*** and ***hormones*** with sewage. Marine outfalls have polluted large swaths of the coast with ***Industrial wastes***.

Maritime pollution

220,000 vessels cross the Mediterranean annually, carrying 30% of the international sea borne trade volume and 20% of the petroleum. Accidental pollution as results of collisions or operational mishaps, and pollution stemming from the regular operation of ships, is significant (Hydrocarbons, litter, noise, aliens, antifoulant biocides).

Hazards and threats

Coastal erosion

Coastal urbanization had a great impact on the dynamics of the littoral. The damming of rivers and the extraction of sand prevent natural beach replenishment. The regression of seagrass meadows and trawling prevent the formation of biogenic deposits that buffer the impact of wave action. Increasing construction of maritime and shore structures, and even some of the engineered defenses used to counteract erosion exacerbate the problem.

Hazards and threats

Industrial fisheries

Fisheries are responsible for both direct and indirect impacts on the marine ecosystem: largely decimating populations of marine species, posing a hazard for non-target species, and causing habitat destruction.

Marine aquaculture Environmental pollution, eutrophication and habitat degradation are commonly associated with intensive fish and shellfish farming. Though most of the species used in cage farming in the Mediterranean are native to the sea (seabream, seabass, mullets), aquaculture operations are susceptible to stock loss and concern over possible deleterious **genetic impact** of escaped cultured stock on native wild populations has grown in recent years. Also much of their feed, and that of the “tuna-farms” is dependent on smaller captured fish and invertebrates, further **depleting stocks** and harming the food web.

Hazards and threats

Opportunists and invasives

Ecosystem degradation may provide conditions that favour opportunistic species (native and alien) that benefit from the reduced competition that follows habitat degradation. Eutrophication and disruption of the food web are thought to have enhanced the chances of opportunistic species and brought on **algal blooms** and **jellyfish blooms**.

Invasive alien species are increasingly seen by scientists and policy makers as one of the most significant components of global change, with far reaching and often harmful effects on biodiversity, and significant impacts on marine industries (including fishing and tourism) and human health. About 530 alien species have been recorded thus far from SES.

Hazards and threats

Global warming

Climate change is a complex issue, but even if we concentrate on a single aspect - rising Mediterranean **sea-water temperature** – there are myriad ways it will affect the biodiversity of SES. Changes in **hydrographical patterns** may enhance dispersal of some species, while restricting others, or change **nutrient distribution** that may impact local food chains.

Warmer waters may allow native **thermophilic biota** to increase its range, and since most of the **alien** species in the Mediterranean are thermophilic, originating in the tropical Indo-Pacific or tropical Atlantic, they would gain a distinct advantage over the native biota.

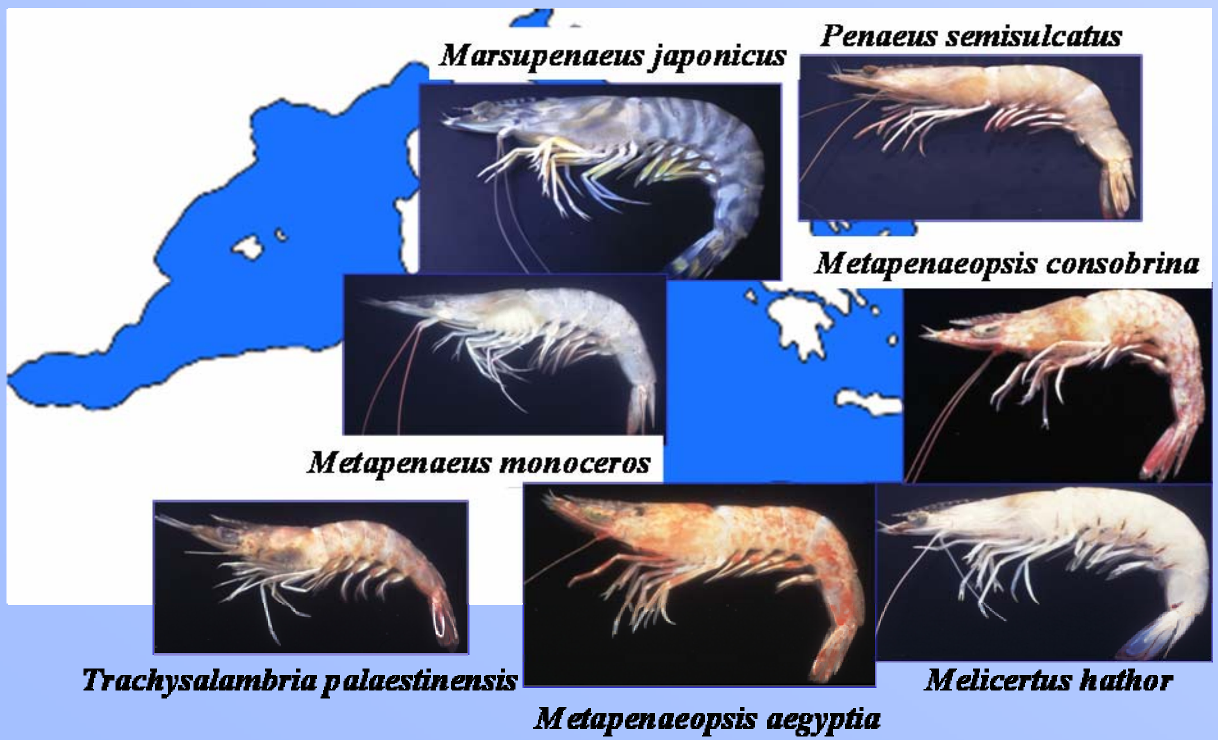
A decline in the **freshwater budget** could have a significant effect by reducing the stratification and enhancing the ventilation of the deep water layers. A reduction of the residence time of the deep waters would increase the oligotrophy of the Mediterranean. If warming augments the freshwater budget, it could increase stratification, having the opposite effects on the ecosystem. Drier conditions could further enhance coastal erosion due to reduction of sediment input from rivers and lateral transport.

