UNEP

UNITED NATIONS ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

MAP

MED POL

MARICULTURE IN THE MEDITERRANEAN

MAP Technical Reports Series No. 140

UNEP/MAP

Athens, 2004

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ISSN 1011-7148 1810 – 6218 (Online)
ISBN 9280723804

For bibliographic purposes this volume may be cited as:

UNEP/MAP/MED POL: Mariculture in the Mediterranean. MAP Technical Reports Series No. 140, UNEP/MAP, Athens, 2004.

The thematic structure of the MAP Technical Series is as follows:

- Curbing Pollution
- Safeguarding Natural and Cultural Resources
- Managing Coastal Areas
- Integrating the Environment and Development

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INTRODUCTION

Marine aquaculture and in particular intensive fish farming, has shown a large expansion in most of the Mediterranean countries over the last 10 years. It provides an important source of high quality food and could be considered to be an important management tool to limit pressure on wild fish stocks, which are heavily stressed due to over fishing and pollution in coastal areas.

This rapid increase in mariculture production has caused conflicts with other activities in the coastal zone and raised significant public concern over environmental issues.

Problems caused by high organic and nutrient loading conflict with other uses of the coastal zone. The use of chemicals (therapeutants, vitamins and antifoulants) and the introduction of pathogens and new generic strains have also raised environmental concerns.

These problems may be overcome by improvement in technology related to aquaculture practices and if marine aquaculture is based on well-balanced interventions through integrated coastal area management plans. These plans should consider aquaculture in relation to all other existing and planned activities and development.

Mediterranean mariculture should and could be sustainable with aquaculture practices that are environmentally not degrading, technically appropriate, economically viable and socially acceptable.

CHAPTER 1: MAIN CHARACTERISTICS AND FEATURES OF MEDITERRANEAN MARICULTURE

Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Aquaculture has been the world's fastest growing food production system for the past decade (Tacon, 1997). Aquaculture production increased from 16.8 million tonnes in 1990 to more than 42 million tonnes in 1999 valued at over US$ 53 thousand million (FAO, 2001).

In Mediterranean aquaculture, the earliest extensive marine fish farms dated from the 6th century BC. Therefore, it cannot be excluded from its evolution and indeed is its pioneer. Aquaculture in the Mediterranean represents about 5% of total world production.

1.1 Recent evolution of mariculture in the Mediterranean

There are two basic factors, which led to exponential development of mariculture in the Mediterranean region:

A new form of aquaculture has arisen over the past 20 years due to mastery of the reproduction of marine fish, the development of research in formulated feeds and technological innovations enabling installations to be located on land as well as in the sea. This type of aquaculture corresponds to the growth in the demand for fish quality products (seabass, seabream etc.) which generally cannot be met by traditional means due to the chronic over fishing of these species and the general relative decline of fisheries production over the last few years in the Mediterranean (Table 1).

Table 1
Total fish catch by Mediterranean countries
for the years 1995 - 1999 (FAOSTAT data base results 2000)

100 Records <;• Copyright FAO 1990-1998

Total Fish Catch (MT)	Year				
Mediterranean and Black Sea (MT)	**1995**	**1996**	**1997**	**1998**	**1999**
Albania	1,46	2,058	923	1,968	2,136
Algeria	105,912	82,024	91,615	92,374	105,725
Cyprus	2,859	3,232	3,173	3,486	3,597
Egypt	45,078	53,932	56,815	77,535	98,877
France	70,636	56,316	61,473	61,555	65,636
Greece	169,838	175,129	194,824	156,673	185,811
Croatia	16,476	18,309	17,412	24,682	21,812
Israel	4,507	3,858	5,15	5,901	6,049
Italy	551,515	510,924	481,479	494,263	472,502
Lebanon	4,065	4,115	3,635	3,5	3,54
Libya	34	32	31	32	32
Malta	1,826	2,382	2,675	2,93	3,035
Morocco	40,993	40,98	32,663	29,582	38,416
Yugoslavia	374	383	380	418	433
Slovenia	1,911	2,203	2,192	2,113	1,885
Spain	149,089	150,61	133,395	123,39	122,445
Syria	1,95	2,67	2,574	2,75	2,6
Tunisia	83,436	83,677	86,867	88,123	91,554
Turkey	594,486	493,467	426,843	456,61	550,137
AGG COUNTRIES	1,880,411.00	1,718,269.00	1,635,088.00	1,659,853.00	1,808,190.00

Mean consumption of seafood around the Mediterranean basin is similar to the levels of world consumption (approx. 18 kg per person/year), with very marked differences amongst different countries. It represents a total of nearly 3 million tons overall, which is much more than the Mediterranean global levels of production from fishing and aquaculture. Italy, France and Spain have a major deficit in the balance of sea products. Practically all Mediterranean countries are in the same situation. A growing demand that exists in this area led to a veritable explosion in Mediterranean aquaculture production.

Fig. 1 (Georgiou G., 2001) shows the production of aquaculture (Fish and Mollusc) in the Mediterranean over the last few years. Indeed the production of fish has increased from a total of 220,000 tonnes in 1985 to 320,000 tonnes in 1995 and to 480,000 tonnes in 1998.

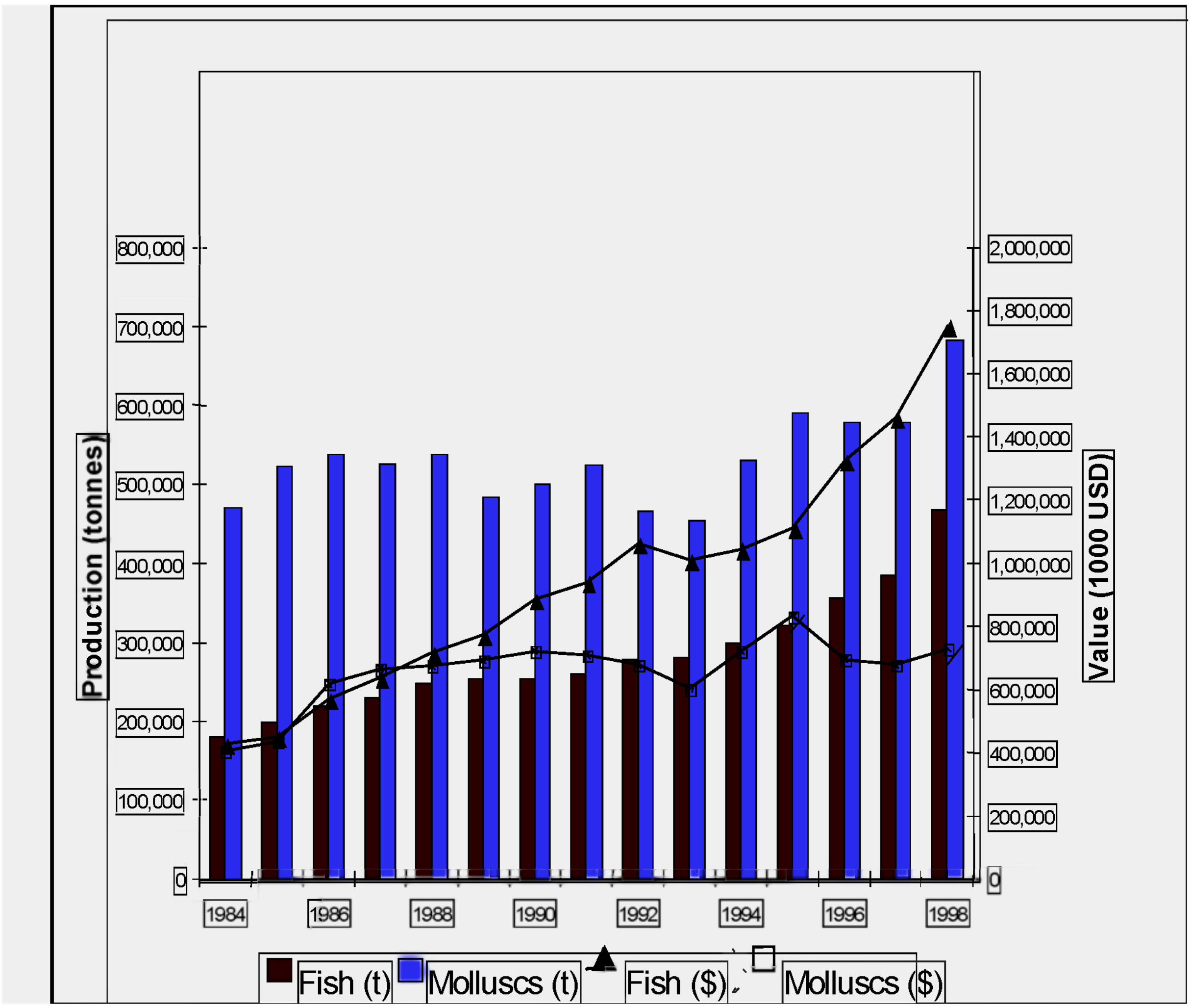


Fig. 1: Fish and mollusc production and value: Mediterranean countries 1984 to 1998 (Georgiou, G. 2001).

Ferling and La Croix (2000) provide (Table 2) - Aquaculture production of the Mediterranean Sea and the Mediterranean watershed (fresh water species) in 1988 and 1998.

Table 2. Aquaculture production of the Mediterranean Sea and the Mediterranean watershed (freshwater species) in 1988 and in 1998 (except the Black Sea). Data (in metric tons) from FAO, Sipam, Infremer.

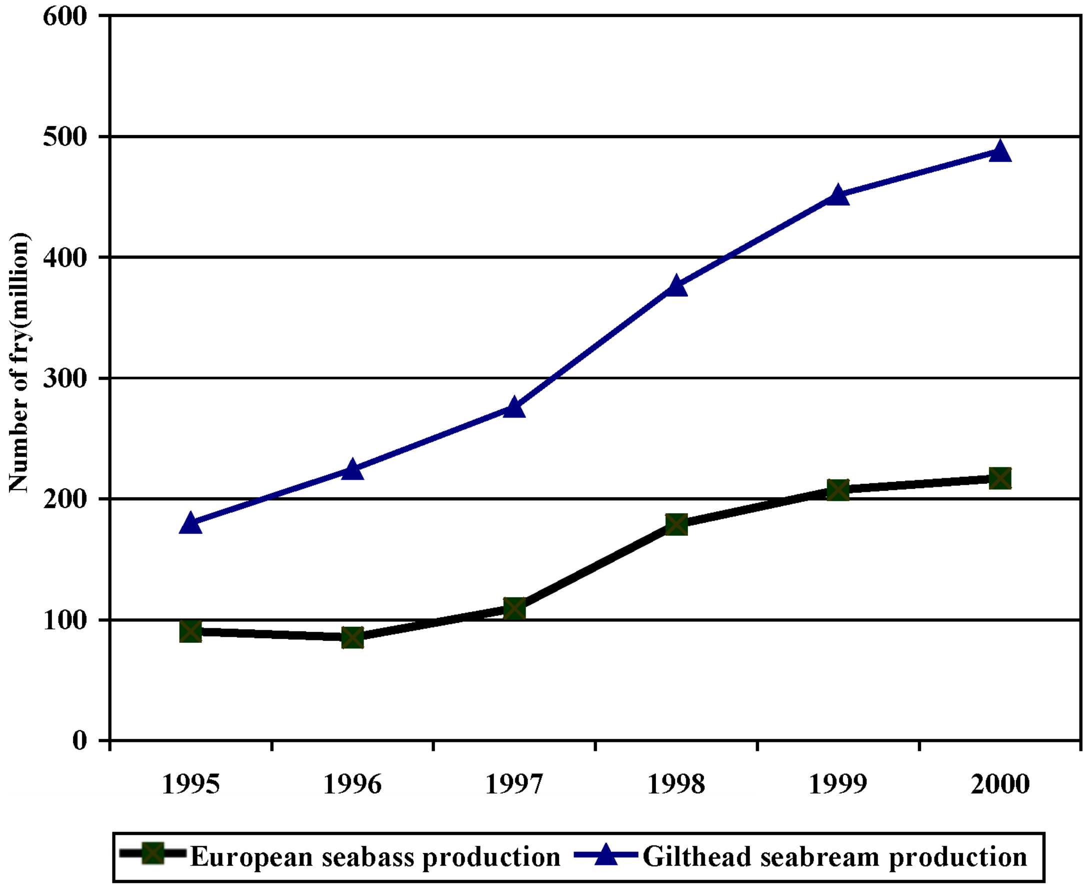
Species, or group of species	Production 1988	Production 1998	Variation: X factor	Variation: (%)
Seabass	1,600	32,000	X 20	
Seabream	1,600	40,000	X25	
Mullet	6,000	20,000	X 3,3	
Other marine fishes	400	6,500	X 16	
TOTALMARINE FISHES	9,600	98,500	X 10	
Trout	46,000	93,000		+ 100 %
Carp	37,000	30,000		- 1 9 %
Tilapia	28,000	34,000		+ 21 %
Other freshwater fishes	3,300	9,000		+ 172%
TOTALFRESHWATER FISHES	114,300	166,000		+ 45%
Oyster	26,000	25,000		-4%
Mussel	195,000	200,000		+ 2%
Clam	3,400	43,000	X 12	
Other molluscs	100	2,900	X 29	
TOTAL MOLLUSCS	230,000	271,000		+ 1 8 %
CRUSTACEAN	1,300	300		-76%
ALGAE	0	5000		
GLOBAL TOTAL	350,000	540,000		+ 54%

(Fenlin and La Croix, 2000)

.

The production of marine fishes has increased remarkably from 9,600 tonnes in 1988 to 96,500 tonnes in 1998. In respect to species the main dynamic trend originates from the seabass, *Dicentrarchus labrax* and seabream, *Sparus aurata*, which account for the bulk of marine aquaculture. As a direct consequence, the greatest share of the Mediterranean hatchery output is represented by the farming of species. Fig. 2 shows the seabass and seabream fry production from the period 1995 – 2000 (G. Georgriou, 2001).

Fig. 2: Seabass and seabream fry production in the Mediterranean area. (Georgiou, G. 2001).



Fry production of the seabass has more than doubled during the period of 1995 – 2000, while the fry production of seabream has reached nearly 500 million in the year 2000 compared with less than the 200 million in 1995.

In terms of type of marine aquaculture intensive culture shows an exponential increase. Table 3 and Fig. 3 show the production of fish and crustaceans from intensive mariculture by Mediterranean countries for the years 1990 to 2000. Production from intensive mariculture has increased from about 6000 tonnes in 1990 to nearly 124,000 tonnes in the year 2000. For the year 2000, Greece has the greatest share of this increase with about 47%, Turkey second, followed by Italy, Spain and France (Fig. 4).

Fig. 3. Total Production of Fish and Crustaceans from intensive mariculture in the Mediterranean for the years 1990 - 2000

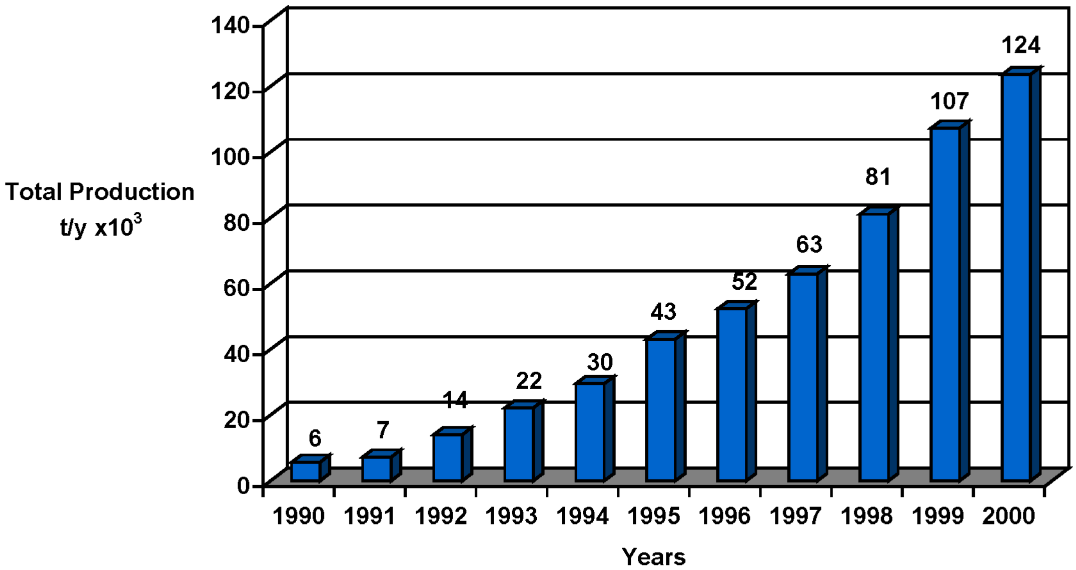


TABLE 3

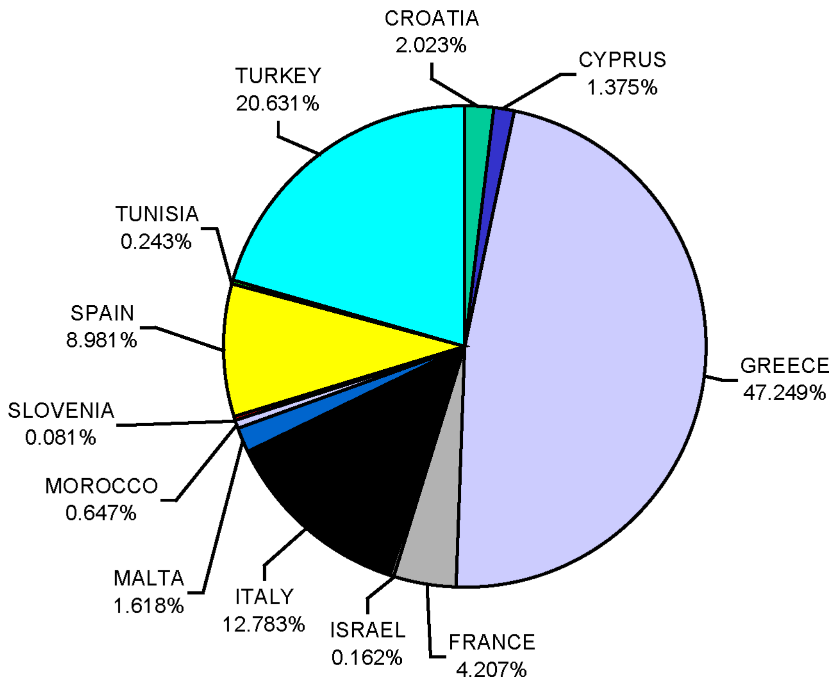
Production of Fish and Crustaceans (t/y x 103) from intensive mariculture by Mediterranean countries for the years 1990 - 2000 (Source: Feap, Sipam).

YEAR	CROATIA	CYPRUS	GREECE	FRANCE	ISRAEL	ITALY	MALTA	MORROCO	SLOVENIA	SPAIN	TUNISIA	TURKEY	TOTAL
1990	1,50	-	1,60	0,50	-	0,90	-	0,20	-	1,00	-	-	**5,70**
1991	0,40	-	2,50	1,00	-	1,50	-	0,30	-	1,20	0,30	-	**7,20**
1992	0,70	0,07	6,00	1,60	-	1,20	0,30	0,50	0,01	1,80	0,20	1,70	**14,08**
1993	1,30	0,20	9,50	2,30	-	2,90	0,60	0,70	0,02	2,40	0,50	1,80	**22,22**
1994	1,50	0,20	13,60	3,80	-	3,30	0,90	1,10	0,08	2,50	0,60	2,00	**29,58**
1995	1,50	0,40	17,80	4,00	-	5,30	1,30	1,20	0,05	3,20	0,40	8,00	**43,15**
1996	1,70	0,70	23,00	3,60	-	6,00	1,60	1,20	0,07	4,90	0,60	9,00	**52,37**
1997	1,80	0,80	25,50	3,80	-	7,30	1,80	0,90	0,09	4,40	0,80	15,80	**62,99**
1998	2,30	1,10	30,90	4,50	-	10,10	1,90	0,70	0,10	8,00	0,40	21,10	**81,10**
1999	2,40	1,30	48,00	4,80	0,20	11,80	2,00	0,70	0,10	11,00	0,30	24,70	**107,30**
2000	2,50	1,70	58,40	5,20	0,20	15,80	2,00	0,80	0,10	11,10	0,30	25,50	**123,60**

1.2 Country by Country situation

Production from mariculture in terms of type (intensive, semi-intensive and extensive) and group of species (fish, Mollusc and Crustaceans) by Mediterranean countries is shown in a series of Tables Ia – Im (Annex I).

Fig 4 % of the total production by each country for the year 2000



Marine aquaculture in Greece is now well established and experienced in order to be able to evaluate its present status and determine its future. Greek production from intensive mariculture represents almost 47% of the total intensive mariculture in the region. Mollusc production in the form of semi-intensive and extensive methods increased from 5800 tonnes in 1990 to 28,100 tonnes in the year 2000. The number of mussel farms in Greece increased rapidly from five in 1980 to 346 in 1998.

Mollusc, with cupped oyster as the principal species, dominate marine aquaculture production in France which in 1999 reached 205,000 tonnes. Mollusc production from semi-intensive mariculture has been quite stable over the last 10 years.

Fish production from intensive culture increased to 7000 tonnes in 2000 from 1410 tonnes of 1990; Crustacean production is around 1200 tonnes per year.

Aquaculture in Spain is dominated by semi-intensive and extensive shellfish farming, mainly mussels. Total production in 2000 was about 280,000 tonnes. (This type of activity is found in the north west of the Iberian Peninsula). During the last few years finfish farming has been developed in a number of Mediterranean locations in Spain with turbot, seabream and seabass as the most important species. Fish production from intensive mariculture was about 11,100 tonnes in 2000. In the last few years blue fin tuna production has increased. The production of tuna in 1990 was 31 tonnes while in 2000 it reached 3,400 tonnes.

In 2000, Italian finfish production in marine waters exceeded 15,800 tonnes mainly due to seabream and seabass production. Mollusc production in 1999 was about 141,000.

In Turkey fish mariculture has grown exponentially over the last few years. Production of marine fish from intensive mariculture increased to 25,500 tonnes in 2000, from 1750 tonnes production in 1992.

