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REVIEWING MED POL MARINE MONITORING ACTIVITIES AND PLANNING FOR THE NEW INTEGRATED MAP MONITORING SYSTEM

UNEP/MAP
Athens, 2011

1. Preamble

Marine monitoring and research are the basic tools for understanding what is happening in the marine environment, why and how effective response measures have been. Then, assessment assembles this knowledge in a form useful for decision making. Therefore, it is very important to undertake a systematic effort to keep under review the status of the Mediterranean marine environment, because without baselines and reference points it is not possible to place current status and recent trends into historical contexts.

The present document reviews the progress made in the implementation of the marine monitoring programme of MED POL Phase IV and presents a spatial and temporal assessment of the hazardous substances in sediment and biota in the Mediterranean, based on the MED POL marine monitoring database. Furthermore, the document presents the link of the MED POL monitoring programme with the new MAP integrated monitoring programme under development, which will cover all relevant issues including pollution and biodiversity, in the framework of the gradual application of the Ecosystem Approach (ECAP) for the management of human activities in the Mediterranean. As a first contribution to the preparation of the new MAP monitoring programme, a methodology is presented for the development threshold limit values for indicators related to the ECAP Ecological Objectives EO5 (Eutrophication) and EO9 (Contaminants).

2. Introduction

According to Article 12 of the Barcelona Convention all Contracting Parties shall establish monitoring programmes and designate the competent authorities responsible for pollution monitoring. In addition, Article 8 of the Land–Based Sources Protocol stipulates that these monitoring programmes should aim:

a) to systematically assess, as far as possible, the levels of pollution along the Contracting Parties coasts, in particular with regard to the sectors of activity and categories of substances listed in Annex I, and periodically to provide information in this respect; and

b) to evaluate the effectiveness of action plans, programmes and measures implemented under this Protocol to eliminate to the fullest possible extent pollution of the marine environment.

In the framework of MED POL Phase IV (2006-2013) the general objectives relevant to monitoring are:

- Assessment of pollution loads from all point and diffuse sources and load of pollution reaching the Mediterranean,
- Assessment of the status and trends in the quality of the marine and coastal environment as an early warning system for potential environmental problems caused by pollution and other anthropogenic pressures;
- Control land-based pollution by means of compliance to national/international regulatory limits (monitoring of the implementation of the action plans, programmes and measures for the control of pollution and assess their effectiveness)
- Contribute, in cooperation with other MAP components, to the application of the Ecosystem Approach to the management of human activities within MAP, with MED POL as the monitoring and assessment component.

The implementation of the Ecosystem Approach roadmap will imply the establishment of an integrated monitoring programme, including marine pollution and biodiversity, in line with the objectives and steps agreed upon for the application of the Ecosystem Approach. The philosophy underlying the integrated approach is that all monitoring activities are integrated in a single, well-defined aim – that of achieving a particular level of environmental quality in a specified ecosystem. This means that common practices have to be adopted across all types of monitoring activities and data management. Furthermore, in order to decide if a marine area is in "Good Environmental Status" (GES), it is necessary to establish threshold values for key criteria in order to distinguish between acceptable (good) and un-acceptable (not good) environmental conditions. Such an integrated monitoring programme will be developed in the biennium 2012-2013, in line with the Ecological Objectives and Operational Objectives agreed upon.

In order to adapt to the new monitoring needs in the Mediterranean Region and following the decisions of Almeria on the gradual application of the Ecosystem Approach, the MED POL Focal Points in their last meeting in Rhodes, Greece, (UNEP(DEPI)/MED WG. 357/10, 1 June 2011), reached the following conclusions in relation to monitoring:

- "The Focal Points expressed deep concern at the gaps in monitoring data resulting from the lack of reporting by a number of countries and urged all Mediterranean countries to comply with the legal obligation under the Barcelona Convention and the LBS Protocol to transmit marine monitoring data regularly to MED POL. The Focal Points requested the MAP Focal Points to address this issue.

- The Focal Points requested MED POL to coordinate the process of preparing the new MAP integrated monitoring programme, in line with the Ecosystem Approach and in cooperation with relevant MAP components and other relevant organizations, as appropriate."