Synergy

The Mediterranean Sea is exceptionally susceptible to **biological invasions**. The principal vectors of introduction are, in descending order of importance, passage through the **Suez Canal, mariculture, shipping**, and the **Atlantic influx**.

A **warming** of the sea, possibly combined with degraded habitats and anthopogenic-induced food-web changes, allow alien opportunistic biota to spread widely. Erythrean species are found as far west as Sicily and Tunisia, and beyond, whereas some tropical Atlantic aliens, like *Percnon gibbesi*, have reached the Levantine Basin. The recent EMT demonstrated how hydrological changes induce range expansions – of both warm water native and alien biota.

The loss of marine biodiversity is of major concern, though **no extinction** of native species because of an alien has been recorded.
Yet biodiversity is not a simple arithmetic. Local population losses and niche contraction may not induce immediate extirpation, but they augur reduction of genetic diversity and increase the risk of **decline and extinction**.
Range **expansion** of aliens and range **contraction** of natives result in graduate transition to **alien-dominated** communities and **biotic homogenization**.
It is important to identify and understand present patterns of **homogenization**, as well as their underlying mechanisms, for insight into their potential consequences.



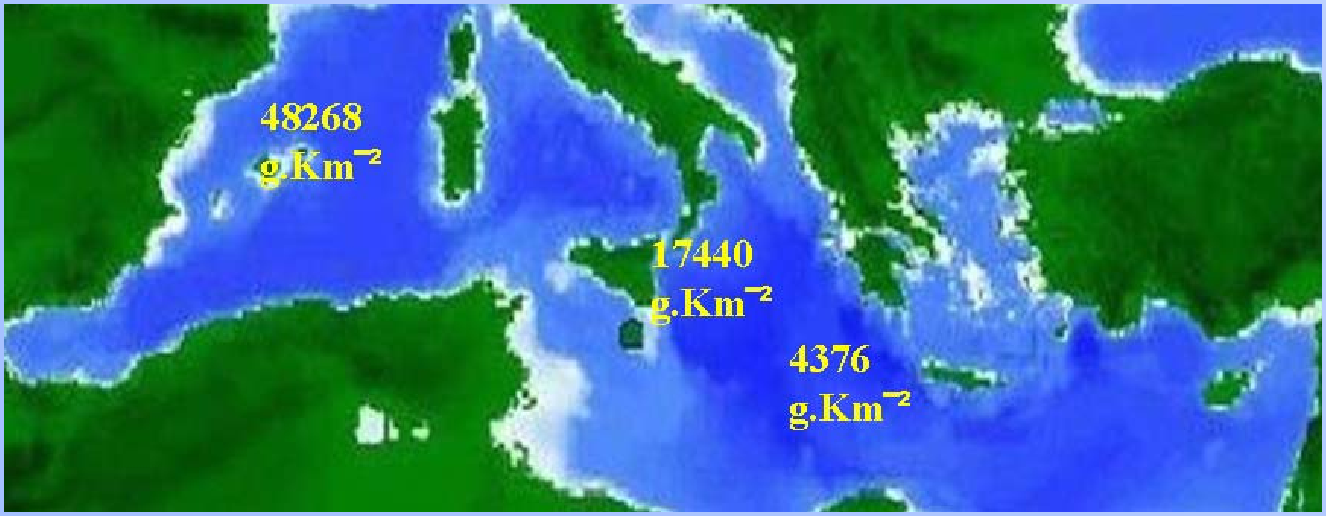
Too little is known on the inter-relationships of native and invasive biota in SES to demonstrate direct competition leading to niche limitation, displacement or extirpation.
The documented instances of concurrent changes in abundance, where populations of native Mediterranean species have been outcompeted wholly or partially displaced from their habitat space by an alien could be attributed to competition for different resources or direct interference between the newcomers and the native species, as part of a **profound anthropogenic alteration** of the marine ecosystem through habitat destruction, pollution, and rising sea-water temperature.

We need to provide a coherent and robust knowledge base for **prediction of future losses of regional distinctiveness.**

