GLOBAL CHANGE AND ECOSYSTEMS

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MARINE LIVING RESOURCES

SECTION 1

FISHERIES

I. THE BLACK SEA

Despite its relatively large surface area and water volume, only a thin surface layer (about 10% of the average total depth) of the Black Sea supports marine life. Hydrogen sulphide is present in the entire lower layer below depths of 150 to 200 m making it the world's largest anoxic basin. Such anoxic conditions, exaggerated by limited water exchange with the Mediterranean, make the Black Sea extremely vulnerable to anthropogenic effects.

Degradation of the Black Sea that was experienced most dramatically since the 80s is both an ecological and an economic problem. The main ecological problems of human origin are inflows of nutrients, resulting in eutrophication; the loss of higher trophic level predator species, which has altered food web structure; the introduction of exotic species, especially the jellyfish *Mnemiopsis leidyi*; and modifications in river flow regimes, which have affected the salinity of the Black Sea and had other effects. As a result, the Black Sea fishery is suffering from major reductions in catches, losses of key species as commercially exploitable populations, etc. There was a dramatic decline in landings from some 850,000 (762 000) in the mid-80s to a low of 250,000 (201 000) tons in 1991, since when some recovery is evident. However, the economic return has not restored because the main improvement is primarily in the low-value anchovy stock while higher valued species have remained depressed or the recovery is slight.

1. STOCK ASSESSMENTS CONDUCTED IN THE REGION

The stock assessments carried out by the riparian countries in the Black Sea for particular marine living resources have been as follows:

Bulgaria

► anchovy, sprat, whiting, pontic shad, turbot, spiny dogfish applying VPA analysis;

► spawning biomass of anchovy and horse mackerel by the daily egg production method (DEPM);

► eggs, larvae and juvenile abundance of anchovy and horse mackerel through ichthyoplankton syrvey.

Georgia

► sprat, whiting, spiny dogfish by trawl survey;

► anchovy – hydroacoustic method by VPA;

► blue mussel and sea snail by dredging

Romania

► sprat, turbot, whiting and dogfish by swept area method;

► spawning biomass of anchovy and horse mackerel by daily egg production method (DEPM);

► stock of Caspian shad, common kilka, sand smelt by surplus production models; gobiidae

► eggs, larvae and juvenile abundance of sprat, whiting, anchovy and horse mackerel through ichthyoplankton survey

Russia

► Sprat, whiting, horse mackarel, red mullet, spiny dogfish, turbot, common stingray, thornback ray by trawl survey

Turkey

► Anchovy, horse mackerel - acoustic method

►Spiny dogfish, common stingray, thornback ray, turbot, whiting, red mullet, gobies, European flounder – swept area

►Sea snail - VPA

Ukraine

► Russian sturgeon, spiny dogfish, turbot by trawl survey,

►Whiting by Ricker's modified method

►Thornback ray, turbot by Baranov's modified method

►Spiny dogfish by dynamic model

1.1. Methods

To assess the resources of the most intensively exploited fish species in the Black Sea annual assessments of the commercially important fish species are required. However, such regularity remains more as wish and recommendation at present. The stock assessment is to be a base for defining the total allowable catches (TAC) upon eventual quoting of the catches. Following the requirements of the Advisory Group on the Environmental Aspects of the Management of Fisheries and other Marine Living Resources (AG FOMLR) to the Permanent Secretariat of the

Black Sea Commission in Istanbul, recently a decision has been taken with the agreement of all Black Sea countries referring the application of certain methods for the assessment of fish population resources.

1.1.1. Pelagic stocks

Virtual Population Analysis (VPA), hydroacoustic and ichthyoplankton surveys (Daily Egg Production Method, DEPM) have been recommended as most appropriate methods.

The results obtained by VPA have been used for estimating the contemporary state of stocks, forecasting the magnitude of catches, spawning biomasses and numbers of recruitment for fixed values of the coefficient of fishing mortality for short periods (up to 2 yrs), with moderate continuance (5-10yrs) and for long-term/ time (equilibrium) periods. The methods allow to appraise if the stock is within the biological safety limits providing its reproduction i.e. the stock productivity not to be seriously affected by the fishery or it is out of these limits i.e. the growth and/or the recruitment abundance are appreciably affected by fishery.
The ichthyoplankton surveys are appropriate in cases when VPA is not possible to be carried out especially for the areas that are spawning grounds and where fish keep rather dispersed not forming commercial agglomerations, when fishery statistics is quite insufficient, etc. Besides, the comparatively new method, Daily Egg Production Method is not much time-consuming, doesn't need extrapolation of field data in comparison to previous similar surveys and gives compatible to other methods results.
The advantages of the hydro-acoustic methods for fish population stock assessments are as follows:

- these methods contribute to obtain recent and general information on the state -of -the-art of different fish species resources;
- allow to evaluate the abundance of the resource without applying bio-statistic methods (VPA);
- allow to investigate some peculiarities of fish biology which cannot be observed otherwise (e.g. fish schools direction, form, etc.);
- when applied in parallel with other techniques of sampling (e.g. referring abiotic and biotic environmental variables), the acoustic methods may be useful in solving some basic issues in marine biology (e.g. those related to fish behavior as aggregation and migration depending on hydrographic conditions and food availability).

Hydro-acoustic methods exhibit also a number of exploitation advantages:

- cover relatively large areas;
- expedience in data collection and processing;
- feasibility and automation of processes;
- independence (self-calibration by acoustic means)
- relatively high precision and reliability

1.1.2. Demersal stocks

Attention has been given to analytical models and swept area method. The latter is applied to obtain express assessment of the index of the demersal fish species biomass.

2. THE FLEET

2.1. Bulgaria

Black Sea fishing in Bulgaria is largely carried out by individual fishermen covered by the fishing licensing system (100% private ownership of open-deck boats and nets, and 95% private ownership of fishing ships). The trawl is the main fishing gear used to harvest pelagic and demersal fish resources in Bulgarian Black Sea area. The trawlers number varied during the last ten years between 3 and 10.

Over the last few years, the structure of the Black Sea fishing fleet was changed. The old medium-sized vessels of and over 80 t of gross tonnage were replaced by smaller-sized and more mobile vessels of 10 to 50 t of gross tonnage. There is an extreme need for fishery biologists to have access to the fishing vessels data and catch statistics that are available in the National Agency of Fisheries and Aquaculture, Ministry of Agriculture and Forestry.

2.2. Romania

Since 1980 a new commercial fishing fleet has been organized in Romania and it included small-size trawlers types B410 (132GRT/570HP), type Baltica (98GRT/300HP) and TCMN (95GRT/365HP). During time period 1980 - 1989 this fleet had 20 trawlers, after 1999 7 and the number is 9 at present The number of fishermen in the commercial fleet decreased from 180 - 200 to 70 - 90.

The fishery gears used by the trawlers are pelagic trawls, equipped for demersal operation.

This kind of activity is focussed on small pelagic species as main target (sprat, Black Sea horse mackerel, European anchovy) and the main object of their activity was the high production, taking no care of the catch diversity and commercial value. Since 1990, the new conditions of fishing (no state subvention, economical competition and privatization) radically changed the national marine fishery. Currently, the nine trawlers operating in the Romanian Black Sea sector are: two B410 type, two Baltica type, three TCMN type and two – other types and only two of them carry out a specialized bottom fishery with turbot gillnets and longline.

2.3. Ukraine

At present 95-99% of catches in the Black sea are obtained by trawl hauls and seiners in Ukraine. 35 fishing vessels of ten different types with displacement of 150 - 1200 t are registered in Sevastopol. Different depth pelagic trawls, and more seldom purse seine nets, mounted on 1 - 2 vessels are used for fish catches. The crew varies from 10-12 persons (SCHS, SR, MRTK) to 26-30 (MRRT, SRTM-K). Total number of fishery vessels in Ukraine has to be determined. All catches since 1987 have been carried out by the state organizations and fishing collective farms. Private companies prevail at the present time, but there are still some fishing collective farms.

3. LANDING SITES, FISH PRODUCTION AND STATE OF STOCKS

3.1.1. Bulgaria
Five are the main landing sites: Burgas, Sozoplo, Varna, Nessebar and Balchik. Part of the fish is marketed fresh while another is salted, chilled or canned.

3.1.2 Romania
The landing ports are: Sulina, Cape Midia, Constanta and Mangalia. The trawlers discharge the catches at the berths where there are deposits. The fish is salted on board of vessels. Part of the landings are marketed, another part is canned. A little fresh quantity is marketed.

3.1.3. Ukraine
The main fishery centers in the Crimea are: Sevastopol is the most important landing port (more than 50% of catches), the others being Kerch, Evpatoria, Feodosia, Yalta. Ukrainian fishermen deliver fish to the Ukrainian ports only. Ukrainian fishermen realize anchovy fishery in the Russian and Georgian economical zones in compliance with the corresponding agreements. Foreign vessels, except Russian, do not work in the Ukrainian economic zone and do not deliver fish to the Ukrainian ports.

Turkish fishing vessels, several tens in number, conduct forbidden catch for turbot and sturgeon by gill nets and more seldom by trawl hauls in the Ukrainian economic zone.

3.2. Fish production and state of stocks
The total productions of capture fisheries in the Black Sea for the period 1970 – 2003 according to the FAO statistics (GFCM, 2003) are presented in Table 1.

Table 1. Total annual production (in tons) in the Black Sea by countries during the period 1970 – 2003

Year	Bulgaria	Georgia	Romania	Russian Fed	Turkey	Ukraine	Total
1970	3783	0	9309	0	129738	0	142830
1971	3913	0	10416	0	111163	0	125492
1972	4249	0	7841	0	132232	0	144322
1973	5191	0	6289	0	122179	0	133659
1974	7460	0	5570	0	102035	0	115065
1975	8623	0	6316	0	86871	0	101810
1976	9901	0	7744	0	106894	0	124539
1977	10129	0	6142	0	115292	0	131563
1978	12006	0	7114	0	174637	0	193757
1979	15104	0	7621	0	281939	0	304664
1980	17856	0	10292	0	325106	0	353254
1981	19591	0	9997	0	345858	0	375446
1982	17294	0	10374	0	379958	0	407626
1983	13509	0	13105	0	413173	0	439787
1984	15404	0	13894	0	442908	0	472206
1985	17028	0	14268	0	445470	0	476766
1986	12941	0	15834	0	435125	0	463900
1987	11995	0	14015	0	460685	0	486695
1988	8142	105008	13963	74031	478002	117322	796468
1989	8602	42611	13836	33675	271278	88453	458455
1990	2882	12748	6326	14803	197199	57303	291261
1991	3026	7116	1288	3639	169129	17136	201334
1992	2512	7785	3845	10826	249477	28023	302468

1993	2310	2191	3952	2969	320587	20990	352999
1994	5340	1397	3060	10479	390042	28315	438633
1995	7225	2470	2719	12119	453886	32735	511154
1996	7694	2447	2682	5230	352809	24690	395552
1997	9340	2582	3872	5743	270816	29236	321589
1998	8370	2997	4431	5777	251207	34995	307777
1999	8061	1396	2507	9524	364396	35857	421741
2000	6102	1769	2476	14816	343379	46331	414873
2001	4831	1628	2431	21483	345292	62329	437994
2002	13553	1801	2122	22974	395176	57029	492655
2003	10188	3267	1612	30995	336208	45445	427715

In compliance with these data the mean total catch in the period 1970-2003 amounted to 340 177.9 tons, with total catch coming to maximum value of 796 468 tons in 1988 and minimum of 101 810 tons in 1975.

3.2.1. Bulgaria

Bulgarian Black Sea fishery changed significantly its structure after the strong decline of commercial catches of mackerel, bonito and bluefish in late 60s and early 70s (Fig.1).

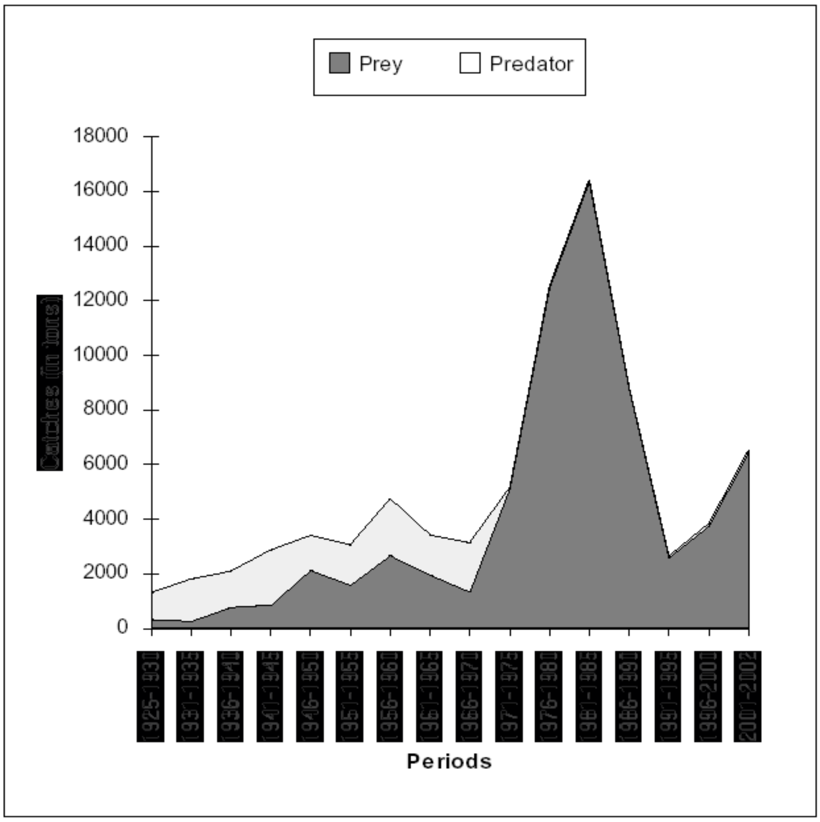


Figure 3.1. Total catches of prey (sprat, anchovy and Black Sea horse mackerel) and predators (mackerel, bonito and bluefish) along the Bulgarian Black Sea coast during 1925 – 2002

During the period 1925 – 1970 the catches of pelagic top predators: mackerel, bonito and blue fish have been commensurable with and, in the beginning of this period, even higher than that of their prey the sprat, anchovy and horse mackerel.

Since 1970 concurrently with the decrease of the pelagic predators' abundance the euthrophication of the Black Sea continued to extend further and fast. This led to the rise of the biomasses of the three most abundant zooplanktivorous fish species (sprat, anchovy and partially horse mackerel). The sharp growth of their catch intensity retained their biomass increase in accordance with the enlarged basin productivity.

The disturbed balance between the trophic links emerging notably strong in the 80s opened widely the doors of the Black Sea ecosystem for penetrating new species, which found favorable conditions for mass development. In the early 80s the ctenophore Mnemiopsis leidyi after some years of adaptation began quickly to expand its abundance and biomass reaching maximum values in late 80s and early 90s. The ctenophore besides being powerful competitor to the planktivorous fish in relation to their fodder zooplankton feeds on their eggs and larvae (Tzikhon – Lukanina, Reznichenko, 1991). As a consequence the catches of nearly all fishes dropped appreciably but most dramatically those of the summer spawning fishes as the anchovy and the horse mackerel. Their catches sharply decreased from 526 462 (1988) to 86 752 (1991) tons (Prodanov, Stoyanova, 2000).

3.2.1.1. Small pelagic stocks

Sprat (Sprattus sprattus)
Sprat catches dominate after 1970. In the period 1970-2002 they represent 86% from the total Bulgarian catches.

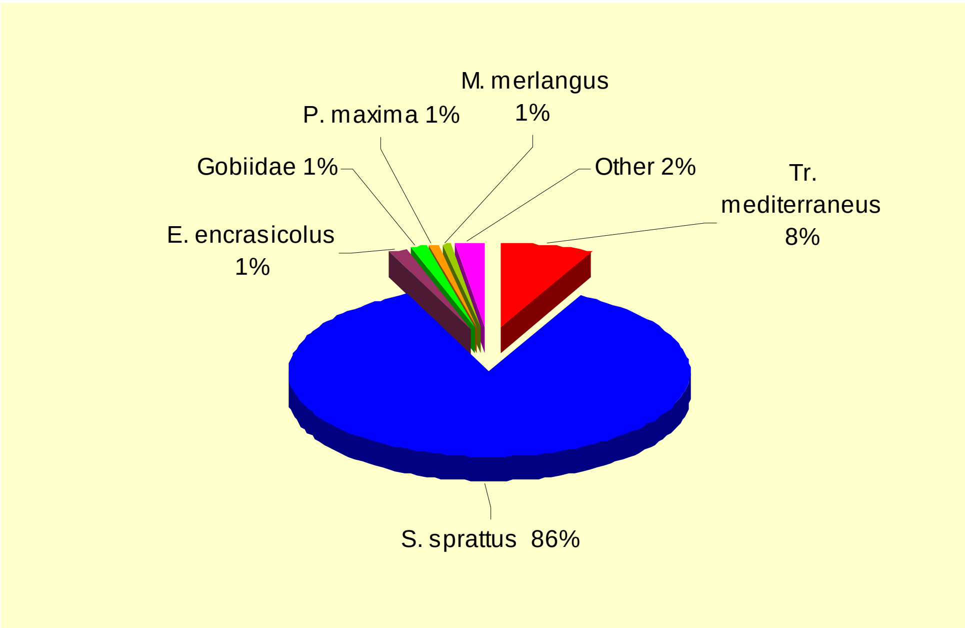


Figure 3.2. Average catches (in percentage) in Bulgaria by fish species during the period 1970-2002 (GFCM capture production 1970-2002, FAO)

During the period 1980-1982 the Bulgarian sprat catches varied from16 524 (1982) to 18 880 (1981), averaging 16 964 tons. During the last 11 years (1992-2002) the pointed catches were in the range from 695.4 (2001) to 11595 (2002), at the average 3644.0 tons, i.e. more that 4 times less than during the period 1980-1982. The small quantities in 2000 and 2001 are due mainly to unrecorded sprat catches. Its mean catch during the period 1992-2002 represented 51.28% from the total catch.

As it is well known, the sprat is of great importance for the ecosystem since it represents an important link between the plankton community and its predators. Thus sprat population exerts top-down control on the lower components of the food web, and bottom-up control on the apical components of the ecosystem.

The Black Sea sprat possesses great adaptive capacity, such as a short life span, hence high stock turnover, high growth rate, early sexual maturity, batch spawning and protracted spawning period. These biological features are specific response to environmental conditions and they compensate for the high rate of elimination that the population is being subjected to.

The sprat biomass in the Bulgarian Black Sea area has been assessed by means of different modifications of VPA. It varied from 33 235 (1997) to 55 947 (2000) tons. The mean biomass during the period 1994-2002 has been 43 284.1 tons. Sprat stock assessments but for the western part of the Black Sea have been made by Daskalov et al (1996) and Prodanov et al. (1997). According to them sprat biomass had varied from 26 000 (1954) to 539 300 tons (1975) during the period 1951-1993.