In the present Working Document a review is presented on the activities implemented during the biennium 2010-2011 on:

I. Marine monitoring and data collection

II. Data Quality Assurance

III. Status and pollution trends monitoring of the Mediterranean marine environment

IV. Development of a harmonized integrated MAP monitoring programme to assess the quality status of the Mediterranean

3. <u>Marine monitoring and data collection: progress report 2010-2011</u>

a. <u>Participation of the countries in the MED POL Phase IV monitoring activities</u>

3.1.1. Status and trends monitoring activities: achievements and problems

During the last biennium (2010-2011) Small Scale Financial Agreements (SSFAs) for the implementation of National Monitoring Programmes were negotiated and agreed with five (5) countries (Algeria, Croatia, Egypt, Morocco and Tunisia - Table 2.1). An additional agreement was under negotiation with Libya, but it was not finalized due to the political events in the country on 2011. All agreements included a financial assistance to the countries, in order to facilitate the implementation of their monitoring programme.

During the biennium 2010 – 2011 MED POL provided assistance to Turkey for its participation in baseline surveys using transplanted mussels to assess marine pollution (MYTITURK). The assistance provided by MED POL helped to the completion of the project with the participation of all interested Mediterranean countries. With the completion of the project MYTITURK (coast of Turkey in the Black Sea, the Aegean Sea and the Levantine

Sea), we will have for a first time a survey on the distribution of specific inorganic and organic pollutants across all the coastal zone of the Mediterranean Sea.

3.1.2. Status of provision of marine monitoring data

During the biennium 2010-2011 monitoring data were provided by 11 countries [Bosnia & Herzegovina (2008), Croatia (2009), Egypt (2009), France (2009), Israel (2008, 2009), Montenegro (2009), Morocco (2009), Slovenia (2009, 2010), Syria (2007), Tunisia (2009) and Turkey (2009, 2010)]. Unfortunately, a number of countries did not transmit monitoring data according to the MED POL Phase IV requirements, although this is an obligation according Article 12 of the Barcelona Convention and Article 8 of the amended LBS Protocol. The need to submit monitoring data to MED POL has been continuously reminded to the parties in all recent major meetings: COP meeting Almeria, Spain, 2008; MED POL Focal Points Meeting, Kalamata, Greece, 2009; MED POL Monitoring Meetings: Athens, Greece, 2007 and Rome, Italy, 2009. Unfortunately many countries still do not provide monitoring data on a regular basis and the gaps in spacial and temporal coverage of the Mediterranean coastline remain.

Given the above mentioned shortcoming, the MED POL database continues to be regularly updated with all new data provided by the countries. Data are controlled in order to correct editing mistakes and omissions, and, if necessary, the data generator (country) is contacted for needed corrections/additions. The data base was corrected, in order to relate station name/ID with geographical coordinates and delete multiple entry of the same station under different names. The corrected data base was used to prepare an assessment of the state and trends of the quality of the marine environment of the Mediterranean (UNEP(DEPI)MED WG.365/Inf.1), UNEP(DEPI)MED WG.365/Inf.2).

Table 3.1. MED POL Phase III and IV data provided (MED POL database)

Country	Nutrients	Chl-a	Biota Trace Metals	Biota Organic contaminants	Sediment Trace Metals	Sediments Organic contaminants	Rivers Nutrients etc.	Oceano-graphic parameters (Temp., etc.)
Albania	2005 2006		2001 2002 2003 2004 2005 2006 2007	2003 2004				
Algeria								
Bosnia-Herzegovina	2006 2007 2008							
Croatia	2009	2009	2009	1999 2000 2003 2004 2005 2006 2009	2002 2003 2004 2005	2009	2000 2001 2002 2003 2004 2005 2009	
Cyprus	2001 2007	2004 2005 2006 2007	1999 2001 2005 2006	2000 2001 2002 2003 2004				2001 2002 2003 2004 2005 2006 2007
Egypt	2006 2007 2008 2009 2010	2009	2006 2009 2010	2009 2010	2009 2010	2009 2010		
France	2009	2009	1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2009	1997, 1999 2000 2001 2002 2003 2004 2005 2006 2009	2006 2009	2006 2009		
Greece	1999, 2000 (few), 2004 2005	1999, 2000 (few), 2004 2005	1999, 2004 2005	1999, 2004 2005	1999 2000 (few), 2004 2005			
Israel	2002 2003 2004 2005 2006 2007 2008 2009	2001 2002 2003 2004 2005 2006 2007 2008 2009	1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009		1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009			2003 2004 2005 2006 2007