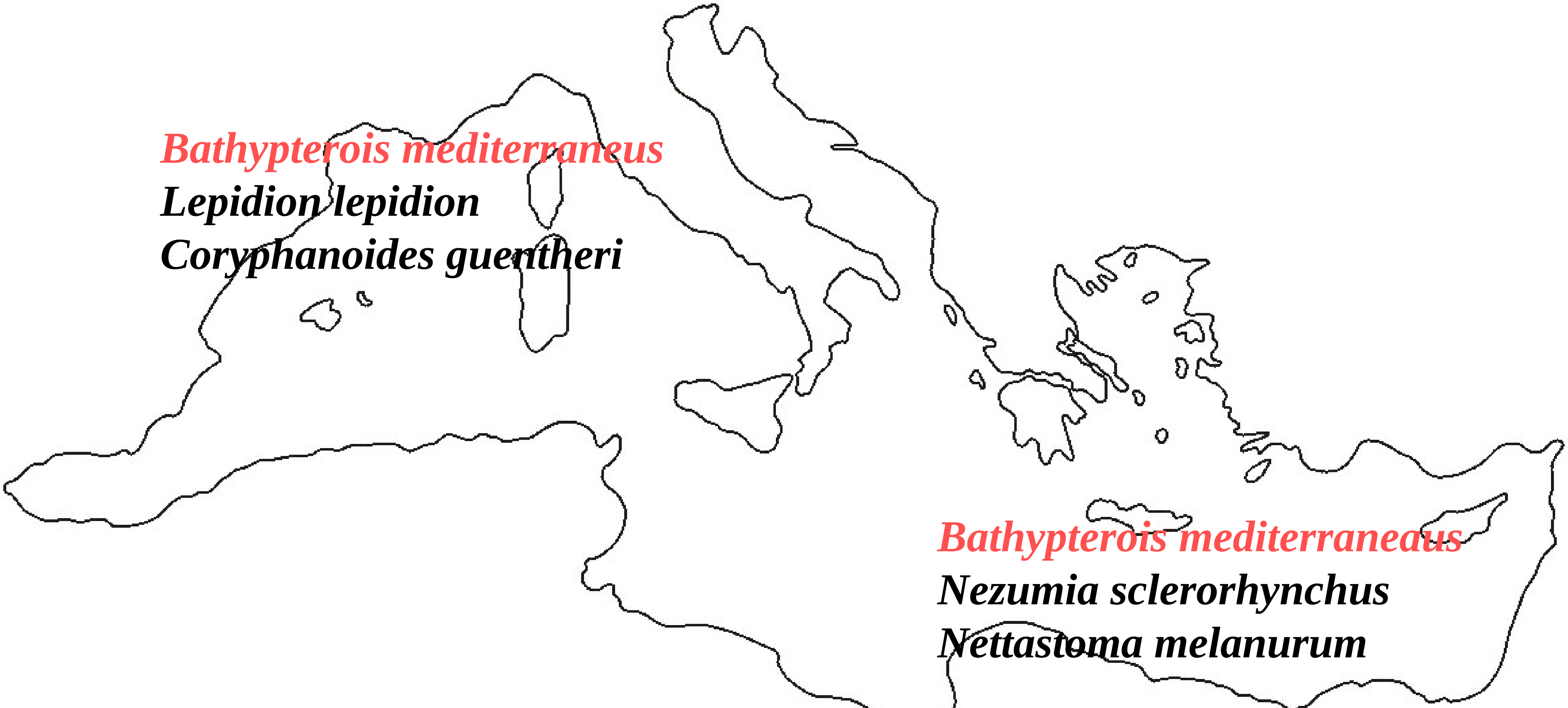
The Mediterranean Deep Sea – too little, too late?

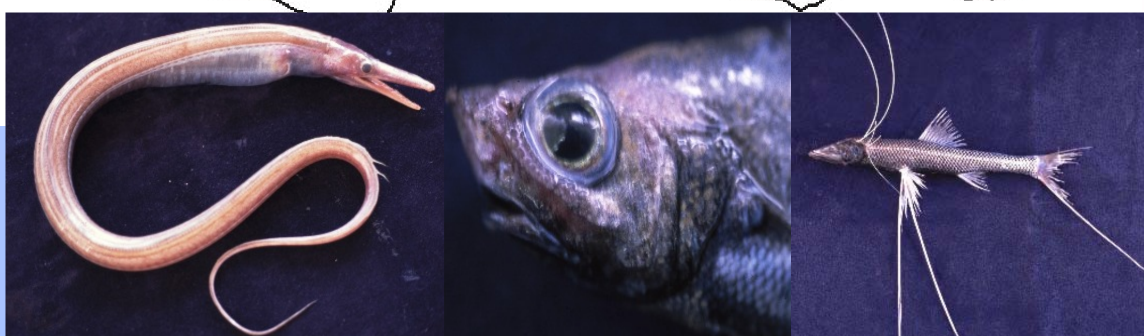
The uniqueness of the Mediterranean deep biota – history and hydrography combined to produce interesting communities, with high level of putative endemism.

"The floro-faunistic impoverishment of the eastern Mediterranean compared with the western Mediterranean richness in species" (Sarà, 1985) has been generally accepted, as well as the perception of a **gradational decrease** from west to east that is more conspicuous for the deep benthos than for the whole fauna (Fredj and Laubier, 1985): a survey of the biota of the Balearic basin, and the Western and Eastern Ionian Sea, at depths between 1000 and 1500 m, has shown that the biomass of demersal decapods was 48268, 17440 and 4376 $g.Km^{-2}$ respectively (Company *et al*., 2004).



Recent studies revealed that the EM bathyfaunal scarcity may cause different parceling of the populations that is reflected in **bathymetric distributions** that differ from those of the western Mediterranean deep water assemblages. Already Marenzeller (1893) reported that species **occur deeper in the Levant than elsewhere in the Mediterranean**.


Bathypterois mediterraneus
Lepidion lepidion
Coryphanoides guentheri
Bathypterois mediterraneaus
Nezumia sclerorhynchus
Nettastoma melanurum



Aristeus antennatus
Acanthephyra eximia
Pontophilus norvegicus
Stereomastis sculpta
Munida tenuimana

Polycheles typhlops
Acanthephyra eximia,
Aristeus antennatus
Geryon longipes

The onset of the warm **homothermy** led to the demise of many cold stenothermic and stenohalinic species and the eventual **impoverishment** of the bathybenthos. The recurring **stagnant** Quaternary episodes resulted in a reduction, or **extinction** of deep bottom-living fauna unable to avoid annihilation by adapting to shallower depth.
Bacescu (1985) believed that the bathyal bottoms of the Levant are still “unfavourable”, or even “azoic”, after the last sapropelic event, dated between 9000 and 6000 years BP, and George and Menzies (1968) suggested “that sufficient time has not elapsed to allow colonization of the deep-sea floor”.

What would be the possible impacts of global warming on the Mediterranean deep sea?

Better knowledge is urgently needed

Topographically and hydrologically isolated, surrounded by dense coastal populations, subjected to intense fishing, fast-growing maritime traffic, the Mediterranean deep sea may be among the most heavily impacted deep sea environments worldwide.