The sprat catches per unit effort (kg per 1 hour trawling) along the Bulgarian coast during the period 1992-2002 have been as follow:

Years	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
kg/hr	350	240	383	350	409	366	546	507	550	600	620

The sprat catches off the Bulgarian Black Sea coast are realized mainly by trawlers type “Baltica” and trap nets. Their fishing activity depends on the market needs. The same is the situation with the catches by the trap nets.

The optimum value of fishing mortality coefficient for sprat is 0.435. Because of this the TAC for sprat has to present about 33% from the sprat biomass in the beginning of corresponding year. Hence, TAC of sprat in front of the Bulgarian coast had been from 10 968 (1997) to 18 463 (2000) tons. During the same years Bulgarian sprat catches had been 3 646 and 1 737 tons, respectively. That is why, despite the significant unrecorded catches, the influence of commercial fishery on the sprat stocks had never been high. The variation of its abundance and biomass are due primarily to the changes of the environmental conditions in the Black Sea. According to the Fishery and Aquaculture Act the minimum landing size (TL) for sprat is 7.0 cm.

Mediterranean horse mackerel (Trachurus mediterraneus)

The horse mackerel catches along the Bulgarian Black Sea coast declined dramatically in late 80s. Its mean catch during 1992-2002 was 94.1 tons - 1.32% from the mean total catch. Bulgarian horse mackerel catches during the period 1972-1991 are as follow (tons):

Years	Catch	Years	Catch	Years	Catch	Years	Catch
1972	534.0	1977	791.0	1982	366.8	1987	826.4
1973	849.0	1978	565.0	1983	496.7	1988	1676.8
1974	2168.8	1979	934.5	1984	1015.8	1989	1100.9
1975	1972.8	1980	813.0	1985	755.8	1990	164.1
1976	1808.7	1981	476.2	1986	850.9	1991	122.9

The mean catch during this period is 914.5 tons, i.e. nearly 10 times more than during the period 1992-2002. The mean catch of horse mackerel has had the highest value during the period 1972-1976 - 1466.7 tons. After 1990 its value dropped sharply. In the whole Black Sea the highest catch has been yielded in 1985 - 141 077.8 from which: Turkey - 100 417; former USSR - 38 870; Romania - 1 035; Bulgaria - 755.8 tons.

The horse mackerel catches by countries during the period 1985-1991 has been as follows (tons):

Years	Bulgaria	Romania	former USSR	Turkey	Total
1985	755.8	1035.0	38870.0	100417.0	141077.8
1986	850.9	945.0	2370.0	100943.0	105108.9
1987	826.4	997.0	543.0	90850.0	93216.4
1988	1676.8	2660.0	398.0	93006.0	97740.8
1989	1100.9	1459.0	305.0	94023.0	96887.9
1990	164.1	165.0	56.0	65163.0	65548.1
1991	22.9	48.0	3.0	19781.0	19954.9

Black Sea horse mackerel is mainly caught by fishing vessels type “Baltica” and trap nets.

After the Black Sea horse mackerel stock assessments performed by Prodanov et al (1997) its spawning biomass had varied from 26.9 (1991) to 514.7 (1985) thousand tons during the period 1971-1995. Hence, the sharp decline of horse mackerel stocks in 1990-1992 is due to the high value of Turkish catches during the period 1985-1989. This conclusion is confirmed by the Bingel’s estimations performed by the Shaefer’s surplus Production model (MSY) - Bingel et al (1993). According to these calculations the value of MSY for the Black Sea horse mackerel is 80 thousand tons. Hence, during the period 1985-1989 the pointed fish species had been subject to over fishing by the commercial fishery, especially along the Turkish Black Sea coast.

According to Prodanov (1989) the value of Fopt for the Black Sea horse mackerel is 0.25. Hence, its total allowable catch (TAC) should be from 6725 (1991) to 128 675 (1985) tons during the period 1985-1991. The pointed annual catch in 1986 should be 82 825 tons. During the mentioned years Black Sea horse mackerel catches had been 141 077.8 and 105 108.9 tons, respectively. All this confirm once again the need of joint fishery stock assessments and management of migratory fish species.

The minimum landing size (TL) for Mediterranean horse mackerel determined by the Fishery and Aquaculture act is 12.0 cm.

Anchovy (Engraulis encrasicolus)
The Black Sea anchovy is of primary importance for the basin. Being most abundant fish species, it has traditionally supported the largest commercial fishery in the Black Sea.

The Bulgarian anchovy catches are negligible and present less than 1.0% from the total catch. The mean catch during the period 1995-2001 is 75.3 tons. During the same period Turkish catches has varied from 195 996 (1998) to 373 782 (1995), at the average 273 840.6 tons. According to Bingel et al (1996) the value of MSY for anchovy is 290 000 tons. Almost the same result was obtained by Prodanov, Stoyanova and Mikhailov (1998) - 269 600 tons. Hence in 1985 are caught nearly 100 000 tons more than maximum sustainable yield (MSY). Such over fishing had been performed during the fishing seasons from 1979/1980 to 1983/1984 and from 1985/1986 to 1987/1988. The mean catches for these periods had been 423 574.0 and 441 721.7 tons, respectively. The highest anchovy catch has been realized in fishing season 1987/1988: 468 807 tons - 338 402 (Turkey), 130 000 (former USSR), 394 (Romania) and 11 tons (Bulgaria). During the last 10 years mainly the Turkish commercial fleet catches this fish species. It is obviously that anchovy also have to be regulated by the future International Fishery commission in order to avoid over exploitation of its stocks.

The minimum admissible length (TL) for anchovy is 8.0 cm. It has been recommended by the institute the limit to be 9.0 cm.

3.2.1.2. Demersal stocks

Turbot (Psetta maxima)
Commercially the Black Sea turbot is one of the most valuable species in the basin and currently is fished with gillnets and bottom trawls even though, at present, the latter gear is prohibited.

The turbot catches had been largest during 1955 – 1969, at the average 319.5 tons. The largest turbot catches has been obtained during spring (April and May) – 50.1% from the mean total catch during the period 1960 – 1989 (Mikhailov, Prodanov, 2003). As it is well known the turbot spawns in these two months. In March it migrates from depths of 70 – 110 m where it is wintering to depths of 20 – 40 m to spawn. Thus it is apparent that till the closure of the turbot fishery (1990 – 1994) the fish species has been caught most intensively during its spawning season thus not giving the population the chance to normally reproduce. Although at present ban for turbot fishery is in force for 45-60 days in April – June, illegal fishing conducted even by Turkish fishermen using turbot gillnets in Bulgarian territorial waters often occurs. Since 2002 the turbot catches are quoted. Nonetheless, the stock is not showing signs of recovery as it may concern the other demersal fish species.

The minimum landing size (TL) for turbot is 45 cm.

Gobies (Family Gobiidae)
There was increase in the gobies catches in the period 1995 –1999, with mean catch of 459.8 tons. In 2000 – 2002 the catches were almost at one level and have only slightly varied from 141.5 to 144.8 tons (Mikhailov, Prodanov, 2003).

Picked dogfish (Squalus acanthias)
The catches of picked dogfish were largest during the period 2000 – 2002. The mean catch had been 109.4 tons. Similar quantities had been caught only in 1985-1987, at the average 103.5 tons. The minimum landing size (TL) for picked dogfish is 90.0 cm.

Shellfish
Out of the remaining water living resources the catches of sea snail (Rapana spp.) are the highest during the last 8-10 years. In the period 1995-2001 the mean catch has been 3 790 tons.

Though the legal and catching difficulties, the good prices, offered mostly by the Japanese market, let increase the Rapana catches. The Fisheries and Aquaculture Act prohibits bottom trawling and dredging on the Bulgarian Black Sea shelf. Molluscs (Rapana spp. and clams, Donax spp. and Venus spp.) should be caught by other, legally allowed fishing gears. Diving remains the only legally allowed method to yield Rapana. In practice however there is not strict control to watch the abidance to the measures undertaken.

3.2.2. Romania

The Romanian marine fishery is characterised by its seasonal character of activities (March-October, November), as well as with the existence of two kinds of marine fishing in the Romanian Black Sea sector:

- Active fishery, using trawlers and operating in the offshore zone, at depths exceeding 20 m;
- Stationary fishery, using passive gears in 30 fishery locations along the littoral between Sulina and Vama Veche in the shallow coastal waters.

There are two kinds of passive fishing:

- Commercial fishing, carried out by private companies or persons authorized by the National Company for the Management of the Fishery Resources or the Danube Delta Biosphere Reserve Administration, in 16 fishery locations in the sector Sulina-Vama Veche, using pound nets, turbot gillnets, trammel nets, longlines, beach seines, gobies gillnets;
- Angling, carried out by persons which are or are not members of the General Associations of Game Hunters and Anglers, in 14 fishery locations between Cape Midia and Mangalia, with handlines.

If in 1960-1989 the stationary fishing was carried out by three state companies, in 18 fishing locations along the Romanian littoral between Sulina and Mangalia, with about 70-150 pound nets yearly, and catches (3120-7900 t) mainly consisting of pelagic species, while the bottom species were to be found only as by-catches, since 1990, similarly to the situation in the coastal fishing fleet, the stationary fishing at the Romanian littoral has declined.

During the last 10 years, the fishing effort decreased continuously, up to 32-41 pound nets on the whole littoral. A number of 150-200 fishermen acted in the last years, compared to 400-500 in the 80's. The total catch has been gradually reduced from 2490 t in 1993 to 423 t in 2001 and 641 t in 2002. The catches resulted from pound nets fishery are preserved and processed through salting in 15 fishery enterprises, situated between Sulina and Mangalia. The fish is marketed as fresh fish or salted fish or is used as fresh food for animals.

An illegal fishery has developed along the entire littoral.

Twenty one private companies and more than 50 persons were authorized to carry out commercial fishery during the last years. Most of the companies practiced bottom fishing with trammel nets, turbot gillnets and longlines.

Generally, passive fishing at the Romanian littoral is characterized by the concentration of the fishing activity during in the first 3-4 months of the fishing season (April-June, July), when the main fishing species come near the coast for feeding and spawning.

The level of capture and fishing productivity oscillated from one year to other, as function of the fishing effort (number of pound nets, effective fishing days), the hydro-meteorological conditions, stocks status of the main fish species and anthropogenic factors.

As a general rule, the pelagic species, small-sized and short life cycle (sprat, anchovy) continue to dominate in catches.

The predatory species, such as Atlantic mackerel and bonito, disappeared from the Romanian catches after 1970. The stocks of these species suffered a considerable reduction as a consequence of inhospitable conditions for reproduction and feeding in the Sea of Marmara (CAUTIS, 1976), as well as due to the continuously deterioration of the environment especially in the North-western part of the Black Sea.

The dramatic reduction, even disappearance, of the traditional predators from the Black Sea ecosystem (bluefish, Atlantic mackerel, bonito, dolphins) led to the increase of the pelagic fish stocks during 1980-2002 (sprat, anchovy, horse mackerel) and to the increase in abundance of some predators without commercial value, such as whiting and spiny dogfish.

The catches of the small-sized species representing the main target of the fishing performed at the Romanian littoral during the last 20-25 years have been highly oscillating up to almost collapsing.

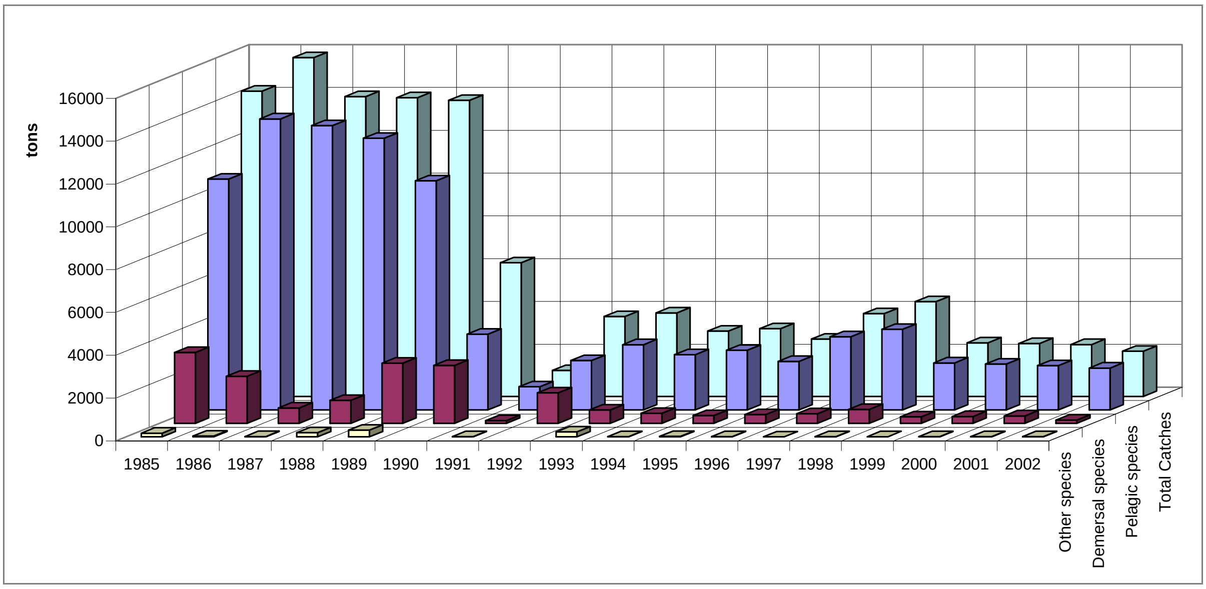


Figure 3.3. Catches in the Romanian Black Sea area

The causes of this situation were multiple and it was almost impossible to differentiate the trigger for such changes. For instance, due to the lack of certain regulations at regional level regarding the catch limits, the countries in whose waters the anchovy and horse mackerel form dense agglomerations, developed very intensive fishery that affected seriously their stocks.
During the period 1991-2002 72% of the total catch obtained in the Romanian marine sector fell to sprat (NICOLAEV et al., 1995; RADU et al., 1996-1997; RADU, 2001).

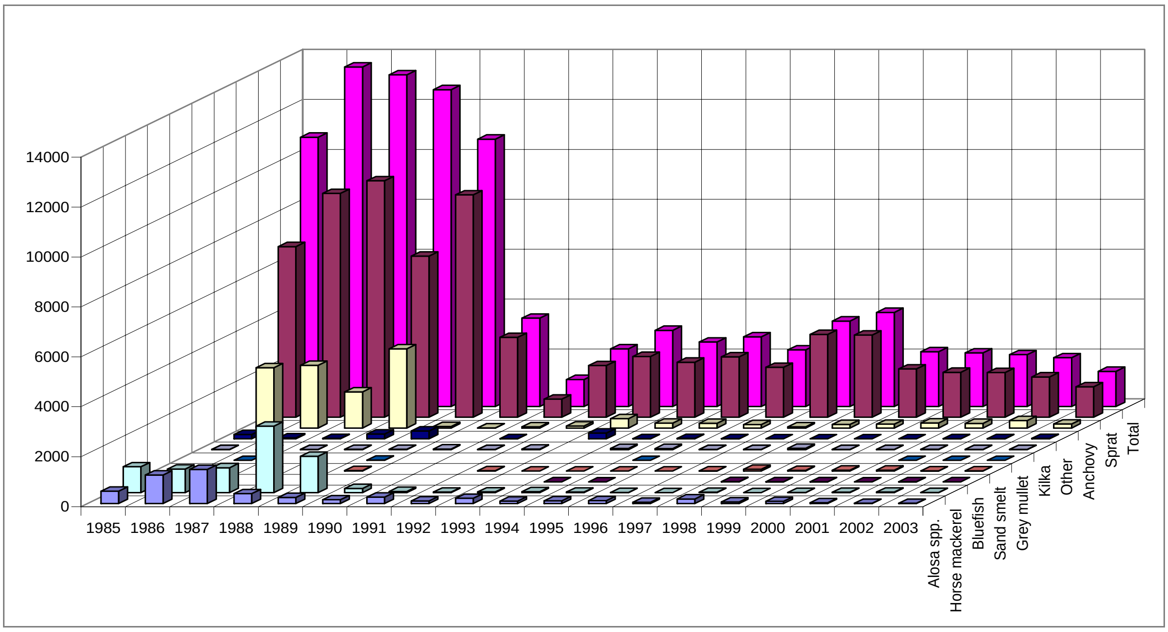


Figure 3.4. Total catches of pelagic species in the Romanian Black Sea area

If for the period 1980-1990, the mean total catch obtained at the Romanian littoral was 12 354 tons, it decreased to 2 956 tons in 1991-2002. The mean catches for **main pelagic species** followed the same tendency, decreasing in 1991-2002 compared to the period 1980-1990. Although, **the sprat** was dominant species, its catches diminished from 5 273 t (1980-1990) to 2 135 t (1991-2002). The same tendency was recorded also for other pelagic species constituting the Romanian commercial fishery. This reduction of the mean annual catch was more pronounced in **the anchovy**, showing decrease from 3 378 t (1980-1990) to 172 t (1991-2002), which means only 7.2% from the total catch. As regards **the horse mackere**l, its catches seriously diminished, ranging from values of 165 t (1990) and 2 666 t (1988) up to values of 1-3 t recorded during the period 1991-2002, meaning a mean catch of 19.7 t (1991-2002) compared to 1 097 t in previous period (1980-1990).

The tendency of decreasing of the mean annual catches was also obviously even for **demersal** fish. So, for **whiting**, this parameter reduced from 1,517 t (1980-1990) to 432 t (1991-2002), for **sturgeons** the difference was from 34.6 t (1980-1990) to 5.3 t (1991-2002), for **red mullet** from 24.7 t (1980-1990) to 4.3 t (1991-2002), and for spiny dogfish from 48.7 t (1980-1990) to 7.7 t (1991-2002) (RADU et al., 1996-1997; RADU, 2001).