Table 3.1 (continued). Status of provision of data MED POL Phase III and IV (MED POL database)

Country	Nutrients	Chl-a	Biota Trace Metals	Biota Organic contaminants	Sediment Trace Metals	Sediments Organic contaminants	Rivers Nutrients etc.	Oceano-graphic parameters (Temp., etc.)
Italy	2001 2002 2003 2004 2005	2001 2002 2003 2004 2005	2001 2002 2003 2004 2005	2001 2002 2003 2004 2005	2001 2002 2003 2004 2005	2001 2002 2003 2004 2005		
Lebanon								
Libya								
Malta								
Monaco								
Montenegro	2009	2009	2009	2009	2009	2009	2009	
Morocco	2006 2007 2008		1998, 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009	2006 2007 2009	2006 2007			2006 2007 2009
Slovenia	1999 2000 2001 2002 2003 2004 2005 2007 2008 2009 2010	1999 2000 2001 2002 2003 2004 2005 2007 2008 2009 2010	1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010	2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010		1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010	2003 2004 2005 2007 2008 2009 2010	
Spain			2004 2005 2006 2007	2004 2005 2006 2007				
Syria	2007		2007		2007	2007		
Tunisia	2002 2003 2004 2005 2006 2007 2008 2009 2010	2002 2003 2004 2005 2006 2007 2008 2009 2010	2001 2002 2003 2004 2005 2006 2007 2008 2009 2010	2007 2008 2009 2010	2001 2003 2004 2005 2006 2007 2008 2009 2010	2001-2002, 2004 2005 2006 2007 2008 2009 2010		2005 2006 2007 2008 2009 2010
Turkey	2005 2006 2007 2008 2009 2010	2005 2006 2007 2008 2009 2010	1998 1999 2000 2001 2002 2003, 2006 2007 2008 2009 2010	2003, 2005 2006 2007 2008 2009 2010	1999 2000 2001 2002 2003 2005 2006 2007 2008 2009	2005 2006 2007 2008 2009	2001, 2006 2007 2008 2009 2010	2006 2007 2008 2009 2010

4. Data Quality Assurance

4.1. Hazardous contaminants

The IAEA-MESL has had the prime responsibility of running the data quality assurance programme (DQA) for chemical contaminants for MED POL for the last 30 years.
The DQA comprises several components:

- Reference methods
- Provision of reference materials and standard solutions
- Training in the analysis of chemical contaminants in sediments and biota
- Training in good laboratory practice, including notably QA/QC procedures
- Laboratory performance studies (inter-comparison exercises, proficiency tests)
- Split sample analysis

4.1.1 Proficiency tests

Particular emphasis was placed on the laboratory performance studies. Such proficiency tests have been held regularly for the determination of both organic and inorganic contaminants. In the alternate years, the test material is either a sediment or biota sample. Laboratories were given about six months to complete analyses and provide results to MESL. The organic compounds encompass petroleum hydrocarbons, including notably polycyclic aromatic hydrocarbons (PAHs); polychlorinated biphenyls (PCBs); several chlorinated pesticides, especially DDT and its breakdown products, and a range of sterols on some occasions. Several metals were tested, especially mercury and cadmium, together with methyl mercury in recent studies.

During the period 2010-2011, the following intercalibration exercises were completed and relative reports were published by IAEA/MESL:

Inter-laboratory comparison exercises

a) IAEA-451 (organic contaminants in biota): Participation of 77 around the world, including 35 laboratories from 12 Mediterranean countries submitted results. The report will be ready 4^{rth} quarter 2011.

b) IAEA-452 (trace elements in biota). 139 Laboratories around the world participated, including 42 laboratories from 13 Mediterranean countries. The report was sent to the laboratories in the 1st quarter of 2011. 23 laboratories were invited for the certification campaign of IAEA-452. 19 including 6 MED POL laboratories sent requested information for the certification. The report will be published soon.

c) IAEA-456 (trace elements in sediment): Sediment samples were distributed to 42 laboratories around the world. Results were received till the end of November 2010. 23 laboratories out of 42 participated in this certification exercise. A statistical evaluation is done with all the results received and the reports should be available in the 3rd quarter of 2011.

d) IAEA-457 (coastal sediments). The exercise will be organized in 2011. The invitation letter was sent to the laboratories around the world in June. Coastal sediment samples were distributed in July/August 2011. The deadline for the results is set on 30 November 2011.