A real evolution in mariculture has occurred also in Cyprus, where marine finfish production reached 1700 tonnes in the year 2000, while marine fish production in 1992 was only 70 tonnes. The main species cultivated are seabass and seabream. Cyprus has a noticeable production level of Crustaceans, which in 2000 was 60 tonnes.

Malta shows a similar picture to Cyprus. The production of fish from intensive culture has increased to more than 2000 tonnes in 2000, from 300 tonnes in 1992.

Production from intensive and semi-intensive mariculture in Croatia shows no substantial increase in the last ten years. Fish production, mainly seabass and seabream, was about 2,500 tonnes in 1999, while in 1992 was 685 tonnes. A slight decrease in mollusc production occurred over the last few years, being less than 1,000 tonnes per year. What is interesting in Croatia is the fast growth of tuna fish production, which started in 1998, with a production of 400 tonnes, while today the production has doubled.

The only marine species produced until recently in Slovenia was that of mollusc with a production of about 50 tonnes. Production of seabream and seabass has been established, since early 1990, with very low production. Today the production level is around 120 tonnes.

Albania has no intensive mariculture. The only production is that of mollusc in brackish waters with a production reaching about 100 tonnes per year.

Egypt has always been the main aquaculture producer in Africa with production of 73,500 tonnes in 1997. However, aquaculture production on the Mediterranean coast represents only the 12% of the total. The most important marine species that are cultured are seabream and seabass. The average annual production during the years 1994 to 1997 was about 200 tonnes with an increase in 1999 to 940 tonnes.

Morocco is a country where mariculture production shows a decrease the last few years. In 1992 production of intensive mariculture was about 200 tonnes. Production increased to 1200 tonnes in 1996 but over the last 3-4 years it has dropped to less than 800 tonnes.

Similar situations exist in Morocco and Tunisia, where intensive mariculture showed an increase in production in the years 1996-97, reaching 800 tonnes: but dropped to about 300 tonnes in 2000.

There is no intensive mariculture in Algeria. The very low level of fish production of about 30 tonnes (1999) and 20 tonnes of mollusc comes from extensive mariculture.

In Israel intensive mariculture, is a recent activity on the Mediterranean coastline. One of the existing seabream farms with a production of 200 tonnes in 2000 was completely destroyed due to bad weather conditions in early 2001. The only farm which is operates today in Israel has a production capacity of 50 tonnes.

In Syria, Libya, Lebanon and Bosnia-Herzegovina there is no intensive mariculture.

CHAPTER 2: WASTES/CONTAMINANTS INTO THE MARINE ENVIRONMENT

The environmental load from marine fish farming is not a recent issue but it has been a subject of increasingly heated debate over the last few years.

A perceived risk of pollution from fish farming in coastal waters relates to the generation of wastes (Gowen and Bradbury, 1987) and the release of chemotherapeutants (ICES, 1994). It has further been argued that coastal aquaculture is potentially harmful to indigenous biota through disturbances of wildlife (Whilde, 1990, Beveridge et al, 1994), influence on the behavior of wild fish (Henrksson, 1991) and the genetic interaction between wild and farmed fish.

The range and amount of waste contaminants from aquaculture is diversely being depended on the form of aquaculture activity. The distinction between extensive aquaculture (that relies upon the availability of natural food) and intensive aquaculture (that relies upon feeding the stock with processed diets) is useful when considering the inputs of aquaculture operation (Gowen et al, 1990).

It is obvious that intensive aquaculture results in large amounts of wastes/contaminants particularly nutrients, and this is undoubtedly a matter of concern for the Mediterranean for two reasons;

- The Mediterranean is more "sensitive" to nutrient inputs, as the term "oligotrophic" has been widely used for its description (Azov, 1986, Vaque et al, 1997).

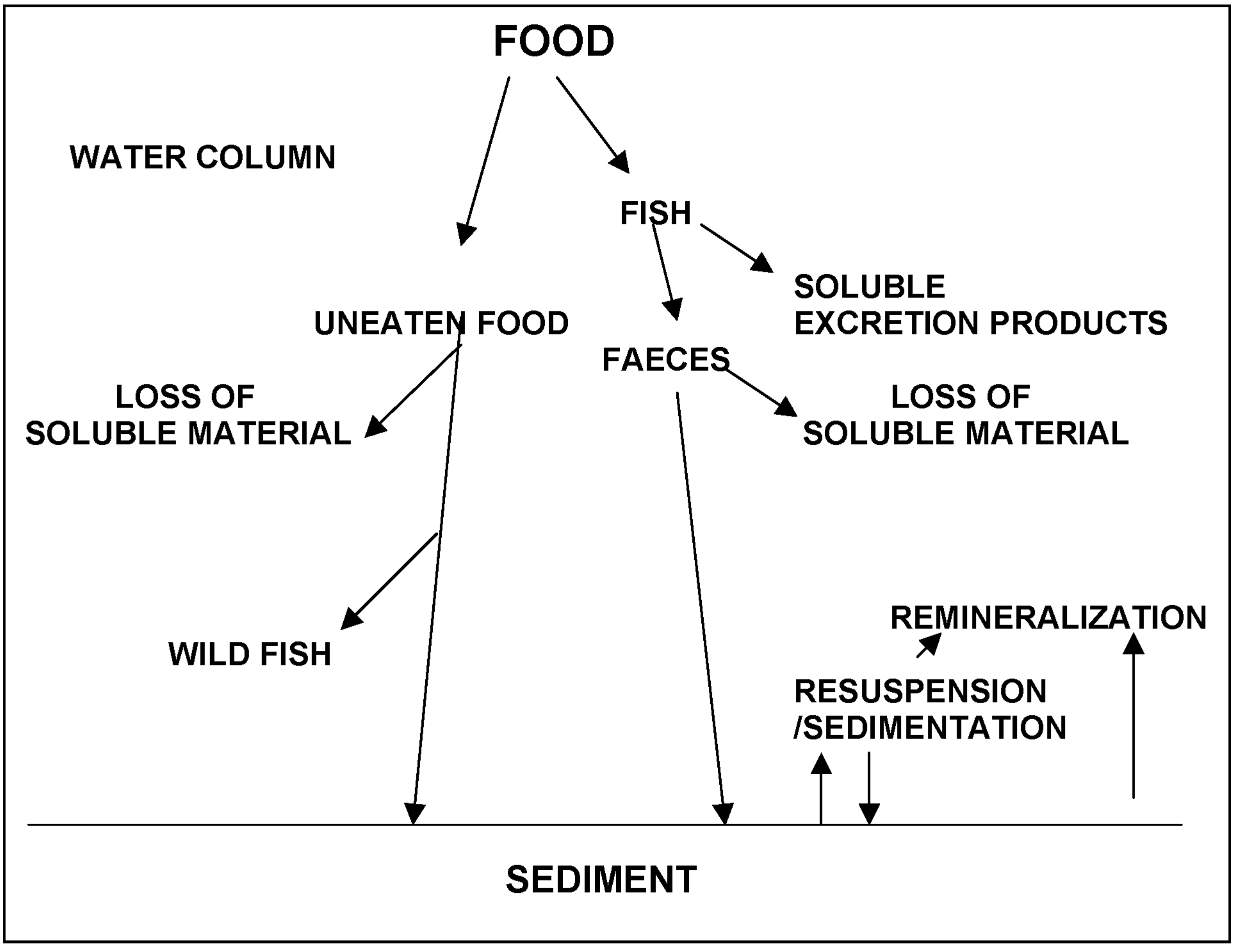
- ***A new form of intensive aquaculture has arisen over the past 20 years due to mastery of the reproduction of marine fish, the development of research in formulated feeds, and the technological innovation enabling installation of very large units located mainly in the sea, where the Mediterranean microtidal regime reduces the potential for dilution and dispersion of nutrients especially in closed bays.***

2.1 Nutrients and Carbon enrichment

Aquaculture can bring about enrichment of ecosystems by the release of metabolic waste products (faecal and excretory materials) and uneaten food into the marine environment.

The fate of these materials is shown in Fig. 5. In general the recipient of the organic waste is the sediment and the recipient for soluble waste is the water column, although as Fig. 5 shows there may be an exchange of material between the sediments and the water column.

Fig. 5 The fate of waste material released from intensive fish farming (Gowen, et al, 1990.)



Most mariculture of carnivorous species in the Mediterranean takes place in cages suspended in more or less open waters. This mean that dissolved components are released directly into the marine environment in a highly biologically active form. The dissolved products include ammonia, phosphorus and dissolved Organic Carbon (DOC). The DOC component contains fractions rich in Nitrogen (DON) and Phosphorus (DOP).

2.1.1 The Nitrogen and Phosphorus budget of intensive fish farming

There are a number of worldwide studies that have examined nitrogen and phosphorus inputs from intensive fish farming, but only few for the Mediterranean.

Most of these studies are using the mass balance estimates based on feed usage and different species.

Hakanson et al, (1990) estimated the loads of Nitrogen and Phosphorus, based on the content of Nitrogen and Phosphorus in feed and its conversion ratio by salmon and trout with the following calculations:

Load (N,P.): Feed conversion ratio x Feed (N, P) - Fish (N, P)

With a Feed Conversion Ratio of 2:1 and feed with 45% protein and 1.5% Phosphorus it was estimated that 100 kg of Nitrogen and 20 kg of Phosphorus are released into the marine environment with each tonne of fish produced. The 67-80% of Nitrogen added to the cage system is lost to the environment (Hall et al, 1992). If it is assumed that Nitrogen content in feed is 8% and that retained by fish is 21%, it is estimated that 84kg to 100 kg of Nitrogen enter the marine environment per tonne of fish produced. Conversion ratio is considered to be 2:1. A value which is similar to that estimated by Hakanson et al.

In the marine environment Holby and Hall (1991) showed that the environmental losses of Phosphorus to be 19.4 to 22.4 kg per tonne of fish produced, 34-41% of which was released in dissolved form, with the remaining being lost in sedimentation. They estimated that 4-8% of the sediment Phosphorus returns to the water column per year.

In a more recent survey Gowen et al (1997) estimated the nitrogen and phosphorus inputs from the seabream and seabass cage farming in Cyprus.

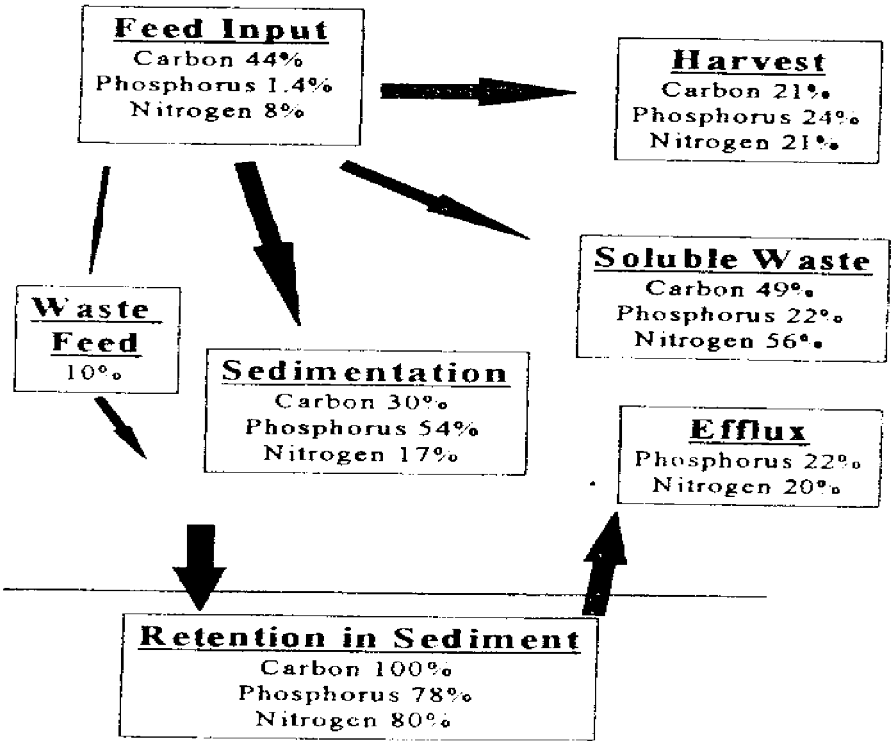


Fig. 6 The mass balance model used to estimate soluble and organic waste output from each of the marine cage farms in Cyprus. (Gowen et al, 1997).

To estimate waste output they used a mass balance model (Fig. 6). The model was derived from (Hall et al, (1992) and Ackefors (1990) for Nitrogen and Phosphorus and from Hall et al (1990) for Carbon. A factor of (10%) for uneaten food was introduced as suggested by Gowen and Bradbury (1987). This is an approximate value, but does not appear unreasonable given the feed conversion ratio in Cyprus farms of 2.6 - 2.7. It should be noted that the above mass balance models are for the salmonid culture in northern European waters. It appears that these models can also used for warm water fish species (Baird and Muir, 1990) and are comparable with data derived from a gilthead sea bream farm (Dominguez et al, 1997).

Estimated total annual (1996) inputs of soluble Nitrogen and Phosphorous were 77,100 kg and 8,000 respectively i.e. 116 kg of Nitrogen and 12 kg of Phosphorus per tonne of fish produced.

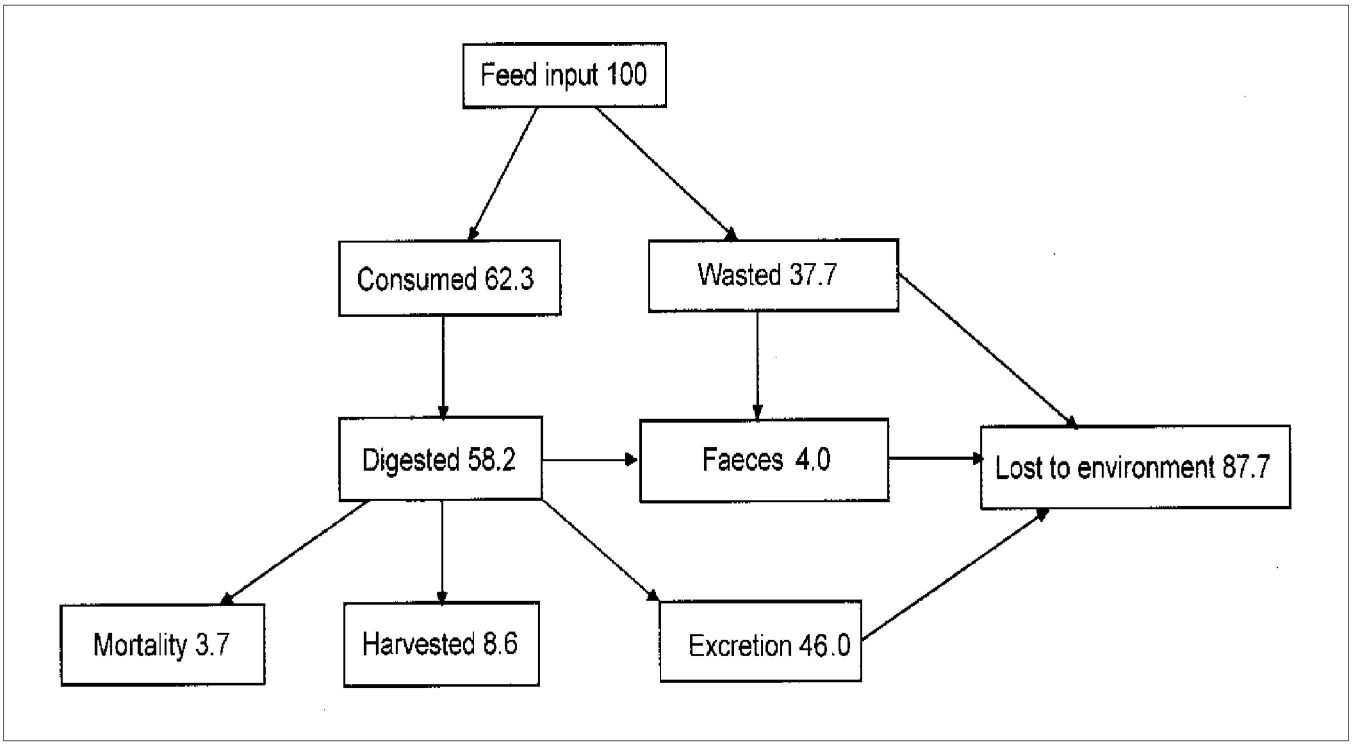
Estimates of N output are similar to those used in the report concerning the Environmental Impact of Aquaculture in Cyprus (Fisheries Department, 1997). There is however a difference in terms of P, which is lower than the values given in the report of the Department of Fisheries. One reason for this is that in the latter report it was assumed all phosphorus waste to be soluble.

Katavic I., (1997) reported 96.5 kg of Nitrogen and 11 kg of Phosphorus annual inputs per tonne of seabass produced in cage farms (266 tonnes/y) in coastal waters of Croatia.

The Nitrogen budget for the aerolated grouper, *Epiniphelus areolatus*, cultured both in laboratory and cage conditions has recently reported. (Leung et al, 1999. These workers attempted to balance the following equation: C = G+M+E+F where, each term relates to a mass of Nitrogen, and: C is consumption, G is nitrogen retained for growth, M represents losses from mortality, E is excretory loss and F loss through faeces. For a fish farm, the budget is represented by: C= I-W where, I is the total input to the farm and W is the food wasted.

Using a variety of techniques, Leung et al (1999) were able to quantify each of these terms either by direct measurement or by difference Fig. 7 shows the budget derived for cage farming of this species.

Fig. 7 Nitrogen budget for aerolated grouper, *Epiniphelus areolatus,* in cage culture Leung et al, 1999.



2.1.2 Carbon inputs

In intensive fish culture, fish faeces are lost to the environment along with the wastage from uneaten food (processed fish meal, trash fish). Processed fish food is composed of highly labile (digestible) mixture of protein, fat, carbohydrate and other minor components such as vitamins and pigment. As it is undigested, uneaten food has a much greater capacity (weight for weight) than faecal material to impact the environment both in terms of energy content and degradation rate.

Several published studies have examined the total amount of particulates released to sediments from fish cages (Hall et al., 1990, Ye et al, 1991, Findlay et al, 1995) Estimates of waste have varied between 29 and 71% of input carbon, depending on the year (Hall et al, 1990) and 78% of input carbon (Ye et al, 1991).

In the mass balance model used by Gowen et al (1997) to estimate waste inputs from seabream and seabass cage farms in Cyprus, carbon input was considered to be 79%. Estimated annual waste output of particulate C for a production 663 tonnes of produced fish was 283 tons i.e. 427 kg per tonne of fish produced. Higher values were reported for seabream cage farms in Malta where he estimated annual waste output of particulate C for fish farms of 500 tons capacity to be 253.5 tons i.e. 570 kg per tonne of fish produced (Grech P., 1999).

2.1.3 Estimated Nitrogen (N), Phosphorus (P) and Carbons (C) loads

The estimation of the loads of nutrients and carbon entering the marine environment and their trend of the last ten years was based on the following criteria, facts and data:

- Main waste outputs come from intensive aquaculture and accurate estimates can be drawn only from intensive culture. Estimated waste outputs in this study are related to intensive mariculture.

- The Nitrogen (N) and Phosphorus (P) loads from semi–intensive mariculture are only 5% and 10% respectively of those from intensive culture.

- Based on existing data (2.1.2 and 2.1.3) for Nitrogen (N), Phosphorus (P) and Carbon (C), the following values were used for the purpose of this study:

  110 kg Nitrogen (N) output per tonne of Fish produced
  12 kg Phosphorus (P) " " " " "
  450 kg Carbon (C) " " " " "

i. Nitrogen (N)

Table 4 shows the estimated inputs of N, (t/y) from intensive mariculture by each country in the Mediterranean region for the years 1990-2000.

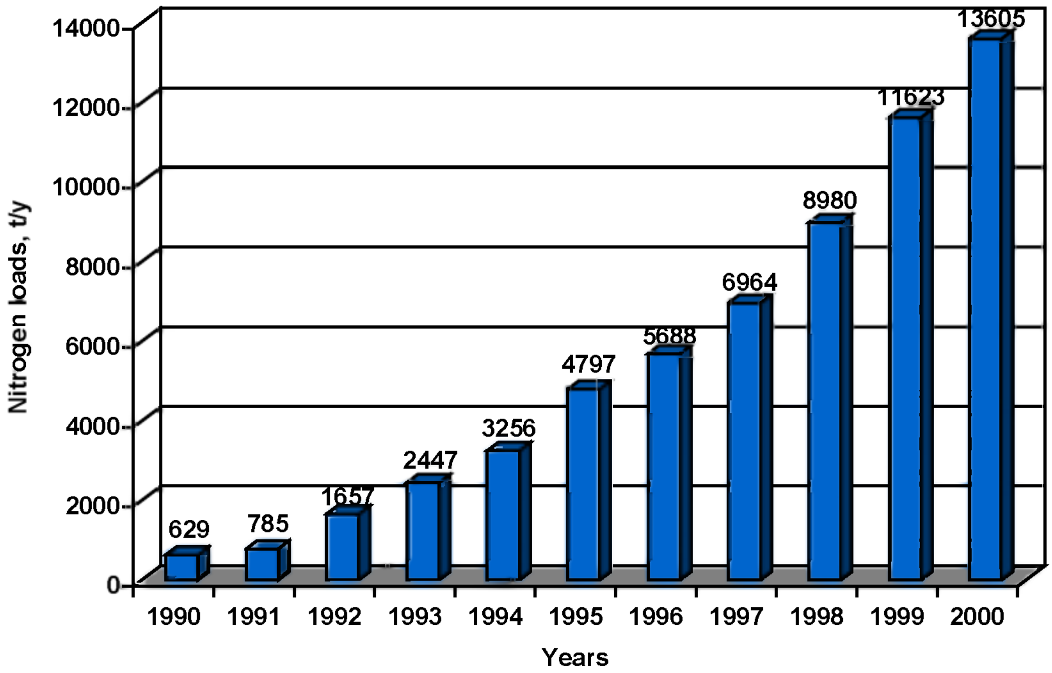
Table 4

Estimated inputs of Nitrogen (N), (t/y) from intensive mariculture in the Mediterranean region for the years 1990 - 2000

YEAR	CROATIA	CYPRUS	GREECE	FRANCE	ISRAEL	ITALY	MALTA	MORROCO	SLOVENIA	SPAIN	TUNISIA	TURKEY	TOTAL
1990	160	-	177	55	-	104	-	24	-	109	-	-	**629**
1991	38	-	272	110	-	162	-	37	-	134	32	-	**785**
1992	75	8	664	174	-	215	33	64	1	204	22	197	**1657**
1993	145	18	1045	260	-	321	66	73	2	266	53	198	**2447**
1994	167	23	1499	416	-	360	99	126	8	270	68	220	**3256**
1995	164	40	1954	435	-	580	143	132	6	350	43	950	**4797**
1996	182	74	2530	340	-	657	170	134	8	542	61	990	**5688**
1997	198	94	2805	413	-	805	198	97	10	482	88	1774	**6964**
1998	248	119	3399	498	-	1113	214	82	11	884	40	2372	**8980**
1999	268	149	5280	529	22	1292	220	82	11	1022	31	2717	**11623**
2000	275	198	6424	570	22	1738	225	82	13	1221	32	2805	**13605**

As it is seen from Figure 8 the total inputs of Nitrogen in 2000 has increased by 25 times from that of 1990. Total Nitrogen input in 1990 was estimated to be about 630 tonnes while this was increased to 13600 tonnes for the year 2000.