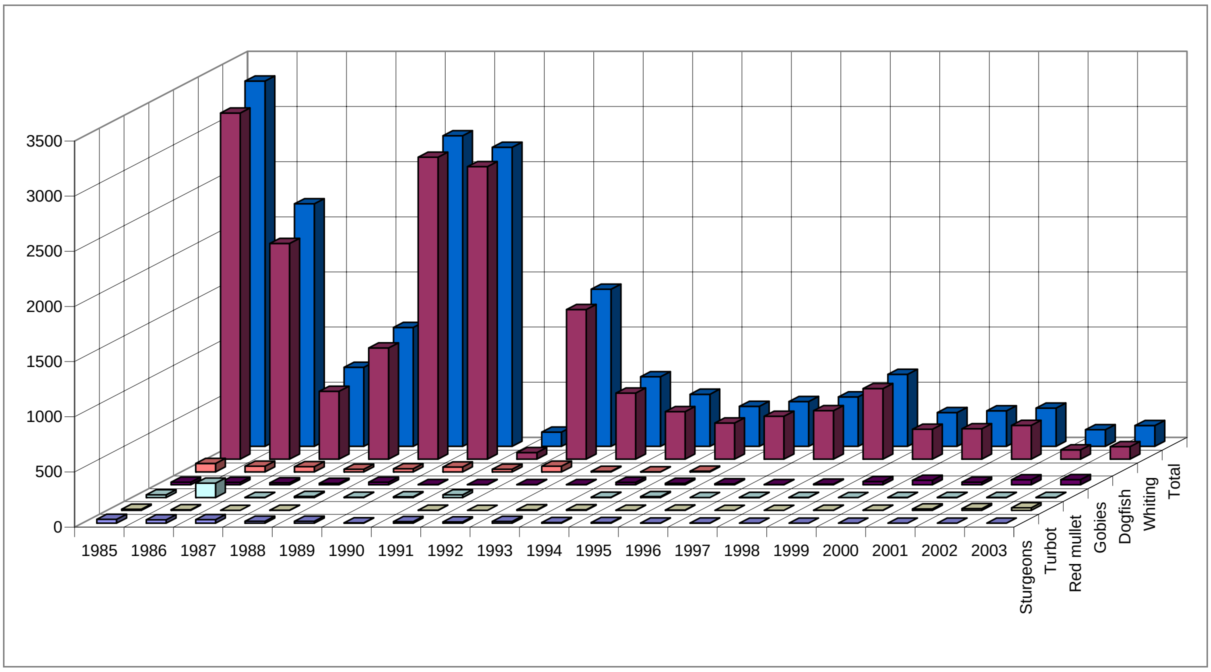


Figure 3.5. Total catches of demersal species in the Romanian Black Sea area

Analysing the dynamics of the fishing with pound nets it can be emphasized that the dominant species were the sprat, whiting and shad. The main target of the fishing with trawlers was the sprat (more then 80%), followed by the whiting, horse mackerel and spiny dogfish.
In the stationary fishery, during the first years of the period (1980-1984) the total mean catch maintained at an almost constant level (about 10,000 t), while after 1985 it gradually decreased up to a minimum of 290 t in 1997.
At the Romanian littoral, the most favourable season for trawl fishery is May-September. The development of the active fishery is determined by the distribution of fish agglomerations especially of the sprat ones. So, during the 3-4 months of the year, the trawlers are fishing in the southern sector of the Romanian littoral, where on depths of 40-60 m they carry out a specialized fishing for sprat. In June, when the warm season is opened, once with the movement of sprat agglomerations toward the North in searching food, the area of activity with the trawlers is spread up to St.Gheorghe, on 20-68 m depths, in relation to the occurrence of fish agglomerations.

In the actively fishery, the main fish keeps to be the sprat, in some years the anchovy (in summer months), and also the horse mackerel and bluefish (in September-October).
The qualitative and quantitative structure of the catches achieved in the Romanian marine sector had an variable evolution accordingly to the status of fish populations, effort of fishing, type of fishing gears and the conditions of forming and maintaining the fish agglomerations, especially in the coastal area.
Some main conclusions can be made:

- The sprat fishing agglomerations, assessed by swept area method, are still at low levels, presenting high fluctuations from one period to another, accordingly with the existence of favourable conditions for formation agglomerations.
- During the last years, the anchovy gave the highest part of catches obtained in the shallow waters (where the pound nets are installed, 3-11 m depths); its contribution in the pound nets catches increased from 34.2% (1999) to 44% (2001).
- The horse mackerel occurs at the Romanian littoral later May, but with small quantities (0.6%) progressively increasing toward September (about 11%). In the offshore sector, the horse mackerel is recorded only in September.
- The agglomerations of bluefish occurred in high quantities, both in shallow and offshore waters, in August, September and October; during the rest of months this species could does not form dense concentrations.

Among the cold water species the sprat was dominant in the ichthyoplankton samples during the winter months.
In the warm period of the year, the variety of the species in the ichthyoplankton and juveniles is higher in comparison with all the rest of the year, however the anchovy was dominant fish species.
The reduction of the catch, during the last 10 years, about 5-6 fold in relation to the earlier period 1985-1986 period have caused loses of about 2.4 million USD referring to the 80s, and about. 4 million USD compared to 1985-1986 (years with the greatest productions).
The economical loses due to the illegal and artisanal fishery practiced by the local fishermen and also by the industrial one practiced by the foreign trawlers especially on the turbot is assessed at about 1000 tons/year (3 mil.USD).

3.2.3. Ukraine

About 25-40 thousand tons of marine living resources are caught annually in the Ukrainian economic zone. In the last years **sprat** became the main fish commercial target in the Ukrainian economical zone, and especially in the Crimea, where its share is from 72 to 98%; **anchovy** is (2-24%) at the second place, and increase in the horse **mackerel abundance** is observed for the past 4 years with catches yielding about 2%; the other 14 species have considerably lower percent shares. Average catch of sprat by Ukraine at the end of the last and beginning of present century made 47 thousand tons, but in 2003-2004 there took place sharp decrease of catches for about 1/3. That led to failure of several fishing firms.
Fishery of these three species is carried out on the shelf by trawls and sometimes by seiners. Light catch is used for the horse mackerel fishing. Traditional coastal/stationary fishery is developed not so well, but there is well-grounded opinion about possibility and need of its restoration. Standing nets and gill nets are used for the fishery in the coastal zone. Positive tendency of some species stocks restoration is observed. **Sturgeon** stock is in danger, and the **turbot** stock decreased considerably.

4. MANAGEMENT

The fishing activity in the Black Sea region is substantial source of food resources, labor busess, economic gain for people engaged in this sector. The accumulation and improvement of knowledge on the biology and ecology of fish and the development of the fishery equipment during the last decades led to abrupt increase in fish catch and other living water resources. As a result we witnessed expressive examples of environmental degradation and fishery decline the last one occurring quite recently.

That brought to negative shifts in the state of most commercially important fish species and necessitate the developing and applying of measures guaranteeing the sustainable utilization of living water organisms as they though being recoverable are not inexhaustible and thus they have to be used and managed in an appropriate manner.

The protection and sustainable utilization of marine living resources includes a number of measures generally aiming at:

- Actualizing the existing norm basis and its harmonizing with conventions treating the problems of preserving species diversity and sustainable utilization of biologic resources
- Control and assessment of the economic activities in sea in respect of their ecologic conformity
- Introduction of protection-recovering activities
- Accomplishment of annual assessment of the stocks of the commercially exploited by contemporary methods aiming at defining the magnitude of total allowable catch by species

In fact, the fisheries legislations of the different Black Sea countries contain a great variety of conservation measures that aim to keep the fishing effort under control and those aiming to make the exploitation patterns more rational.

The theory for sustainable utilization of marine living resources is based on the concept for the existence of Reference points for exploitation of different organisms. These points should be determined on the basis of analyses of fishing effort (fishing mortality), the catches yielded and the state of the stocks. For this purpose the relation between the fishing effort and biomass of the exploited fish species should be elucidated. However this relation is not easy to be established as the environmental conditions affect significantly not only its abundance and biomass but also its distribution of the species i.e. they exert influence on its catchability, too.

In the case with the Black Sea fishery in particular, for establishing the references points is needed the following:

1. Agreement between all riparian countries for the fishery impact on the stocks of the species considered – control on the fishing effort (fishing mortality) as well as on the fishery regime (mesh size of the fishing gears used, closed fishing seasons, etc.)
2. Adoption of appropriate Reference points as criterion for long-term fishery management – defining of the total catch and the corresponding values of f and F. Adoption of regulatory measures when a stock is threatened with over exploitation
3. Establishing of current status quo of fisheries analyzing the data of the fishery statistics and biological research aimed at control on fishing mortality (F), biomass and catch (Y)
4. Convention on the catch size and the corresponding fishing mortality levels (fishing efforts) among all the riparian countries in accordance with the outlined “Reference points” for exploitation of particular living marine organisms.
5. Establishing if the adopted “Reference points” in long term are appropriate in short-term and whether the industrial fish stocks need recovery. In the last case long-term strategies have to be adopted for re-establishing the stocks of the relevant species.
6. Coordination at regional level regarding the assessment of fish stocks and the environmental factors influencing them.

It is needed regional standardization of the methods and means of sampling, processing, analyzing and interpreting of the data, as well as the assessment of the fish stocks, in compliance with the international regulations.
For sustainable utilization of marine living resources and biodiversity conservation, approaches considering the contemporary state of living resources and such sparing the Black Sea ecosystem has to be applied. For the purpose it is suggested the following measures to be implemented.

- Limiting of the fishery activity impact on the environment
- Applying of ecosystem approach in the fishery
- Applying of preventive approach in fishery
- Conservation of biodiversity and endangered species

The effective management of fisheries on regional level must be built through the implementation of:

- Regionally harmonized regulations
- Regular regionally coordinated stock assessment
- Regional/national quota system
- Regional/ national vessel licensing system
- Implementation of FAO Code of Conduct for Responsible Fisheries
- Establishment of fisheries free zone

II THE MEDITERRANEAN SEA

The Mediterranean is a semi-enclosed marine area with generally narrow continental shelves. With the exception of the Adriatic Sea, the Gulfs of Lion and Gabes, in the rest of the areas the levels of biological production is considered low. The area is connected with the Atlantic Ocean and the Black and Red Sea through narrow straits or channels that limit the exchange of water among the bodies of water they interconnect. The Mediterranean Sea is divided into a western and an eastern basin by a sill at a depth of about 400m extending from Sicily to the north African coast.

Mediterranean fisheries offer a great variability according to their location, their production methods as well as the adjustment of human communities to the environmental conditions. With an average production around 1.2 million tons for the most recent years (Fisheries Yearbook 1993-2002, Office for the Official Publication of the European Communities, 2003, ISBN: 92-894-6338-4). These figures are known to be under estimated since, in several countries, statistics are usually obtained directly from fishermen for tax collection purposes or at selected official marketing points where not all of the fish landed pass through. Mediterranean fishing production represents a limited proportion of the world production, which is about 100 million tons. But, on the other hand, the average price of the products of this activity, intended almost exclusively to be consumed when fresh, are five to ten times higher than those in most other regions of the world.
Besides, from the European point of view, Mediterranean fishing is far from being marginal since it represents about 23% of the total Community fleet expressed in tonnage and 35% in engine power. In numbers, it represents about 48% of Community fishing vessels. On average, fishing vessels in the Mediterranean are smaller than in the rest of the Community. More than 34000 vessels, around 80% of the Mediterranean vessels, are smaller than 12m in length, giving the Mediterranean fleet its characteristics of a small scale artisanal fishery, although a large proportion of the catches is taken by larger, non artisanal vessels (Fisheries Yearbook 1993-2002, Office for the Official Publication of the European Communities, 2003, ISBN: 92-894-6338-4). The landings in volume in the Mediterranean represent a relatively modest share of about 12% of total Community landings. .

1. THE FLEET

The EU Mediterranean fleet in 2002 was composed of 58767 vessels from which 33.6% belong to Greece, 27.3% belong to Italy, 25.3% belong to Spain and 13.8% belong to France (Fisheries Yearbook 1993-2002, Office for the Official Publication of the European Communities, 2003, ISBN: 92-894-6338-4). The Mediterranean fisheries can be broken down into three main categories: small scale fisheries, trawling and seining fisheries.

The term "small-scale fisheries", attempting to integrate aspects of the "coastal" and "artisanal" fisheries and to avoid the vagueness, inconsistencies and differences of previous definitions, is virtually absent from the official terminology of the most Mediterranean countries. This term was introduced at first in 1990 by the European Commission, when the Commission presented a proposal (COM(90) 358 final of 7 September 1990) to amend Regulation 4028/86 on measures to improve and adapt structures in the fisheries and aquaculture sector (ANONYMOUS, 1990).
Most of the trawlers could be considered as semi-industrial or industrial vessels, taking into account the international practice. Trawls are widely used in the Mediterranean and there are two main types: (a) bottom, and (b) pelagic trawlers.

Seine nets (purse seines) are one of the main types of fishing gear used in the Mediterranean. The purse-seiners are distinguished into two major types: purse-seiners operating during the day and purse-seiners operating at night. There are no significant differences among the two types as far as equipment and vessel construction are concerned. The difference is that they employ a different fishing methodology, and their activities focuses on different species. Concerning the number of the "semi-industrial" fishing vessels, mostly trawlers and purse-seiners, operating in the EU ports, it has been estimated to be about 4300 vessels of which 45%, 32%, 17% and 6% are registered to Italy, Spain, Greece and France respectively (FARRUGIO, 1996).

2. THE FISH PRODUCTION

The total production of capture fisheries in the Mediterranean (all countries included) is illustrated in Fig. 2.1. (Annex I). It can be seen that the cephalopod and crustacean production is almost stable the last 15 years. The demersal fish production shows a decline during the last 10 years probably showing the effects from overfishing from the medium fishery sector (trawlers and purse seiners). Pelagic fisheries show a fluctuation during the last 15 years and form the largest component of the Mediterranean landings

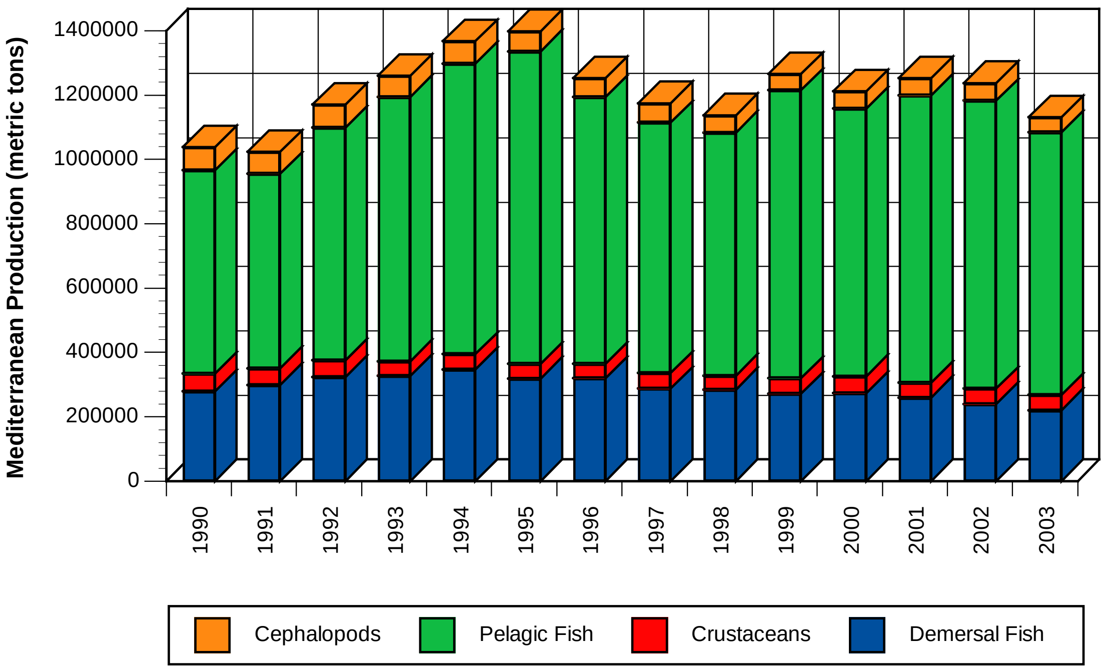


Figure 2.1. Total annual production of Mediterranean countries

The exploited depth range for demersal fisheries in the Mediterranean is usually from 10 to 800m, but is mainly within 400m for shallower shelf species such as coastal species , e.g. grey mullets, sea breams, sea bass, some shrimps (*Crangon crangon*), and many molluscs. Continental shelf fisheries are usually dominated by red mullets (*Mullus barbatus, M. surmuletus*), sole (*Solea solea*), gurnards (*Trigla sp.*), poor cod (*Trisopterus minutus capelanus*), Black Sea whiting (*Merlangius merlangus euxinus*), common spiny lobster (*Palinurus elephas*) and the karamote prawn (*Melicertus kerathurus*). On the continental slope however, there are many species of economic interest. Thus on the upper slope (200 - 400m) there are hake (*Merluccius merluccius*), flatfishs (*Lepidorhombus boscii, Citharus linguatula*), Norway lobster (*Nephrops norvegicus*) etc and various shrimps (e.g. *Peneus longirostris*). In deeper waters, from 400 to 600m, dominant species are the greater forkbread (*Phycis blennoides*), the blue whiting (*Micromesistius poutassou*) and the red shrimps (*Aristeus antennatus* and *Aristaeomorpha foliacea*).

3. THE STATE OF THE RESOURCES

Periodical updating of the research activities dealing mainly with demersal and small pelagic Mediterranean living resources and fisheries have been realized by GFCM (General Fisheries Council for the Mediterranean) since 1970 , during working group occasions and technical consultations at a regional level. OLIVER (1983) reviewed the fisheries resources and activities in the Western Mediterranean giving information on the state of the stocks, the production, the landings etc. The scientific knowledge of large pelagic stocks and fisheries is annually updated for more than 20 years by ICCAT (International Commission for the Conservation of Atlantic Tunas). Furthermore, a detailed review has been prepared for the EU Diplomatic Conference on Fisheries Management, held in Crete at 1994 (CADDY, 1996) and in Venice two years later, in 1996 (FARRUGIO, 1996; TSIMENIDES, 1997; PAPACONSTANTINOU & FARRUGIO, 2000), as well as in the meeting held at Crete for the Coordination of Fishery Research to the Eastern Mediterranean (OLIVER *et al*., 1997). On the other hand, the FAO fisheries statistics database has been now updated until 1994 (FAO, 1995). All these allow drawing a fairly complete panoramic synthesis of the situation.

Through the work of its former sub-regional Consultations and now through the Stock Assessment Committee of SAC, GFCM (The General Fisheries Commission for the Mediterranean) depends on the presentation of stock assessments and analyses by member country scientists. However, assessment coverage and frequency of updating is poor, perhaps because the motivation provided by quota management requiring regular annual repetition of assessment activities as for Northern European seas is absent. Stock assessment databases are thus fragmentary, and not very suitable as a basis for indicator series, although they may provide benchmarks for trend analysis or 'extent-of-decline' indicators (see later for stocks of sub-regional species). Fishery landings trends provide the only indication on important changes that might have occurred in the past.