Proficiency Tests for MED POL Laboratories

Two Analytical Performance Studies for the MED POL Programme were carried out in 2010. Final reports were sent to the participating laboratories. Summary of these two PTs are attached in the annex.

Also, two Analytical Performance Studies for the MEDPOL Programme are initiated in June 2011:

1. *Trace Metals Proficiency Test (IAEA MEL 2011 02 PT)*

   The invitation letter was sent to MED POL laboratories for the IAEA MEL 2011 02 PT. The coastal sediment PT sample will be sent to the laboratory in July/August 2011. The deadline for the results is set on 30 November 2011.

2. *Organic Contaminants Proficiency Test (IAEA MEL 2011 06 PT)*

   The invitation letter was sent to MED POL laboratories for the IAEA MEL 2011 06 PT. The coastal sediment PT sample will be sent to the laboratory in July/August 2011. The deadline for the results is set on 30 November 2011.

Overall, the records of laboratories' participation in the DQA exercises for hazardous substances in biota and sediments over the last years indicate that most of the Mediterranean countries participate in the proficiency tests organised by IAEA/MESL. However, there are important differences between laboratories on the level of data quality for most of the contaminants analysed.

The countries that for various reasons did not participate consistently until now have to try to encourage the laboratories involved in the National marine monitoring programmes in the framework of MED POL to participate in futures proficiency tests in order to ensure quality to the monitoring data. Furthermore, the National MED POL Focal Points have to assure that all laboratories which are involved in the country's national monitoring programme, are participating in these tests. However, because of financial constraints, only MED POL-participating laboratories should participate in the tests offered by MED POL.

In the IAEA/MESL Reports a detailed analysis is made on the quality of data for every single participating laboratory and the potential causes of errors are highlighted. However, more active feedback and follow up are needed in order to assure that the errors are corrected and the quality of the analytical data provided by the non-performing laboratories is improved.
A survey of the participation and performance of Mediterranean laboratories in recent MED POL organized Proficiency Tests and World-wide Intercomparison Exercises is presented in Tables 4.1 and 4.2 (2010-2011).

Table 4.1. Number of Laboratories and countries participating in recently completed intercalibration exercises organized by IAEA/MESL

Sample tested	IAEA-451	IAEA-452	SD-MEDPOL-PT-2010/TM	SD-MEDPOL-PT-2010/TM
	Organic contaminants Biota	Trace elements Biota	Trace elements Sediment	Organic contaminants Sediment
Albania	2	1		1
Algeria				
Bosnia-Herzegovina		1		
Croatia	7	6	3	4
Cyprus				
Egypt		1	4	2
France	2	9		
Greece		2		1
Israel	2	3	2	
Italy	3	6		
Lebanon				
Libya				
Malta				
Monaco				
Montenegro	1			1
Morocco	3		2	1
Slovenia	3	2		1
Spain	5	5		
Syria	1	1		
Tunisia	2	1	2	2
Turkey	4	4	1	2
TOTAL	**35**	**42**	**14**	**16**

Table 4.2. Participation and performance of Mediterranean Laboratories in Proficiency Tests and World-wide Intercomparison Exercises for Trace Metal analysis

Exercise	Contaminant/ Matrix	Nb of Participants[1]	Nb of results reported
IAEA-451	Organic contaminants/ Biota	67	35 (52.2%)
IAEA-452	Trace elements / Biota	58	42 (72.4%)
SD-MEDPOL-PT-210/TM	Trace elements/ Sediment	25	14 (56%)
SD-MEDPOL-PT-210/ORG	Organic contaminants/ Sediment	26	13 (50%)

[1] Number of laboratories that had received the material

For Proficiency Test (SD-MEDPOL-PT) a selected list of laboratories was determined in collaboration with MEDPOL Focal Points and all laboratories in that list received the PT material

For World-wide intercomparison Exercises laboratories recorded as MEDPOL in IAEA database received before the exercise a letter of invitation (reminding them that this exercise was done under MEDPOL project) and only laboratories that accept the invitation received the material.