WP 2: ECOSYSTEM FUNCTIONING

D2.1: Biodiversity and ecosystem functioning in the Black Sea

Biotic shifts in the Black Sea

The temporal subdivision of the history of the Black Sea is:

(i) a pristine period, high diversity (60-70-ies);

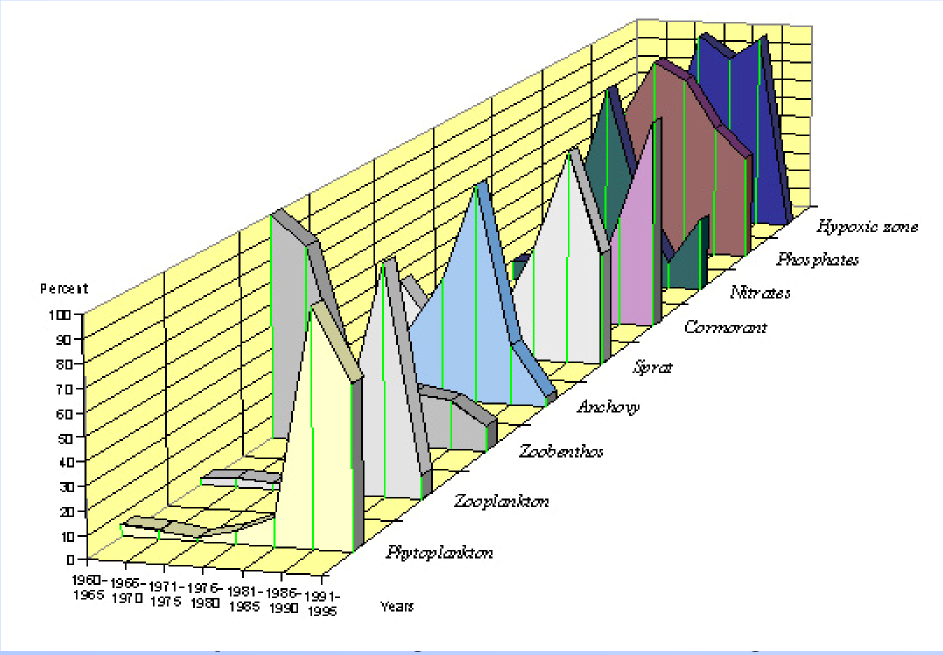
(ii) period of *Aurelia aurita* expansion (70-80-ies);

(iii) late 80s-90s - recognized as “*Mnemiopsis* era”

(iv) a contemporary phase- the period after 1997, when the ctenophore *Beroe ovata* reached the Black Sea,and

(v) the 2000-2005 with signs of biodiversity recovery (Kamburska et al, 2002, Gommoiu, 2006, Mee, 2006, Alexandrov, 2006).

After Alexandrov, 2006



time were recorded in the NWBS again

Species extinctions

BLACK SEA RED BOOK

All species (160)
Plante (43), Crustaceae (29), Pisces (41), Mammalia (6)
......

PHYLLUM	BAVARU 1977	VASILIU 1976-1995	BOLOGA & SAVA 1996-2005
Chlorophyta (green algae)	31	22	16
Phaeophyta (brown algae)	14	9	5
Rhodophyta (red algae)	41	24	10
TOTAL	86	55	31

Biocenoses replacement

Ostrea edulis, **edible oyster** Black Sea oyster population is almost completely destroyed by predator **Rapana venosa** whelk and protozoan parasite **Bonamia**
Crassostrea gigas, instead of disappearing edible oyster *Ostrea edulis*

The meaning of biodiversity- How many species we can loose?

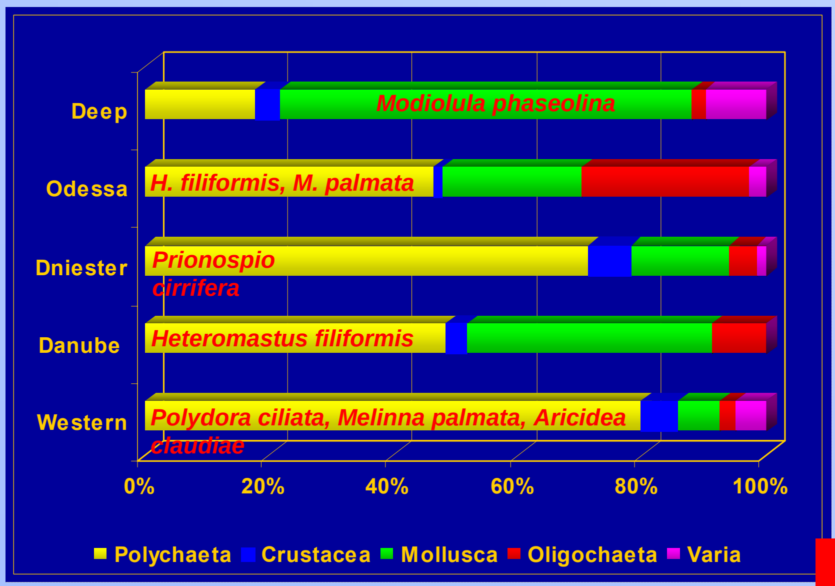
Biodiversity should be preserved like a Mozart concerto score is conserved. How many notes can be deleted before it starts loosing its meening?

Kunin W.E., Lautwtan G.H., 2004. Biodiversity: a biology of numbers and difference.