Fig.8 Estimated loads of Nitrogen (N) from intensive mariculture for the years 1999 - 2000



The percentage contribution by each country to the total input of Nitrogen for the year 2000 is shown on Fig. 9. Greece shares 47% of the total input with Turkey to having about 20% of the total input, Italy having about 12% and Spain and France have about 9% and 4% respectively. The percentage contributions by the rest of the countries range from 0.09 to about 2%.

Fig. 9. % of the total Nitrogen (N) loads by country for the year 2000

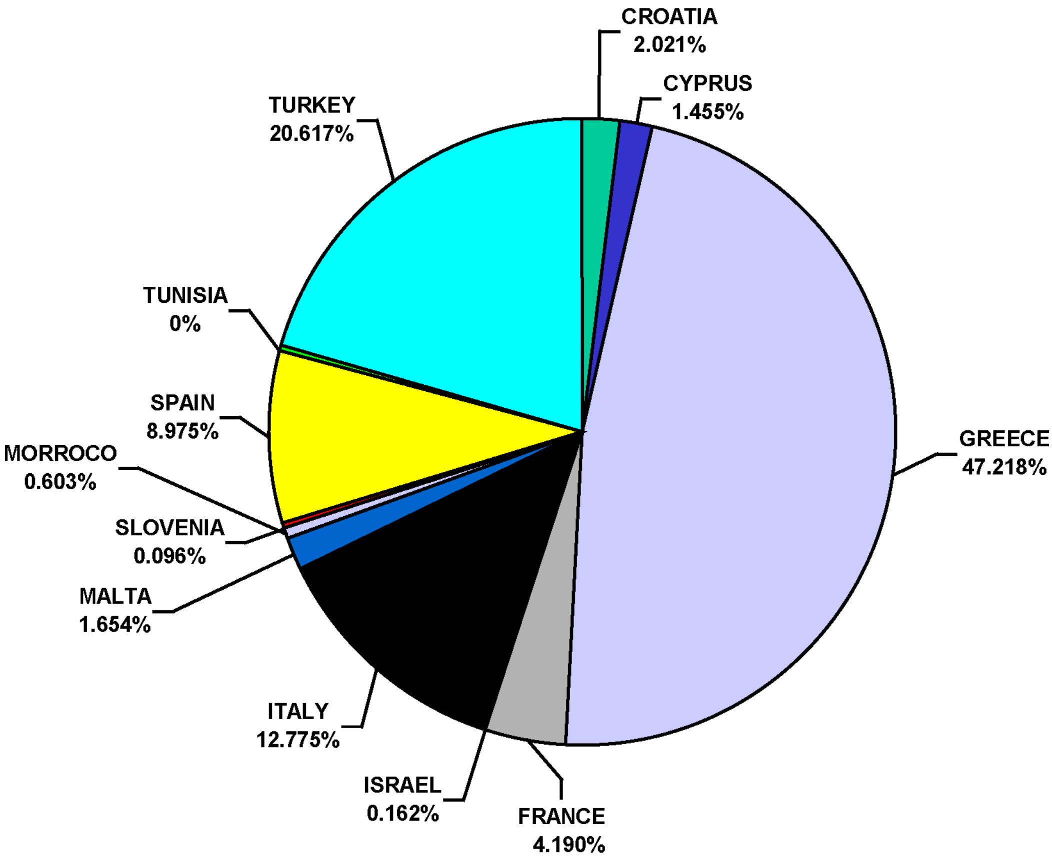


Table 5

Estimated inputs of Phosphorus (P) (t/y) from intensive mariculture in the Mediterranean region for the years 1990 - 2000

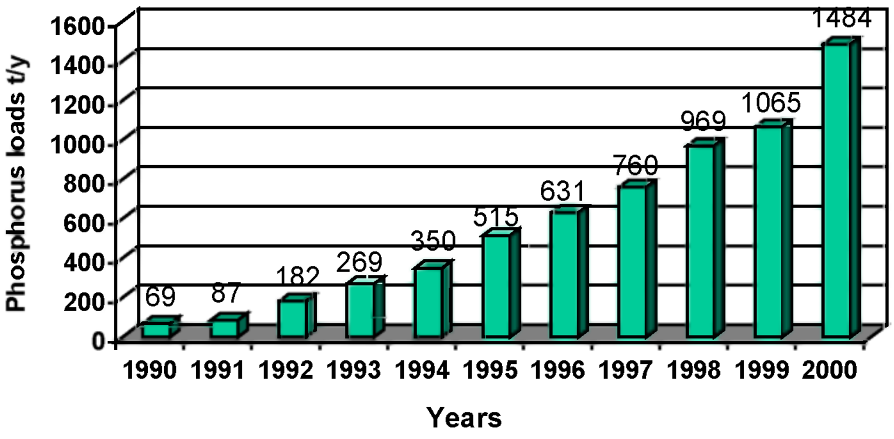
YEAR	CROATIA	CYPRUS	GREECE	FRANCE	ISRAEL	ITALY	MALTA	MORROCO	SLOVENIA	SPAIN	TUNISIA	TURKEY	TOTAL
1990	18	-	19	6	-	11	-	3	-	12	-	-	**69**
1991	4	-	30	12	-	18	-	4	-	15	4	-	**87**
1992	8	1	72	19	-	26	4	7	-	22	2	21	**182**
1993	18	2	114	28	-	35	7	8	-	29	6	22	**269**
1994	18	3	164	40	-	39	11	14	1	29	7	24	**350**
1995	18	4	213	47	-	63	16	14	1	38	5	96	**515**
1996	20	8	276	44	-	71	19	15	1	59	7	111	**631**
1997	22	10	306	45	-	88	21	11	1	53	10	193	**760**
1998	27	13	370	54	-	122	23	9	1	96	4	250	**969**
1999	29	16	376	58	2	141	24	9	1	109	3	296	**1065**
2000	30	22	701	62	2	189	25	9	1	133	3	306	**1484**

ii. Phosphorus

Table 5 shows the estimated inputs of Phosphorus (t/y) from intensive mariculture in the Mediterranean region.

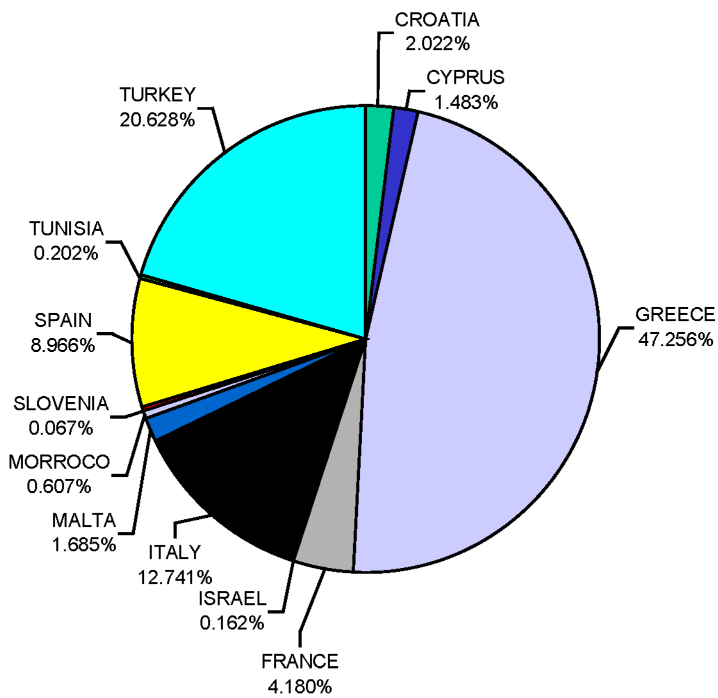
Phosphorus input was estimated to be 69 tonnes in 1990 while this figure was increased to about 1500 tonnes for the year 2000 Fig. 10).

Fig. 10 Estimated loads of Phosphorus (t/y) from intensive mariculture in the Mediterranean for the years 1990 - 2000



The percentage contribution by the countries to the total inputs of Phosphorus for the year 2000 is similar, as expected, with that of Nitrogen. (Fig. 11)

Fig. 11 % of the total Phosphorus load by each country for the year 2000



iii. Carbon

The estimated input of carbon for each country for the years 1990 to 2000 is shown Table 6. In the year 2000 the estimated total carbon input was about 55,700 tonnes compared with the 2,600 tonnes for the year 1990 (Fig. 12). The percentage contribution by each country is similar to that of N and P. (Fig. 13).

Fig. 12 Estimated loads of Carbon (C) (t/y) from intensive mariculture in the Mediterranean for the years 1990 - 2000

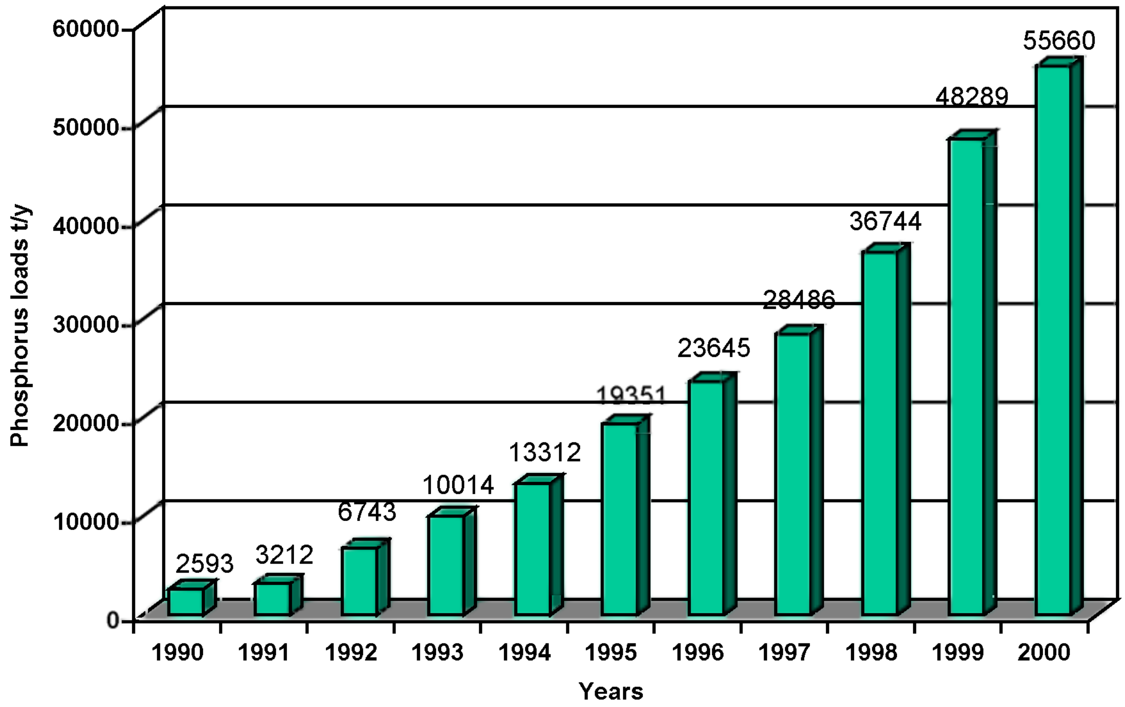
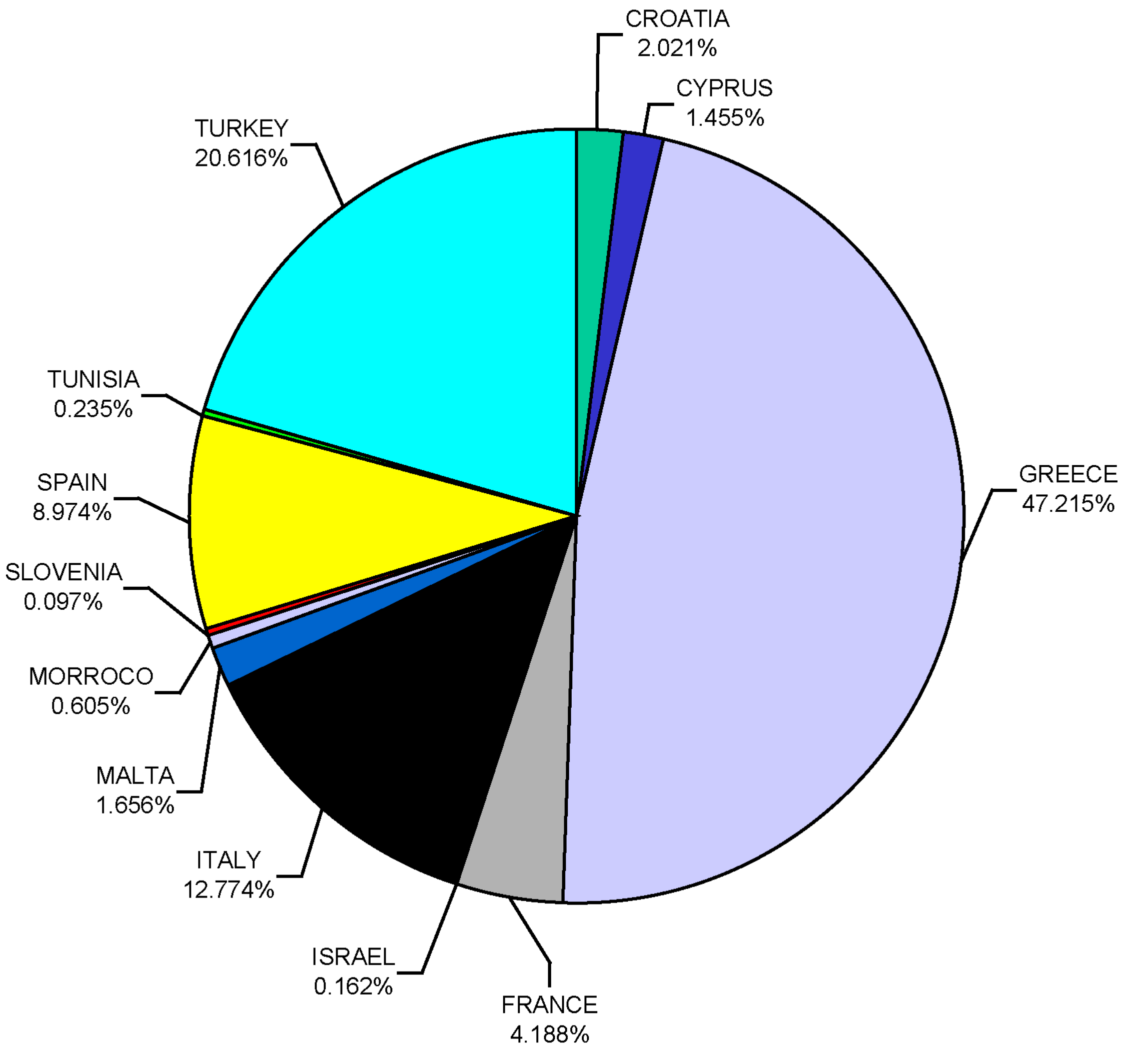


Table 6

Estimated inputs of Carbon (C) (t/y) from intensive mariculture in the Mediterranean region for the years 1990 - 2000

YEAR	CROATIA	CYPRUS	GREECE	FRANCE	ISRAEL	ITALY	MALTA	MORROCO	SLOVENIA	SPAIN	TUNISIA	TURKEY	TOTAL
1990	673	-	723	225	-	427	-	98	-	447	-	-	**2593**
1991	156	-	1114	445	-	666	-	151	-	549	131	-	**3212**
1992	308	32	2714	710	-	881	135	245	5	836	90	787	**6743**
1993	596	76	4275	1062	-	1313	270	299	8	1088	217	810	**10014**
1994	684	95	6133	1700	-	1462	406	518	34	1103	277	900	**13312**
1995	670	159	7993	1781	-	2373	585	540	22	1433	177	3618	**19351**
1996	747	304	10350	1635	-	2687	698	548	38	2219	248	4171	**23645**
1997	810	379	11475	1691	-	3293	810	396	40	1974	360	7258	**28486**
1998	1013	485	13905	2036	-	4556	877	334	46	3620	166	9706	**36744**
1999	1098	610	21600	2164	90	5287	900	335	46	4918	126	11115	**48289**
2000	1125	810	26280	2331	90	7110	922	337	54	4995	131	11475	**55660**

Fig. 13 Percentage (%) of the total Carbon load by each country for the year 2000



As mariculture is a coastal activity, the inputs of N, P and C were estimated in terms of the coastline for each country.

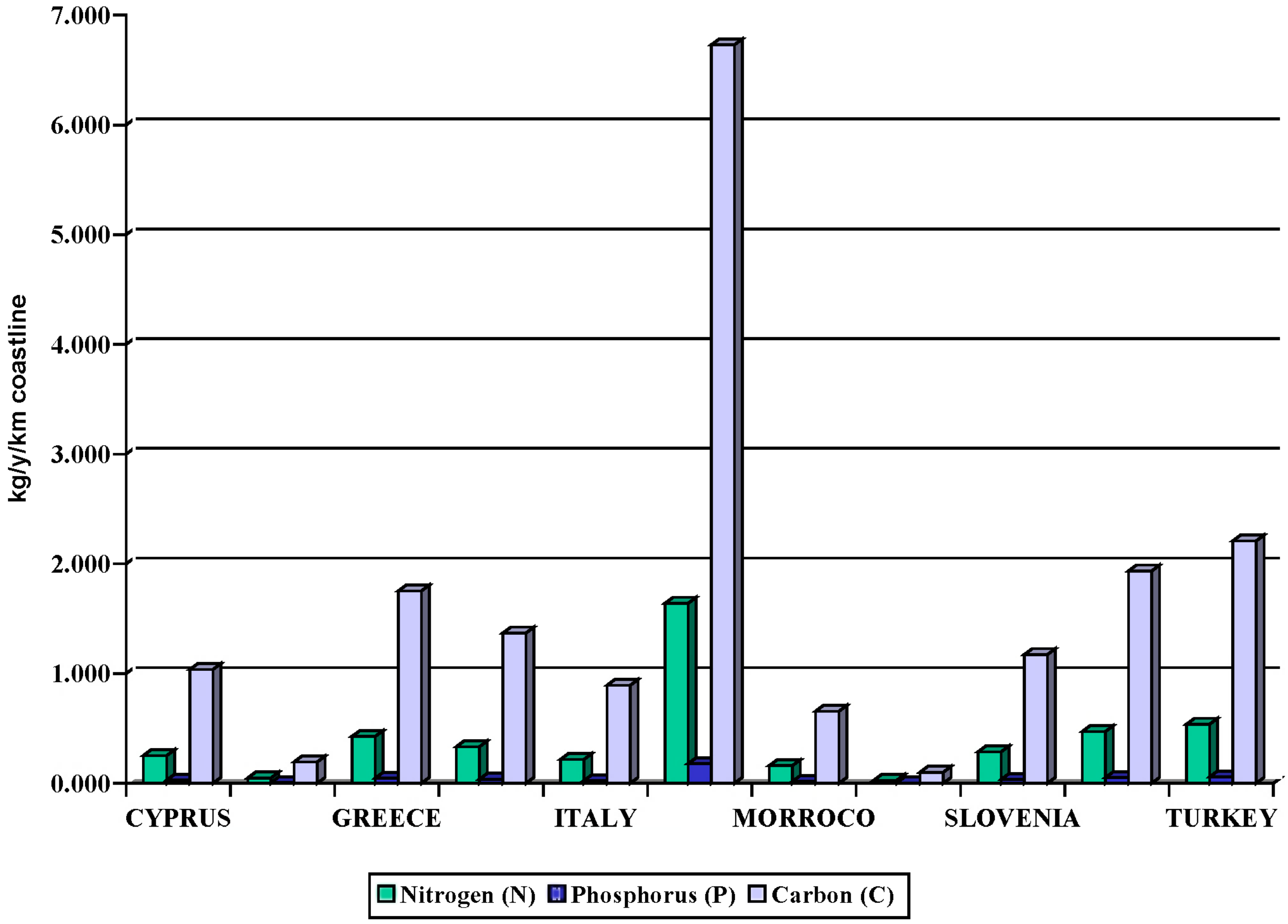
Table 7 and Fig. 14 show the inputs of N, P, and C per km of coastline. As it is seen Malta has the higher inputs per km coastline (with the others to be in the same range, (1000 to 2000kg/y/km) with the exception of Tunisia and Morocco, which have lower inputs in this respect.

Table 7

Waste outputs from intensive mariculture t\y\km coastline for the year 2000.