Time series of fishery landings can provide important indications for changes in a fishery, or changes to the underlying environment (CADDY, 1990). Often, as in the case of Mediterranean fisheries, this is essential in the absence of complete or independent information such as on the fishing intensity or fishing mortality affecting the stock. LLEONART (1997) describing the fisheries assessment methodology applied in the Mediterranean concluded that the most fisheries research projects have a local contingency. The only exception is the MEDITS programme (BETRAND *et al*., 2002), funded from EU and France, Greece, Italy and Spain and extended along the north coasts of the Mediterranean Sea, including Albania, Croatia and Slovenia since 1994, and Tunisia and Morocco later. Fishery landings trends can provide the only indication about important changes that might have occurred in the past. The state of the commercial stocks in the Mediterranean appears in the Annex II

Based on documents submitted to GFCM Technical Consultations (Table 4.1), and on the 45-year time series of landings, some general observations can be reached for the West and East Mediterranean (FIORENTINI *et al.,* 1997):

(a) Despite some significant differences, the overall pictures from the West and the East Mediterranean are not strikingly different,
(b) From the study of catch trends, a high proportion of species or species groups in both the West and East Mediterranean showed increases in landings over the whole time period until the late 1990s;
(c) From the perspective of stock assessment, very few time series showed stable yield levels, suggesting a considerable dynamism caused by environmental and/or trophic or fishery-related impacts in the fisheries of the sub-region.

What is remarkable here is the general lack of quota control and the relatively modest control of fishing capacity that applies, with relatively small minimum effective sizes at harvest. Despite the long-term upward trends, short-term trends over the last 5 years tell a different story. Roughly the same proportions have shown short-term declines and short-term increases over the last five years of the data series. One tentative deduction from this is that multispecies landings may have reached a peak for the Mediterranean as a whole; with new increases (especially in the South and East Mediterranean) being balanced by recent declines; especially in the West and North.

Table 3.1. Comparison between percentage of resources in West and East Mediterranean showing different trends in landings (FIORENTINI *et al*., 1997)

	NEW	RECOVERING	RISING	DOME-SHAPED	STABLE	DECLINING	INTERMITTED	COLLAPSED
WEST	11%	9%	33%	11%	3%	8%	25%	1%
EAST	12%	18%	41%	4%	5%	4%	17%	0%

The exploitation of deep waters for fisheries is probably a new perspective for the development of fisheries in the Mediterranean Sea.

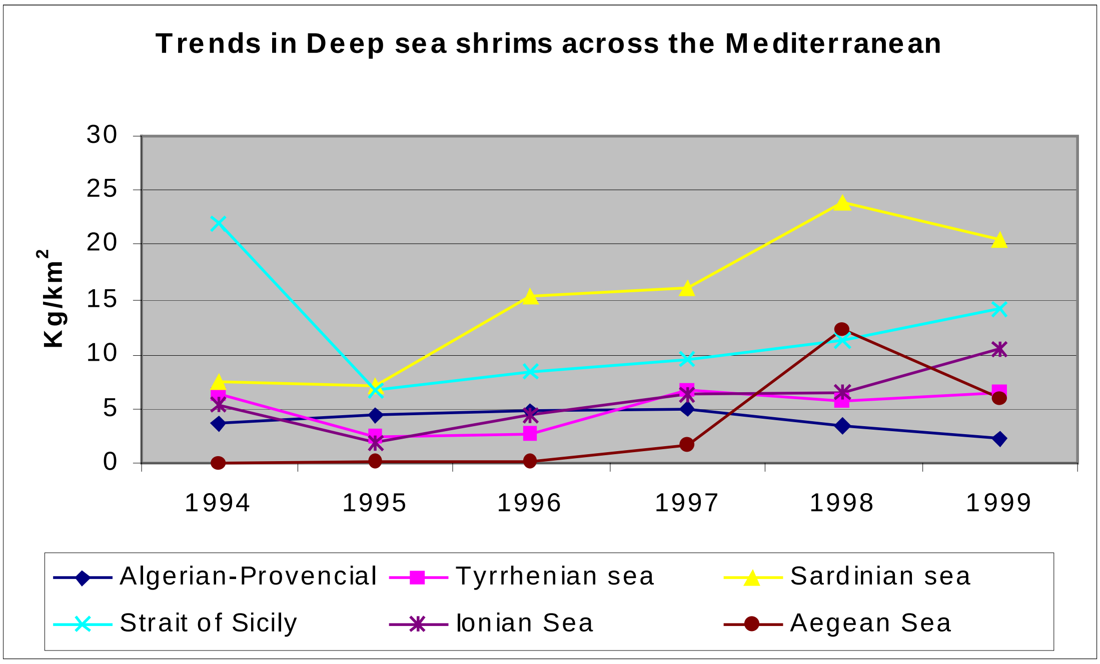


Fig.3.1. Trends in deep sea shrimps across the Mediterranean

Deep fisheries in the Mediterranean are developed mainly in the west region and in some areas of the central region (Italian coast of Ionian Sea) at depths extended down to 800-1000 m, while recently this fishery is under development in the Greek seas also. The most important stocks in these areas are 2 species of red shrimps: *Aristeomorpha foliacea* and *Aristeus antennatus*, and of lesser importance the hake and the red fishes. Fishing activity is carried out with gears such as trawlers and netters or longliners adapted accordingly for fishing in deep waters. The condition of the red shrimps stocks along the coasts of Spain is considered satisfactory regarding overfishing while along the Italian coasts, the stocks are overfished.

3.1. Report on the state of the resources in the Mediterranean Sea and their expected development

Catch statistics on demersal and small pelagics species show a negative trend in the 1990's for the most important species or groups of species (FIORENTINI et al., 1997). Daily catch rates per vessel have fallen dramatically when compared to catch rates of some decades ago, despite the fact that the power and efficiency of fishing vessels has increased in recent times. Also the catch quality, both in terms of species and size composition, has been changing over time. Long life-span species and bigger size specimens have practically disappeared from demersal catches in several areas and fisheries. The current evaluation of demersal, small and large pelagic fisheries, carried out within the GFCM and ICCAT frameworks, confirm this picture of overexploitation of several resources and highlights the need to reduce the mortality on juveniles and the overall current fishing effort by about 15-30% for those fisheries catching some overexploited stocks (COM/(2002), 535 final. 09.10.2002). Despite the recognized over-exploitation of several resources, there are few scientifically reported cases of stocks at risk of collapse. Anchovy in the northern Spanish coast, black spot seabream in the Alboran sea and hake in the Gulf of Lions are among those.

The extension of bottom trawl fishing activities in deep waters would take pressure off the shallow water species and would provide the fish market with new products. However, this could involve the danger of disturbing the deep water ecosystem which is more fragile, and where the recovery of the depleted stocks will require more time and complicated management interventions as related with other shallow water stocks. Therefore, knowledge on the biology and on the inter-specific relationships of the deep waters species is needed in order to plan a reasonable managing design.

Evaluations of small and demersal species are derived from summaries compiled and adopted by STECF and the Sub Committee on Stock Assessment of GFCM-SAC. Results coming from MEDITS survey (Mediterranean Trawl Survey) are included although the time series is not yet relative abundance of the available demographic fractions (BERTRAND et al., 2002). Assessments of large pelagic species are derived from ICCAT.

Management areas have not yet been adopted by GFCM in the Mediterranean, therefore this description is presented on a species basis.

3.1.1. Mediterranean small pelagic stocks

Most small pelagic species are distributed coastally over the continental platform and to some extent beyond, but undertake a rather well defined seasonal migration, which explains the seasonal character of their fisheries. Sardine, anchovy, mackerel and horse mackerel move close to the coast during the summer; the main fishing period for these species and move away from the coast during the winter to deeper waters.

Large-scale fluctuations in stock size occur for small pelagic resources which are as yet unexplained by science. It is presumed from the general similarity of such changes in several areas that these are environmentally driven, although the decline of some anchovy fisheries suggests that this highly–sought after species is subjected to excessive fishing. For most other small pelagic species, including the sardine, existing assessments indicate that they do not seem to be fully exploited everywhere (this situation is likely to be related to difficulties in achieving effective utilization and marketing).

Anchovy (*Engraulis encrasicholus*) The state of the anchovy in the Mediterranean basin varies according to management area. In the northern part of the Alboran region, the evolution of the catches and the CPUEs indicates a decline in the resources. In Catalonia and Valencia region, the results of acoustic surveys have indicated that recruitment in the last four years has been poor. Furthermore, in the Alicante region (Spain) the situation cannot be considered good, although the recruitment has increased in the last year. In the Gulf of Lions, the acoustic biomass estimates, during the last two years summers, have increased. In the Adriatic Sea the CPUE trend indicates a decrease from 1978 to 1987 and then a stable or slight upward trend up to 1996. The estimated biomass from analytical assessments shows a marked increase over the last ten years. Recruitment is also highly variable and correlates with catch rates, indicating the importance of recruitment for catch rates in this fishery.

Sardine (*Sardina pilchardus*) occurs everywhere in the Mediterranean and is exploited by fleets from all countries bordering it. Sardine is a coastal pelagic species, which is exploited both at juveniles and adult stages by purse-seiners and mid water pair trawlers. There is a traditional and localized fishery of fry sardine (termed whitebait) by beach seines and mainly boat seines, during wintertime. However it is a species with a low overall level of exploitation.
The existing assessment in waters off the Spanish continental coast, excluding the Alboran Sea, indicates that sardine seems to be under-exploited or moderately exploited. In the Gulf of Lion the stock is considered moderately exploited.

In the Adriatic Sea the catch in the last 15 years indicates a decrease in sardine availability. It seems that fishing effort has not a significant effect on stock biomass over the period for which data is available results from the projection model, indicate that biomass would continue to increase even assuming a 30% increase of the fishing effort.

3.1.2. Mediterranean demersal stocks

The long-term resilience of demersal stocks in the Mediterranean, without so far detected dramatic collapses of target resources, is usually explained by the fact that some proportion of the adult stocks has most probably remained consistently unavailable to small mesh trawling. This feature of the Mediterranean fisheries, as determined by fishing practices, gear and vessel characteristics and by the presence of several un-trawlable bottoms, has led to the creation of spatial/temporal enclaves within the normal range of distribution of several species which allow a proportion of the stock to survive in order to mature, thus preventing the collapse of the population. However, the situation has changed rapidly in the last decade, with the increasing efficiency of fishing methods, both in-terms of vessel engine power and the size of fishing gears, greater use of improved electronic positioning systems and, above all, the development of fixed gear fisheries targeting spawners of several long-lived species in so far un-trawlable areas.

Red mullet (*Mullus barbarus*) is a highly exploited resources in Mediterranean waters. Fleets from Spain, France, Italy and Greece fish these species. The species is widely dispersed over the entire Mediterranean basin. Assessments carried out regionally indicate that the stocks appear to be over-exploited and subject to growth over-fishing. MEDITS catch rates, although highly variable among areas, are consistent and quite stable in time within areas

Norway lobster (*Nephrops norvegicus*) is a very valuable resource. Specialized otter bottom trawler from Spain, France, Italy and Greece exploit this species. The fishery is characterized by a seasonal pattern, with catches declining during the winter and increasing during the spring and summer. The fisheries are subject to technical measures such as minimum landing size and, in some areas, by not take zones, but these measures are not adequately enforced. In several areas the state of the stock(s) is unknown. In general, however, different analyses indicate situations from moderate exploitation to weakly over-exploited.

Red shrimps (*Aristeus antennatus* and *Aristeomorpha foliacea*) are exploited in deep bottom trawl fisheries targeting both these species and Norway lobster. *A. antennatus* is more abundant in the W. Mediterranean, while *A. foliacea* is caught more frequently in the Central Mediterranean (Italian waters). Historical but local records in some areas indicate that these resources show fluctuations in stock abundance. The state of the stocks of red shrimps in the Mediterranean is not known. Assessments have been carried out regionally for *A. antennatus,* but there is no information on the overall state of the stocks. In Northern Spanish waters and the Gulf of Lions *A. antennatus* is fully under-exploited. In the Ligurian and Tyrrhenian Seas, Corsica and Sardinia it is over-exploited. For the Strait of Sicily and Tunisia, the stock of *A. antennatus* appears fully exploited.

Hake (*Merluccius merluccius*), is caught all over the Mediterranean and is the most important commercially exploited demersal resource in the area. A significant proportion of the landings of hake from the Mediterranean is composed smaller than the minimum legal landing size (20 cm TL). Assessments have been carried out locally, but there is no information on the overall state of stocks. In northern Spanish waters and the Gulf of Lions the stock appears over-exploited. In the Ligurian and Tyrrhenian Seas, Corsica and Sardinia the stock is fully- or over-exploited. For the Strait of Sicily and Tunisia the stock appears over-exploited. In the Adriatic Sea all indicators point to over-exploitation of hake. For the Ionian the information available indicates over-exploitation of hake in the NW Ionian Sea and full exploitation in the SW part. For the Aegean Sea the available information is somewhat contradictory but the majority of studies conclude that it is over- or fully exploited. MEDITS catch rates, although highly variable among areas, are consistent and quite stable in time within areas. On the other hand, widespread illegal trawl fisheries in coastal areas have reduced the “refuge” effect (CADDY, 1993; 1999; ABELLA et al., 1997), resulting from the poor enforcement of the current regulations.

3.1.3. Mediterranean large pelagic stocks

This category consists of large migratory fish living near the surface, including schooling species such as tunas and solitary species such as swordfish and pelagic sharks.
From 1983-99, the Mediterranean provided on an average, 65000 tonnes of tunas and billfishes, i.e. 8% of the overall Mediterranean yearly catch. Among these stocks, bluefin tuna is considered as fully to overexploited, including juveniles of this species, and swordfish are also considered fully to overexploited and mean sizes in the catch have diminished considerably. The Mediterranean is an important spawning area tunas, and also for bluefin tuna from the East Atlantic. A major problem concerns the stock structure of this species, and the unknown rate of mixing between the Mediterranean and the Atlantic, and available data are insufficient to quantitatively estimate migratory rates. It seems that in the Mediterranean, there are local stocks of swordfish and albacore, but their degree of isolation from Atlantic stocks is not well known.

Due to a lack of biological and statistical data, tuna evaluations have largely been confined to bluefin tunas evaluation of the state of the tuna and the associated species in the Mediterranean have principally been carried out on the bluefin tuna, where the increasing trend in catches, (and the increased proportion taken from the Mediterranean) during the last thirty years, is mainly the result of a constantly increasing fishing effort, although high abundance of forage fishes in the Mediterranean has probably also played a part. As for demersal catches, improved catch statistics may partly have played a role here also Statistics also show massive and systematic catches of juvenile bluefin tuna, which are extremely negative for the stock productivity.

Bluefin (*Thunnus thynnus*), eastern bluefin are taken by a variety of vessels and types of fishing gears, with landing sites located in many countries. Catches reached an average of 30.000 MT in the 1950-65 period, and then decreased to an average of 14,000 MT during the period 1965-1980. Since then, there has been a huge and continuous increase of bluefin catches, especially due to purse seine activity in the Mediterranean Sea, but also due to long-liners and other gears. The annual landings were probably over 50,000 t during the last three years.

Many of the inputs to the assessment of this stock are highly uncertain (including large uncertainties in the total recent catches and in the abundance trends). Fishing mortality rates have greatly increased during the 1970-1997 period, particularly in the most recent years for the older age groups. The corresponds with a severe decline of the spawning stock since 1970. Projections made by the SCRS during the 1998 meeting indicated that current catch level is not sustainable, and a reduction to 75% of the 1994 level is not sufficient to halt a continuing decline in spawning stock biomass. A catch of 25,000 t could halt the decline of the spawning stock in the medium term, but spawning stock biomass is not expected to return to its estimated historic levels. The only positive point in the present stock status is that the recruitment levels remain quite high, despite the low level of the spawning stock (i.e. still no clear evidence of recruitment over-fishing), Bluefin tuna is a long living species (about 20 years classes exploited) with quite a large biomass, but a quite low biological productivity, These biological characteristics and the lack of reliable stock assessment should lead to more precautionary management.

Albacore (*Thunnus alalunga*). Italy and Greece are the main countries involved in the albacore fishery in the Mediterranean. French purse seiners, Spanish coastal fleets and sport fishery, also occasionally catch albacore. Since 1985, the Spanish baitboat fleet based in the Atlantic has also been catching albacore in the Western Mediterranean and in the Alboran Sea in autumn. Reported albacore catches in the Mediterranean are still small, fluctuating between 2,000 and 4,000 t since 1984. The recent catch data are very incomplete due to the lack of reporting by many countries (including EU Member States), hampering any stock assessment by ICCAT. Until now no attempt haw been made to analyze the status of this stock due to insufficient data.

Swordfish (*Xiphias gladius*). Fishing has been carried out in the Mediterranean using harpoons and driftnets since ancient times. Landings showed an upward trend from 1965-72, stabilized between 1973-1977, and then resumed an upward trend reaching a peak of 20,000 t in 1988. Since then, the reported landings have declined and since 1990 they fluctuated from about 12,000 t to 16,000 t. The biggest producers of swordfish in the Mediterranean Sra in 1977 were Italy (43 %), Morocco (33%) and Spain (7%). Other countries have also reported incidental catches of swordfish. At present, longline and driftnet are the main gears used. No stock assessment has been conducted since 1995 partly because of a lack of sufficient improvements to input data. To unknown status of the stock, the probable high exploitation rate (taking into account the very large catch of nearly 15,000 t taken in a small area), the probably large catch of very small fish, and warning signs from the fishery are causes for serious concern.

3.2. SAMED: Status of demersal stocks in the Mediterranean – Abundance, Biomass and Catch per Unit Effort (CPUE) (ANONYMOUS, 2002)

In terms of abundance, the temporal variations (1994-1999) of the 7 most important commercial species in the Mediterranean shows that the major ones in decreasing order were *M.merluccius* (maximum abundance in 1998), *M. barbatus* (highest abundance in 1999) and *N. norvegicus* (highest values in 1996) with the rest species exhibiting lower values and limited temporal variations.