Monachus monachus (Hermann, 1779)

Increase of species diversity-stability vs instability

ABUNDANCE STRUCTURE



V. Todorova, 2005

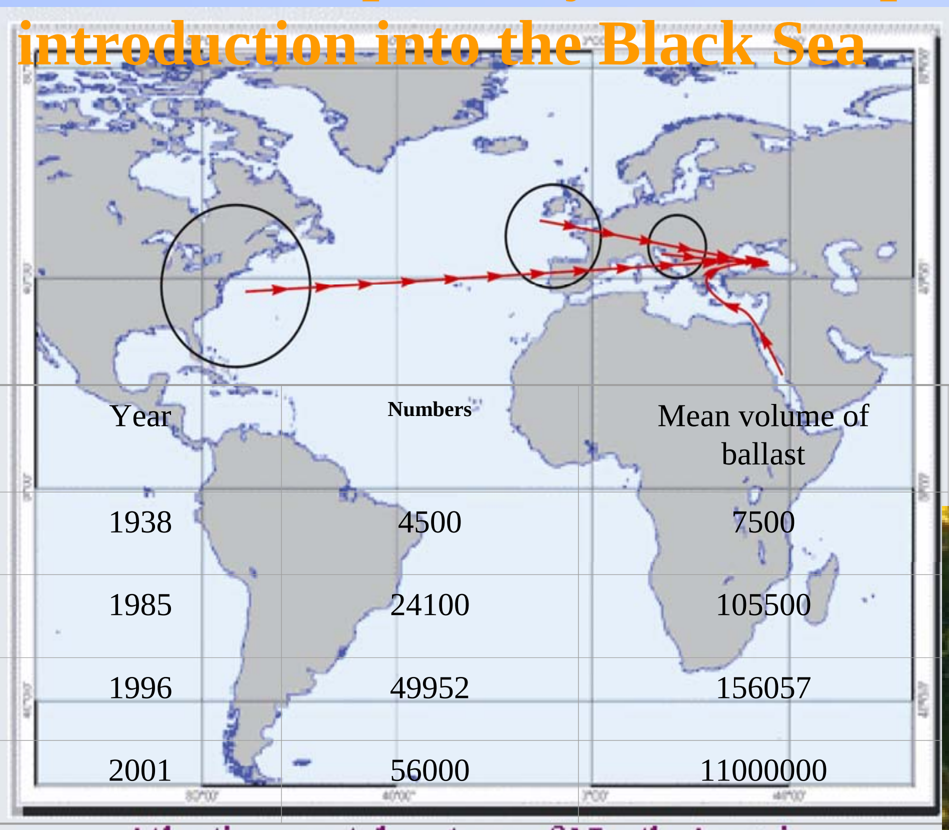
Main groups	before 1965	after 1965	Totally
Fungi	6	70	75
Phytoplankton	360	635	776
Infusorians	27	169	189
Zooplankton	155	165	185
Macrophytobenthos	273	193	275
Meiobenthos	33	246	255
Macrozoobenthos	330	305	423
Parasites	170	169	207
Fish	124	121	126
		2073	**2511**

increase by 30 %
(about 400 species)

Alexandrov, 2005

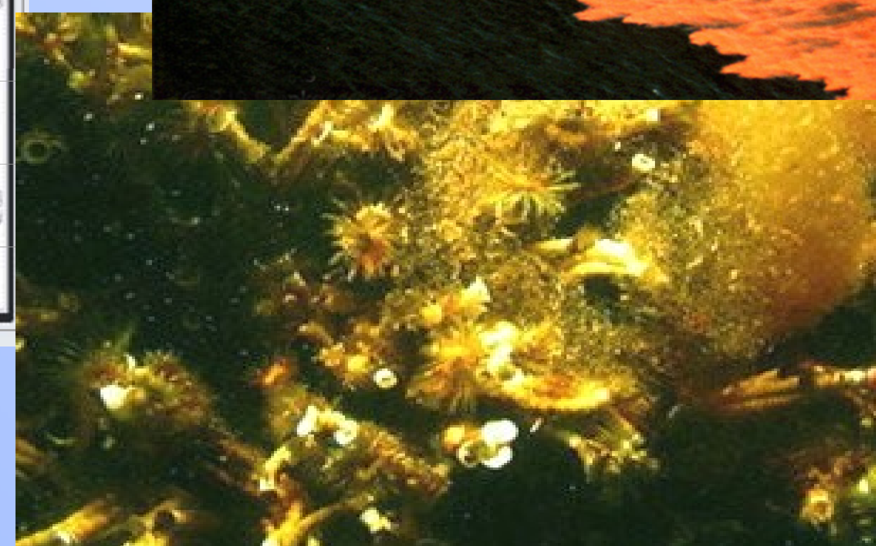
Gelatinous species in the Black Sea and the story of Mnemiopsis

Vectors and pathways of alien species introduction into the Black Sea



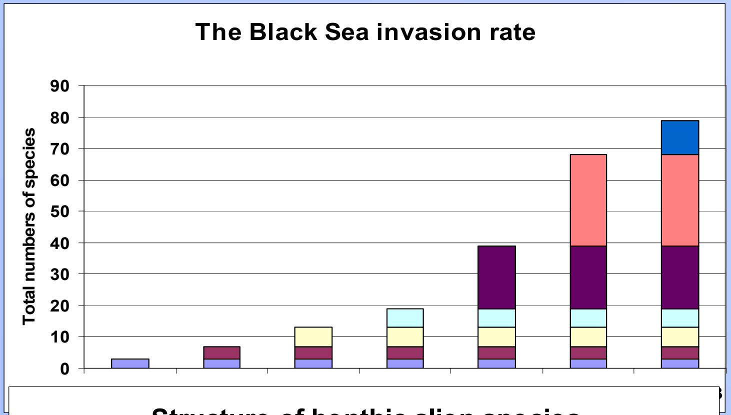
Year	Numbers	Mean volume of ballast
1938	4500	7500
1985	24100	105500
1996	49952	156057
2001	56000	11000000