COUNTRIES	Waste outputs per km coastline		
	Nitrogen (N)	Phosphorus (P)	Carbon (C)
CYPRUS	0,253	0,028	1,037
CROATIA	0,048	0,005	0,197
GREECE	0,428	0,047	1,752
FRANCE	0,335	0,037	1,369
ITALY	0,219	0,024	0,894
MALTA	1,642	0,180	6,730
MORROCO	0,161	0,018	0,658
TUNISIA	0,025	0,002	0,101
SLOVENIA	0,287	0,033	1,174
SPAIN	0,473	0,052	1,936
TURKEY	0,540	0,058	2,210

Fig. 14. Waste outputs from intensive mariculture for the year 2000, kg/y/km coastline



2.2 Chemicals used in the mariculture industry

The chemicals used in coastal aquaculture include those associated with structural materials, soil and water treatments, antibacterial agents, other therapeutants, pesticides, feed additives, anesthetics and hormones.

The above chemicals can be grouped into three categories (GESAMP, 1997). The first consists of aquaculture chemicals that pose an inherently high level of hazard and on this basis alone their use should be curtailed. The second category includes chemicals that can be used safely if standard precautions are followed, but pose a threat to the environment and/or human health if misused. The third category of chemicals, include those that may be environmentally benign under most situations but detrimental at specific sites because of the unique attributes of such sites.

2.2.1 Chemicals and their applications

There is no doubt that chemicals are used more in intensive mariculture as they are essential for increased and controlled production of seed in hatcheries, the control of pathogens and diseases and reduction of transport stress. Chemical needs are minimal in extensive and semi-intensive culture methods.

Many Mediterranean countries engaged in mariculture have few regulatory controls and/or little documentation used by the industry. Even in countries that maintain a list of approved chemicals and control their use, had no drugs licensed for Mariculture (Silvert et al, 2001), and rarely have information on the quantities actually used. Consequently, the compilation of a complete and quantitative listing of mariculture chemicals used in the Mediterranean is at present impossible.

In the literature, Alderman et al, (1994) is an important source of information for chemicals used in mariculture, while the ICES report (1990) on environmental impacts of mariculture provides information, on practices in the ICES countries.

2.2.1a Chemicals associated with structural materials

Structural materials, such as plastics, contain a wide range of additives including stabilizers (Fatty acid salts), pigments (chromates, cadmium soleplate), antioxidants (hindered phenols, UV absorbers (benzophenoles), flame-retardants (organophosphates), fungicides and disinfectants. Although some protection is provided by their low water solubility and slow rate of leaching and dilution, many of those compounds can have adverse effect on aquatic life at low levels of exposure.

Antifoulants are used in coastal aquaculture on solid surfaces and on net and rope structures. They increase the intervals between the manual or mechanical washing of such materials.

2.2.1b Soil and water treatments

Alum (potassium – aluminium sulphate) is widely used on flocculants to reduce turbidity shrimp ponds. EDTA is added to larval rearing water in some shrimp hatcheries.

2.2.1c Disinfectants

Great quantities of disinfectants are used in intensive culture, particularly in finfish and shrimp hatcheries and grow out facilities. They are used in site and equipment preparation, to maintain hygiene throughout the production cycle and in some cases to treat diseases. There is little or no use in extensive systems. The most commonly used disinfectants are chloramines.

2.2.1d Antibacterial agents

Antibacterial chemotherapy is applied in mariculture and particularly in intensive culture systems. Antibacterial agents are important in human and veterinary medicine. Thus their use in aquaculture may contribute to increased resistance and detrimental effects. In most Mediterranean countries their use is controlled by drug licensing, supported by surveillance programmes to monitor compliance with limits on tissue residues. Since these are relatively new controls, their level of enforcement may vary in different countries. The most commonly used antibacterial agents are the following:

- *Nitrofurans.* They have been used extensively in fish and shrimp farming although recently their use by European countries has declined as more active compounds have become available.
- *"Phenicols":* Two derivatives, the sulphonated tiamphenicol and the fluorinated florophenicol, have been developed for veterinary use and are in use in mariculture in a number of Mediterranean countries.
- *Tetracyclines:* The member of this group in most common use is oxytetracycline. Oxytetracycline is probably the most widely used antibiotic in mariculture. Unfortunately resistance increases readily so that recently in many situations, treatment is ineffective (Capone et al, 1996, Smith, 1996).

2.2.1e Pesticides

The most commonly used are the organophosphates.

- Dichlorvos is a widely used organophosphate pesticide applied to control ectoparasitic crustacean infections and infections in finfish culture.
- Trichlorfon is also used as an ectoparaside in finfish culture and rapidly degrades to dichlorvos in water. Trichlorfon is the most effective treatment against monogeans infecting the gills of seabass and seabream.

2.2.1f Feed additives

The addition of additives to fish and crustacean feeds represent a non-intrusive and hence, stress-free method by which a variety of absorbable compounds may be delivered to culture stock. A recent development has been the successful delivery by dietary incorporation of artificial and natural pigments, vaccines and immunostimulants, to both fish and crustaceans. The most commonly used additives are:

Astaxathin: Artificial coloration of flesh. Vitamin C (ascorbic acid) which is of wide spread use, reported to enhance disease resistance and to prevent deficiency syndromes in fish including lordosis, scoliosis and petechial hemorrhaging.

Vitamin E*:* Widespread use. Reported to enhance disease resistance although contradictory evidence is available (Lall et al, 1988, Hardie et al, 1990).

2.2.1g Anesthetics

A number of anesthetic agents have been used in mariculture to assist immobilization of brood animals during egg and milt stripping. Anesthetics are also extensively used to sedate and calm animals during transportation. The most commonly used anesthetics are:

- *Benzocaine:* Widespread use. Applied during egg and milt stripping and for transportation purposes.
- *Quinaldine:* Common use employed for the transport and handing of fish.
- *Tricaine methanesalphonate (MS222):* Used worldwide. Low persistence in the aquatic environment.

CHAPTER 3: IMPACTS

3.1. Impacts on the marine environment

The environmental impact of marine fish farming depends very much on species, culture method, stocking density, feed type, and hydrography of the site and husbandry practices.

In many instances there is little direct evidence of an impact and in such cases the impact must be regarded as potential, since the threat to the environment is derived from our current understanding of ecology or more broadly based on direct comparison with known effects of the farms, of agriculture and industry. However, it should be pointed out that a lack of scientific validation of a perceived impact does not reduce its potential importance (Gowen et al, 1990).

The possible environmental impacts of aquaculture activities in the coastal environment are shown in Table 8. (Chua, T.E., 1992)

TABLE 8
Possible environmental impacts of aquaculture activities in the coastal environment

	Aquaculture inputs/activities									
Environmental impact	Cultured organism	Feeds	Drugs	Pesticides	Hormone/ growth promoter	Faecal wastes	Siting physical structure	Exotic species	Ground water extraction	Antifouling compounds & plastic additives
Water enrichment	-	●	-	-	-	●	-	-	-	-
Marine food web	●	●	0	0	-	●	-	0	-	0
Oxygen consumption	●	●	-	-	-	●	-	0	-	-
Mangrove habitat destruction	-	-	-	-	-	-	●	-	-	-
Biodiversity	-	●	●	●	0	0	-	●	-	0
Bio fouling	-	-	-	-	-	-	●	-	-	●
Changes in benthic	-	0	●	0	-	0	-	0	-	0
Antibiotic resistance	-	-	●	-	-	-	-	-		-
Salinization of aquifers	-	-	-	-	-	-	●	-	●	-
Acidification of soil	-	0	-	-	-	●	●	-	-	-
Land subsidence	-	-	-	-	-	-	●	-	●	-
Wildlife	-	-	-	-	-	-	0	-	-	-
Salinizafion of agriculture	-	-	-	-	-	-	●	-	0	-
Hardening of seabed	-	●	-	-	-	●	-	-	-	-
Growth of undesirable	-	●	-	-	-	●	-	-	-	0
Eutrophication	-	●	-	-	-	●	-	-	-	-
Toxicity to marine animals	-	-	-	-	-	-	-	-	-	●

●Significant impacts. O— Likely impacts. -—No relationship.
(Chua, 1992).

The fish farm industry in the Mediterranean has grown at its most exponential rate during the last 10 years (Chapter 1). Although a large proportion of the available information on the impacts of salmonids culture may be applicable to the Mediterranean, there are differences in the characteristics of main species, bream and bass cultivated in the Mediterranean and main features of the ecosystems (Karakassis, 2001), which should be taken into consideration, particularly when examining the impacts from nutrients.

Mediterranean marine ecosystems present an idiosyncratic combination of characteristics, which make them very different from north European conditions. These differences listed below, affect both the fish farming industry and the ecological processes as they determine the fate of wastes.

- High temperatures (annual minimum of 12°C, reaching up to 25°C during summer) include high metabolic rates, thus affecting both the production of the farm fish and the activity of microbial communities.
- The microtidal regime (tidal range is typically less than 50cm) reduces the potential for dilution and dispersion of solute and particulate wastes, especially in enclosed bays where wind driven currents are relatively weak.
- Oligotrophy: low nutrient, low primary production and low phytoplankton biomass are typical of most Mediterranean marine ecosystems, particularly in the eastern basin (Bethoux, 1981, Azov, 1986). Low phytoplankton biomass induces high transparency of the water and light penetration deeper in the water column (Ignatiades, 1998) thus allowing photosynthesis at a greater depth.
- Primary production is considered to be phosphorus limited (Krom et al, 1991) as opposed to nitrogen limitation in the Atlantic and in most of the world's oceans. In this context, eutrophication could be expected only when phosphate is released in adequate quantities.
- The biotic component of the ecosystems i.e. the fauna and flora is highly diverse particularly in the coastal zone and consists of a large proportion of endemic species (Tortonnese 1985, Fredj et al., 1992) as a result of the dynamic geological past of the Mediterranean. They are of low abundance and biomass as a result of the prevailing oligotrophic conditions (Karakassis and Eleftheriou, 1997).
- Finally, the morphology of coastal bays where most of mariculture is practiced is also very different from that of Scottish lochs and Norwegian fiords. They are typically not associated with permanent fresh water supply.

3.1.1. Enrichment

Assessing the impacts from nutrients environment, the distinction between extensive and intensive aquaculture is very useful as extensive aquaculture relies upon the availability of natural food, while intensive aquaculture on artificial feeds.

In the Mediterranean mariculture is more than necessary. It is a fact that intensive culture production in the Mediterranean has been increased by 20 times the last ten years, while production of extensive mariculture has only slightly increased.

3.1.1a Enrichment of marine ecosystems

It has been argued that the quantities of Phosphorus and Nitrogen released from aquaculture operations are small relative to the total discharges from human activity. The estimated loads of Phosphorus and Nitrogen to the Mediterranean Sea from agriculture were 976,000 (t/y) and 1,570,000 (t/y) respectively (Izzo, 2001). In the same study the loads of Phosphorus and Nitrogen from aquaculture were reported to be 394 t/y and 8,678 t/y respectively. Estimated loads of Phosphorus and Nitrogen for the year 2000 from intensive mariculture in this study were 1484 (t/y) and 13,600 (t/y) respectively.

However, discharge from intensive mariculture often represents a localized, point source discharge of waste into unpolluted, oligotrophic (nutrient poor) waters and such one impact could be significant. Large proportion of Nitrogen and Phosphorus are released in solute form into the water column (Holby and Hall 1991, Hall et al, 1992).

Thus the discharge of dissolved inorganic Nitrogen (ammonia Nitrate and Nitrite) and Phosphorus from intensive mariculture (cage and land-based fish farming and land-based farming of crustacean could lead to eutrophication.

Furthermore, the pattern of nutrient release presents a significant deviation from the natural fluctuation of nutrient concentrations in the water column (Pitta et al., 1999). In temperate regions, for example, the Mediterranean phytoplankton presents seasonal maximum growth during spring and autumn as a result of nutrient availability due to mixing and other physical process as well as adequate light conditions. By contrast, the released of nutrients by fish farms is a continuous process throughout the year, reaching maximal values during summer when high water temperature imposes the need for higher feeding rates.

Despite the rapidly expanding marine fish culture industry very little information has been published regarding the impacts from nutrients in the Mediterranean.

A seasonal survey of the water column characteristics (physical, chemical and biological) was carried out in three Mediterranean farms (Pitta et al., 1999). A significant increase in concentration of phosphate and ammonium was detected within the cages but without significant effect on chlorophyll concentration. Analysis of variation within the data set identified location and season as the major factors of variability in most of the variables examined except phosphate and ammonium for which variability induced by fish farming seemed to be of major importance.

Plankton abundance for the major groups, micro plankton species diversity and community structure were also determined by the effects of season and location rather than by fish farming.

Similar data was obtained in a series of baseline studies conducted for the main fish farms in Cyprus (Andronikou and Apostolidou, 2001). In three farms of capacity range from 200 to 300 tonnes of fish, there were not significant differences in chlorophyll and other phaeopigments concentration neither in the control nor in the stations close to the farms.

Beveridge (1996) reviewed a wide range of information sources including papers and technical reports and concluded that in marine waters, several studies have failed to established a relationship between nutrient concentrations and phytoplankton growth.

The inconsistency between nutrient enrichment and the lack of a significant increase in chlorophyll may attribute to the limited utilization of the excretory wastes due to rapid flashing time, so that phytoplankton are not present long enough to capitalize on the high production of nutrients as has also been suggested by Gowen et al (1987). Mesocosm experiments in the Eastern Mediterranean (Pitta, 1996) have shown that there is a time delay of 3 to 8 days (depending on season) between nutrient enrichment and the peak of phytoplankton biomass.

3.1.1b Benthic enrichment

The general picture emerging from of the existing studies indicates that the impact from intensive culture is on the seabed and that the most widely known effect is benthic enrichment beneath the sea farms. The existing studies for the Mediterranean, although small in number, have covered, the different Mediterranean areas. Delgado et al (1999) studied the effects of fish farming on a seagrass (*Posidonia oceanica*) meadow at Fornells Bay, Minorca (Balearic Islands, Spain). Changes in plant and meadow features (e.g. shoot morphology, shoot density and biomass) were observed in the stations closest to the fish cages. The same picture appeared in an inshore seabass cage farm in Croatia, producing around 200 t/y, over almost

15 years. The well-developed *Posidonia oceanica* beds have almost disappeared beneath the cages and they were in regression in the entire bay (Katavic I. and Antolic, 1999).

A seasonal survey combining sediment geochemistry and macro fauna was carried out in three fish farms in Greece (Cephalonia, Ithaki and Sounion), situated at a depth of 20-30m, in areas with different types of substratum and with varying intensity of water currents (Karakassis et al., 2000). The results of this study indicated that the impacts of fish farming on the benthos in the Mediterranean could vary considerably depending on the specific characteristics of the farming site. At the sampling stations under and near the cages, redox potential was found to decrease but reached negative values only out the silt site. The organic Carbon and Nitrogen content of the sediment near the cages was found to increase by 1.5 to 5 times and ATP content by 4 to 28 times. No azoic zone was encountered in any of the stations, but the macro faunal community was affected at as distance of up to 25m from the edge of the cages. At the coarse sediment sites abundance and biomass increased by more than 10 times and at all sites diversity indicated that the ecotone was in the vicinity of 25m from the cages.

In the eastern Mediterranean, environmental impact studies on three fish cage farms, in Cyprus situated at depth of 25 to 30 meters show that the areas below the cages displayed a gradient of biotic enrichment being reflected in changes of macro fauna diversity and abundance (Adronikou, and Apostolidou, 2001).

The result of a study on benthic communities of soft bottom has shown that they have been subjected to environmental disturbances by floating cages situated in the Gulf of Olbia, northeastern Sardinia, as reported by Martinelli M. et al., (1995). The zoobenthos appears to be sharply modified in the area below the cages; the community was sharply dominated by *Capitella capitata*, a species typical of organic enriched and polluted bottoms.

The environmental impacts of extensive and semi-intensive mariculture is difficult to evaluate since the incorrect balance between available foods, food supplement and fish yield could result in either impoverishment or enrichment.

However a number of studies describing the impact from these activities have published.

Bivalve cultivation can be broadly spilt into three main processes (1) seed collection, (2) seed nursery and on-growing, (3) harvesting. A growing number of studies of the ecological effects of mechanical collecting devices have demonstrated direct mortality on non-target species and the distraction of suitable settlement substrata and habitats (Kaiser, M. et al, 1998).

The impact of suspended oyster culture on oxygen and nutrient fluxes has been studied in situ in a coastal lagoon (Thau, France) Ammonia and Nitrates were released into the water column at rate of 11,823 m^{-1} h^{-1}. Phosphate released was low (Mazouni, N. et al., 1998). Another study for the same lagoon (Casabianca, M. et al., 1999) it was concluded that maximal shellfish farming results to the growth of red macro algae, especially, *Gaillardia.*

Sdrigotti et al., 1999, reported that the diatom community living at the water-sediment interface has been influenced, by the presence of suspended mussels culture in the Gulf of Trieste Italy.

One of the main causes of outspreading of dystrophic conditions which endanger the Marsala Sound (Italy) is the aquaculture plant constructed near the northern mouth at the beginning of the eighties (Giani et al, 1999).

The Comacchlo Lagoon system (Northern Adriatic Sea, is still recovering after the intensive farming of eel and fish has stopped in 1992. The increased release of organic matter from fish farming resulted in a bloom of Cyanobacteria and an almost imination of eukaryotes at both the planktonic and benthic level (Crema et al., 2000).

3.1.2 Impacts from used chemicals

Evaluation of environmental impacts of the chemicals used in a mariculture must be based on the following issues;

- Their fate and persistence in the marine environment and their longevity in animal tissues and
- The development of transfer of resistance in microbial communities.

Many mariculture chemicals degrade rapidly in aquatic systems. For example formalin, has a half-life in water of 36 hours (Katz, 1989). The half-life of dichlorvos is in the range of 100-200 hours (Samuelsen, 1987).

With oxytetracycline in seawater it has been established that its gradation proceeds rabidly (Samuelsen, 1989).

However, most oxytetracycline become bound to particulates and is deposited at the bottom of (or beneath) the fish farm cage sites. Within the sediments, oxytetracycline may remain in concentrations capable of causing antibacterial effects for 12 weeks after the cessation of treatment (Jacobsen and Berglind, 1988). In anoxic fish-farm sediments the compound may be very persistent (up to 419 days). However, this was not biologically available in this case (Bjoerklund et al., 1990).

Salmon net – cage culturists, in the USA use oxytertacycline and to a lesser extent Romet® and amoxycillin to prevent or treat bacterial disease. Capone et al (1996) examined the fate of these chemicals in three farm sites. The area of sediments containing measurable oxytetracycline residues was very localized, with residues defactable only under the cages and to distance of 30 meters.

Crabs and oysters from the over surrounding the farm area were collected. No more than trace oxytetracycline residues were found in oysters, but about half of the rock crabs collected under the cages during and within 12 days after the treatment contained oxytetracycline in meat at concentrations of 0.8 to 3.8 mgg^{-1}.

Oxytetracycline concentration was determined in samples of blue mussels collected in the vicinity of Atlantic salmon farms during and after the treatment (Coyne et al, 1997).

Although oxytetracycline is the most commonly used antibiotic in seabream and seabass cage culture, there are no reports for its fate for the Mediterranean.

Toxicological effects of non-target species may be associated with the use of chemicals. Among the pesticides that may have toxicological effects on the surrounding invertebrate fauna are the organophosphates ectoparasites. Organophosphates bath treatments result in the release into the surrounding waters of significant quantities of toxic material liable to affect crustaceans particularly larval stages (Egidius and Moster, 1987). The use of carbaryl pesticides to eliminate burrowing shrimp from oyster beds in the North-Western United States results in the unintended mortality of Dungeness crab, a commercially explored species (WDF/WDOE, 1985).

The environmental effects of pigments and vitamins are poorly known. Biotin has been shown to simulate growth of certain phytoplankton species and is implicated in the toxicity of the dinoflage Mate *Cymnodinium aureoles* (Growen and Bradbury, 1987). Vitamin B12 has been shown to be one of the growth-promoting factors of the alga *Chrysochromulina polylepis* and the dinoflagellate, *Heterosigma alashivo* (Graneli et al., 1993, Honjo, 1993).

Indiscriminate use of drugs, especially antibiotics to control or prevent fish diseases in coastal fish farms has shown that some native aquatic microbial communities develop antibiotic resistance (GESAMP, 1991) and the possibility of transfer resistance to human pathogen has also raised concern, (Aoki, 1989, Dixon, 1991).

The development of resistant bacteria population in the sediment has been documented. For example, up to 100% of oxytetracycline resistant bacteria have been recorded from marine sediments near fish farms after medication and resistance persisted for more than 13 months afterwards (Torsvik et al., 1988, Samuelsen et al., 1992).

3.1.3 Interaction between escaped farmed stock and wild species

The rapid development of marine cage farming of salmonids has raised concerns about the impact of escaped fish on natural populations. There are a number of studies (McGinnity 1997, Hutchinson, 1997) with reference to the possible genetic impact of escaped cultured Atlantic salmon on native populations. The demonstration that farmed and hybrid progeny can survive in the wild to the smolt stage, indicates that escaped farmed fish can perhaps produce long-term genetic changes in the natural population. There is however insufficient available information to judge whether this interaction is a serious ecological impact. Some countries have initiated studies to address this issue and in recognition of the potential problem Norway prohibits the sitting of salmon farms within 30km of important salmon rivers.

Regarding the Mediterranean region this problem has drawn none or little attention. It seems that the tremendous increase of cage farming in the Mediterranean, along with the fact that the number of escapes can be large, is an issue to be considered. Frequency analysis of the damages of Greek mariculture Industry during the period 1986-1994, (Report on SELAM, Network, Montpelier – France, 1995) showed that lost of 70 cages, with loses valued of 1.76 million US$ which in terms of production is about 3000 tons of fish, was due to bad climatic conditions. Very recently, February 2001, the full production of cage farm in Israel about 200 tonnes was lost to the open sea due to very bad weather conditions, while in December 2001, due to extreme weather conditions, tonnes of fish, were escaped in open sea environment in Cyprus.

3.1.4 Introduction and transfers

A number of fish, invertebrate and seaweed species have been transferred or introduced from one region to another for aquaculture purposes. A distinction has been made between the two kinds of movements, which differ in their purpose, and potential effect (Welcomme, 1988)

Transfers take place within the same geographical range of a species and are intended to support stressed population, enhance genetic characteristics or re-establish a species that has failed locally. Introductions are movements beyond the geographical range of a species and are intended to insert totally new taxa into flora and fauna.