An overall assessment of the performance of Mediterranean laboratories participating in recent proficiency tests is presented in Table 4.3. The acceptable results in sediment samples represent 66% for metals and 66-92% for the organic contaminants. However, the number of laboratories that are reporting results usually is around 50% of the laboratories contacted. This is an indication that more effort has to be made from the part of the countries, to encourage the participation of national laboratories to the Proficiency Tests organized by MED POL, in order to check the quality of their monitoring results. These results indicate that the DQA in the Mediterranean Laboratories is still far from satisfactory and needs to be further developed.

From the presented statistical data, it appears that the organization of Proficiency tests cannot alone guarantee the improvement of the quality of the monitoring data produced, if the laboratories do not participate in the exercises. The MED POL Focal Pint have to play a more active role in encouraging the laboratories participating in the National Monitoring Programmes to take part in the Proficiency Test organized by MED POL. Also, a more active response is planned to deal with underperforming laboratories. Until now, the results of the Proficiency test was communicated to the participating laboratories and the MED POL Focal Points of the countries. In the next biennium (2012-2013), it is planned to take a more dynamic approach and, depending on the availability of funds, to contact directly the underperforming laboratories in order to provide assistance to improve DQA through capacity building.

Table 4.3. Number of results submitted in the different performance groups

Exercise (labs reporting/labs contacted)	No of reported results (% of reported results)	Acceptable results	Questionable results	Unacceptable results
PT2007 Determination of Trace Elements in Biota (22/36)	142 (54%)	105 (74%)	14 (10%)	23 (16%)
PT2007 Determination of Chlorinated pesticides in Biota (15/41)	112 (36%)	91 (81%)	2 (2%)	19 (17%)
PT2007 PCB congeners (7/41)	71 (48%)	50 (70%)	3 (4%)	18 (25%)
PT2008 Petroleum hydrocarbons (12/41)	138 (44%)	104 (75%)	9 (7%)	25 (18%)
PT2008 Determination of Trace Elements in Sediment (26/33)	244 (63%)	162 (66%)	25 (10%)	57 (23%)
PT2008 Determination of Chlorinated pesticides in Sediment (16/26)	74 (37%)	67 (92%)	1 (1%)	6 (8%)
PT2008 PCB congeners (8/26)	62 (41%)	55 (89%)	2 (3%)	5 (8%)
PT2008 Petroleum hydrocarbons (10/26)	150 (43%)	134 (89%)	5 (3%)	11 (7%)
PT2010 Determination of Trace metals in Sediment (14/25)	116 (64%)	77 (66%)	15 (13%)	24 (21%)
PT2010 Determination of Chlorinated persicides in Sediment (16/25)	118 (53%)	86 (73%)	2 (2%)	30 (25%)
PT2010 PCB congeners 2010 (7/25)	54 (55%)	36 (67%)	3 (6%)	15 (28%)
PT2010 Petroleum hydrocarbons (8/25)	115 (48%)	88 (77%)	17 (15%)	10 (9%)
PT2010 Determination of Chlorinated pesticides in Sediment (14/25)	116 (64%)	77 (66%)	15 (13%)	24 (21%)

- Performance is considered to be acceptable if $|Z| \leq 2$
- The results are of questionable quality when: $2 < |Z| < 3$
- The measurement is regarded as out of the acceptable range when: $|Z| \geq 3$.

$\mathbf{Z = (\bar{x}_1 - \bar{x}_2) / s_b}$ where x_1 is the arithmetic mean of the reported value of the analyte concentration in the sample; x_2 is the certified or assigned value; and s_b is the target standard deviation. This score effectively expresses the difference between the mean of the laboratory and the assigned value in units $\mathbf{s_b}$.

This type of score represents a simple method of giving each participant a normalized performance score for bias. This method of assessing laboratories has been accepted as a standard for ISO/IUPAC.