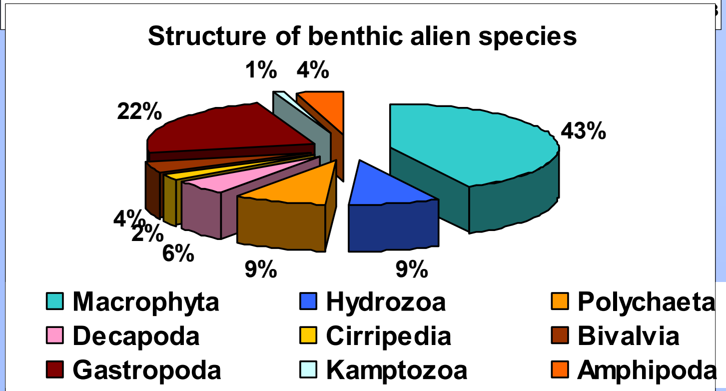
Numbers and volume of vessels passing Bosphorus (after Shiganova T. unpublished)

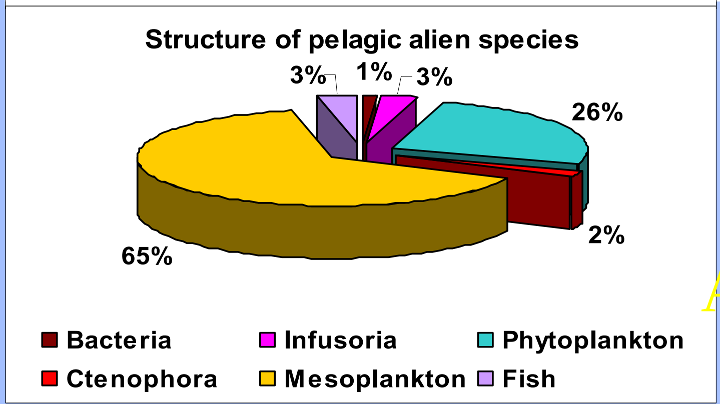


Alien species

Since 1960 the rate of invasions increased more than 10 times, recently in average 3-4 species/ year