The problem associated with transfers and introductions have been well studied and recorded (Rosenthal, 1976, Welcomme, 1988, Munro, 1988, Turner, 1988). This movement can pose risks to human health the integrity of ecosystem, aquaculture and related primary industries.

Example of the type of disease problem which have arisen in the past from such movements are illustrated by the transfer of salmon molts from Sweden to Norway and Finland and of Japanese oysters (*Crassotrea gigas*) to France (Murno, 1988).

3.2 Human health impacts

The major public health concern associated with mariculture is the consumption of products raised in unhygienic conditions. Many fish farms located near the coast are often contaminated with human pathogens (e.g. bacteria and viruses). Some of these pathogen belong to such genera as *Salmonella, Shigella, Vibrio* and *Escherichia.*

Many outbreaks of human diseases are associated with the consumption of fish products that are raw or well cooked. For example typhoid fever, cholera, dysentery and Hepatitis-A have been associated with consumption of bivalve *Anadara gramosa*, grown in coastal mudflats in pensicula Malaysia facing the strait of Malacca (ADB / NACA, 1991).

It was clear from the result of major cholera epidemic in Italy during 1973 that contaminated mollusc could be effective vectors of *Vibrio cholerae* (Baine, 1974). The cholera epidemic in Naples, the coastal regions of Campania and Puglia and in Sardinia resulted in 278 confirmed cases.

Although such episode has not been reported since then in the Mediterranean, Naples-type out breaks could occur anywhere, especially as El Tor cholera is pandemic and airline travel permits the rapid dissemination of pathogens through susceptible populations. It has been estimated that human cholera patient may excrete 10^3 organisms/day. These organisms could contaminate shellfish beds via improperly treated sewage (GESAMP, 1991).

The occurrence of toxic species of phytoplankton represents of a considerable threat to the economic sustainability of coastal aquaculture development in many countries. A relatively small number of algal species produce a range of toxins. Human illness and death have resulted from the consumption of phycotoxin-contaminated shellfish during red-tide (toxic algal blooms) outbreaks (Hallegraeff and Maclean, 1989, Shumway, 1990).

Several toxins are responsible for paralytic shellfish poisoning (PSP) (Sullivan, 1988), which is perhaps the most well documented group of phycotoxins. The toxins produced by several dinoflagellates, including A*lexandrium tamarense, Gymnodinium catenatum* and *Pyrodinium bahamense.*

Human illness has also been attributed to the consumption of fish containing saxitoxin. There is however, no evidence of human illness as a result of consumption of farmed fish containing phycotoxins.

A group of toxins are responsible for diarrheic shellfish poisoning (DSP). Diarrheic shellfish poisoning which is caused by another group of dinoflagellates (*Dinophysis* and *Procentrum*) has been reported in many parts of the world.

Amnesic shellfish poisoning (ASP) recorded for the first time 1987 in eastern Canada (Bernoth, 1990) affects the nervous system. The chemical compound for ASP is domoic acid a neuroexcitatory amino acid produced by the pennate diatom *Nitzschia pungens*.

In some coastal regions the occurrence of toxic species and toxicity in bivalves is almost an annual event and this has necessitated the establishment of extensive programmes to monitor bivalve stocks. Most European countries have routine monitoring programmes for PSP and DSP.

The wide application of drugs (antibiotics and other chemicals) in intensive fish farming can pose healthy hazards from drug residue in produce destined for human consumption. In Taiwan, 8% of eels and 3% of shrimp (*Penaeus japonicus*) have measurable amounts of drug residues (ADB/NACA, 1991).

While therapeutant residues resulting from aquaculture treatments may not appear to be so significant a hazard to human health considering the extremely small number of cases reported, producers must be alert to the significant public concern created by potential residues (Armstrong, 1997).

There is potential for some compounds used in mariculture to pose health risks to site workers. Some chemicals such as organophosphates must be handled with respect especially those in concentrate form. If proper health and safety precautions for handling aquacultural compounds presenting significant health risk to humans are enforced, the operators' risk will be minimized.

Increasing attention, particularly in the developed Mediterranean countries, has been given to assuring food safety in the consumer. Legislative and institutional measures have been developed to provide food that is hygienic and free of pathogens and contaminant substances that could cause ill health.

Issues such as BSE (Bovine Spongiform Encephalitis), popularly known as Mad Cow Disease and dioxin contamination have contributed to higher public awareness of this topic. However both of these issues have an additional dimension that of the procedures used in farming. In these examples, the very nature of the components of the feeds has been highlighted, raising doubts as to the viability of the materials used and to the integrity of livestock feed manufacture.

Additional complex issues are entering the debate nowadays, for example, the potential use of genetically modified feed materials and fish and is being discussed and questioned by many different interests (Hough C., 2000).

3.3 Socio-economic considerations

The over-rabid development of Mediterranean mariculture, with undoubtedly success, has been tarnished by a number of socio-economic problems; like the market availability, suitable sites, the quality and quantity of inputs and disease.

3.3.1 The market

The market for aquaculture products experiences two sometimes-parallel constraints: competition from fishing and overproduction.

The production from fishing is characterized by irregular market availability, which results in fluctuations that cause major problems for fish farmers. Certain types of mariculture may enter into conflict with fishing industry development, as they include stocking with young fish harvested from natural sources. Such is the situation for mullet in Egypt and eels in France where the harvesting of juveniles worries fishermen from other Mediterranean countries. Similar problems were reported in, Malta and Israel (FAO, Fisheries Report No. 606, 1999).

Another related issue to the above, which is of real concern, is the newly developed tuna farming in the Mediterranean.

The last few years massive expansion in tuna farming, reaching nowadays a production of about 11.000 tonnes, threatens to decimate the already over-fished wild tuna in the Mediterranean as only fish captured in the wild is used for this activity. It is worth mentioning here what Dr. Simons Cripps, Director of WWF´s Endangered Seas Programme, said on the matter.

The highly migratory blue-fin tuna is already by direct fishing in the Mediterranean. This so-called tuna farming avoids every regional and international rule set-up to conserve and manage the fishery. Governments must urgently take action to close yet another loophole within European fisheries management and step-up controls on this growing practice while there is still time.

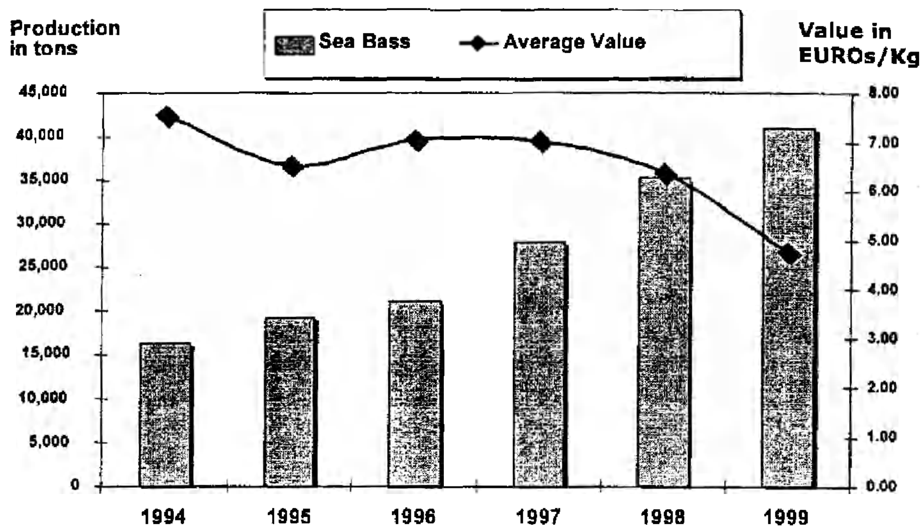
3.3.2 Overproduction

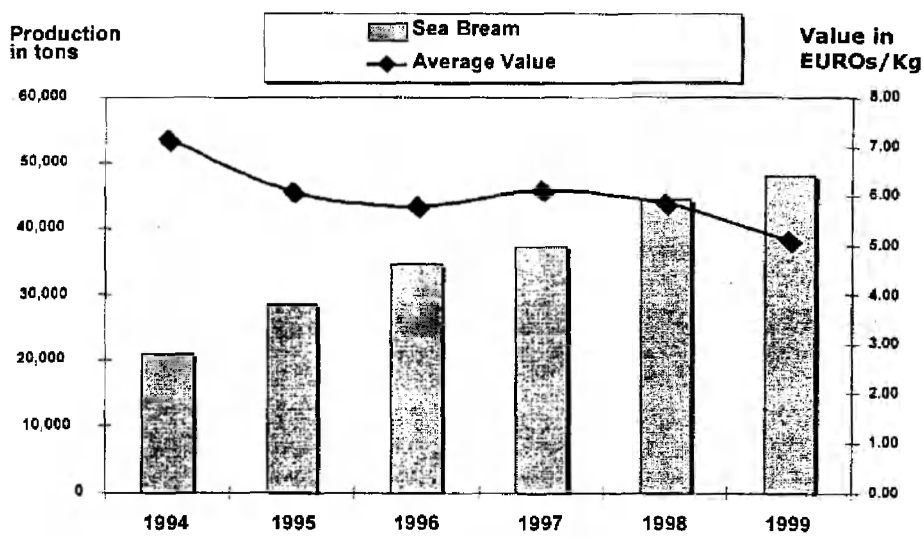
Overproduction is often a temporary phenomenon, linked to deficiencies in forecasting, in the organization of production and in commercial policy.

In the case of seabass and seabream, "overproduction" seems to lead to the drop of the price of the final product (Fig. 15) (Christofilogianis, P. 2000).

Fig. 15

Production versus price for sea bass and sea bream (source: FEAP)





(Cristofilogianis, 2001).

3.1.3 Availability of suitable sites

This constraint is the most critical for the Mediterranean mariculture, which is now competing for suitable sites with other growing, sometimes incompatible activities, such as tourism, urban development, transport, nature reserves and agriculture. Thus valuable sites have been lost over the past 30 years, as in the case for most sheltered bays (Toulon, Bizerte, Tarento etc).

3.1.4 Pathological factors

The growth of farms and their intensification have been associated with appearance of pathological conditions and major epizootic diseases. Fortunately these phenomena are rare and belong to the past. An example is the disappearance of Portuguese oysters from all French coasts over a three year period; the infestation of that oysters by two protozoans, had reduced the French production from 15,000 tonnes to 1500 tonnes during the early 1980’s.

CHAPTER 4: PROPOSED INTERVENTIONS (MANAGEMENT, LEGAL AND ADMINISTRATIVE) TO THE MAJOR PROBLEMS AND ISSUES IDENTIFIED

A. AT NATIONAL LEVEL

4.1 Intervention to environmental impacts

The environmental impacts which are analyzed in Chapter 3, can be summed up as follows:

- Hypernutrification and Eutrophication
- Benthic enrichment
- Chemicals and chemotherapeutants
- Species introduction and genetic loss
- Direct impact on wildlife.

In order to propose interventions and solutions to these impacts, it is necessary first to assess their significance and secondly to consider the spatial and temporal scales of processes creating these impacts.

Karakassis, 2001 provides the spatial and temporal scales of process affected or related to mariculture (Table 9).

Table 9
Spatial and temporal scales of processes affected by or related to mariculture.

Impact	Spatial scale	Time scale
Diel nutrient increase in (P + N) concentrations	10 –1 00 of m	hours
Thickness of farm sediment	cm	weeks – months
Distance of anoxic area around cages	5 – 50m	months
Recolonization of anoxic sediments by microfauna	m	years
Residence time of antibiotics in wild species	km	days
Propagation of microbial strains resistant to antibiotics or introduced parasites	10 – 100 km	2 – 10 years
Replacement of biota by introduced species	depending on motility and larval propagation	depending on life cycle
Modification of gene pool of wild stocks	10 – 100 km	several generations (> 10 years)

(Karakassis, J 2001).

4.1.1 Technological interventions

Impairment in technology and management practices could assist in minimizing the general effects of mariculture on the environment as well as in avoiding specific impacts.

At present in most of the fish farms diets are used with phosphorus content of 1.4% and the reported feed conversion ratio is high (2.2 to 2.7, Cyprus, Malta, Croatia, Greece), although it is acknowledged that these ratios may be artificial because of the loss of fish when cages are damaged. It is suggested that improvements in management should aim at reducing the feed conversion ratio. Improved feed conversion ratios will reduce cost, the level of organic enrichment directly beneath the farms since this is largely the result of the deposition on uneaten feed.

The industry should also improve feeding strategies and should also investigate the use of low Phosphorus diets.

A related issue of concern is the recent culture of tuna fish in Spain and Croatia. The feed used in these farms are trash fish (mainly sardines). It is known in this case that the percentage of feed wastage is 50% and therefore the pollutant loading. It is recommended that alternative diets should be employed for this type of culture, otherwise possible further expansion of tuna culture will create serious ecological problems.

Specific technologies based on the use of marine organisms such as biological filters to reduce mariculture (land-based) wastes are recommended. Such technologies involve the culture of mussels for the reduction of particulate material (Kautsky and Folke, 1989) or the use of *Ulva sp* for the reduction of dissolved nutrients released into the water column (Cohen and Neori, 1991, Krom et al, 1995).

In respect of antifouling agents, the use of new environmentally benign antifouling agents will reduce the introduction of metals like copper and zinc into the marine environment and so their toxic consequences. The replacement of antibiotics by vaccines (Braaten, 1992) should be further expanded. Geographical information system and satellite remote sensing could be also useful tools for site selection for the development of mariculture (Ross et al, 1993).

4.1.2 Policy and regulation interventions

Site selection is an important process for the sustainable development of mariculture with minimum environmental consequences and therefore there is an increasing effort in developing general or region-specific criteria (Munday et al, 1992, PAP/RAC, 1996, GESAMP, 2001). Monitoring of the impacts has been considered as a necessity (Munday et al., 1992, Rosental, 1994, Wu, 1995) and specific protocols to monitor ecological impacts have been proposed by GESAMP (1996). Firstly, it is necessary to define objectives and standards in order to evaluate and limit ecological changes in a logical and transparent manner, and then to elaborate a monitoring protocol with the variables to be monitored. These variables among others will include sediment chemistry, benthic biota and water chemistry.

The concept of self-monitoring should be considered as most of the monitoring programmes at present (with the exception of Greece) are carried out by the competent authorities.

Another basic regulatory instrument is the application of environmental impact assessment studies. In most of the Mediterranean countries there are provisions for an EIA, either in EIA legal framework or as part of licensing procedures (FAO, 1999). The existing EIAs are however too broad and cover almost every kind of construction. In the particular case of mariculture the purpose of the EIA should be the evaluation of the likely effects from development or increased production. This could only be achieved through the use of validated models and the evaluation of base line data.

Aquaculture policies, administration and legislation are very diverse throughout the Mediterranean with lack of specific aquaculture policy in most areas (except Cataluna, Greece and France). There is also a lack of centralized administrative framework (except in Spain and overlapping between authorities).

Uniformity in regulation on a regional scale is important for sustainability of mariculture, both in terms of effectiveness and in relation to ecological consequences. Legal restrictions and monitoring obligations could increase the production cost locally. In particular, regionally important issues such as species introduction and restriction in the use of antibiotics should be subjected to uniform regional regulations and monitored with equal efficiency region-wide, since the preventing system in this case is as efficient as its less efficient component.

4.2 Interventions to human health impacts

Human health impacts caused from the consumption of contaminated fish food are nearly always related to the environment quality where the aquaculture products are produced.

Two aspects are identified where measures and interventions should be exercised in this respect namely the quality of the environment where the mariculture takes place and the safety of food products from mariculture.

4.2.1 Quality of the aquaculture environment

As the main source of pathogen organisms (bacteria, viruses) and nutrients, is the domestic sewage and that of bioaccumulating toxic substances are the industrial effluents, the following measures are proposed:

- Promotion of treatment (primary and secondary) of municipal sewage prior to its discharge to estuaries and coastal areas.

- Disinfections of treated sewage effluent to be discharged in the marine environment.

- Reduction of the emissions and discharges of bioaccumulative toxic substances from the industry sector, into marine environment, which is allocated for mariculture.

- Promotion of controls over anthropogenic inputs of nitrogen and phosphorus that enter the coastal waters where eutrophication can be expected.

- Monitoring, particular microbial monitoring of the waters in the vicinity of effluent discharge points.

- Application of the EC Directive for the protection of waters in shellfish growing areas. This Directive is mandatory for Mediterranean member countries of the E.U. while a number of other Mediterranean countries have been introduced these provisions in their national legislation.

4.2.2 Safety of food products from mariculture

Today's awareness of public health concepts of prevention and control of food-born diseases by consumers has diminished health hazard risks. However, a number of preventive measures could restrict these risks even further.

- Promotion of policies for the minimum application of chemotherapeutants in mariculture.

- Strict controls on chemical residues in fish food.

- Adherence to the provisions in the Codex Commission document: Draft Code of Hygiene Practice for the Products of Aquaculture (FAO, 1996).

- The application of the HACCP (Hazard Analysis Critical Control Point) system should be considered. This system is applied from production to consumption and offers a systematic sequential approach to the control of food-born hazards avoiding the many weaknesses inherent in the traditional inspection approach.

It may not be difficult to apply the HACCP based system to large-scale commercial mariculture ventures. However, in small-scale subsidence mariculture systems, where fish are mainly farmed for domestic consumption under minimal inputs, knowledge and application of an effective HACCP based system will pose considerable difficulties.

4.3 Interventions for socio-economic problems

There are two major socio-economic issues of concern in Mediterranean mariculture; the overproduction and dependence of the industry of intensive farming of finfish upon the capture fisheries for sourcing their feed inputs (i.e. their use of fish meal, fish oil and other fishery by-products in compound aqua feeds).

Proposed interventions:

- Organization of marketing efforts and search for new types of outlets.

- Diversification of the products, species and presentations.

- Urgent need for the industry to reduce its dependence by using alternative more sustainable dietary protein and lipid sources.

- To further expand the independence of the industry from the fingerlings i.e., promotion of hatchery yields. The normal production of a hatching facility in 1985 was in the scale of 200,000 young fish. Hatcheries with a production capacity of 5 million fingerlings now exist in several Mediterranean countries.

B. AT REGIONAL LEVEL

As Mediterranean mariculture is a fast growing industry taking place at sites with multiple use and interrelated interests, the following intervention/actions at regional level are proposed:

- Development of financial and technical cooperation with aim to enhance the capacity of developing countries in mariculture in a sustainable way.

- Need for further promotion of regional systems for collection and exchange of data related to the production and marketing of mariculture products and the fish food quality.

- The protection of the marine environment from mariculture activities and the protection of mariculture from other activities.

- Development of financial, scientific and technical cooperation with an aim to promote transfer of environmentally sound technology for mariculture.

- Initiatives towards the implementation of programmes related to the monitoring and regulation of marine aquaculture. Programmes like, the EU, MARAQUA is a good example.

- Promotion of research where information related to the impacts of mariculture is lacking. The EU MEDVEG programme related to the fate of nutrients from mariculture to the marine environment is a very good initiative.

- Creation of training opportunities for farmers, in order to undertake the task of self-monitoring.

- Assistance to non - EU countries in order to harmonize their legislation, particularly that relates to aquaculture products with existing EU legislation.

- To increase the awareness of all stake holders and the public on the need for sustainability in mariculture.

Table 10 summarizes the major problems, their root causes and possible solutions.

Table 10

Major problems, their root causes and possible solutions

ISSUE/PROBLEM	INDICATOR OF MAGNITUDE		IMPACTS				ROOT CAUSES	POSSIBLE SOLUTIONS
	Spatial Scale	Time scale	Human health	Marine Environment	Socio-economic Loss	Global Environment		
A. ENVIRONMENTAL 1. Hypernutrification and Benthic enrichment result to changes of composition and diversity of marine community and decline of seagrass beds.	Up to 300 km from Farm site	Months	N.A.	2	1	1	Inputs of Nutrients. No proper site selection. Inadequate Monitoring Protocol, Insufficient E.I.A No quality standards.	Use of low Phosphate diets and better husbandry. Site selection based on EIA. and CAM (Coast Area Management). Application of guidelines and standards. Continuous Monitoring based on Protocol.
2. Chemotherapeutants residues in fish and effect on non-target species, metal inputs to the marine environment	1 km	days	0	1	1	1T	Excess application of antibiotics and other drugs and application of antifouling agents	Control application of chemicals, replacement of antibiotics by vaccines. Use of environmentally benign antifouling agents.
3. Modification of gene pool of wild stocks from escaped farm stock	10-100 km	Several genera-tion	N.A.	1	1	1T	Escaped fish from farms, mainly cage farms, due to bad weather conditions	Use of monosex culture, or the manipulation of chromosomal sets to avoid genetic interactions with wild population.

ISSUE/PROBLEM	INDICATOR OF MAGNITUDE		IMPACTS				ROOT CAUSES	POSSIBLE SOLUTIONS
	Spatial Scale	Time scale	Human health	Marine Environment	Socio-economic Loss	Global Environment		
B. HUMAN HEALTH			3	N.A.	3	3 T	Inadequate quality of the environment for aquaculture production	Treatment of domestic sewage, Restriction of discharges even of treated effluent . Continuous microbial monitoring at the discharged sites. Respect to the draft Code of Hygiene Practice for the aquaculture products. To consider the application of HACCP perspective.
1. Human diseases associated with the consumption of fish products mainly shellfish	No limits	impos-sible to be evaluated						
2. Human illness due the consumption of shellfish affected by toxic algae	1-5 km	Months	2	2	3	2 T	Introduction of nutrients from agricultural runoff, rivers and other anthropogenic sources	Application of Code of Practice to the Agriculture fertilizers, elimination if possible of all municipal sewage discharges.
C. SOCIO-CONOMIC								
1. Market/price problems	N.A.	N.A.	N.A.	N.A.	2	2	Overproduction from mariculture and its relation with the uncontrolled wild fish catches.	Organization of marketing efforts and search for new types of outlets. Diversification of the products and cultured species.
2. Conflicts with fishing industry and dependence of feed on capture fisheries	N.A.	N.A.	N.A.	N.A.	1	1	Harvesting of juveniles for farm stocking. Use of fish meal, fish oil in compound aquafeeds	Promotion of Hatcheries. Use of alternative more sustainable dietary protein and lipid source.