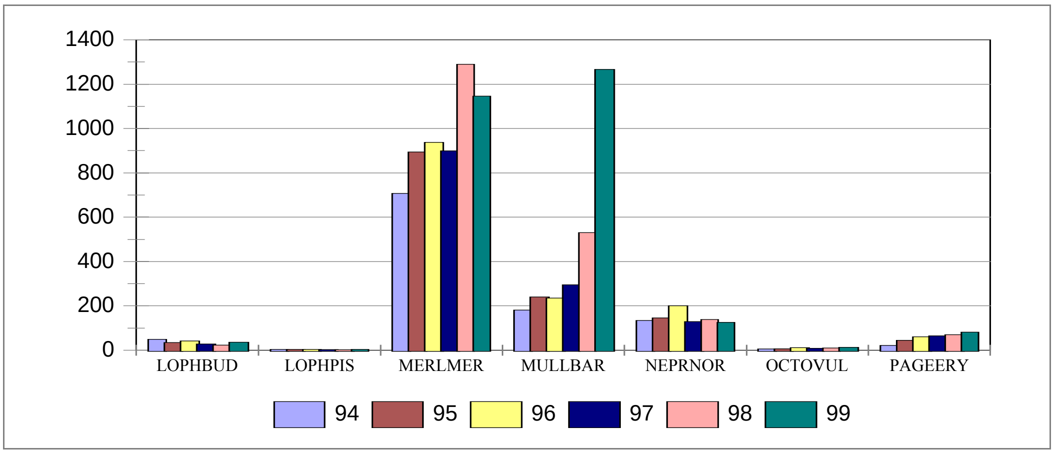


Fig 3.2.1. Temporal variation in abundance for selected species in Mediterranean

Notes: MERMER: Merluccius merluccius (European hake), MULLBAR: Mullus barbatus (Red mullet), LOPBUD: Lophius budegassa (European anglerfish), LOPPIS: Lophius piscatorius (Angler), PAGERY: Pagellus erythrinus (Pandora), NEPRNOR: Nephrops norvegicus (Norway lobster) , OCTVUL: Octopus vulgaris
Compiled by ETC. data Source: MEDITS project for the period 1994-1999

In terms of biomass the picture is somewhat different mainly because species such as *Lophius sp.*και *O. vulgaris* with low abundance were recorded high in terms of biomass and vice versa (eg. *M .barbatus*) and differences among species were lower. *M .merluccius, L. budegassa, M. barbatus*, in decreasing order were the 3 top species. In contrast *M. barbatus* (with biomass half of that previously) showed the highest abundance in 1999, with a gradual decrease towards 1994.

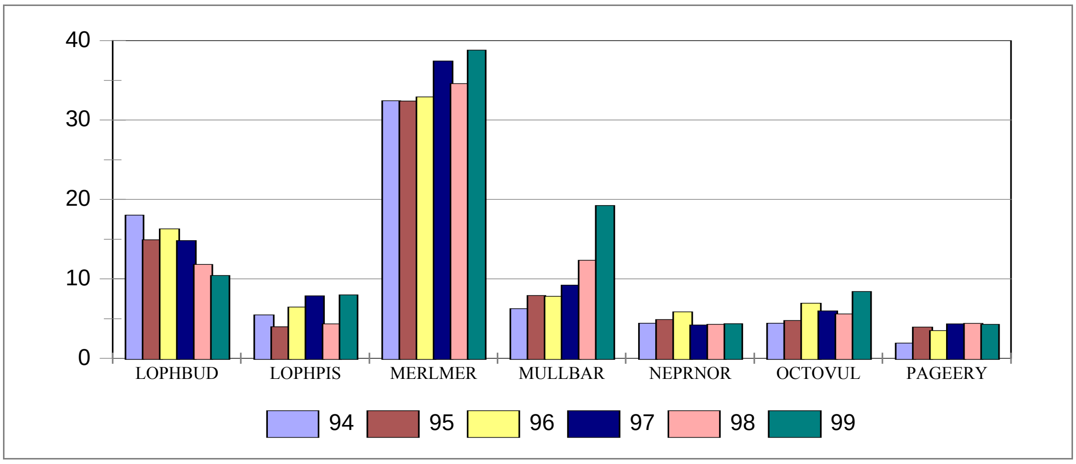
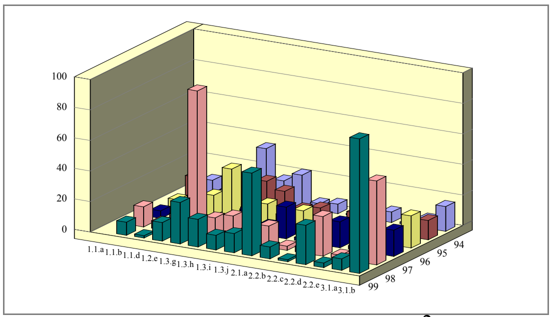
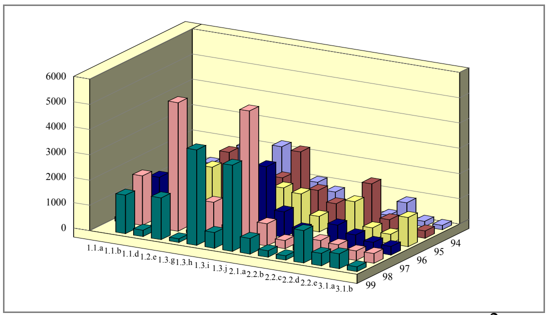


Fig. 3.2.2.Temporal variation in biomass for selected Mediterranean finfish species.

Notes: MERMER: Merluccius merluccius (European hake), MULLBAR: Mullus barbatus (Red mullet), LOPBUD: Lophius budegassa (European anglerfish), LOPPIS: Lophius piscatorius (Angler), PAGERY: Pagellus erythrinus (Pandora), NEPRNOR: Nephrops norvegicus (Norway lobster) , OCTVUL: Octapus vulgaris (Common octopus).
Compiled by ETC. data Source: MEDITS project for the period 1994-1999



Merluccius merluccius (N/km^2)



Mullus barbatus (Kg/km^2)

Figure 3.2.3. Temporal and Spatial variation in abundance (N/km2) and biomass (kg/km2) across the Mediterranean

Note: Spatial variation is demonstrated in reference to GFCM management units: from west to East 1.1.a-Balearic island; 1.1.b-Northern Spain; 1.1.d-Alboran Sea; 1.2.e-Gulf of Lions; 1.3.g-Corsica island; 1.3.h-Sardinia; 1.3.i-South and Central Tyrrhenian Sea; 1.3.j-Ligurian and North Tyrrhenian Sea; 2.1.a-Northern Adriatic; 2.2.b-Southern Adriatic; 2.2.c-Western Ionian Sea; 2.2.d-Eastern Ionian Sea; 2.2.e-Malta Island and South of Sicily; 3.1.a-Aegean Sea ;3.1.b-Crete Island

Compiled by ETC. data Source: MEDITS project for the period 1994-1999

Temporal variations in Catch Per Unit Effort (CPUE) resemble closely those for biomass, largely due to the way CPUE was calculated. Hence *M. merluccius* had the highest CPUE values followed by *L. budegassa* and *M. barbatus*. The lowest CPUE values were noted for *P. erythrinus*. Other species *L. piscatorius, N. norvegicus* and *O. vulgaris* did not differ significantly.

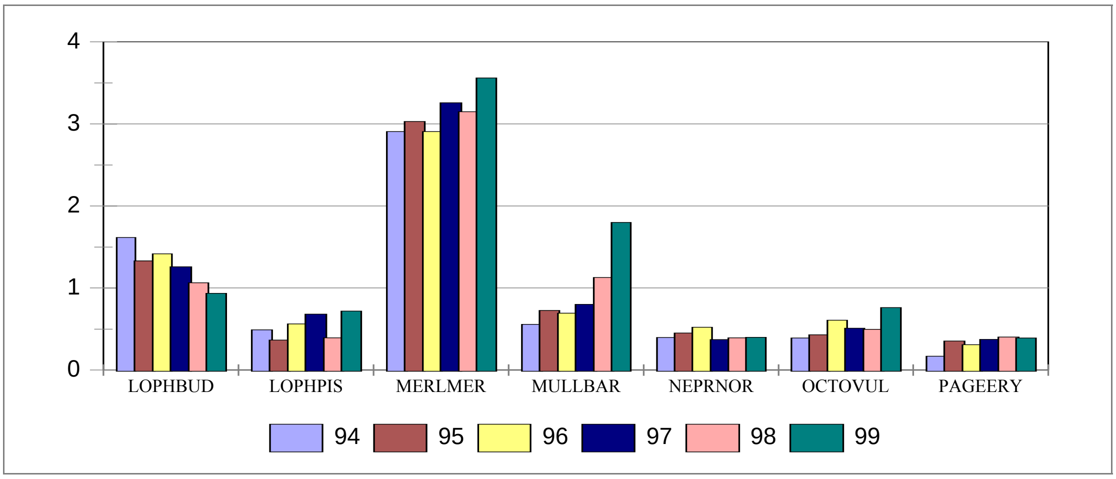


Figure 3.2.4. Temporal variation in CPUE (kg/h) for selected species in Mediterranean

Notes: MERMER: Merluccius merluccius (European hake), MULLBAR: Mullus barbatus (Red mullet), LOPBUD: Lophius budegassa (European anglerfish), LOPPIS: Lophius piscatorius (Angler), PAGERY: Pagellus erythrinus (Pandora), NEPRNOR: Nephrops norvegicus (Norway lobster) , OCTVUL: Octapus vulgaris (Common octopus).

Compiled by ETC. data Source: MEDITS project for the period 1994-1999

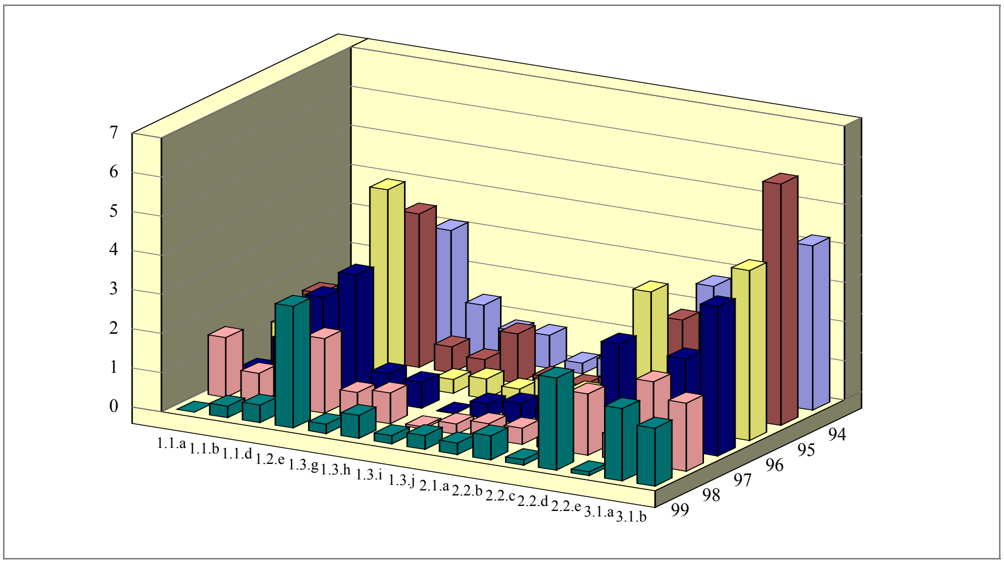


Figure 3.2.5. Temporal and Spatial variation in CPUE (Kg/h) across the Mediterranean for Lophius budegassa

Note: Spatial variation is demonstrated in reference to GFCM management units: from west to East 1.1.a-Balearic island; 1.1.b-Northern Spain; 1.1.d-Alboran Sea; 1.2.e-Gulf of Lions; 1.3.g-Corsica island; 1.3.h-Sardinia; 1.3.i-South and Central Tyrrhenian Sea; 1.3.j-Ligurian and North Tyrrhenian Sea; 2.1.a-Northern Adriatic; 2.2.b-Southern Adriatic; 2.2.c-Western Ionian Sea; 2.2.d-Eastern Ionian Sea; 2.2.e-Malta Island and South of Sicily; 3.1.a-Aegean Sea ;3.1.b-Crete Island

Compiled by ETC. data Source: MEDITS project for the period 1994-1999

4. THE CONSERVATION OF MEDITERRANEAN FISHERIES RESOURCES

Following extensive discussions in the early 1990’s on the general principles of a conservation and management policy specifically for the Mediterranean, the Council adopted Regulation (EC) No 1626/94 laying down certain technical measures for the conservation of fishery resources in the Mediterranean.

A number of amendments have been introduced to that Regulation in order to implement recommendations issued by the International Commission for the Conservation of Atlantic Tunas (ICCAT) for the management of bluefin tuna and swordfish. These concerned minimum landing sizes, seasonal closures and restrictions on the use of aircraft as an aid to fishing operations.

As a consequence of problems encountered in the enforcement of minimum landing sizes for certain species, the Commission issued a proposal for amending Regulation No 1626/94 with the aim of introducing progressive adaptation of fishing practices to legislation (COM(96)128). Following a negative opinion by the European Parliament, the Council did not adopted the proposal. Finally a new Regulation for the management of fisheries in the Mediterranean has been adopted at spring 2005, but the proposed regulation didn’t adopted by the Council in the summer of the same year. The problem of minimum landing sizes will also need to be dealt with the context of GFCM.

In 2000, the Council decided to prolong the derogations of Articles 3(1) and 6(1) of Regulation No 1626/94 until 31 December 2002, subject to technical conditions alleviating their impact on resources. The debate on the reform of the CFP should provide a basis for a long-standing solution to this and other problems of certain Mediterranean fisheries.

Until now the technical measures Regulation for the Mediterranean has not been success. They may be a need to seriously re-evaluate mesh-sizes and landing sizes. There is also a need to consider the introduction of an effort-control management scheme in the absence of TACs. The current inability of the GFCM to adopt such a scheme for the whole area should make the Community reflect on the initiatives that need to be taken on her part.

5. MANAGEMENT

Fishing not only reduces the abundance of the target species but also affects biodiversity. The Mediterranean is a sea with a high level of biodiversity that is concentrated mainly between 0 and 50m depth, whereas at a depth below 1000 meters there is only 9% of the total amount of the species. The impact of the fishing activities is very important in the littoral zone, and the result of the decreasing biodiversity is evident not only in the sense of the disappearance of species, but also on the diminution of effective habitats. Furthermore, the survival rate of the majority of the discards is very low. Several fishing gears can damage the seabed. The benthos, the seagrass beds, the rocky and coral bottoms can be severely damaged and can lead to sediment erosion by waves and currents which makes it difficult for species to re-establish.

According to TUDELA (2004) the Mediterranean fisheries are not an exception in the context of the general declining trend shown by all marine populations due to their fisheries around the world. Information indicating to unsustainable catch rates of some demersal species, as well as the disappearance of certain elasmobranch taxa from commercial catches. The high elasmobranch by-catches - and even commercial catches - achieved in many pelagic fisheries, notably longlining and driftnetting, also appear to be a potential danger for several species. Longline fishing is also the main cause of seabird mortality in Mediterranean fisheries. Indirect effects of fishing on seabirds related to food availability, driven by discards, are particularly important. The above author continues that fishing in the Mediterranean basin is clearly a major threat to marine turtle populations, which are massively by-catch. Concerning the marine mammals, the information available describes a wide variety of interactions between cetacean populations and fishing fleets in the Mediterranean, involving almost every kind of major fishing gear commonly in use. However, driftnet fisheries and, to a much lesser extent, small-scale fisheries using fixed nets and purse seine fisheries appear to account for the highest impact and are also responsible for the highest rates of direct human-induced mortality. The impact of fishing on the seabed concerns mostly the use of bottom-trawling gears or dredges, together with some aggressive practices affecting rocky bottoms such as dynamite fishing and fishing for coral and date mussels. Trawling impacts on seagrass beds by both suspending sediments and directly damaging the vegetal mass, have the most dramatic consequences on *Posidonia* beds. As for particular fishing gears, bottom trawling, longlining and driftnets arise as those with most impact on marine ecosystems in the whole Mediterranean region (TUDELA, 2004).

At present, the management of commercially exploited stocks in European waters is based on scientific advice. The uncertainties inherent in this advice are generally large and the costs to industry and environment are substantial. Obvious limitations in current approaches are due to a variety of causes: imprecise survey methods, the neglect of ecosystem constraints and climatic effects in final resource assessment, erroneous reporting from industry itself.

In general fisheries management in the Mediterranean is at a relatively early stage of development, judging by the criteria of North Atlantic fisheries. Quota systems are generally not applied, mesh-size regulations usually are set at low levels relative to scientific advice, and effort limitation is not usually applied or, if it is, is not always based on a formal resource assessment. Despite this, there has been some progress towards management by means of closed seasons and areas, which has provided positive results. Moreover, national fisheries administrations do not always have adequate links to the administrations of other countries and therefore the fisheries management practices and related technical measures adopted so far are uncoordinated, or in some instance, may even be incompatible.

The fisheries legislation of the different Mediterranean countries contains a great variety of conservation/management measures which can be broadly separated into two major categories: those aiming to keep the fishing effort under control and those aiming to make the exploitation patterns more rational. The first set of measures is based on restrictions imposed on the number or fishing capacity of the vessels, rather than on catch limits and control of discards and by-catches, upon which the fisheries policy in the Atlantic mostly relies. Among these measures, some aim at preventing the expansion of the number of fishing vessels through a licensing system, and can be characterized as direct, while other measures aim at placing upper limits on the fishing capacity of individual vessels, through engine power and tonnage limitations, and can be characterized as indirect.

The second set of measures is based on provisions concerning gear specification, gear deployment, fishing practices or techniques, fishing seasons or areas, and resource exploitation patterns, and are commonly known as technical measures. However, in the absence of satisfactory results from scientific investigations on spawning or nursery grounds, first maturity sizes, mesh selectivity studies etc, the adequacy, effectiveness and suitability of many measures have yet to be verified.

Apart from the main target of a management policy, which is the conservation of fisheries resources, the establishment of a common fisheries policy in the Mediterranean should also take into account the political and socioeconomic aspects of the Mediterranean nations that share in the exploitation of these resources. A number of technical measures have already been woven into the national laws of all FAO/GFCM Member States (TSIMENIDES, 1994). These measures include:

- limited entry to fisheries (vessel licensing)
- limitation of fisheries in certain areas and during certain time periods.
- use of a specific minimum mesh size
- limitation on the use of some gear during certain time periods and/or in certain areas.
- limitation on the horsepower and length of fishing vessels,
- limitation on the minimum size and weight of certain species.

The GFCM has attempted to harmonize, on a Mediterranean level, some of those technical measures. One of its efforts concerns the establishment of the 40mm mesh size for the bottom trawlers. This measure has been adopted by most of the Mediterranean countries, but its implementation has been less successful in others. However, the need for a reduction in overall fishing effort, particularly in inshore waters, remains the main priority for management action. So far, few Mediterranean countries have taken management action to control increases in fishing effort, in spite of repeated recommendations by the GFCM. For the Mediterranean countries, members of the EU, a limitation in total fleet capacity and horsepower are in effect. Even in cases where management can be done entirely at local or national levels, the setting up of common rules and the harmonization of management policies (particularly as regards technical measures) would be desirable, given the advantages that can result from the exchange of experiences in the implementation and enforcement of management actions.

Regarding Mediterranean fishing effort control, it has been suggested that it may be achieved through shares in the total number of standard effort units exerted on a common stock. This implies a common approach at a regional level, when the key demersal resources are straddling stocks lying across the boundaries between territorial seas and international waters where open access conditions apply. On the other hand, a reduction approach alone may not prove sufficient to tackle the issue of the conservation of Mediterranean ecosystems and their biological diversity satisfactorily. Furthermore, conservation policies targeting vulnerable species or habitats shouldn't be separated from fisheries management policies, given that they have essentially the same goal (TUDELA, 2004).