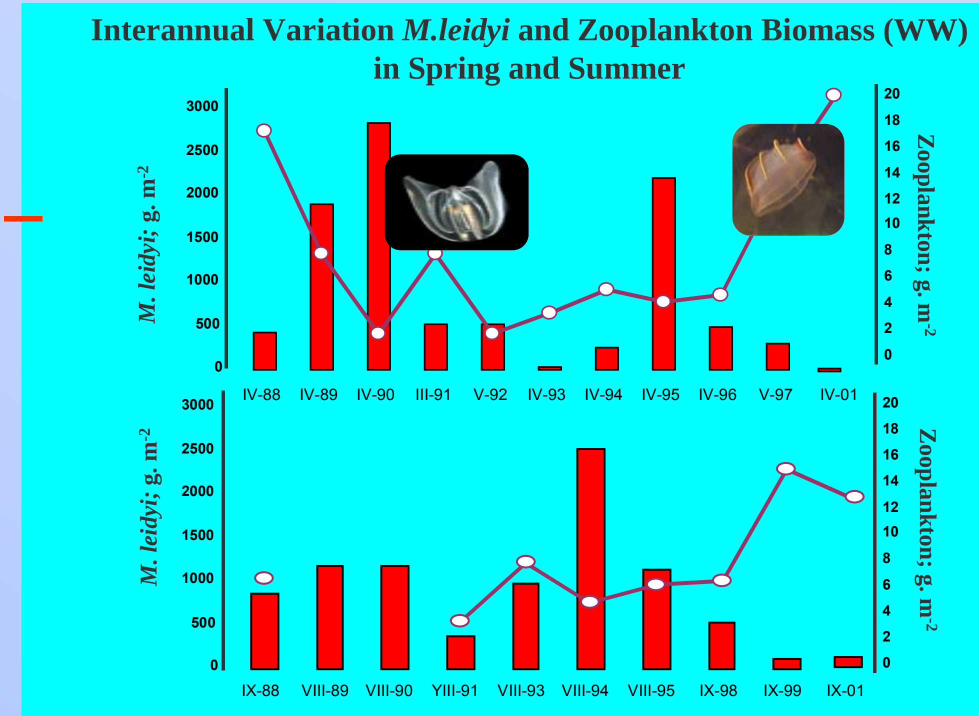






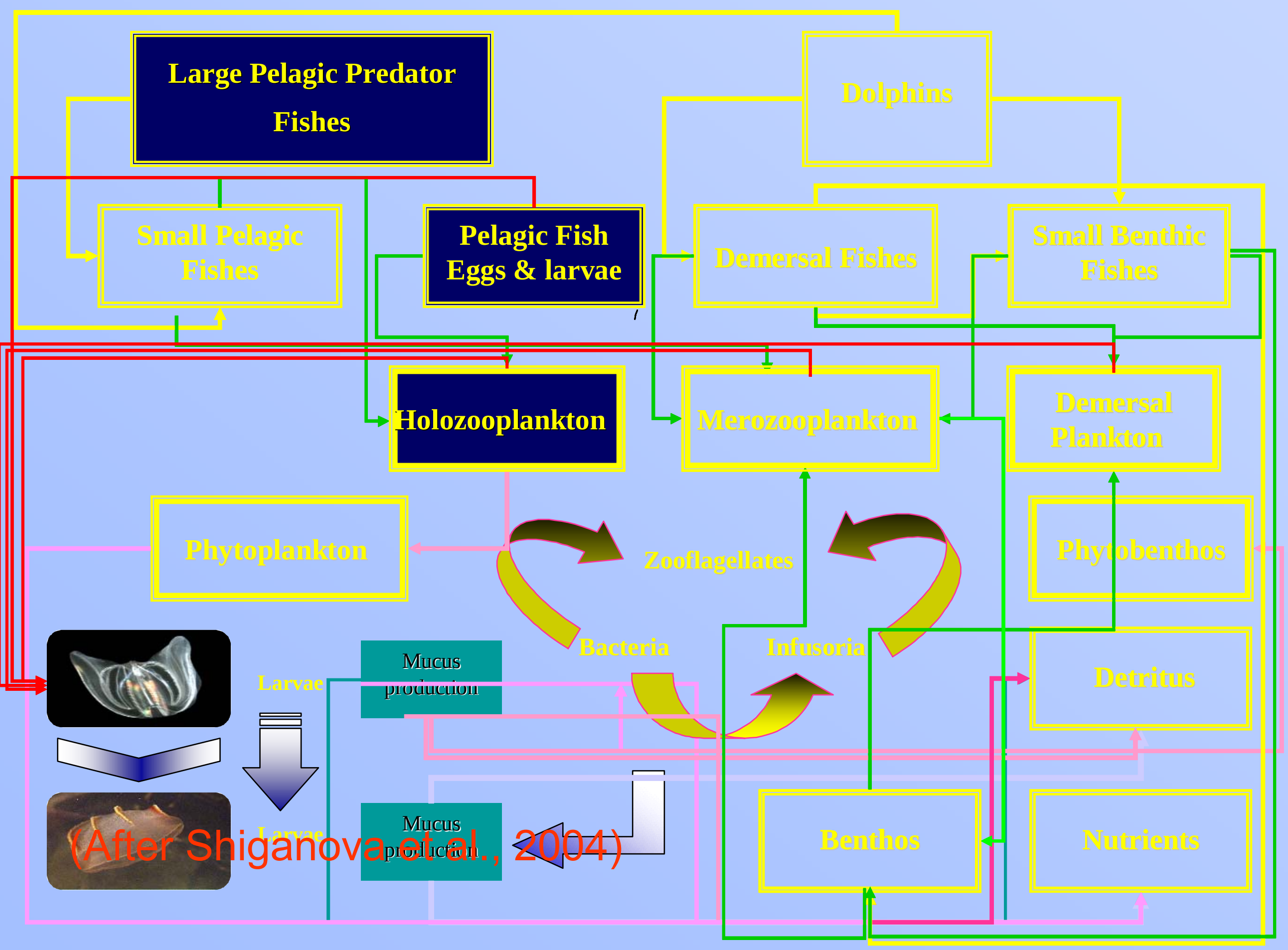
After Shiganova T. (unpublished)

Economical loss for fisheries – 250 mil $



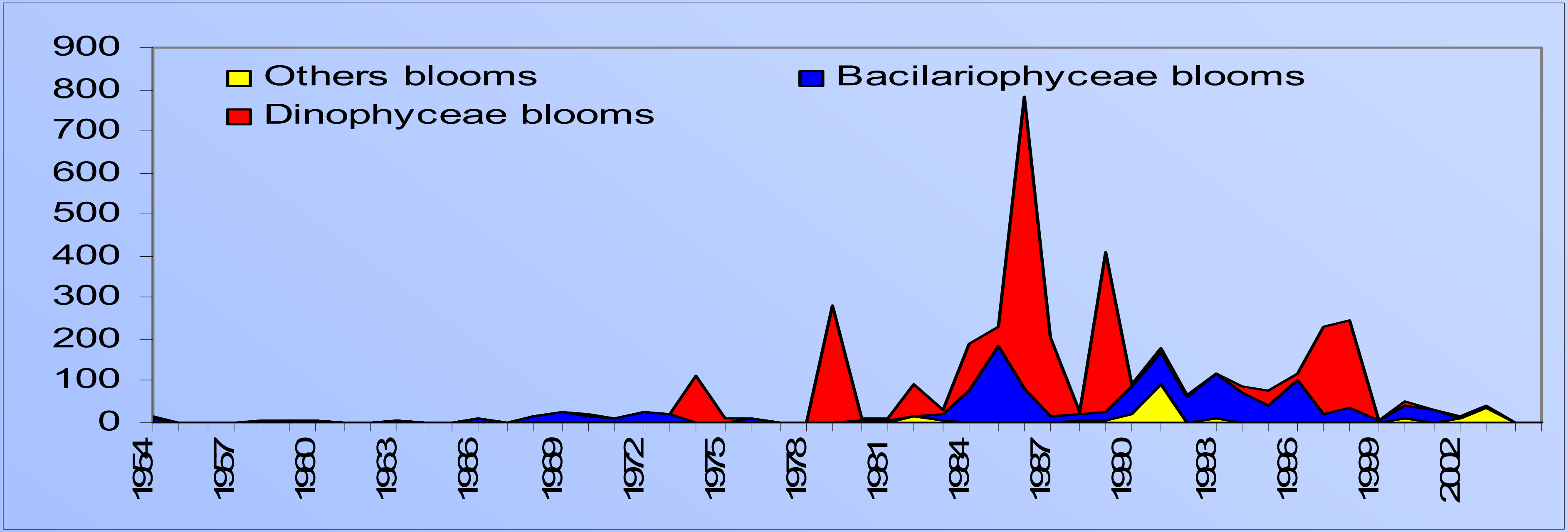
Mnemiopsis was suggested one of the key factors for the adverse changes in the planktonic community structure, leading to the collapse of fisheries in the whole basin (Mutlu, 2001; Shiganova et all, 2001, Kideys, 2002).

Cascading effect of Mnemiopsis (bottom up and top-down) in the Black Sea



M. leidyi naturalization in the Black Sea ecosystem reached in spring 1988 a biomass of 20 to 60 g m-2 and in the central part as high as about 1 kg/m-2 (Vinogradov et al. 1989, while in summer 1990, in several coastal zones (Anapa and Bulgaria) its biomass amounted to 10 to 12 kg m-2, and up to 1,5-3 kg m-2 in the open sea.