IMPACTS: 0: Not known, 1: Slight impact
2: Moderate impact, 3: Severe impact
N.A.: Not Applied T: Transboundary impacts

BIBLIOGRAPHY

(ADB/NACA) (1991). Fish health management in the Asia-Pacific. Report on a regional study and workshop on fish disease and fish health management ADB. Agric. Dept. Rep. Ser. No. 1 Bangkok, Thailand.

Ackefors, H. (1990). Discharge of nutrients from Swedish fish farming to adjustment sea areas. Ambio No. 19, pp. 28-35.

Alderman, D., Rosenthal, H., Smith, P., Stewart, J. and Weston, D., (1994). Chemicals used in Mariculture ICES Coop. Res. Rep. (202):100p.

Andronikou, K. and Apostolidou, T., (2001) Environmental Impact Assessment Studies of annual fish farm production increase to 300 tonnes. Report of the Department of Fisheries and Marine Research, MANRE, Cyprus.

Aoki, T. (1989) Ecology of antibiotic resistant determinants of R plasmids from fish pathogenic bacteria. In: Recent Advances in Microbial Ecology. (T. Hattovi, Y. Ishida Y. Maruyana, R.Y. Mordiax A. Uchida, (Eds), pp. 571-576, Japan Societies Press, Japan.

Armstrong, R. (1997). International hazards controls for aquaculture. In R.E. Martin, RL Collette and J.W. Slavin (eds). Fish inspection quality Control and HACCP: A Global focus pp. 403-406.

Azov, Y. (1986). Seasonal patterns of phytoplankton productivity and abundance in near-shore oligotrophic waters of the Levant Basin (Mediterranean). J. Plankton. Res. Vol. 8 pp. 41-53.

Baine, W.R. (1974). Epidemiology of cholera in Italy in 1973. Lancet Dec. 7, 1974:1370

Baird, D.J. and Muir, J. (1990). The environmental impact of the Telia Aqua Marine fish farm on the coastal environment at Liopetri in Cyprus. A report for the Department of Fisheries of Cyprus Government under the auspices of the United Nations Development Programme (Cyprus Office) 44pp.

Belias, C., Bikas, B., Scoullos, M. and Dassenakis, M. (2000). Effects of intensive cultivation of gilthead bream, *Sparus aurata* and seabass, *Dicentrarchus labrax*, at Astakos Gulf. Part II metals In Proc. of the 6th Hellenic Symposium on Ocean and Fisheries May 23-26, 2000 Vol. 1 pp. 344-348.

Bernoth, E.M. (ed.) 1990. Public health aspects of seafood-borne zoorotic diseases. In Proceeding of the WHO Symposium, 14-16 No. 1989, Hanover, Fed. Rep. of Germany.

Bethoux, J.P. (1981) Le phosphore et l´ azote en Méditerranées bilans et fertilité potentielle. Mar. Chem. 10. pp. 141-158.

Beveridge, M.C.M., Ross, L. G. and Kelly, L.A. (1994). Aquaculture and biodiversity, Ambio, 23 pp. 497-502.

Beveridge, M.C.M. (1996). Cage culture Fishing News Books, Blackwell Oxford.

Bjoerklund, H., Bondestam, J. and Bylund, G. (1990) Residues of Oxytetracycline in wild fish and sediments from fish farms. Aquaculture 86, pp. 359-367.

Braaden, B., (1992). Impact of pollution from aquaculture in six Nordic countries. Release of nutrients, effects, and wastewater treatment In: Aquaculture and the Environment. (De Pauw N. X ; Joyce J. eds) pp. 79-101. Eur. Aquacult. Soc. Spec. Publ. No. 16.

Casabianca, M., Laugier, T. and Collard, D. (1997). Impact of shellfish farming eutrophication on benthic macrophyte community in the Thau Lagoon, France Aquac. Inter. 5(4) pp.301-314

Capone, D., Weston, D.P. Miller, V. and Shoemaker, C. (1996). Antibacterial residues in marine sediments and invertebrates following chemotherapy in aquaculture. Aquaculture Vol. 145, No. 1-4 pp. 55-75

Chistofilogianis, P. (2001). Codes of Practice in southern Europe. In Proc. of the Workshop of (MARAQUA): Implications of directives, convention and codes of practice for monitoring and regulation of Marine Aquaculture in Europe. Published as Scottish Exec. Report No. 09532-83852, Fisheries Research Services, Aberdeen, Scotland.

Chua, T.E. (1992). Coastal Aquaculture Development and Environment, Marine Poll. Bull. Vol. 25, 1-4 pp. 98-103.
Cohen, J. and Neori, A., (1991). *Ulva lactura* biofilters for marine fishpond effluents 1. Ammonia uptake kinetics and nitrogen content. Bot. Mar. No. 34, pp. 475-482
Coyne, R., Hiney, M., Smith, P. (1997). Transient presence of oxytetracycline in blue mussels (*Mytilus edulis*) following therapeutic use at a marine Atlantic salmon farm. Aquaculture, Vol. 149, No. 3-4 pp. 175-181
Crema, R. Prevedelli, P., Valentini, A. and Castelli, A. (2000). Recovery of macro zoo benthic community of the Camacho Lagoon system (Northern Adriatic sea) OPHELIA. Vol. 52 No. 2 pp.143-152.
Delgado, O., Ruiz, J., Perez, M., Romero, J. and Ballesteros, E. (1999). Effects of fish farming on seagrass (*Posidonia oceanica*) in a Mediterranean by: seagrass decline after organic loading cassasion. Oceanol. Acta 22(1) pp. 109-117
Dixon, B.A. (1991) Antibiotic resistance of bacterial fish pathogens. In Fish and Crustaceans Larviculture Symp. p. 419. Special Public. Eur. Aquacult. Soc. No. 15
Dominguez, L., Calero, G., Martin, J., Robaina, L. and Fernandez-Palacios, H. (1997). Relation and discharge of nutrients from a marine cage farm in the Canary islands. Preliminary results pp. 291-300. In Cahiers Options Mediterraneen nes. 22.
Egidius, E. and Master, B. (1987) Effects of Neguvon and Nuvan treatment on crabs (*Cancer pagurus, C. maenas* lobster (*Homarus gamarus*) and the blue mussel (*Mylitlus edulis*), Aquaculture 60 pp. 165-168
FAO (1999). Report on the consultation on the application of article 9 of the FAO code of conduct for Responsible Fisheries in the Mediterranean, Rome, 19-23 Jul. 1999. FAO Fisheries Report No. 606 FIRI/R606(Bi).
FAO, 2001. Aquaculture Production Quantities 1970-1999 and values 1984-1999 (included in Fishstat plus version 2.3 universal software for Fishery statistical time series). FAO Information, Data and Statistics Unit.
Ferling, P. and La Croix, D. (2000). Current state and future development of aquaculture in the Mediterranean region. World Aqua. Magazine vol. 31(1) pp. 20-24
Findlay, R. H., Walting, L. and Mayer, L.M. (1995). Environmental impact of salmon net-pen culture on marine benthic communities in Maine: a case study. Estuaries, 18 pp. 145-179.
Fisheries Department (1997). Environmental aspects of marine aquaculture development. Fisheries Department, Ministry of Agriculture Natural Resources and Environment, Nicosia, Cyprus 18pp.
Fredj, G., Bellan-Santini, D. and Menardi, M. (1992) Etat de connaissances sur la faune marine Mediterranne, Buil. Inst. Oceanogr. Monaco 9 pp.133-145.
Georgiou, L.G., (2001) The suitability of the seaweed, *Padina pavonica* as a diet for the mass production of the rotifers as food for the Nutrition of Gilthead seabream larve, M.Sc Thesis. University of Malta.
GESAMP (1996). Monitoring the ecological effects of coastal aquaculture wastes. GESAMP Reports and Studies No. 57, 38p.
GESAMP (1997). Towards safe and effective use of chemicals in coastal aquaculture GESAMP Report and Studies No. 65 40p.
GESAMP (IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP) Report (1991). Reducing environmental impacts of coastal aquaculture Rep. Stud. GESAMP, NO. 47:35p.
GESAMP, (2001). Planning and Management for sustainable coastal aquaculture development. Report and Studies No. 68, 87p.
Giani, M., Mecozzi, M., Sunseri, G., Davi, A. and Andaloro, F. (1996). Observation on the superficial distribution of hydrological and bacteriological parameters in Marsala Sound. In Proceedings of the 11th Conference of the Italian Association of Oceanology and Limnology, Sorrento, 26-28 Oct. 1994.
Gowen, R.J. and Bradbury, N.B., (1987). The ecological impact of salmon farming in coastal waters: a review. Oceanogr. Mar. Biol. Annual Rev. 25 pp.563-575

Gowen R.J., Rosenthal, H., Makinen, T. and Ezzi, I. (1990) Environmental impacts of aquaculture activities. - AQUACULTURE EUROPE´ 89-BUSINESS JOINS SCIENCE - N. De Pauw and R. Billard (Eds). E.A.S. Special Publication No. 12 Belgium, 1990.

Gowen, R.J, Karakassis, J. and Tett, P. (1977). Gage Farming of fish and the Mar. Environment in Cyprus. FAO mission Report, Rome, 1997

Graneli E. Paasche, E. and Maestrini, S.V. (1993). Three years after the *Chrysochromulina polylepis*, bloom in Scandinavian waters in 1988: some conclusions of recent research and monitoring. In: Toxic phytoplankton blooms in the sea. T.J. Smayda and Shimizu, (eds) Vol. 3 pp. 23-32, Elsevier, The Netherlands.

Grech, B. (1999). Aquaculture in Malta. Marine Pollution Section. Ministry of Environment, Malta. Pers. Communication.

Hakanson, L. Ervik, A., Makinen, T. Moller, Bo. (1990): Basic concepts concerning assessments of environmental effects of marine fish farms. Nordic Council of Ministers, Nord 1988:90.

Hall, P.O.J., Holby, O., Kolberg, S. and Samuelsson, M.O. (1992): Chemical fluxes and mass balances in marine fish cage farm 4. Nitrogen. Marine Ecology Progress Series, 89 pp.81-91

Hall, P.O.J. , Anderson, L.G., Holby, O., Kollberg, S. Samuelsson, M.O. (1990). Chemical fluxes and xxx balances in a marine fish farm. 1. Carbon. Mar. Ecology Progress Series No. 61 pp. 61-73

Hallegraeff, G. M. and Maclean, J.C. (eds) (1989) Biology, epidemiology and management of *Pyrodinium* red tides ICLARM conf. Proc. 21.

Hardie, L. Fletcher, T. and Secombes, C. (1980) . The effect of Vitamin E on the immune response of the Atlantic salmon aquaculture, 87(1) pp. 1-13

Henriksson, S. (1991). Effects of fish farming on natural Baltic fish communities: pp. 85-104 In Makinen, T. (ed) Marine Aquaculture and Environment. Nordic Council of Ministers.

Holby, O. and Hall, P.O.J., (1991) Chemical fluxes and mass balances in a marine cage fish farm, 2. Phosphorus. Marine Ecology Progress Series, 70, pp. 263-272.

Honjo, T. (1993). Overview on bloom dynamics and physiological ecology of Heterosigma akashivo. In: toxic phytoplankton blooms in the sea (T.J. Smayda and Shimizu, eds) Vol. 3 pp. 33-42 Elsevier, The Netherlands.

Hough, C (2001), Codes of Conduct and Aquaculture. In Proceedings of the Workshop (MARAQUA). “The Implications of Directives, Conventions and Codes of Practice for Monitoring and Regulation Marine Aquaculture in Europe. Published as Scottish Exec. Report No. 09532-83852, Fisheries Research Services, Aberdeen, Scotland.

Hutchinson, P. (1977). A review on behavioural interactions between culture and wild Atlantic salmon. In: Proceedings of an ICES/NASCO Symposium held in Bath, England 18-22 April, 1997, Vol. 54, No. 6 pp. 1031-1039

ICES (International Council for the Exploration of the Sea) (1994). Chemicals used in mariculture, ICES Coop. Res. Rep. No. 202

ICES Report, 1990: Report of the working Group on Environmental Impacts of Mariculture C.M. 1990/F.12, Mariculture committee Ref. Marine environmental committee ref. Marine Environmental Quality Committee 65p.

Ignatiades, L. (1998). The productive and optical status of the oligotrophic water of the Southern Aegean sea (Cretan Sea) Eastern Mediterranean. J. Plankton Res. Vol. 20. pp. 985-995

Izzo, G. (2001). Monitoring of Mediterranean marine eutrophication: strategy, parameters and indicators. UNEP(DEC) Report (draft) presented in Review meeting of MED-POL, Rome 5-7 Dec. 2001

Jacobsen, P. and Berglind L. (1988). Persistence of oxytetracycline in sediments from fish farms. Aquaculture 70, 365-70.

Kaiser, M., Loing, I., Utting, S., and Burnell, G. (1998). Environmental impacts of bivalve mariculture. Journal of Shellfish Research Vol. 17, No. 1 pp. 59-66

Karakassis, I., (2001): Ecological Effects of Fish farming. In the Mediterranean Cahiers Options Meditteraneenes (in press).
Karakassis, I. and Eleftheriou, A., (1997) The continental shelf of Crete: structure of macrobenthic communities. Mar. Ecol. Prog. Ser. 160, pp. 185-196
Karakassis, J. (2001). Aquaculture and coastal marine biodiversity. Oceanis Vol. 24. No. 4. pp 272-286
Katavic, I. and Antolic, B. (1999). On the impact of a seabass (*Dicentrarchus labrax*) cage farm on water quality and macrobenthic communities. Acta Andriatica Vol. 40(2) pp.19-32
Katz, S., 1989. Environmental impact assessment for the use of formaline-F in the control of external protozoa on penaid shrimp. Unpublished report to US FDA August 1989, 12p.
Kautsky, N. and Folke, C. (1989). Management of coastal areas for a sustainable development of aquaculture. Biota, No. 5 pp.1-11
Krom, M., Ellner, S., VanRijn, J. and Neori, A., (1995). Nitrogen and phosphorus cycling and transformations in a prototype "non-polluting integrated mariculture system. Eilat, Israel. Mar. Ecol. Prog. Ser. No. 118, pp. 25-36
Lall, S.P., Olivier, G. Hines, J. A., Ferguson, H. (1988) The role of Vitamin E in nutrition and immune response of Atlantic salmon. Bull.Aquacult. Assoc. Can. 88(2) pp. 76-78
Leung, K., Chu, J. and Wu, R. (1999). Nitrogen budgets for the aerolated grouper Epiniphelus areolatus under laboratory conditions and in open-sea cages. Mar. Ecol. Prog. Ser. 186, pp. 271-281
Mackay, D., (1999) Prospective on the environmental effects of aquaculture. In : Aqua Culture Europe magazine Vol. 24(2), pp. 5-9
Martinelly, M., Milella, I., Virdis, G., Deledda, M. and Castelli, A. (1995). Characterization of the benthic component of an area affected by experimental rearing of prestigious fish species. Biol. Mar. Mediterr. Vol. 2 No. 2 pp 151-155
Mazouni, N., Desious-Pooli and Landrein, S. (1998). Impact of oyster culture on nutrients and oxygen fluxes in a coastal lagoon. Oceanogica Acta, Vol. 21 No. 6 pp. 845-860.
Mc Ginitty, P., Stone C, Taggart J.B., Cooke, D., Cotter, D. Hynes, R., Mc Camley, C., Gross T. and Ferguso, A. (1997). Genetic impact of escaped farmed Atlantic Salmon (*Salmo salar*) on native populations. In Interactions between Salmon Culture and Wild Stocks of Atlantic salmon: the scientific and management issues. Proc. of an ICES/NASCO Symposium, England 18-22 April, 1997, Vol. 54, No. 6 pp. 998-1008
Munday, B., Eleftheriou, A., Kentouri, M. and Divanach, P. (1992). The interactions of aquaculture and the environment: a bibliographical review. Commission of the European Communities. Dir. Gen. for Fisheries, Brussels 325p.
Murno, A. L. (1988) Advantages and disadvantages of transplantations. In Efficiencies in Aquaculture Production, "Aquaculltura 86" Verona, Italy, 9-10 Oct. 1986.
PAP/RAC (1996). Approaches for zoning of coastal areas with reference to Mediterranean aquaculture. PAP-IO/EAM/GL.2 Split. 35p.
Pergent, G., Menzedzer, S., Pergent-Martini, C. and Pasqualini, V. Preliminary data on the impact of fish farming facilities on *Posidonia oceanica* meadows in the Mediterranean. Ocean. Acta Vol. 22 No. 1 pp. 95-107
Pitta, P. (1996). Dynamics of the phytoplankton in seabream (Sparus aurata) rearing mesocosms. PhD. Thesis, University of Crete, Heraclion.
Pitta, P., Karakassis, I., Tsapakis, M. and Zivanovic, S. (1999) Natural vs mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. Hydrobiologia, 391, pp.181-194
Rosenthal, H. (1976). Implications of transplantations to aquaculture and ecosystem, FAO, FIR:AQ/Conf. 76/E65, 19p.
Ross, L., Mentoza, Q., and Beveridge, M. (1993). The application of geographical information system to site selection for coastal aquaculture: an example based on salmonid cage culture. Aquaculture, No. 112 pp. 165-178

Samuelson, O.B, Torsvik, V. and Ervik, A., (1992). Long range changes in oxytetracycline concentration in bacterial resistance towards oxytetracycline in a fish farm sediment after medication. Sci. Total Environ. 114, pp. 25-36

Sdrigotti, E. Barvariol, V. and Welker, C. (1999). Diatoms assemblages in coastal shallow waters at the water sediment interface (Gulf of Trieste, North Adriatic Sea) ANN. AN ISTRSKE MEDITER. STUD. (Hist. Nat. 9) Vol. 2 No. 17 pp. 191-202

Shumway, S.A. (1990). A review on the effects of algae blooms on shellfish and aquaculture. J. Word Aquaculture Soc. 212, pp. 65-104.

Silvert, W. and Cromey, C.J., (2001) Modeling impacts. In: Environmental impacts of aquaculture ed. By Kenneth D. Black, Sheffield Acad. Press 213p.

Smith, P. (1996). Is sediment deposition the dominant fate of oxytetracycline used in marine salmonid farms: a review of available evidence. Aquacult. 146 pp. 157-169

Sullivan, J.J. (1988). Methods of analysis for DSP and PSP toxins in shellfish: a review. J. Shellfish Res. 7, pp 587-595.

Tacon, A.G.J. (1997). Contribution of food fish supplies. FAO Fish. Circ, (886) Rev. 1. pp.17-21

Torsvik, V., Soerheim, R. and Goksoer, J. (1988) Antibiotic resistance of bacteria from fish farm sediments. Copenhagen, Denmark-ICES 9pp.

Tortonese, E. (1985). Distribution and ecology of endemic elements in the Mediterranean fauna (Fishes and Echinoderms). In Mediterranean marine Ecosystems, Moraitou-Apostolopoulou, M. and Kiortsis, V. (eds). Plenum Press New York pp57-83

Turner, G.E. (ed) (1988). Codes of practice and manual of procedures for consideration of introduction and transfers of marine and freshwaters organisms. EIFAC Occas. Pap. 23, 44p. and ICES Coop. Res. Rep. (195), 44p.

Vaque, D., Blough, H. A. and Duarte, C.M. (1997). Dynamics of ciliate abundance, biomass and community composition in an oligotrophic coastal environment (NW Mediterranean). Aquat. Microb. Ecol. Vol. 12 pp. 71-83.

WDF/WDOE (1985). Use of the insecticide Sevin to control ghost and mud shrimp in oyster beds of Willapa Bay and Grays Harbour. Final Environmental Impact Statement, Olympia, Washington USA: Washington Department of Fisheries and Washington Department of Ecology.

Wellcome, R. (1988). Proposed international regulations to reduce risk associated with transfers and introduction of aquatic organisms. In: Efficiency in aquaculture production. Disease control. Proc. of the Third Int. Conf. of Aquafarming, Verona, Italy 9-10 Oct. 1981, edited by E. Grimaldi and Rosenthal, Milano Italy, Edizione del Sole 24 ore, pp. 65-74.

Whilde, T. (1990) Sharing the environment with the original inhabitants-some thoughts on aquaculture and the environment pp. 56-59. In: Oliver, P. and Colleran, E. (eds). Interaction between aquaculture and the environment. An Taisce. The National Trust for Ireland, Dublin 8 Ireland, 75pp.