The basis for such a management system is suggested to be:

- The cooperative setting up of a fishing effort control system, the basis requirement being to build a close to real-time database of information on fishing vessel operations, linked to some form of regularly updated vessel registration list, according to a proper fleet typology that allows to establish standardized fishing vessel lists, which have to be regularly upgraded.
- The development of cooperative research programmes to monitor the environment and resources and to manage the shared stocks on the basis of stock assessments, carried out in a standard form and regularly updated.

Following some preliminary assessment results, it has been suggested that a fishery aimed particularly at small fish may be sustainable if a small - but sufficient - proportion of spawners could survive. This suggests the inclusion on the yield-per-recruit analyses (that have been the basis of mesh size regulations in the past) of considerations related more to the stock size of mature fish left in the populations.

Recently, the evolution of the political context of the Mediterranean has enable deeper collaboration to be developed directly between some of the numerous research organizations in the different coastal countries. Such research has confirmed, among others, that most stocks are shared and that they often have different biological phases in the waters of several countries. It has also suggested that there is an escalating risk that fishing operations will not be conducted in a responsible manner, if the competitive race by fishermen to maintain their individual shares of the dwindling fish stocks is not stabilized in a coordinated fashion.

6. ABOUT SOME ACUTE PROBLEMS IN THE MANAGEMENT OF THE MEDITERRANEAN RESOURCES, (a) MULTISPECIFICITY, AND (b) FISHERY STATISTICS.

All the Mediterranean fisheries research institutes have scientific teams capable of studying the biological and dynamic parameters of the most important stocks as well as the fleets dynamics and interactions, however catch and effort statistics remain the main weak point. Official statistics are not full accurate and so they are not reliable; in several countries suggestions have been made to improve those data, but the majority of the statistical data are still often very far from reflecting the reality. According to the cases, underestimations of catches (they are suspected to represent frequently not more than a third of the reality) are detected, as well as overestimations of some productions. This situation is directly linked to the fact that an important part of the Mediterranean production often elude from the traditional circuits for the gathering of information (auctions, markets...). Moreover, most statistical services are not tailored to deal with that problem with adequate sampling systems.

The lack of reliable official statistics is a considerable handicap for researchers who must devote a significant proportion of their resources to estimate the corrective factors to apply to official statistics.

As for the inventory of the fleets, it leaves much to be desired in most of the coastal countries. The statistics does not describe well the structure and capacity of the fleets, which depends on heterogeneous factors such as the depth of the fishing grounds, the type of fishing activity, the economic level of the fishermen, the shipbuilding, traditions etc. Particularly, as regards the small-scale fleets, the files available in the national administrations are generally quite incomplete. An underestimation of about 50% compared to the real figures is not rare and of course it can introduce important biases in the analyses.

To avoid this situation, the latest works in the area have focused on improving sampling and assessment strategies, essentially based on the installation of networks of samplers on the coasts, which particularly fit to the Mediterranean fisheries.

Another important point is that, despite the apparent very complex situation which the multispecificity of the Mediterranean catches seems to show, some ‘target species’ can be identified as main indicators of the status of composite stocks and thus there is a possibility of reducing the assessment tasks to a relative level very similar to what it is in other parts of the world. For example, as noted during the EU Meeting on Mediterranean Fisheries (Ancona, Italy, 1992) it can be defined, for the north-western Mediterranean fisheries, a group of 13 species which constitute the ‘basic production’. Even if imperfect, the landing statistics show that this group represents more or less 50% of the overall demersal production of the European fleets (ANONYMOUS, 1992). It has to be noticed that these proportions would certainly increase if it could be possible to know the real composition of the item ‘various species’ of the official statistics, which include part of the catches of those species.

7. REQUIRED ACTIONS AT INTERNATIONAL LEVEL

7.1. Cooperation within multilateral fisheries organizations.

The two regional fisheries organizations in the Mediterranean (ICCAT and GFCM) have different degrees of development and activity. ICCAT plays and should maintain an essential role in the management of highly migratory species in the region. EU is committed to this organization at both management and scientific level, and it has been to the forefront in pressing the on-going work within that organization for the establishment of a control and enforcement scheme.

GFCM, which is the most appropriate forum for the management of demersal and small pelagic fisheries in the Mediterranean, has made considerable strides in recent years, essentially due to initiatives which have been taken by the EU and Member States. Such improvement, however, would not have been possible without the willingness and active contribution of several Mediterranean scientists.

As regards scientific research in general, most of the findings of the research projects in recent years have proved to be useful to support scientific work within the scientific bodies of the Regional Fisheries Organizations and of the FAO sub-regional projects e.g. ADRIAMED, COPEMED, MEDSUNMED, EASTMED. However, initiatives still need to be taken by the EU to support the scientific work carried out within the Mediterranean regional fisheries Organizations and to strengthen their role to stimulate scientific and technical activities among their parties. The dispersal of scientific information together with the absence of a unique scientific forum where Mediterranean issues could be properly addressed, has so far weakened the scientific advice provided by the Mediterranean scientific community and has made it less operational for management purposes.

7.2. Harmonization of measures in the Mediterranean Basin

Although the EU have taken the initiative on fisheries management regardless of whether other countries of the region will follow, it is obvious that there is an interest in ensuring harmonization of the management measures applied in the region. The Net should pursue the discussion and adoption of Mediterranean-wide management measures, particularly within GFCM, to ensure as much consistency as possible between the EU initiative and the management carried out by other countries of the Mediterranean basin.

7.3 Co-operation among States and among industries

The Mediterranean Sea is characterized by a high number of coastal states with little tradition and means to ensure fisheries management. A multilateral fisheries policy in the region should have an active co-operation policy as a fundamental element. This co-operation should be focused, most notably, on enhancing coastal States’ capability to carry out their international obligations. Data collection, basic research and monitoring and control of fishing activities are some of the possible actions to be favored in this context.

The current experience of co-operation at sub-regional level is very encouraging. Participants have improved their respective co-ordination with full exchange of information and participation among the three above mentioned projects. A similar action for the eastern Mediterranean need to be undertaken, in order to complete the whole region.

Therefore the Net should promote the development of a Mediterranean-wide co-operation programme, using scientific experience and the existing financial frameworks and EU regulations e.g. 1453/2000, as much as possible.

7.4. The new objectives for fisheries research.

The new objectives for fisheries research in Europe summarized as follows (ANONYMOUS, 2000):

- to improve the operational monitoring and forecasting of marine resources through better understanding of the relationship between biological and environmental dynamics on different time scales.
- to ensure the sustainability of operational resource management by improving survey assessment and by integrating relevant knowledge of ecosystem functioning and climate fluctuations
- to assess and mitigate the detrimental effects of commercial exploitation of marine habitats
- to develop the biological basis for aquaculture production, including the knowledge of pathologies and the application of genetic engineering
- to counteract negative impacts of industrial aquaculture on the environment
- the direct application of ecosystem and climate science in order to improve sustainability.

Future models must enable an ecosystem approach that considers the system from plankton to sea mammals as a unit. Since commercial exploitation can seriously damage the marine habitats and its biological diversity, there is an urgent need for methods to detect and quantify the impacts of harvest and to develop environment-friendly harvesting technology. The main priorities in the fisheries research in the Mediterranean are the following. Several of the describe topics are cross disciplines. Studies in the following areas should take priority (ANONYMOUS, 2001):

Fisheries ecology and management

Research is required on:

- the biology and life histories of target and not-target species
- interactions between species and improved knowledge of the ecosystem
- identification of indices, baseline levels and limits for important ecological parameters
- climate change and its effects on stocks and fisheries
- fish population structure, to examine relationship between coastal and offshore stocks and define appropriate biological management units
- fisher's knowledge and its integration into the advisory and management processes
- development of management strategies for dealing with for complex and uncertain systems – ecological, multi-specific and bio-economic modelling, adopting a simulation approach
- alternative methods of stock assessment based on fisheries-independent data
- new methodological approach for the assessment of multi-species assemblages
- hybrid methodologies, using where appropriate baysesian approaches for integrating different types of data and information, e.g. quantitative, semi-quantitative and qualitative.
- Impact of fisheries, especially trawling on the environment, non-target species and ecosystems
- The conservation benefits of closed areas, including real-time closures based on monitoring of catches, and
- The conservation benefits and economic costs of technical measures and other management instruments, cooperative research, involving scientists, economists and fishers

Social and economic

- bio-economic simulation models and others methods aimed at understanding the economic and other factors which influence fishing effort allocation and investment behaviour
- the classification of fisheries, to identify true multi-species fisheries in terms of landed weight and value
- the implications of extended coastal jurisdiction
- identification of fishery management units and a revaluation of EU fleet segmentation

- user rights systems
- the complexity and structure of historical systems of management, particularly in relation to fishers' relationship with the ecosystem – interdisciplinary studies evaluating 'old' systems of management that have worked
- market-based instruments
- post-harvest economics, investigations aimed at identifying constraints on the fishing and processing industries.
- The development of methods for assigning intrinsic and economic values to marine ecosystems and habitats and species, and
- The role of governments in fisheries management, identification and analysis of motivational behavior, policy drivers and the impact of policy changes

Technology

- more selective, environmentally friendly fishing methods and gears
- energy efficient fishing vessels; and
- more efficient preservation and processing systems to improve product quality

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ANNEXES

Annex I.

	1995	1996	1997	1998	1999	2000	2001	2002	2003
1: Albania	1,127	1,768	833	1,860	1,931	2,365	1,527	2,113	1,531
2: Algeria	105,872	81,989	91,580	92,344	102,396	100,000	127,613	127,571	134,328
3: Bosnia and Herzegovina									
4: Bulgaria	7,250	7,727	9,356	8,421	8,081	6,137			
5: Croatia	15,901	17,799	16,627	21,914	18,865	20,963	16,875	19,438	19,541
6: Cyprus	2,183	2,125	1,946	2,049	1,988	1,964	2,007	1,725	1,606
7: France	35,463	26,245	30,787	30,995	37,317	43,484	40,217	41,000	39,306
8: Gibraltar									
9: Israel	3,577	3,159	3,557	3,999	3,641	3,966	2,660	2,596	2,205
10: Italy	275,199	252,636	239,962	199,210	171,471	185,347	183,801	156,727	164,037
11: Lebanon	4,065	4,115	3,635	3,500	3,540	3,646	3,650	3,673	3,613
12: Libyan Arab Jamahiriya	34,000	32,000	31,000	32,000	32,000	32,500	29,450	27,504	27,500
13: Malta	922	830	875	980	1,033	1,039	813	1,015	1,086
14: Monaco									
15: Morocco	39,676	39,652	31,485	28,658	37,290	38,650	24,565	27,110	32,795
16: Romania	2,554	2557	3821	4192	2437	2388	2389	2106	1599
17: Slovenia	1,849	2,078	2,065	1,959	1,783	1,630	1,619	1,459	1,083
18: Spain	149,001	150,485	133,290	123,302	121,824	140,273	130,806	105,742	79,694
19: Syrian Arab Republic	1,859	2,580	2,424	2,422	2,258	2,001	1,860	2,687	2,938
20: Tunisia	82,915	83,028	86,002	87,179	91,267	94,718	92,682	92,371	88,787
21: Turkey	585,506	477,322	407,793	430,950	522,638	459,621	469,406	497,938	416,712
22: Egypt	39,461	46,298	48,225	62,041	81,000	54,872	51,842	52,358	41,421
23: Gaza Strip (Palestine)	1,229	2,493	3,791	3,625	3,600	3,600	1,850	2,247	1,375
24: Serbia and Montenegro	364	377	373	410	423	424	415	430	456
25: Greece	139,498	138,513	149,402	99,845	109,558	90,697	70,200	73,429	71,463
TOTALS	**1,529,471**	**1,375,776**	**1,298,829**	**1,241,855**	**1,356,341**	**1,290,285**	**1,256,247**	**1,241,239**	**1,133,076**

Annex II. State of Commercial stocks in the Mediterranean in 2002

(Overfished stocks per area are coloured red; stocks within safe limits are coloured blue; grey cells indicate that no assessment has been made.)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	out																out	out				out								
Black Sea Whiting																														
Blue whiting																														
Bogue																														
Breams																														
Flat fish																														
Greater forkbread																														
Gurnads																														
Grey mullet																														
Hake																														
Horse Mackerel																														
Mackerel																														
Megrim																														
Pilchard																														
Poor cod																														
Red Mullet																														
Sea Bass																														
Sardinella																														
Sole																														
Sprat																														
Bluefin tuna																														
Swordfish																														

Data sources: GFCM, SAC, 2002 Report

Notes: 1. Northern Alboran, 2. Alboran Island Sea, 3. Southern Alboran Sea, 4. Algeria, 5. Balearic Island, 6. Northern Spain, 7. Gulf of Lions, 8. Corsica Island, 9. Ligurian and North Tyrrhenian Sea, 10. South and Central Tyrrhenian Sea, 11. Sardinia, 12. Northern Tunisia, 13. Gulf of Hammamet, 14. Gulf of Gabes, 15. Malta Island, 16. South of Sicily, 19. Western Ionian Sea, 20. Eastern Ionian Sea, 21. Libya, 17. Northern Adriatic18. Southern Adriatic Sea, 22. Aegean Sea 23. Crete Island, 24. South of Turkey, 25 Cyprus Island, 26. Egypt, 27. Levant, 28. Marmara Sea, 29. Black Sea, 30. Azov Sea

SECTION 2

A Review on

MARINE BIOTECHNOLOGY IN THE EASTERN MEDITERRANEAN AND THE BLACK SEA

Marine Biotechnology – An introduction

The term marine biotechnology refers to a wide range of methods and aims. Historical records of sponge farming go back to as early as to the beginning of 18^{th} century (Pronzato et al., 2000). Industrial fish, shrimp or shellfish production in terms of mariculture is certainly one end of a large range. One might judge the chemical production of secondary metabolites from marine organisms as the other extreme covered by the term marine biotechnology. Other branches like wastewater treatment or conservational biotechnology of course are also important branches.

Marine biotechnology could provide entirely new products from the sea and new ways of utilizing marine resources while providing improved technologies for the existing aquaculture and fishing industry. At the same time it can help us to monitor and harvest the diverse marine resources in a more predictable way.
Marine model systems could provide new insight into basic biological principles that will benefit further development of medicine and industry. One of the most exiting biological systems is a functional sponge (Porifera): the system we are interested in most. A wide knowledge and understanding of how the different organisms live together in a sponge, how the sponges get their nutrients and how sponges reproduce could enable us to develop new chemical compounds of high economical value.

Branches of marine biotechnology found so far in the eastern Mediterranean and the Black Sea

Marine production of biomass

Black Sea:

- Mariculture of the Black Sea Bass (Atwood et al., 2001; Bender et al., 2004; Berlinsky et al., 2000; Copeland et al., 2003; Cotton et al., 2003; Gwak, 2003)
- Mariculture of the Rainbow Trout (Bugrov, 1992; Sahin et al., 1999)
- Mariculture of the Black Sea Turbot (Basaran & Samsun, 2004)
- Mariculture of the Black Sea Bream (Kelly et al., 1999; Mana & Kawamura, 2002)
- Mariculture of Black Sea Oysters and Mussels (Kas'yanov, 1996; Stefanov et al., 1987; Staykov, 1997; Smietanka et al., 2004; Karayucel et al., 2002, 2003; Uyan & Aral, 2000; Kozintsev et al., 1989)

Eastern Mediterranean:

- Mariculture and growth of captured tuna
- Mariculture of mussels

Exploitation of marine microbial metabolisms

Black Sea:

- Waste Water Treatment underneath maricultures by microbial mats (Bender et al., 2004)

Hazards by introduction of new species

Mugil so-iuy is a freshwater fish living in Amu Darya River Basin, Far East Asia. It was first introduced to the area around the Sea of Azov for fish farming, but then migrated to the Black Sea, and from there to the Sea of Marmara (Kaya et al., 1998; Leppakoski, 1991).

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First overview of the Sponges of the eastern Mediterranean Sea and biotechnology aspects

North Adriatic Sea

From the beginning of marine science sponges from the Mediterranean Sea were of interest as they served several purposes in daily life. Many type species of new described families and genera have been found in the Mediterranean, where a rich sponge fauna lives: Pulitzer-Finali (1983) listed around 550 sponge species and today at least 564 species are reported from the Mediterranean Sea (Pansini, 1996). For the Croatian Adriatic Sea 201 species (28 Calcarea and 173 Demospongiae) were numeralised in 2000, one of them is threatened (Radovic, 2000).

A first remarkable overview of the sponge fauna for the Adriatic Sea was given by Schmidt (1862) as he felt the lack of basic literature to identify his sponge samples. He complained about the imprecise descriptions of sponges in Olivi's "Zoologia Adriatica" (Olivi, 1792) and the disinterest of Nardo, author of "Spongiariorum classificatio" (Nardo, 1833), to publish his own names and descriptions of a large number of sponge samples or at least to co-operate. The "Spongiariorum classificatio" contained a system based primarily on Adriatic sponges but as Schmidt missed the descriptions to Nardo's names he saw no other possibility then to ignore most of them.

Schmidt published a descriptive list of 115 species of which 95 were considered as new to science (Schmidt, 1862). In this work he also suggested that the regenerative characteristics of sponges might be utilized in sponge culture. This idea was set to practice one year later on the island of Hvar (Lesina), Croatia (Moore, 1908).

Based on these research activities, the Adriatic Sea became one of the best studied parts of the Mediterranean. This was advantaged by the foundation of several marine institutes and stations in the late 19th century, among those some of the oldest marine stations of the world. The Biological Station of Rovinj, Croatia, was founded in 1891 as field station of the Berliner Aquarium (Berlin, Germany) to ensure the supply of living organisms. It is now a department of the Institute "Ruder Bošković", Zagreb (HR) (Zavodnik, 1995).

Systematic sponge studies in the area of Rovinj began with Graeffe (1882), who noted three species from Rovinj. Zimmermann (1907) published a list of 25 species but the first (and most) comprehensive work for the area of Rovinj was done by Vatova (1928) who gave an overview of the distribution of the benthic species, the geological formations and climate conditions. Including most former works he listed 60 sponge species with their distribution and bibliography. "With regard to its complexity and conception, this work has remained unique up to the present day" (Zavodnik, 1995).

But Vatova - like previous authors - depended on dredged sponges or on dried and fixed material that was collected in shallow waters and on the beach. This led to systematic confusion, because of the alterations of the sponges skeletons and morphology due to fixation and drying processes (Rützler, 1965).

Therefore Rützler used SCUBA diving for his examinations. He listed and described a total of 62 sponge species for the area of Rovinj (Rützler,1965). Combining this list with Vatova's work, unpublished findings and the work of some other authors, he sorted 112 sponge species according to their habitat (Rützler, 1967).

Further strong interest for the sponges of the Rovinj area was shown by Müller who recorded several new species (Müller & Zahn, 1968; Müller *et al.,* 1979, 1983) and published a list of 139 species (Müller *et al.,* 1984) of which 137 seem to be valid today.