Red tides, Harmful Algal Blooms



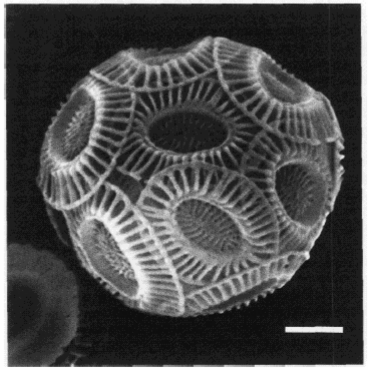


Fig. 1. *Emiliania huxleyi.* Scanning electron micrograph of a C cell from a culture of the Scandinavian coastal clone SC 91. Scale bar 1 µm.

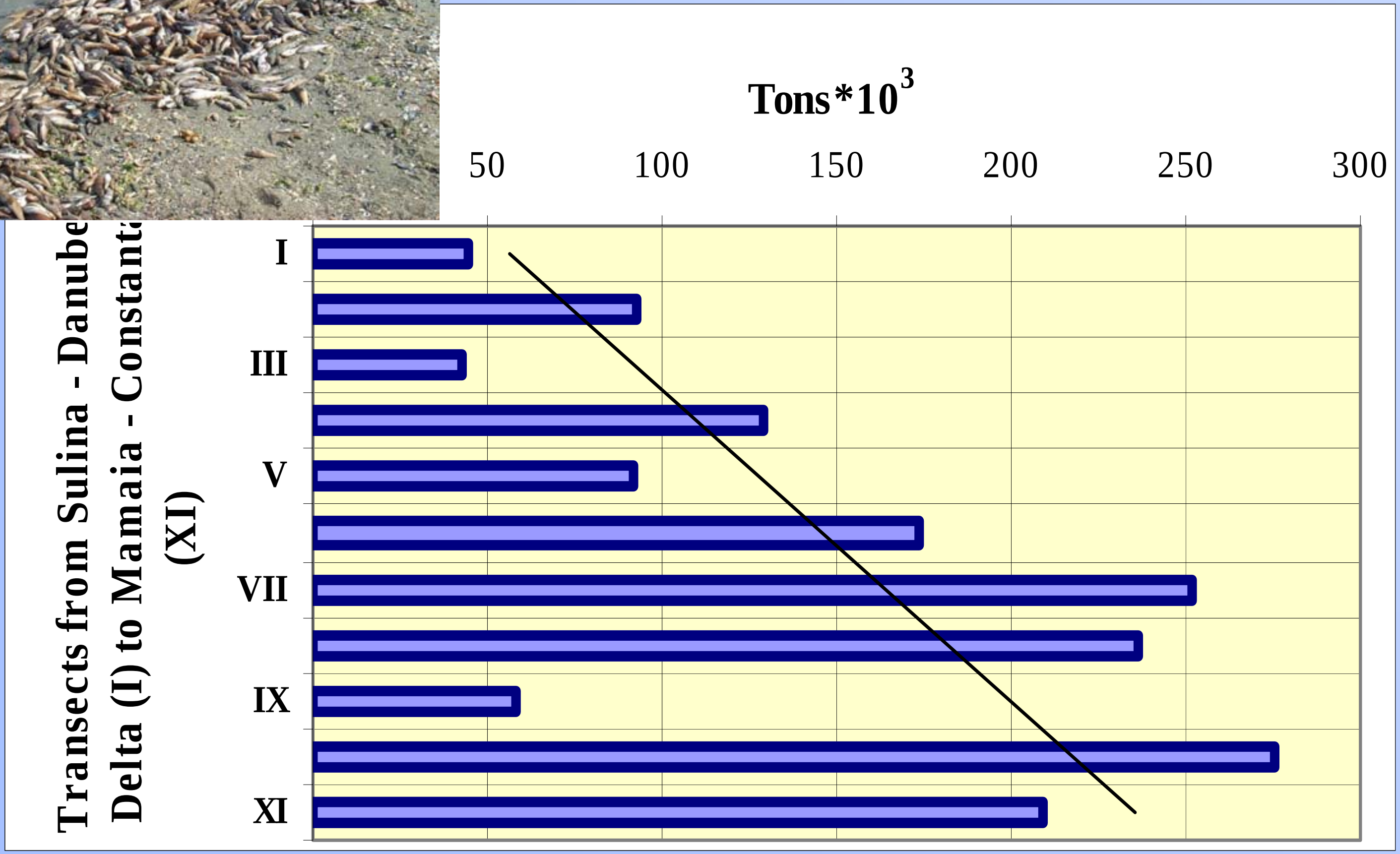
Decrease in number and duration

Decrease of abundance and biomass

Shifts in the taxonomic structure

Short-term events-long-term consequences

Spatial distribution of *Mya arenaria* losses by mass mortality at the Romanian Black Sea coast.



Gommoiu, 2005

We need

To work in **closer cooperation with physical oceanographers** to better understand how changes in the thermohaline circulation that determines the biogeochemical characteristics of the marine ecosystem affect the biota, at present and in future scenarios.

To Improve the **understanding of ecosystem functioning**. Basic research on biodiversity and ecosystem functioning is vital to our understanding of change. Parts of SES are almost unexplored in terms of biodiversity. The list of habitat types is far from being representative, and the present categorizations are largely dependent on the expertise of those who formulated them. The mapping of the distribution of both species and habitats is incomplete. The gaps in knowledge are even greater when functional aspects are considered.

Biodiversity inventories, with the publication of faunas and floras, and the test of hypotheses on **ecosystem functioning**, based on experimental work, are essential to build up a basic knowledge on the "normal" functioning of ecosystems.