Ye, L. X., Ritz, D.A., Fenton, G.E. and Lewis, M.E., (1991). Tracing the influence on sediments of organic waste from salmonid farm using stable isotope analysis. Journ. of Exper. Mar. Biol. and Ecol. Vol. 145 pp. 161-174

ANNEX I

Fish, Mollusc and Crustacean Production by Country for the Years 1990 - 2000)

Source: FEAP, SIPAM

TABLE 1a. ALGERIA

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990		71			48	**119**
1991		22			54	**76**
1992		6			20	**26**
1993		32			16	**48**
1994		18			17	**35**
1995		22			16	**38**
1996		12			19	**31**
1997		19			20	**39**
1998		26			26	**52**
1999		26			8	**34**
2000		27			15	**42**

TABLE 1b. CROATIA

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990	1495	13300		1421		**16216**
1991	347			1110		**1457**
1992	685			1950		**2635**
1993	1325			1515		**2840**
1994	1520			1215		**2735**
1995	1490			1085		**2575**
1996	1660			1100		**2760**
1997	1800			894		**2694**
1998	2252			990		**3242**
1999	2441			1200		**3641**
2000	2500			1100		**3600**

TABLE 1c. CYPRUS

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990						**0**
1991						**0**
1992	70		0			**70**
1993	169		0			**169**
1994	209		2			**211**
1995	348		6			**354**
1996	663		12			**675**
1997	841		22			**863**
1998	1054		25			**1079**
1999	1314		43			**1357**
2000	1638		60			**1698**

TABLE 1d. EGYPT

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990		0				**0**
1991		0				**0**
1992		680				**680**
1993		1570				**1570**
1994		1510				**1510**
1995		18				**18**
1996		80				**80**
1997		81				**81**
1998		82				**82**
1999	940					**940**
2000	N.A.					**-**

TABLE 1e. FRANCE

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	**FISH**		**CRUSTACEANS**	**MOLLUSCS**		**ALGAE**	**TOTAL**
	INTENSIVE	**EXTENSIVE**	**INTENSIVE**	**SEMI-INTENSIVE**	**EXTENSIVE**		
1990	1410		620		201032	80	**203062**
1991	1820		729		206527	40	**209076**
1992	2445		805		206595	50	**209845**
1993	48719		33		229253	70	**278005**
1994	5736		850		223779	100	**230365**
1995	6243		932		219960	200	**227135**
1996	5947		1074		217000	62	**224021**
1997	6801		1182		217150	62	**225133**
1998	6918		1280		219914	70	**228112**
1999	7114		1160		204653	62	**212927**
2000	7200		1210		N.A.	N.A.	**N.A.**

TABLE 1e. - bis FRANCE

Estimated Production of intensive mariculture in the Mediterranean for the years 1990-2000

YEAR	**PRODUCTION**
1990	**501**
1991	**990**
1992	**1578**
1993	**2362**
1994	**3778**
1995	**3958**
1996	**3635**
1997	**3759**
1998	**4526**
1999	**4811**
2000	**5180**

TABLE 1f. GREECE

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990	1607			5800		**7407**
1991	2475			7580		**10055**
1992	6032			13670		**19702**
1993	9500			16700		**26200**
1994	13630			16884		**30514**
1995	17763			21204		**38967**
1996	23002			26556		**49558**
1997	25500			25430		**50930**
1998	30900			27000		**57900**
1999	48000			28000		**76000**
2000	58400			28100		**86500**

TABLE 1g. ITALY

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS	TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE AND EXTENSIVE	
1990	950				**950**
1991	1480			90000	**91480**
1992	1958			84500	**86458**
1993	2918			90000	**92918**
1994	3250		25	100000	**103275**
1995	5250		25	105000	**110275**
1996	5950		22	100000	**105972**
1997	7300		19	103000	**110319**
1998	10100		25	130000	**140125**
1999	11750		0	130000	**141750**
2000	15800		N.A.	130000	**145800**

TABLE 1h. MALTA

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990	0					**0**
1991	0					**0**
1992	300					**300**
1993	600					**600**
1994	904					**904**
1995	1300					**1300**
1996	1552					**1552**
1997	1800					**1800**
1998	1950					**1950**
1999	2002					**2002**
2000	2050					**2050**

TABLE 1i. - SLOVENIA

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990	0				0	**0**
1991	0				65	**65**
1992	11				140	**151**
1993	18				43	**61**
1994	76				27	**103**
1995	50				13	**63**
1996	75				50	**125**
1997	89				37	**126**
1998	102				44	**146**
1999	102				37	**139**
2000	120				40	**160**

TABLE 1j. - MOROCCO

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990	217				178	**395**
1991	336				223	**559**
1992	546		35		162	**743**
1993	666		31		113	**810**
1994	1095	55	7		121	**1278**
1995	1200		1		331	**1532**
1996	1218				260	**1478**
1997	881	28			295	**1204**
1998	743	27			201	**971**
1999	746	28			217	**991**
2000	749	31			210	**990**

TABLE 1j. - bis MOROCCO

Estimated Production of intensive mariculture in the Mediterranean for the years 1990-2000

YEAR	PRODUCTION
1990	
1991	**217**
1992	**336**
1993	**546**
1994	**666**
1995	**1095**
1996	**1218**
1997	**881**
1998	**743**
1999	**746**
2000	**749**

TABLE 1k. - SPAIN

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990	1970	125	201	176277	4167	**182740**
1991	2599	56	92	197587	3925	**204259**
1992	4263	121	153	141692	3534	**149763**
1993	4563	112	185	93301	3586	**101747**
1994	5171	156	160	145021	4621	**155129**
1995	6053	139	168	185431	5204	**196995**
1996	7440	212	227	192388	3327	**203594**
1997	7306	171	247	192400	5593	**205717**
1998	10812	154	185	264869	5831	**281851**
1999	14396	88	138	266266	5905	**286793**
2000	14912	88	156	269000	6000	**290156**

TABLE 1k. - bis SPAIN

Estimated Production of intensive mariculture in the Mediterranean for the years 1990-2000

YEAR	PRODUCTION
1990	
1991	**995**
1992	**1221**
1993	**1859**
1994	**2417**
1995	**2451**
1996	**3184**
1997	**4931**
1998	**8045**
1999	**10929**
2000	**11100**

TABLE 1l. TUNISIA

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	INTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990						
1991	292				151	**443**
1992	202				138	**340**
1993	483				150	**633**
1994	616				46	**662**
1995	393				128	**521**
1996	552				142	**694**
1997	800				140	**940**
1998	368					**368**
1999	280					**280**
2000	292					**292**

TABLE 1m. TURKEY

Fish, Mollusc and Crustacean production (tonnes) for the years 1990-2000

YEAR	FISH		CRUSTACEANS	MOLLUSCS		TOTAL
	INTENSIVE	EXTENSIVE	EXTENSIVE	SEMI-INTENSIVE	EXTENSIVE	
1990						
1991						
1992	1750		40			**1790**
1993	1800		-			**1800**
1994	2000					**2000**
1995	8000		40			**8040**
1996	9000		270			**9270**
1997	15800		330			**16130**
1998	21100		470			**21570**
1999	24700		0			**24700**
2000	25500		0			**25500**

ANNEX II

Case Study

The Influence of Fish Farming on Coastal Marine Sediment in Slovenia (Piran Bay, northern Adriatic) - Summary

Authors: N. Kovac, B. Cermelj, B. Vrišer, S. Lojen
with the support of UNEP/MAP

Case Study:
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(Piran Bay, northern Adriatic) - Summary

Authors: *N. Kovac, B. Cermelj, B. Vrišer, S. Lojen with the support of UNEP/MAP
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Introduction

Mariculture, the farming of different organisms such as fish, molluscs and crustaceans, is an important and fast growing method of food production. Many studies showed that overfeeding in fish farms causes changes in the sediment and benthic community structure. The organic matter (OM) originating in fish-food remains and the excreta of the cultured fish often accumulates in the sediment. In response, oxygen becomes depleted and sulphate reduction is stimulated leading to increased H_2S production and subsequent impoverishment and/or displacement of fauna and benthic algae (Duplisea and Hargrave, 1996; Mazzola et al., 1999; Karakassis et al., 2000; Christensen et al, 2003). The degree of impact depends on many factors such as water movement, sediment composition, resuspension, benthic fauna and organic loading from fish farm activity. In addition to particulates solute waste also affects the water quality (Pitta et al, 1999) that can influence the phytoplankton growth (Arzul et al., 1996; Frid and Mercer, 1989). The fisheries of Adriatic Sea do not escape from this general context.

In this summary we present the main results obtained from a casual study entitled *“The influence of fish farming on coastal marine sediment in Slovenia (Piran Bay, northern Adriatic)”* that was carried out with support of UNEP/MAP (Memorandum of understanding between NIB and UNEP/MAP, Project Account: No ME/6030-00-04 BL2208).

Materials and methods

The sampling was performed on 7-8 May 2003 at the Fish farm Lera d.o.o. that is one of two Slovenian farms situated in the coastal waters of the Bay of Piran - Gulf of Trieste (northern Adriatic Sea, Figure 1). In the investigated fish farm about 50-70 tons of European seabass (*Morone labrax*) are produced in cages.

Samples were collected (Figure 1) from the fish area i.e. beside the fish cages (sampling site-SL) and away from the influenced area (control sites: CL-1 and CL-2). The control site *CL-1* was established a few kilometres from fish farm and *CL-2* was located about 200 m from the fish cages.

Figure 1: Location of sampling site (SL) in the fish farm area and the control sites (CL-1 and CL-2) in Piran Bay-Gulf of Trieste (northern Adriatic), (drawing by T. Makovec)

The sedimentation rates (of total suspended matter, particulate organic carbon and total particulate nitrogen) were measured over a period of 24 hours using moored sediment traps and traps located on the support array at a depth of 5 m. Additionally, stable isotope analyses were used to investigate the sedimented particulate matter.

In order to estimate the impact of the organic output from fish cages on the benthos (sediment), a sampling scheme in the shape of a star was established on sediment under the fish cages (mesh sampling) and at a control site (one sampling point). Within the sampling mesh (sampling site), three points i.e. S, S1, S2 were selected as principal sampling points in addition eight other sampling points (A1, A2, B1, B2, C1, C2, D1, D2). Sediment samples were used for subsequent analyses of the porosity and the granulometry (grain size), organic carbon (TOC) and total nitrogen content (TN), isotopic composition (^{13}C and ^{15}N), phytoplankton pigment concentrations (microphytobentos) and analyses of meiofauna. In the interstitial water we determined alkalinity, pH, the concentrations of total CO_2, hydrogen sulphide and nutrients (ammonium (NH_4^+), orthophosphate (PO_4^{3}), ortosilicate (SiO_4^{4-}), sulphate (SO_4^{2-})).

Results and discussion

Particulate matter: The composition of settled particulate matter in terms of POC and TPN showed in general higher values in the samples from the fish farming area due to the supply of organic matter from fish farming activity (Table 1). This is in accordance with results of previous similar studies performed in the Slovenian coastal sea (Kovac et al., 2001, Kovac et al., 2003). Based on the material collected in a trap during 24 hours under the fish cages at 5m, the atomic C/N ratio of organic waste originating from the fish farm was lower (11.6) than that measured at the control (CL-1: 13.76, CL-2: 14.63) sites. This is due to a larger contribution of proteinaceous material (fish food) which leads to higher content of nitrogen and consequently to lower C/N ratio of settling matter. The δ^{15}N values of the trap sample from the sampling site also indicated the important contribution of fish faeces at a depth of 5 m.

Table 1: Analyses performed on the settled particulate matter at sampling (SL) and control (CL-1 and CL-2) sites

SEDIMENT TRAP SAMPLES (Mean values)	SEDIMENT TRAP LOCATION				
	Sampling site		*Control site*		
PARAMETER	***SL-5 m***	***SL-bottom***	***CL-1 (at 5m)***	***CL-2 (5 m)***	***CL(2) – bottom***
Content of organic carbon (%)	*8.24*	*5.35*	*6.98*	*16.41*	*5.08*
Content of total nitrogen (%)	*0.83*	*0.44*	*0.59*	*1.30*	*0.46*
C/N ratio (atomic)	*11.60*	*14.29*	*13.76*	*14.63*	*13.08*
Sedimentation ratio of total particulate matter (g $m^{-2}d^{-1}$)	*23.59*	*31.16*	*2.56*	*1.68*	*4.03*
Sedimentation ratio of total particulate nitrogen (mg $m^{-2}d^{-1}$)	*187.12*	*132.74*	*14.28*	*16.11*	*18.37*
Sedimentation ratio of particulate organic carbon (mg $m^{-2}d^{-1}$)	*1802.90*	*1625.58*	*167.97*	*202.04*	*204.16*
$\delta^{13}C_{PDB}$ (‰)	*-23.4*	*-24.3*	*-23.7*	*-25.0*	*-23.7*
$\delta^{15}N_{air}$ (‰)	6.2	7.4	*7.8*	*5.5*	2.0

During this sampling, the highest values of POC and TPN contents were determined from the trap sample from CL-2 site suggesting the presence of polisaccharidic material related to local phytoplankton bloom. Considering the location of this control site, located about 200 m from the fish cages, particles from fish farm could also have contributed to those results but that is not confirmed by $\delta^{15}N$ and $\delta^{13}C$ values. In spite of the high percentage of organic carbon and similar content of nitrogen in particles from both sites i.e. SL and CL-2 the sedimentation rates of POC and TPN were much higher at the sampling site. The average sedimentation rates of POC, TPN and TPM measured at the fish farm were higher than that of the control site due to food supply to fish and organic waste from the fish framing activity. The same trend, but with higher values, has already been reported for another Slovenian fish farm in the Gulf of Trieste (Kovac at al, 2001). At the sampling site, the layer at 5 m coincided with the depth of the cages and was therefore more influenced by organic particulate loading (particularly by fish-food remains and organic waste products) in comparison to the bottom layer. Consequently, the sedimentation rates measured at 5 m were about 29 % (POC) and 10 % (TPN) higher than those determined at the bottom. The differences in POC and TPN content between 5 m- and bottom-layer suggest degradation and transportation of particulate matter during sedimentation. In comparison to previously reported sedimentation rates (Kovac et al., 2001; Kovac et al., 2003; Faganeli, 1989; Faganeli et al, 1995), all measured values were relatively low. These results were probably due to the low riverine discharge (only a few rain events) during January-May of 2003. Low riverine inflows resulted in low inputs of particulate matter and nutrients that couldn't promote new phytoplankton production or a high concentration of autohtonic particulate matter. Additionally, during the sampling period the feeding of fish with commercial food was not at its maximum rate. The measured sedimentation at the fish farm area (mean carbon flux = 1.7 $gm^{-2}d^{-1}$ on May 2003) was approximately 76% lower than the level of organic matter reported elsewhere (Gowen and Bradbury, 1987; Angel et al., 1992).

Sediment: In order to assess the horizontal extent of the impact of the fish farming activity, surface sediment samples were taken at the control site and under the sea bass cages i.e. directly below the cage (sampling point - S) and at several other sampling points beneath the cages. All sediments were clayey silt with the similar sediment grain size distribution.

In the solid phase of the sediment, the concentration of organic carbon ranged from 0.66 wt % to 2.20 wt % and the concentration of total nitrogen ranged from 0.07 wt% to 0.27 wt%. In all cases both concentrations decreased with depth (Figure 2).

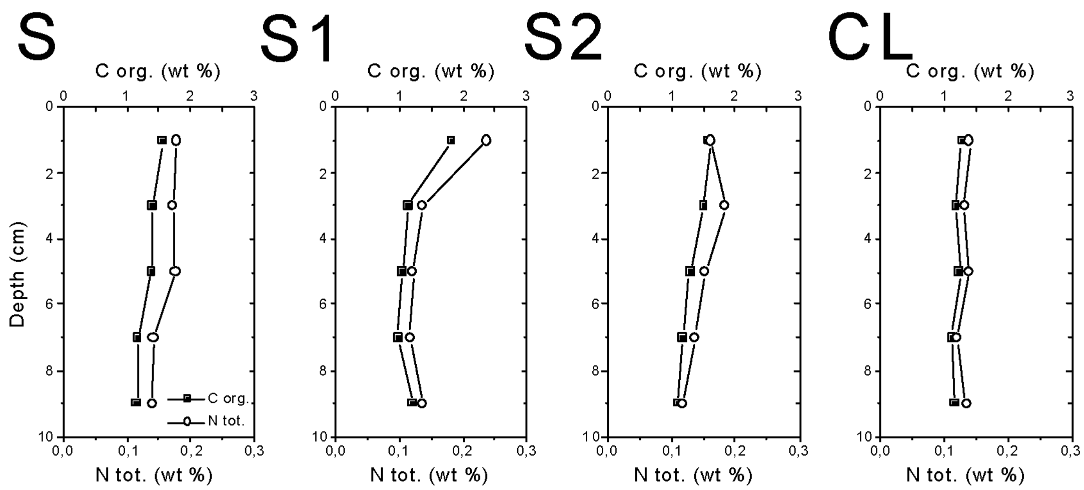

Figure 2. Organic carbon and total nitrogen content in the sediment versus depth at sampling points S, S1, S2 and at CL

The rate of OC and TN accumulation can be approximated by the concentration decrease with depth. At some sampling locations the decrease was almost linear while at others where the decrease was almost exponential, the organic matter accumulation was much more intensive. By measuring organic carbon and total nitrogen content of solid state of surface sediments (Fig.3) we also determined the patchy accumulations of organic material in fish farm area. This was also expressed in the vertical profiles. From the same vertical profiles it was evident that within the last 50 years the conditions and directions of organic loading have changed significantly (presuming an average sediment rate of 2 cm/year).

The $\delta^{13}C$ values of sediment at the control site reflect marine particulate matter while at the sampling site deviation from marine phytoplankton material was observed (Fig. 4). Considering the Corg./Ntot. ratio and $\delta^{13}C$ and $\delta^{15}N$ values in sediments, correlation analyses showed that the organic matter at the fish farm area today mostly originates in fish food and faeces (Fig 4).

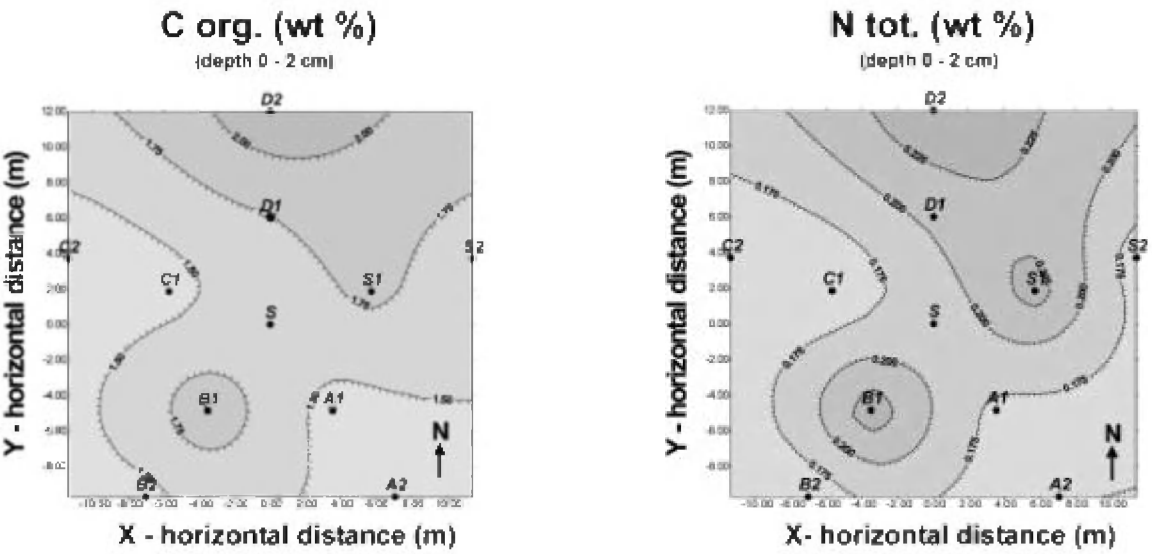

Figure 3. Superficial (depth = 0-2 cm) concentrations of total organic carbon and nitrogen below the fish farm cages. Sampling point S is located below the center of the cage

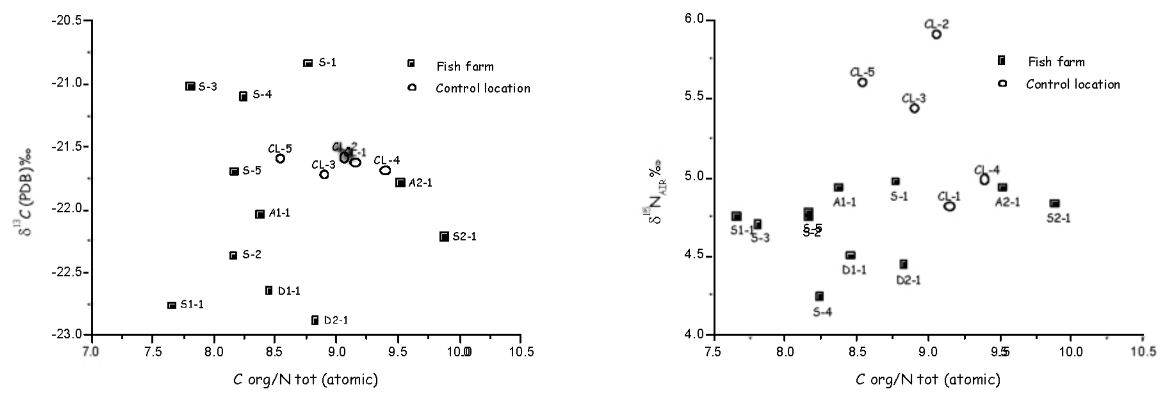

Figure 4: Relationship between $\delta^{13}C$, $\delta^{15}N$ and Corg./Ntot. ratios in the sediments at the control location and at beneath the fish farm

Interstitial water concentrations of ammonium (NH_4^+), orthophosphate (PO_4^{3}), ortosilicate (SiO_4^{4-}) and sulphate (SO_4^{2-}) indicated the greatest impact to be directly under the cages. With respect to the control site all measured nutrients in the interstitial waters of the sediments beneath the fish cages showed higher values. In the upper 10 cm of the sediments, the remineralization of organic matter predominantly proceed via dissolved oxygen consumption rather than by sulphate consumption. The decrease of sulphate was mainly observed at sampling point S (directly below the fish cages) at a depth of 1 cm. This was also shown by ammonia increase. However, due to the benthic activity enough dissolved oxygen penetrates deep into the sediment to sustain low H_2S concentrations in the interstitial waters of sediments.

Environmental changes were most evident in benthos showing a long-term impact on meiofauna communities. High organic matter supply, i.e. settling of unconsumed food, waste and fish faeces under and adjacent to fish cages, may favour some organism over others. That was evidenced from the slight decrease of benthic meiofauna biomass and from the impoverishment of species diversity. The abundances of the main meiofaunal groups (Nematoda, Harpacticoidea, Polychaeta, Turbellaria, Bivalvia) gradually increased from the fish farm in the direction of unaffected area. However, the impact of fish farming was more evident from the species diversity. The impoverishment of species was more pronounced in the sediment directly below the cages. In addition to slightly lower abundances of total meiofauna and the leading group of meiofauna at the impacted zone, we also observed the absence of some meiofaunal groups (Gastropoda, Acarina, Ostracoda, Ophiuroidea). Diversity increased from a low level under the cages to a higher level at 200 m from the cages (control site). According to the data, the meiofauna from the control site reflect the typical (normal) spring community of unaffected area.