In the context of marine biotechnology as all as the use and exploration of sponges we would like to give a comparative overview on the chemical substances discovered each year from different marine taxa (Tab. 1) and also of the formidable possibilities of treating different diseases using substances from sponges (Tab. 2).

Tab. 1: Quantity of chemical substances discovered in different marine taxa in the last 10 years.

Year	**1995**[1]	**1996**[2]	**1997**[3]	**1998**[4]	**1999**[5]	**2000**[6]	**2001**[7]	**2002**[8]	**2003**[9]	**2004**[10]
	Quantity									
Total	**766**	**809**	**757**	**841**	**885**	**869**	**793**	**756**	**718**	**767**
Microorganisms	86	55	73	99	118	140	119	120	125	112
Green algae	5	8	5	5	3	8	6	14	13	2
Brown algae	26	12	39	27	34	10	13	16	35	34
Red algae	34	33	55	43	33	39	49	38	32	21
Sponges	**304**	**326**	**305**	**366**	**385**	**316**	**303**	**275**	**207**	**299**
Coelenterates	134	168	100	127	170	193	155	162	167	170
Bryozoans	10	16	12	5	13	7	4	10	3	11
Molluscs	37	62	54	43	53	45	64	23	40	24
Tunicates	72	55	79	72	62	74	59	51	46	37
Echinoderms	39	67	31	40	9	24	21	44	47	54
Miscellaneous	19	7	4	14	5	13	0	3	3	3

1 Faulkner, D. J. (1997). "Marine Natural Products." Nat. Prod. Rep. **14**: 259-302.

2 Faulkner, D. J. (1998). "Marine Natural Products." Nat. Prod. Rep. **15**: 113-158.

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5 Faulkner, D. J. (2001). "Marine Natural Products." Nat. Prod. Rep. **18**: 1-49.

6 Faulkner, D. J. (2002). "Marine Natural Products." Nat. Prod. Rep. **19**: 1-48.

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Tab. 2: Possible action and treatments of diseases using secondary metabolites (bioactive substances) from sponges

Effect	Compound	Species	Compound class
Antiinflammatory			
	Manoalide	*Luffariella variabilis*	Cyclohexane sesterterpenoid
	Ircinin-1 and -2	*Ircinia oros*	Acyclic Sesterterpenoid
	Spongidines A-D	*Spongia sp.*	Pyridinium alkaloid
	Topsentin	*Topsentia genitrix*	Bis-indole alkaloid
	Jaspaquinol	*Jaspis splendens*	Diterpene benzenoid
Antitumor			
	Halichondrin B	*Halichondria okadai*	Polyether macrolide
	Latrunculin A	*Latrunculia magnifica*	Thiazole macrolide
	Crambescidins 1-4	*Crambe crambe*	Pentacyclic guanidine derivative
	Agelasphin	*Agelas mauritianus*	α-Galactosylceramide
	Peloruside A	*Mycale hentscheli*	Macrocyclic lactone
Immunosuppressive			
	Simplexides	*Plakortis simplex*	Glycolipid
	Xestobergsterol	*Xestospongia berquistia*	Pentacyclic sterole
	Taurodispacamide A	*Agelas oroides*	Pyrrole-imidazole alkaloid
	Pateamine A	*Mycale sp.*	Thiazole macrolide
Blood-related diseases			
	Cyclotheonamide A	*Theonella sp.*	Cyclic pentapeptide
	Halichlorine	*Halichondria okadai*	Cyclic aza-polyketide
	Eryloside F	*Erylus formosus*	Penasterol disaccharide
Neurosuppressives / Muscle relaxants			
	Dysiherbaine	*Dysidea herbacea*	Unusual amino acids
	Xestospongin C	*Xestospongia sp.*	Macrocyclic bis-oxaquinolizidine
	Bromotopsentin	*Spongosorites sp.*	Bis-indole alkaloid
	Okinonellin B	*Spongionella sp.*	Furanosesterterpenoid
Antiviral			
	Avarol	*Dysidea avara*	Hydroquinone, sesquiterpenoid
	Hamigeran B	*Hamigera tarangaensis*	Phenolic macrolide
	Hennoxazole A	*Polyfibrospongia sp.*	Bisoxazole
	Haplosamate	*Xestospongia*	Sulfamated steroid
Antimalarial			
	Kalihinol A	*Acanthella sp.*	Diterpenoid
	Manazamin A	*Haliclona sp.*	Alkaloid, isocyanates, isonitriles, terpenoid
	Axisonitril-3	*Acanthella klethra*	Isocyanide
Antibacterial / Antifungal			
	Discodermins B - D	*Discodermia kiiensis*	Cyclic peptide
	Topsentiasterol sulfates A - E	*Topsentia sp.*	Sulfated sterol
	Axinellamines B - D	*Axinella sp.*	Imidazole alkaloid
	Spongistatin	*Hyrtios erecta*	Polyether macrolide lactone
	Leucascandrolide A	*Leucascandra caveolata*	Oxazole-containing polyether macrolide
Antifouling			
	C_{22} ceramide	*Haliclona koremella*	Ceramide
	Kalihipyran B	*Acanthella verrucosa*	Isocyanoterpenoid
	Formoside	*Erylus formosus*	Striterpene glycoside, sterol diperoxide
	Axinyssimides	*Axinyssa sp.*	Sesquiterpene carbonimide dichlorides

see also: Sipkema, D.; Franssen, M.C.R.; Osinga, R.; Tramper, J.; Wijffels, R.H. (2005): Marine sponges as pharmacy. Marine Biotechnolgy 7: 142-162.

Sponges and other biotechnological useful animals from the eastern Mediterranean and the Black Sea

Both regions here mentioned are only scarcely explored. Nevertheless there are some recent contributions especially to the sponge fauna.

Eastern Mediterranean Sea

It is common knowledge, that the eastern Mediterranean Sea is less well researched as the western or central parts. This is especially true for sponges (Porifera). The most important work on sponges at the coast of Israel has been accomplished by Lévi (1957). This work mentioned 31 species (one new) of Demospongiae. These specimens were sampled mainly in depths of 0 – 30 m. Some of the present knowledge about the sponge communities of the shallow waters of this region originated from Tsurnamal (1967, 1969a). He also described five new species. Researching the biodiversity of this region, one always has to expect Lessep's migrants from the Red Sea. This is also true for sponges. Burton (1936) and Tsurnamal (1969b) have found seven species from the Red Sea in the shallow waters of Levante.

Noteworthy are several, more recent studies on taxonomy and zoo-geography of sponges in the Greek parts of the Aegean Sea. First in this series is the work of Voultsiadou-Koukoura and van Soest (1991a, b, c, 1993) and of Voultsiadou-Koukoura and Koukouras (1993). Based on these, works of Kefalas, Castritsi-Catharios & Miliou (2003), Kefalas, Tsirtsis & Cartritsi-Catharios (2003) and Voultsiadou & Vafidis (2004) followed. In addition, an older recent description of Rhodos was compiled by Rützler & Bromley (1981).

In working on the biodiversity of the Medterranean fauna, Lessep'schen migration must always be considered. Indeed Burton (1936) and Tsurnamal (1969b) found seven sponge-species of Red Sea origin in the Mediterranean Sea.

From Greece appeared in the 80s and 90s papers by Voultsiadou- Koukoura (1987), Voultsiadou-Koukouras & van Soest (1991a-c), Voultsiadou-Koukoura & van Soest (1993) and Voultsiadou-Koukoura & Koukouras (1993).

Recently one paper appeared about sponge-associated animals from Turkey (Cinar et al. 2002). However, it has to be mentioned that M.E. Cinar does not study sponges, but is actually a specialist on Polychaeta.

Important recent papers from Greece are Kefalas et. al. (2003a + b), Voultsiadou & Vafidis (2004) and Voultsiadou (2005a +b). Koukouras et al. (1995) cite 81 Ascidian-species from the eastern Mediterranean.

There are only very few studies done on the deep sea fauna of the eastern Mediterranean Sea. Even less studies have been done on deep sea sponges and those were almost exclusively conducted in the western Mediterranean. After all, Kröncke et al. (2003) and Galil & Zibrowius (1998) mentioned the existence of sponge populations in the deep sea of the eastern Mediterranean Sea. The latter of the works describes two species of encrusting sponges. Explicitly from the deep sea region of Israel are two studies by Ilan et al. (1994, 2003). Within the older of the two, three sponge species are described, one of which is a new species, and a series of sponge-associate animals (mainly polychaetes, one of which is a deep sea Lessep's migrant) are mentioned. In addition, they also addressed the function of many sponges as islands for settlements of other organisms. In the more recent work (Ilan et al., 2003) four minute sponge species (three new ones) are described and their special adaptations to soft bottom substrate discussed.

Furthermore, Voultsiadou and Vafidis (2004) found two sponge species, which were previously know from the deeper waters of Gibraltar and the North Atlantic, in the shallow waters of the Greek Aegean Sea

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Black Sea

On an internet-site (http://www.ibss.ua) 25 sponge-species are listed. Koukoura et al. (1995) mentioned 10 Ascidian-species for the Black Sea.
Recently some biotechnological research was done on various sponges and other animal, mainly papers about sterol-content.

Popov et al. (1996) deals with invertebrates in general and in particular with sponges. Elenkov-Vvaylo et al. (1996) work with *Lissodendoryx variisclera* and Christie et al. (1994) with *Hymeniacidon sanguinea*. Two papers (Nesterova 1993, Gayeskaya & Nesterova 1995) focused mainly on the Ecology of *Cliona* sp. All other Papers dealt either with *Haliclona* spp. (Elenkov et al. 1999, Joh et al. 1997, Elenkov et al. 1997) or with *Dysidea fragilis* (de Rosa et al. 2000, Elenkov et al. 1994, Christie et al. 1992, Mikova et al. 1992).
Concerning Cnidaria the papers of Ma & Burcell (2005), Anonymos (2003), Belousova 1991 and Vafidis & Koukouras (2002) are ecological or taxonomical contributions. The papers of de Rosa et al. (1999) and Stefanov et al. (1992) deal mostly with chemistry.
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MARINE NON-LIVING RESOURCES

A Review on

GAS HYDRATES IN EASTERN MEDITERRANEAN AND BLACK SEA

Introduction

Mud volcanoes comprise the largest gas seepage features on continental margins and they are considered as the surface expression of buried hydrocarbon accumulations at depth. Gas hydrates are considered as a very promising energy source for the future. On the other hand, the role of sub-surface methane and other gases to global climatic changes, is not yet known and should be investigated. In addition, it is important to understand how gas seepage and gas hydrates induce slope instability.

Gas Hydrates in Eastern Mediterranean

The Anaximander Mountains is the only region that gas hydrates have been sampled in the Mediterranean Sea. Assumptions that the Olimpi mud volcano field (Central Mediterranean ridge, South of Crete) was hosting gas hydrates has been abandoned (Dählmann and De Lange, 2003).

Since the initial discovery of mud volcanoes in the eastern Mediterranean during the late 1970s (Cita et al., 1981), mud volcanoes, mud dipirism and fluid seeps have been found in a number of different environments in the area. Most have been found on the accretionary prism of the Hellenic Arc (Mediterranean Ridge) and within the Anaximander Mountains (Woodside et al., 1998); but they have also been found from offshore Sicily (Holland et al., 2003) to the Nile deep sea fan (Loncke, 2002; Loncke et al., 2004), as well as along the Florence Rise (Zitter et al., 2003) and in SE Aegean sea (Perissoratis et al., 1998). International interest resulted in ODP drilling on the Napoli and Milano mud volcanoes in the Olimpi Field on the central Mediterranean Ridge in 1995 (Cita et al., 1996; Robertson et al., 1996; Robertson and Copf, 1998). To some degree the increased interest was fuelled by the inferred presence of gas hydrates based on chlorinity decrease and δ18O increase in pore waters from Milano Mud Volcano (de Lange and Brumsack, 1998), whereas only a recent isotopic study showed that the fresher pore water originates from clay mineral diagenesis rather than gas hydrate dissociation (Dählmann and De Lange, 2003). However, gas hydrates were sampled in 1996 at Kula Mud Volcano in the Anaximander Mountains (Woodside et al., 1997; 1998). The discovery of mud volcanoes in the Anaximander Mountains was a result of a multibeam survey conducted as part of the Dutch ANAXIPROBE project in 1995 and from a follow-up survey in 1996 with seafloor sampling and deep-tow side scans imagery (Woodside et al., 1997; 1998).

The Anaximander Mountains comprise a group of three main seamounts located between the Cyprus and Hellenic arcs (Fig.1). They are currently undergoing a neotectonic deformation characterized by strike slip faulting (Zitter et al., 2003; ten Veen et al., 2004) between the westerly moving Anatolian Plate and the African Plate (McClusky et al., 2000). The Anaximander Mountains are described as large faulted and tilted blocks that originally were geologically continuous with south-western Turkey.

The mud volcanoes of Anaximander Mountains were unexpectedly discovered in 1995 during a detailed multibeam bathymetric survey with the swath system Simrad EM-12 of the French research vessel ‘L’Atalante’ in the framework of the Dutch ANAXIPROBE project In 1996, the combined expedition of the ANAXIPROBE project and the International Training Through Research programme (TTR-6), aboard the Russian research vessel R/V ‘Gelendzhik’, used the MAK-1 deep-tow side scan sonar, sub-bottom profiling and detailed dredging and sampling, to verify the presence of the mud volcanoes, and sampled the first gas hydrates in the Mediterranean, from the Kula Mud Volcano (Woodside *et al.,* 1997; 1998). Furthermore in 1998, the MEDINAUT programme using the submersible Nautile, deployed by the French research ship ‘Nadir’, performed a closer examination and took site-specific samples (MEDINAUT/ MEDINETH Shipboard Scientific Parties, 2000; Olu *et al.,* 2004; Charlou *et al.,* 2003). The following year, 1999, the MEDINETH and SMILABLE cruises with the Russian R/V ‘Professor

Logachev', investigated mud volcanism through high-resolution side-scan sonar (O.R.E. Tech), sediment core recovering and specific measurements of methane in the water column above the mud volcanoes (MEDINAUT/ MEDINETH and SMILABLE Shipboard Scientific Parties, 2000). Several mound-like features, expressed as high reflectivity patches on EM-12D backscatter intensity maps, were examined, but only seven were proven by sampling to be mud volcanoes at that time; and two of them were identified as bearing gas hydrates – the Amsterdam and Kula mud volcanoes. Gas hydrates, first sampled from Kula mud volcano during the 1996 ANAXIPROBE/TTR-6, were sampled again at Kula during the 1999 MEDINAUT/MEDINETH expedition (MEDINAUT/ MEDINETH Shipboard Scientific Parties, 2000), as well as at Amsterdam mud volcano.

The data regarding gas hydrate sampling were acquired during the two cruises of the ANAXIMANDER project in the Anaximander Mountains, in May 2003 (Lykousis *et al.,* 2003) and October-November 2004. The seafloor bathymetry/backscatter survey was carried out using a SEABEAM 2120 swath system installed the Greek research vessel "AEGAEO" of the Hellenic Centre for Marine Research The high resolution seismic profiling system used during the first expedition, was an analog recorder 10in^3 air gun system (PAR BOLT US). Digital data acquired, using a Delph (Triton Ellics) system. In both expeditions, a total of 64 sediment gravity cores and 17 box-cores were recovered at "targeted" sites, selected primarily on the assessment of their backscattering intensity map.

Gas hydrate sites in the major mud volcanoes of Anaximander Mountains
(Amsterdam, Kazan, Koula, Athina and Thessaloniki)

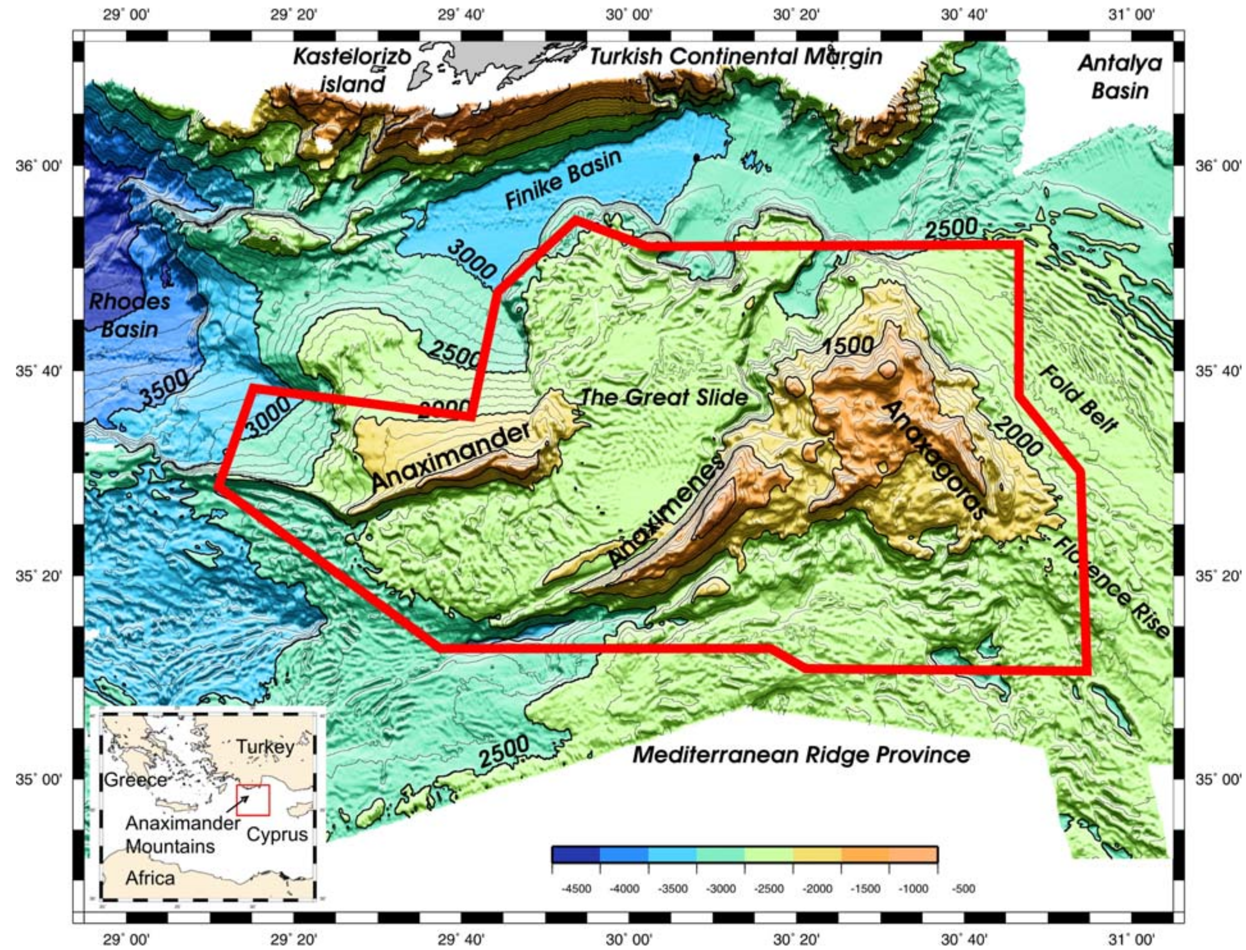

Fig 1. Bathymetric map of the Anaximander Mountains region

Amsterdam mud volcano

The Amsterdam mud volcano, the most prominent mud volcano in the Anaximander Mountains, is located on the southern flanks of the Anaximenes Mountain (Fig.2). It appears as a flat-topped circular-shaped mound, extending over an area of about 6 km^2, at a water depth on its summit of 2025m. At the periphery of the mound, a ring-shaped sea-floor depression is formed, creating a relatively deep (50 m) moat northwards. Detailed morphological analysis of the Amsterdam MV indicated that there are two discrete craters the “external” and the “internal” that merge to the southeast. Both are sub circular with dimensions of 6 x 5 km and 4 x 3.3 km respectively, slightly elongated in an N-S direction. One common morphological feature is that the craters are open in the southernmost part and directly connected to the slope with a 400 m wide canyon extending down to a depth if 2250 m.