Training courses

Two training courses financially supported by MED POL have been organized in Monaco by MESL-IAEA (25 October to 5 November 2010): one training course on the determination of chlorinated pesticides and PCBs with the participation 4 trainees from 4 countries (Albania, Morocco, Syria and Turkey) and one training course on the determination of heavy metals with the participation of 5 trainees from 5 countries (Albania, Algeria, Egypt, Israel and Tunisia). Two more training courses are scheduled for 5-16 December 2011.

The records indicate that in recent years many countries have sent trainees to the training courses organised by IAEA/MESL and financed by MED POL. However it is not clear if the training courses have contributed to the improvement of the DQA in the laboratories from which the scientists originate. It would therefore be appropriate to follow up on the performance of the laboratories where these trained scientists are working after the completion of their training course and also to ensure that they are involved in the generation of data in the framework of MED POL.

4.2. Eutrophication

For eutrophication parameters an intercalibration exercise was completed in 2010 using the services of QUASIMEME. MED POL supported the participation of 19 Mediterranean laboratories in the exercise for the determination of nutrients and chlorophyll-a in seawater Table 4.4.).

Table 4.4. Participation of Mediterranean laboratories in intercalibration exercises for nutrients and chlorophyll-a (QUASIMEME)

Country	AQ1 (Nutrients in seawater)	AQ2 (Nutrients in low salinity seawater	AQ11 (Ch-a in seawater)
Albania			
Algeria	X	X	
Bosnia-Herzegovina			
Croatia	XX		XX
Cyprus	X		X
Egypt			
France			
Greece	X	X	X
Israel	XX	X	XX
Italy			
Lebanon			
Libya			
Malta			
Monaco			
Montenegro			
Morocco	XXX	XX	XXX
Slovenia	XX	XX	X
Spain	XXX	XXX	XX
Syria			
Tunisia	X	X	X
Turkey	XX	XX	XX

4.3. Biological effects monitoring

An intercalibration exercise financed by MED POL was organised in 2010 by DiSAV (Italy) with the participation of 11 Mediterranean laboratories from 8 countries (Croatia, Egypt, Greece, Italy, Slovenia, Spain, Syria and Tunisia) and 3 non-Mediterranean laboratories (Norway and UK, from the OSPAR region). The results of the intercalibration exercise showed excellent performance of all laboratories for the measurement of lysosome membrane stability and very good performance for the measurement of Metallothioneine content. Also a Training course on the measurement of two biomarkers (lysosome membrane stability and micronuclei frequency) was organised in Alessandria, Italy by DiSAV on 2010, with the participation of 15 scientists from 10 countries (Algeria, Croatia, Egypt, Greece, Italy, Morocco, Slovenia, Spain, Tunisia, Turkey) and with the contribution of scientists from ICES-OSPAR (UK).

The programme of capacity building on biological effects monitoring continued with the procurement of necessary equipment for lysosome membrane stability and training of scientific personnel for one laboratory in Morocco.

Based on the work already done, the results of the intercalibration exercises and the publication of relevant papers by Mediterranean scientists involved in MED POL programme on biological effects monitoring, it is possible to claim that, following MED POL efforts in the last years, there is a network of laboratories in the Mediterranean region with the capacity to carry biomonitoring activities, in line with the new monitoring requirements to be defined in the framework of the Ecosystem Approach for the management of human activities in the Mediterranean.

4.4. Conclusions DQA

During the MED POL Phase IV many laboratories form Mediterranean countries have participated in intercalibration exercises for hazardous substances, nutrients, Chl-a and biological effects. In most case a group of 14-15 countries are active in these exercises and are usually the same countries that are also providing monitoring data. Therefore, one goal is to increase the participation of countries to the analytical performance tests, since participation in such exercises (organized by MED POL or other international/regional bodies) is mandatory for all laboratories providing monitoring data to the MED POL database.

A second goal is to use the results of the analytical performance tests in order to improve the quality of the analytical results. A more direct feedback from MED POL/IAEA to the underperforming laboratories is needed, in order to improve the quality of their results through a problem-oriented capacity building programme. During the next biennium, depending on funds availability, efforts will be made to address this issue, including direct lab-to-lab collaboration on specific analytical performance issues.