In comparison to the control site, higher sediment chlorophyll *a* and phaeopigment concentrations were determined at the fish farm. Sediment chlorophyll *a* concentrations suggest that chlorophyll *a* in sediment was mostly related to phytobenthos rather to the sedimentation of phytoplankton cells since concentration of chlorophyll *a* measured in the water column was very low during the sampling period. In comparison to the control site, a pronounced increase in chlorophyll *a* and phaeopigment content was observed directly below the centre of the cages. (at sampling point S, Table 2). This could be attributed to a higher contribution of nutrients such as ammonium and phosphate thus influencing the growth of benthic microflora at that time. High sediment phaeopigment concentrations also suggest that some of the photosynthetic pigments in the farm-affected sediments were depositional chlorophyll degradation products derived from fecal and pseudofecal materials (Christensen et al., 2003). All measured values at the sampling site were higher than averages reported for sediments of unaffected areas in Slovenian coastal sea (Juriševic, 1992).

Table 2: Sediment chlorophyll *a* and phaeopigment concentrations

	Concentrations (mg/m^2)			
	Sampling site			*Control site*
Sampling point	**S**	**S1**	**S2**	**CP**
Chlorophyll *a*	*45,80*	*28,07*	*37,12*	*18,47*
Phaeopigment	*113,50*	*108,11*	*73,47*	*30,11*

Conclusions

The results presented in this study indicate the impact of fish farming activity on the benthic environment in fish farming areas in the Slovenian coastal sea. Considering the identification of heterogeneous/patchy organic enrichment in sediments, additional analyses are needed for a more detailed estimation of this activity's influence on sediment characteristics. This data-base (especially identification of the main direction of organic loading in a fish farm area) could provide basic information for the better planning of future investigations of the fish farm's impact in the Slovenian coastal sea.

References

Angel, D., Krost, P., Zuber, D., Neori, A., 1992. Microbial mats mediate the benthic turnover of organic matter in polluted sediments in the Gulf of Aqaba. Proc.U.S.-Israel Workshop on Mariculture and Environment, Elat, Israel, June 1992, 66-73.

Arzul, G., Clément, A., Pinier, A., 1996. Effects on phytoplankton growth of dissolved substances produced by fish farming. Aquat. Living. Resour. 9, 95-102.

Christensen, P.B., Glud, R.N., Dalsgaard, T., Gillespie, P., 2003. Impacts of longline mussel farming on oxygen and nitrogen dynamics and biological communities of coastal sediments. Aquaculture 218, 567-588.

Faganeli, J., 1989. Sedimentation of particulate nitrogen and amino acids in shallow coastal waters (Gulf of Trieste, northern Adriatic). Mar. Chem. 26, 67-80.

Faganeli, J., Kovac, N., Leskovsek, H., Pezdic, J., 1995. Sources and fluxes of particulate organic matter in shallow waters characterized by summer macroaggregate formation. Biogeochemistry 29, 71-88.

Frid, C.L.J., Mercer, T.S. 1989. Environmental monitoring of caged fish farming in macrotidal environments. Mar. Pollut. Bull. 20, 379-383.

Gowen, R.J., Bradbury, N.B., 1987. The ecological impact of salmonid farming in coastal waters: a review. Oceanogr. Mar. Biol. Ann. Rev. 25, 563-575.

Juriševic, A. 1992. Annual dynamic of microphytobenthos in eastern part of Gulf of Trieste (Letna dinamika mikrofitobentosa v vzhodnem delu Tržaškega zaliva), B.Sc.Thesis. University of Ljubljana, Biotehnical Faculty, 61 pp. (in Slov).

Karakassis, I., Tsapakis, M., Hatziyanni, E., Papadopoulou, K.N., Plaiti, W. 2000. Impact of cage farming of fish on the seabed in three Mediterranean coastal areas. ICES Journal of Marine Science 57, 1462-1471.

Kovac, N., Vrišer, B., Cermelj, B. 2001. Impacts of net cage fish farm on sedimentary biogeochemical and meiofaunal properties of the Gulf of Trieste. Annales, Ser. hist. nat. 11, 65-74.

Kovac,N., Cermelj, B., Lojen, S. Sedimentation and composition of particulate matter in a marine fish farm (Gulf of Trieste, northern Adriatic); Preliminary results. Annales, Ser. hist. nat. 13 (Supplement), 13-16.

Mazzola, A., Mirto, S., Danovaro, R. 1999. Initial Fish-Farm Impact on Meiofaunal Assemblages in Coastal Sediments of the Western Mediterranean. Mar. Pollut. Bull. 38, 1126-1133.

Pitta, P., Karakassis, I., Tsapakis, M., Zivanovic, S. 1999. Natural vs. mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. Hydrobiologia 391, 181-194.

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MTS 62. UNEP/MAP/IAEA: **Assessment of the State of Pollution of the Mediterranean Sea by Radioactive Substances.** UNEP/MAP: Athens, 1992 (English, French).
Evaluation de l'état de la pollution de la mer Méditerranée par les substances radioactives.

MTS 61. UNEP/MAP **Integrated Planning and Management of the Mediterranean Coastal Zones. Documents produced in the first and second stage of the Priority Action (1985-1986).**, Priority Actions Programme, Regional Activity Centre, Split, 1991 (Parts in English or French only).
Planification intégrée et gestion des zones côtières méditerranéennes. Textes rédigés au cours de la première et de la deuxième phase de l'action prioritaire (1985-1986).

MTS 60. UNEP/MAP/WHO: **Development and testing of sampling and analytical techniques for monitoring of marine pollutants (Activity A): Final reports on selected microbiological projects (1987-1990).** UNEP/MAP: Athens, 1991. (Parts in English or French only).
Mise au point et essai des techniques d'échantillonnage et d'analyse pour la surveillance continue des polluants marins (Activité A): Rapports finaux sur certains projets de nature microbiologique (1987-1990).

MTS 59. UNEP/MAP/FAO/IAEA: **Proceedings of the FAO/**UNEP**/IAEA Consultation Meeting on the Accumulation and Transformation of Chemical contaminants by Biotic and Abiotic Processes in the Marine Environment (La Spezia, Italy, 24-28 September 1990), edited by G.P. Gabrielides.** UNEP/MAP: Athens, 1991. (English).

MTS 58. UNEP/MAP/FAO/**WHO**/IAEA: **Assessment of the state of pollution of the Mediterranean Sea by organophosphorus compounds.** UNEP/MAP: Athens, 1991. (English, French).
Evaluation de l'état de la pollution de la mer Méditerranée par les composés organophosphorés.

MTS 57. UNEP/MAP/WHO: **Research on the toxicity, persistence, bioaccumulation, carcinogenicity and mutagenicity of selected substances (Activity G): Final reports on projects dealing with carcinogenicity and mutagenicity.** UNEP/MAP: Athens, 1991. (English).

MTS 56. UNEP/MAP/IOC/FAO: **Assessment of the state of pollution of the Mediterranean Sea by persistent synthetic materials, which may float, sink or remain in suspension.** UNEP/MAP: Athens, 1991. (English, French).
Evaluation de l'état de la pollution de la mer Méditerranée par les matières synthétiques persistantes qui peuvent flotter, couler ou rester en suspension.

MTS 55. UNEP/MAP/WHO: **Biogeochemical cycles of specific pollutants (Activity K): Final report on project on survival of pathogenic organisms in seawater.** UNEP/MAP: Athens, 1991. (English).

MTS 54. UNEP/MAP/WHO: **Development and testing of sampling and analytical techniques for monitoring of marine pollutants (Activity A): Final reports on selected microbiological projects.** UNEP/MAP: Athens, 1991. (English).

MTS 53. UNEP/MAP/WHO: **Epidemiological studies related to environmental quality criteria for bathing waters, shellfish-growing waters and edible marine organisms (Activity D). Final report on epidemiological study on bathers from selected beaches in Malaga, Spain (1988-1989).** UNEP/MAP: Athens, 1991. (English).

MTS 52. UNEP/MAP/FAO: **Final reports on research projects dealing with bioaccumulation and toxicity of chemical pollutants.** UNEP/MAP: Athens, 1991 (Parts in English or French only).
Rapports finaux sur les projets de recherche traitant de la bioaccumulation et de la toxicité des polluants chimiques. (parties en anglais ou français seulement).

MTS 51. UNEP/MAP/FAO: **Final reports on research projects dealing with mercury, toxicity and analytical techniques.** UNEP/MAP: Athens, 1991 (Parts in English or French only).
Rapports finaux sur les projets de recherche traitant du mercure, de la toxicité et des techniques analytiques.

MTS 50. UNEP/MAP: **Bibliography on marine litter.** UNEP/MAP: Athens, 1991 (English).

MTS 49. UNEP/MAP/WHO: **Biogeochemical cycles of specific pollutants. Survival of pathogens. Final reports on research projects (Activity K).** UNEP/MAP: Athens, 1991 (Parts in English or French only).
Cycles biogéochimiques de polluants spécifiques. Survie des Pathogènes. Rapports finaux sur les projets de recherche (activité K).

MTS 48. UNEP/MAP/FAO: **Final reports on research projects (Activity G).** UNEP/MAP: Athens, 1991 (Parts in English or French only).
Rapports finaux sur les projets de recherche (Activité G).

MTS 47. UNEP/MAP: **Jellyfish blooms in the Mediterranean. Proceedings of the II workshop on jellyfish in the Mediterranean Sea.** UNEP/MAP: Athens, 1991 (Parts in English or French only).
Les proliferation's de medusas en Méditerannée. Actes des IIèmes journées d'étude sur les méduses en mer Méditerranée.

MTS 46. UNEP/MAP/WHO: **Epidemiological studies related to environmental quality criteria for bathing waters, shellfish-growing waters and edible marine organisms (Activity D). Final report on project on relationship between microbial quality of coastal seawater and rotarus-induced gastro-enteritis among bathers (1986-88).** UNEP/MAP: Athens, 1991 (English).

MTS 45. UNEP/MAP/IAEA: **Transport of pollutants by sedimentation: Collected papers from the first Mediterranean Workshop (Villefranche-sur-Mer, France, 10-12 December 1987).** UNEP/MAP: Athens, 1990 (English).

MTS 44. UNEP/MAP: **Bibliography on aquatic pollution by organophosphorus compounds.** UNEP/MAP: Athens, 1990 (English).

MTS 43. PNUE/UICN/GIS: **Posidonie: Livre rouge "Gérard Vuignier" des végétaux, peuplements et paysages marins menacés de Méditerranée.** UNEP/MAP: Athens, 1990 (français seulement).

MTS 42. UNEP/MAP/IUCN: **Report on the status of Mediterranean marine turtles.** UNEP/MAP: Athens, 1990 (English, French).
Rapport sur le statut des tortues marines de Méditerranée.

MTS 41.UNEP/MAP: **Wastewater reuse for irrigation in the Mediterranean region.** Priority Actions Programme, Regional Activity Centre, Split, 1990 (English, French).
Réutilisation agricole des eaux usées dans la région méditerranéenne..

MTS 40. UNEP/MAP/FAO: **Final reports on research projects (Activities H, I and J).** UNEP/MAP: Athens, 1990 (English, French).
Rapports finaux sur les projets de recherche (Activités H, I et J).

MTS 39. UNEP/MAP/FAO/WHO/IAEA: **Assessment of the state of pollution of the Mediterranean Sea by organohalogen compounds.** UNEP/MAP: Athens, 1990 (English, French).
Evaluation de l'état de la pollution par les composés organohalogénés.

MTS 38.UNEP/MAP: **Common measures adopted by the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against pollution.** UNEP/MAP: Athens, 1990 (English, French, Spanish and Arabic).
Mesures communes adoptées par les Parties Contractantes à la Convention pour la protection de la mer Méditerranée contre la pollution.
Medidas comunes adoptadas por las Partes Contratantes en el convenio para la Proteccion del Mar Mediterraneo contra la Contaminacion.

MTS 37. UNEP/MAP/FAO: **Final reports on research projects dealing with eutrophication and plankton blooms (Activity H).** UNEP/MAP: Athens, 1990 (Parts in English or French only).
Rapports finaux sur les projets de recherché consacrés à l'eutrophisation et aux efflorescences de plancton (Activité H).

MTS 36. PNUE/UICN: **Répertoire des aires marines et côtières protégées de la Méditerranée. Première partie - Sites d'importance biologique et écologique.** UNEP/MAP: Athens, 1990 (français seulement).

MTS 35. UNEP/MAP: **Bibliography on marine pollution by organotin compounds.** UNEP/MAP: Athens, 1989. (English).

MTS 34. UNEP/MAP/FAO/WHO: **Assessment of the state of pollution of the Mediterranean Sea by cadmium and cadmium compounds.** UNEP/MAP: Athens, 1989 (English, French).
Evaluation de l'état de la pollution de la mer Méditerranée par le cadmium et les composés de cadmium.

MTS 33. UNEP/MAP/FAO/WHO/IAEA: **Assessment of organotin compounds as marine pollutants in the Mediterranean.** UNEP/MAP: Athens, 1989 (English, French).
Evaluation des composés organostanniques en tant que polluants du milieu marin en Méditerranée.

MTS 32. UNEP/MAP/FAO: **Biogeochemical cycles of specific pollutants (Activity K).** UNEP/MAP: Athens, 1989 (Parts in English or French only).
Cycles biogéochimiques de polluants spécifiques (Activité K).

MTS 31. UNEP/MAP/WMO: **Airborne pollution of the Mediterranean Sea. Report and proceedings of a WMO/**UNEP **Workshop.** UNEP/MAP: Athens, 1989 (Parts in English or French only).
Pollution par voie atmosphérique de la mer Méditerranée. Rapport et actes des Journées d'étude OMM/PNUE.

MTS 30. UNEP/MAP: **Meteorological and climatological data from surface and upper measurements for the assessment of atmospheric transport and deposition of pollutants in the Mediterranean Basin: A review.** UNEP/MAP: Athens, 1989. (English).

MTS 29.UNEP/MAP: **Bibliography on effects of climatic change and related topics.** UNEP/MAP: Athens, 1989 (English).

MTS 28. UNEP/MAP: **State of the Mediterranean marine environment.** UNEP/MAP: Athens, 1989 (English).

MTS 27. UNEP/MAP **Implications of expected climate changes in the Mediterranean Region: An overview.** UNEP/MAP: Athens, 1989 (English).

MTS 26. UNEP/MAP/IUCN: **Directory of marine and coastal protected areas in the Mediterranean Region. Part I - Sites of biological and ecological value.** UNEP/MAP: Athens, 1989 (English).

MTS 25. UNEP/MAP: **The Mediterranean Action Plan in a functional perspective: A quest for law and policy.** UNEP/MAP: Athens, 1988 (English).

MTS 24. UNEP/MAP/FAO: **Toxicity, persistence and bioaccumulation of selected substances to marine organisms (Activity G).** UNEP/MAP: Athens, 1988 (Parts in English or French only).
Toxicité, persistance et bioaccumulation de certaines substances vis-à-vis des organismes marins (Activité G).

MTS 23. UNEP/MAP: **National monitoring programme of Yugoslavia, Report for 1983 -1986.** UNEP/MAP: Athens, 1988 (English).

MTS 22. UNEP/MAP/FAO: **Study of ecosystem modifications in areas influenced by pollutants (Activity I).** UNEP/MAP: Athens, 1988 (Parts in English or French only).
Etude des modifications de l'écosystème dans les zones soumises à l'influence des pollutants (Activité I).

MTS 21. UNEP/MAP/UNESCO/FAO: **Eutrophication in the Mediterranean Sea: Receiving capacity and monitoring of long-term effects.** UNEP/MAP: Athens, 1988 (Parts in English or French only). **Eutrophisation dans la mer Méditerranée: capacité réceptrice et surveillance continue des effets à long terme.**

MTS 20. UNEP/MAP/WHO: **Epidemiological studies related to environmental quality criteria for bathing waters, shellfish-growing waters and edible marine organisms (Activity D). Final report on project on relationship between microbial quality of coastal seawater and health effects (1983-86).** UNEP/MAP: Athens, 1988 (English).

MTS 19. UNEP/MAP/IOC: **Assessment of the state of pollution of the Mediterranean Sea by petroleum hydrocarbons.** UNEP/MAP: Athens, 1988 (English, French).
Evaluation de l'état de la pollution de la mer Méditerranée par les hydrocarbures de pétrole.

MTS 18. UNEP/MAP/FAO/WHO: **Assessment of the state of pollution of the Mediterranean Sea by mercury and mercury compounds.** UNEP/MAP: Athens, 1987 (English, French).
Evaluation de l'état de la pollution de la mer Méditerranée par le mercure et les composés mercuriels.

MTS 17. UNEP/MAP: **Seismic risk reduction in the Mediterranean region. Selected studies and documents (1985-1987).**, Priority Actions Programme, Regional Activity Centre, Split, 1987 (Parts in English or French only).
Réduction des risques sismiques dans la région méditerranéenne. Documents et études sélectionnés (1985-1987).

MTS 16. UNEP/MAP: **Promotion of soil protection as an essential component of environmental protection in Mediterranean coastal zones. Selected documents (1985-1987).** Priority Actions Programme, Regional Activity Centre, Split, 1987 (Parts in English or French only).
Promotion de la protection des sols comme élément essentiel de la protection de l'environnement dans les zones côtières méditerranéennes. Documents sélectionnés (1985-1987).

MTS 15. UNEP/MAP: **Environmental aspects of aquaculture development in the Mediterranean region. Documents produced in the period 1985-1987.** Priority Actions Programme, Regional Activity Centre, Split, 1987 (English).

MTS 14. UNEP/MAP: **Experience of Mediterranean historic towns in the integrated process of rehabilitation of urban and architectural heritage. Documents produced in the second phase of the Priority Action (1986).** Priority Actions Programme, Regional Activity Centre, Split, 1987 (Parts in English or French only)

MTS 13. UNEP/MAP: **Specific topics related to water resources development of large Mediterranean islands. Documents produced in the second phase of the Priority Action (1985-1986).** Priority Actions Programme, Regional Activity Centre, Split, 1987 (Parts in English or French only).
Thèmes spécifiques concernant le développement des ressources en eau des grandes îles méditerranéennes. Textes rédigés au cours de la deuxième phase de l'action prioritaire (1985-1986).

MTS 12. UNEP/MAP: **Water resources development of small Mediterranean islands and isolated coastal areas. Documents produced in the first stage of the Priority Action (1984-1985).** Priority Actions Programme, Regional Activity Centre, Split, 1987 (Parts in English or French only).
Développement des ressources en eau des petites îles et des zones côtières isolées méditerranéennes. Textes rédigés au cours de la première phase de l'action prioritaire (1984-1985).

MTS 11. UNEP/MAP: **Rehabilitation and reconstruction of Mediterranean historic settlements. Documents produced in the first stage of the Priority Action (1984-1985).** Priority Actions Programme, Regional Activity Centre, Split, 1986 (Parts in English or French only).
Réhabilitation et reconstruction des établissements historiques méditerranéens. Textes rédigés au cours de la première phase de l'action prioritaire (1984-1985).

MTS 10. UNEP/MAP: **Research on the toxicity, persistence, bioaccumulation, carcinogenicity and mutagenicity of selected substances (Activity G). Final reports on projects dealing with toxicity (1983-85).** UNEP/MAP: Athens, 1987 (English).

MTS 9. UNEP/MAP: **Co-ordinated Mediterranean pollution monitoring and research programme (MED POL - PHASE I). Final report, 1975-1980.** UNEP/MAP: Athens, 1986 (English).

MTS 8. Add. UNEP/MAP: **Biogeochemical studies of selected pollutants in the open waters of the Mediterranean (MED POL VIII). Addendum, Greek Oceanographic Cruise 1980.** Addendum. UNEP/MAP: Athens, 1986 (English).

MTS 8. UNEP/MAP/IAEA/IOC: **Biogeochemical studies of selected pollutants in the open waters of the Mediterranean (MED POL VIII).** UNEP/MAP: Athens, 1986 (Parts in English or French only).
Etudes biogéochimiques de certains polluants au large de la Méditerranée (MED POL VIII).

MTS 7. UNEP/MAP/WHO: **Coastal water quality control (MED POL VII).** UNEP/MAP: Athens, 1986 (Parts in English or French only).
Contrôle de la qualité des eaux côtières (MED POL VII).

MTS 6. UNEP/MAP/IOC: **Problems of coastal transport of pollutants (MED POL VI).** UNEP/MAP: Athens, 1986 (English).

MTS 5. UNEP/MAP/FAO: **Research on the effects of pollutants on marine communities and ecosystems (MED POL V).** UNEP/MAP: Athens, 1986 (Parts in English or French only).
Recherche sur les effets des polluants sur les communautés et écosystèmes marins (MED POL V.

MTS 4. UNEP/MAP/FAO: **Research on the effects of pollutants on marine organisms and their populations (MED POL IV).** UNEP/MAP: Athens, 1986 (Parts in English, French or Spanish only).
Recherche sur les effets des polluants sur les organismes marins et leurs peuplements (MED POL IV).

MTS 3. UNEP/MAP/FAO: **Baseline studies and monitoring of DDT, PCBs and other chlorinated hydrocarbons in marine organisms (MED POL III).** UNEP/MAP: Athens, 1986 (Parts in English, French or Spanish only).
Études de base et surveillance continue du DDT, des PCB et des autres hydrocarbures chlorés contenus dans les organismes marins (MED POL III).

MTS 2. UNEP/MAP/FAO: **Baseline studies and monitoring of metals, particularly mercury and cadmium, in marine organisms (MED POL II).** UNEP/MAP: Athens, 1986 (Parts in English, French or Spanish only).
Etudes de base et surveillance continue des métaux, notamment du mercure et du cadmium, dans les organismes marins (MED POL II).

MTS 1. UNEP/MAP/IOC/WMO: **Baseline studies and monitoring of oil and petroleum hydrocarbons in marine waters.** UNEP/MAP: Athens, 1986 (Parts in English, French or Spanish only).
Etudes de base et surveillance continue du pétrole et des hydrocarbures contenus dans les eaux de la mer.