Sediment containing gas hydrates has been sampled since 1999 at two sites, during the MEDINETH and SMILABLE cruises with R/V professor Logachev and during the two cruises of R/V Aegaeo. During the later, seven cores containing gas hydrates from five new sites were recovered from Amsterdam MV (Fig. 3).

Kazan mud volcano

Kazan is an isolated hill with a hight of 50 m, lying on the edge of a relatively flat plateau of 1750 m average depth (Fig. 2). The plateau lies on the southern flanks of the Eastern Anaximander Mountains, and eastwards from a major NW-SE trending fault zone separating Anaximenes from Anaxagoras SMs. It is an oval 0.6 x 0.9 km dome aligned in a N-S direction.

Gas hydrates were recovered for the first time at Kazan MV during the first cruise. Overall, during both missions, gas hydrates were sampled in 6 gravity and one box corers from four different sites on the summit. The gas hydrate crystals appeared as small rice-like lumps and were rather regularly dispersed throughout the sediment matrix deeper than about 0.3m of core depth.

Kula mud volcano

The Kula and San Remo mud volcano cluster lies on a small triangular plateau bounded to the east and south by seamounts at the northern tip of the Anaxagoras SM range. Four mound-type edifices have been defined on the bathymetry map (Fig. 2). The eastern one, closer to the Anaxagoras slope, is an irregular feature with a summit depth of 1650 m and which continues northeastwards as a low elevation ridge. West of it, Kula MV is a larger circular dome-shaped mount, with a diameter of 1 km and a height of 100 m (Woodside *et al.,* 1998). Northwestwards, a cone-shaped mound of 50 m height and about 1 km in diameter corresponds to the San Remo mud volcano (Woodside *et al.,* 1997).

The sediment cores recovered from the summit of the Kula mud volcano show that gas hydrates exist in a rather limited area and are difficult to be sampled.

Athina mud volcano

The newly discovered Athina MV (Lykousis *at al.,* 2004) is located at the south-eastern slope of the Anaximenes SM. The whole topography is rather complicated with steep slopes, two isolated deep basins and two mound-like topographic features along the top of the rise that separates the two basins. Both mounds display at least two distinct summits at water depths of about 1800 m, with a relative height of 10-100 m. Four sediment cores were recovered from both summits of the northward-located mound. Typical mud breccia from gravity cores on the south-western and the north-eastern summit confirmed mud volcanism and active methane seepage (Lykousis et al., 2004). The core from the south-western summit (water depth 1798 m) recovered 1 m of mud breccia with a greyish matrix supporting angular-sub angular clasts of mudstone The soupy structure with high amounts of water that appeared locally in the middle of the core may be is indicative of hydrate dissociation (Lykousis et al., 2004). The core taken from the water depth of 1783 m consisted mostly of fragments of authigenic carbonate crust, bivalves (*Lucinoma kazani)*, and worm tubes characteristic of active venting sites (Salas and Woodside, 2002).

Thessaloniki mud volcano

North-eastwards of Athina MV, at a distance of 9 Km along the south-eastern slope of the Anaximenes mountain, and at a depth of 1260 m, a small circular dome with a radius of 1.5 Km, defines the Thessaloniki mud volcano. Four sediment cores were recovered from the Thessaloniki MV, all with textures of active mud volcanism (mud breccia, gas hydrate, dissociation features, etc). From two of the sediment cores gas hydrates were collected identifying Thessaloniki as the fourth mud volcano bearing gas hydrates in the Mediterranean. Small gas hydrate lumps or flakes were dispersed in the fluidised mud. This fluidised muddy structure rich in free methane and small gas hydrate crystals was not observed previously, at least among the mud volcanoes of the European margins, indicating freshly emitted mud during a very recent activity. The unexpected discovery of gas hydrates in the Thessaloniki MV is of great importance since it is a fairly shallow MV (1260 m) and it just falls near the borders of the stability/instability zone of gas hydrate stability diagram (bottom temperature 14^{o}C).

Conclusions

During the two recent research cruises of R/V Aegaeo in May 2003 and October-November 2004, the Anaximander Mountains were surveyed by sea-beam bathymetry and detailed seabed backscatter imagery, extensive sea bed sampling and (locally over mud volcanoes) by high resolution seismic profiling. The multi-beam topography/imagery accurately delineated not only new morphological features of the greater Anaximander Mountains but also detailed morphological and acoustic characteristics of each individual mud volcano. The analysis of the seabed backscattering indicated potential new mud volcanoes that were confirmed by sediment gravity coring (Athina and Thessaloniki MVs). The Amsterdam mud volcano displays a well-developed almost flat-topped central dome while the Kazan, Kula, Thessaloniki and Athina MVs are rather mound-like conical mud volcanoes, probably indicating lower intensities of activity, and lower reactivation periods, narrower feeder channels, or extrusion of mud with higher shear strength, in comparison with Amsterdam mud volcano.

The large number of the sediment cores recovered enables the extension of the active mud volcanism, the delimitation of the gas hydrate field and the verification of new gas hydrate sites like the Kazan and Thessaloniki MVs. The Amsterdam MV is the most active mud volcano in the Anaximander Mountains in terms of volume and extent of erupted mud breccias and the extent of gas hydrate occurrence. A prominent characteristic is the southward moving mud flow that bears gas hydrates. On the basis of systematic sampling it appears that gas hydrates occur mostly towards the central and north-eastern parts of the central dome of Amsterdam MV. Gas hydrates were also sampled, for first time, at Kazan and Thessaloniki MVs, while gas hydrate dissociation structures were found within the sediment cores from Kula and Athina MVs. Gas hydrates were observed and sampled at various depths within the sediment cores but were present usually deeper than 0.4m from the seabed surface. The texture resembles compacted snow and the external morphology is like flakes, lumps (nodular aggregates), or big rice crystals (Kazan MV). The sediment cores from the Thessaloniki MV contained gas hydrates and implied recent activity. This is the shallowest mud volcano bearing gas hydrates in the Mediterranean (1260 m) and is at the edge of the stability zone determined by the depth and the seafloor temperature (~14ºC). The gas hydrates at Thessaloniki MV are thus sensitive to temperature and sea level fluctuation and therefore this could be regarded as an ideal site for studies of mud volcano activity, and their environmental impact, and gas hydrate stability.

The potential aerial extension of the gas hydrates based in the core sampling and the multi-beam backscatter imaging is estimated to about 46 km3.

Gas Hydrates in the Black Sea

Introduction to the Black Sea area

Fluid vents, including mud volcanoes and associated gas hydrate accumulations are common features in the Black Sea. In fact, active venting, gas-saturated sediments and associated authigenic carbonate accumulations have been observed in the Black Sea on its northwestern (Thiel et al., 2001); Michaelis et al., 2002), central and northeastern (Bohrmann et al., 2003; Mazzini et al., 2004), and southeastern (Çifci et al., 2002; Ergun et al., 2002) margins. Throughout the Black Sea, methane release at high-density vents can generate bubble curtains or plumes (Greinert et al., 2006). Mounds or mud volcanoes are formed in areas of moderate venting (Aloisi et al., 2000), whilst regions where fluid escape is limited commonly show bottom-simulating reflectors (BSR's) representing the accumulation of gas hydrates below the sea bottom (Popescu et al., 2006).

The formation of the Black sea as the World's largest anoxic basin dates from the Upper Cretaceous. The area evolved firstly as a back-arc basin formed in relation to the northward subducting Thetys Ocean (Robinson et al., 1996). During the Cenozoic, the gradual closure of the basin and subsequent global sea-level variations promoted its present anoxic character. Associated tectonic inversion was responsible for the onset of diapirism and fluid venting in the Black Sea. In the newly formed basin, the Holocene global sea level rise allowed the invasion of high salinity waters from the Mediterranean through the Bosphorus strait, approximately at 9,000 years BP (Ross et al., 1970) or at 7,000 years BP (Ryan et al., 1997). A permanent stratification of the water body was then established between the original fresh water body and the underlying marine waters, with anoxic conditions prevailing in the bottom layers (Ross and Degens, 1974). At present, 80% of the water column is anoxic, with the oxic-anoxic interface located between 130m and 180m water depth (Ross et al., 1978).

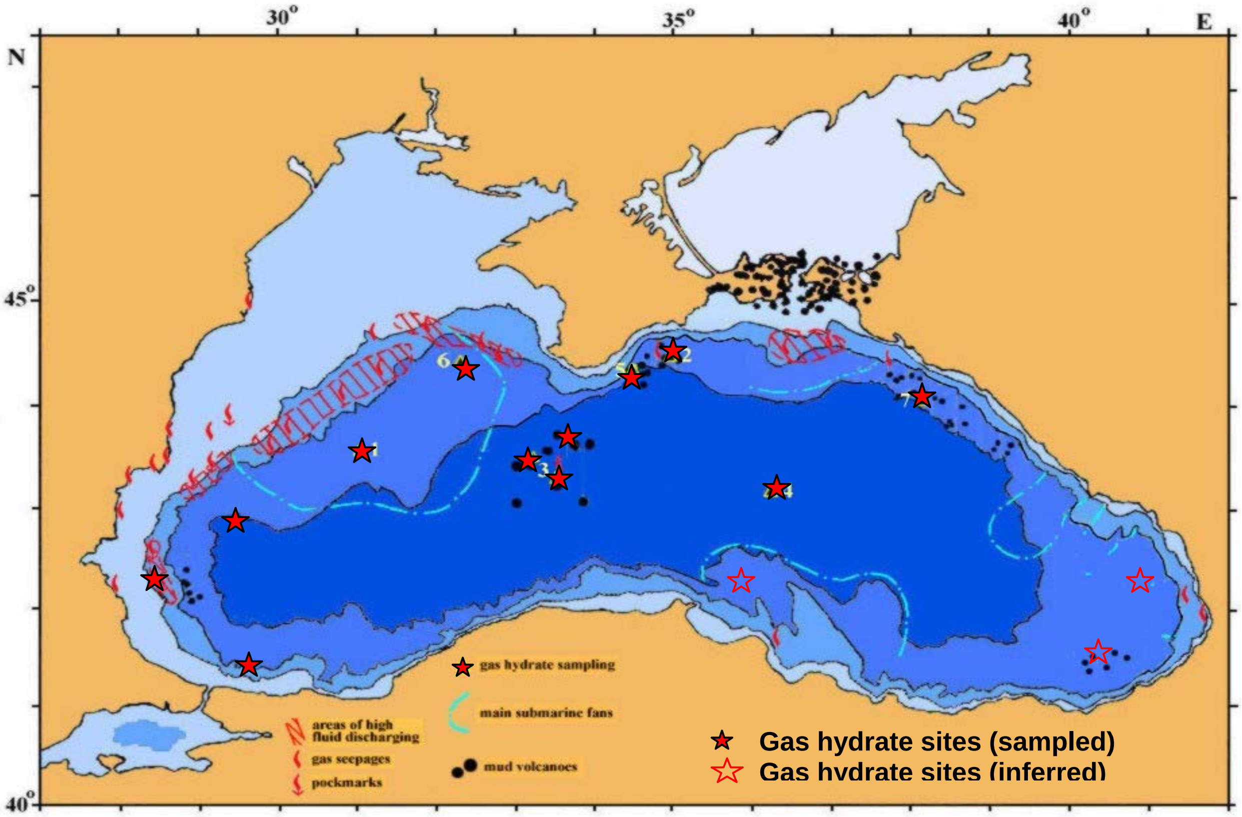

Fig 2. Map of known gas venting areas in the Black Sea basin

Known areas of gas venting include 6 main regions according to their geographical distribution, sea-bottom morphology and local geological conditions:

1) Danube deep-sea fan area, offshore Bulgaria and Romania;
2) SW Crimea, offshore Ukraine;
3) Central Black Sea area, on the deep-margin south of Crimea (Ukraine);
4) Sorokin Trough area, east of Crimea;
5) Southwest Russia (Yuzhny Federal District), west of Caucasus;
6) Offshore Georgia (Batumi area) and Northern Turkey.

Ongoing research

Current and recently finished projects on the Black Sea comprise: i) regional surveys for the identification of new gas seepage areas, ii) geophysical studies in regions with known gas-hydrate fields and/or seepage features, iii) biological and geochemical analyses over and adjacently to gas vents. In particular, the precipitation of authigenic carbonate deposits have been used as a proxy to identify areas of active mud volcanism and where the relative amount of methane rising favours the formation of gas hydrates (Ivanov et al., 1999; Aloisi et al., 2000).

Subsurface gas hydrates and seafloor vents are known to in the Black Sea since, at least, the late 1960's (Danube paleodelta, Yefremova and Zhizhchenko, 1974; Crimea 49 cruise, Degens & Ross, 1972). Subsequent campaigns led to the discovery of important new fields on the Crimean and Eastern Mediterranean (e.g. Bohrmann et al., 2003; Ergun et al, 2002; TTR-15 Post-Meeting Conference Abstracts, 2006). Recent cruises in the Eastern Black Sea confirmed the presence of extensive hydrocarbon seepage features offshore Russia (Dolgovskoi Mounds, offshore Caucasus) and Georgia (Batumi Seep Area) (TTR-15 Post-Meeting Conference Abstracts, 2006).

Some of these latter discoveries have been followed by projects funded by the European Union (e.g. ASSEMBLAGE, CRIMEA, METROL) and international organisations (e.g. OMEGA, Training Trough-Research Programme, BlaSON, GEOTECHNOLOGIEN, GHOSTDABS, OMEGA, etc.), with the aim of surveying regions where available geophysical and sedimentological data is still scarce. When new vent areas are discovered, seafloor sampling and geochemical analyzes over active seepage areas are common procedures in scientific cruises on the Black Sea.

In comparison with other gas-seepage regions of the Mediterranean Sea (Lykousis et al., 2003) and South Atlantic (Pinheiro et al., 2003), rising gas bubbles, flares and plumes form spectacular features within the water column adjacent to some of the mud volcano areas of the Black Sea. This character allows the combined use of hydroacoustic (e.g. echosounders) and geochemical measurements for the recognition and analysis of newly-discovered and identified mud volcano fields. Some of the current research is focused on the improvement of current hydroacoustic methods for the identification of gas-seepage areas. In particular, it is of interest to correlate the flux and composition of escaping gases with the occurrence of gas hydrates below the sea bottom, a potential source of methane to the Oil Industry. Comprising features which denote the existence of hydrocarbons below the surface, gas vents can be related to the occurrence of extensive oil and gas fields on continental margins. The recognition of such seepage areas is, therefore, a crucial element for the future exploration of hydrocarbons in Black Sea.

Conclusions - Pending research questions

Significant questions on the regional and global (worldwide) importance of fluid vents and associated gas hydrate accumulations are still pending. In the Black Sea area, the most important research issues still to be addressed relate to:

1) The role of sub-surface methane and other gases to global climatic changes, particular those related to marine geochemical cycles;
2) The relative importance of sea-floor seepage as indicators of hydrocarbon fields below the surface;
3) Ecosystem research on mud volcanoes and other areas of significant gas seepage;
4) Gas hydrates as proxies for old climatic conditions, development and preservation of gas hydrates on continental margins;
5) Gas seepage and gas hydrates as inducers of slope instability on continental margins.

Fluid and gas expulsion in active mud volcanoes influence the geochemical budget of sea water in the Sorokin Trough, Central Black Sea (Aloisi et al., 2004). Globally, diagenetic processes are known to concentrate geochemically important species such as Sr^{2+}, Ba^{2+}, Li^{+}, B and I, together with dissolved inorganic nitrogen (DIN). Studying the relative concentration of some of these elements in seawater through time helps to reconstruct the paleosea conditions during the Late Cenozoic as, for instance, seawater pH, old hydrothermal processes acting on oceanic crust, paleoproductivity, ocean circulation and paleoclimate. By providing local, but oftentimes dramatic sources of geochemical elements to oceans, mud volcanoes and associated structures can suddenly alter the marine cycles of Sr^{2+}, Li^{+}, B, I and DIN, with subsequent environmental and climatic implications (Aloisi et al., 2004), particularly in a restricted basin as the Black Sea.

Mud volcanoes comprise the largest gas seepage features on continental margins, and they are oftentimes considered as the surface expression of buried hydrocarbon accumulations at depth. Therefore, the identification of new mud volcano fields on continental margins is significant to the recognition of new areas for future oil and gas exploration, particularly when mud volcanoes can be associated at depth with extensive gas hydrate fields. Such association has been demonstrated in several mud volcano sites in the Black Sea (e.g. Popescu et al., 2006; TTR-15 Post-Meeting Conference Abstracts, 2006).

As the locus of active seepage, mud volcanoes and associated fluid seepage structures on continental margins are preferential sites for the development of complex, if rare, ecosystems. Complex diagenetic and geochemical processes are also responsible for the accumulation of authigenic carbonates and mineralogically enriched sea-floor crusts, forming coherent substrates for the implantation of benthic species (TTR-15 Post-Meeting Conference Abstracts, 2006). By comprising biological and geochemical hot-spots in otherwise deep barren areas of the continental margins, mud volcano areas of the Black Sea are environmentally significant.

'Fossil' gas hydrate fields were identified on the Western Black Sea (Popescu et al., 2006) and may provide sea-bottom paleotemperatures and a fairly complete record of P-T conditions during their formation. Thus, they may constitute proxies for deciphering past climatic conditions. Moreover, when considering climatic variations recorded during the Quaternary, the role of gas hydrates and associated fluids in slope instability processes is a key question still to be addressed in global and regional scales. Gas hydrate dissolution and 4D exchanges of free gas in the sediment column can provide the necessary conditions to trigger major landslides on continental margins.

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