Regarding the training courses organized by MED POL and IAEA, since 1987 more than 140 Mediterranean scientists have been trained in the analysis of trace metals and organic contaminants. However, some laboratories show low performance in the proficiency tests, meaning that DQA practices are not embedded in the everyday routine of some laboratories. It is therefore necessary to find additional approaches targeting specific analytical problems in laboratories with lower analytical performance.

Furthermore, the upcoming new integrated monitoring programme, which will be developed in 2012-2013, will include additional contaminants in all matrices. It is already planned to undertake during the next biennium an assessment of the countries' needs for implementing the new integrated monitoring programme and to prepare accordingly a capacity building programme.

5. **Status and trends monitoring : Evaluation of environmental quality of the Mediterranean marine environment (Information documents UNEP(DEPI)MED WG.365/Inf.3 and UNEP(DEPI)MED WG.365/Inf.3)**

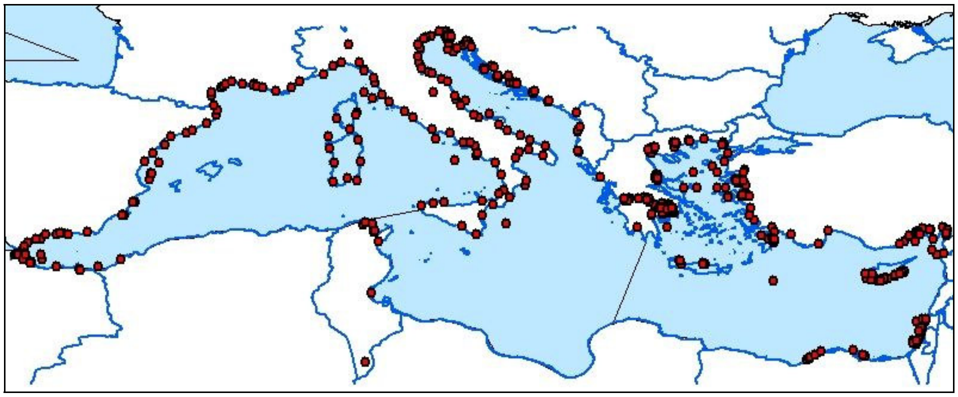
Marine monitoring is a basic component of the MED POL Phase III (1996-2005) and Phase IV (2006-2013) programme and the data generated every year from National monitoring authorities are uploaded to the MED POL database. Furthermore, in line with Article 8 of the Land–Based Sources Protocol monitoring programmes should aim: (a) to systematically assess, as far as possible, the levels of pollution along the Contracting Parties coasts, in particular with regard to the sectors of activity and categories of substances listed in Annex I, and periodically to provide information in this respect; and (b) to evaluate the effectiveness of action plans, programmes and measures implemented under this Protocol to eliminate to the fullest possible extent pollution of the marine environment. Therefore, a key objective of the MED POL programme is "to assess the status and trends in the quality of the marine and coastal environment as an early warning system for potential environmental problems caused by pollution and other anthropogenic pressures" (MED POL Phase IV).

5.1. Hazardous substances in the Mediterranean: a spatial and temporal assessment

The Thematic Assessment Report on Hazardous Substances in the Mediterranean coastal environment, is presented as information document UNEP(DEPI)MED WG.365/Inf.1. The assessment adresses sediment and biota contamination, and it is based on the MED POL database, as well as available international literature. Also general pollution trends, not necessarily statistically supported, are presented. The analysis covered the full period of MED POL Phase III and Phase IV, until 2010, and incorporated additional scientific information included in the four sub-regional assessment reports, which were prepared by MAP in the framework of the gradual application of the Ecosystem Approach for the management of human activities in the Mediterranean (UNEP/MAP, 2011). The MED POL monitoring database is at the moment hosting monitoring data of 14 Mediterranean countries and although the content is highly variable and the portion of data for each component and country is uneven, it constitutes a relevant source of information. In principle, only representative data was used, basically considering the existence of sufficiently large datasets. In this respect, only trace metals were found suitable for assessment at the regional level in sediments and trace metals and organochlorinated compounds in marine biota. In the case of biota, the Database includes a large number of marine species, but the Thematic Assessment Report is focused on the bivalve *Mytilus galloprovincialis* and the benthic fish *Mullus barbatus*, as they are the more common and widely analyzed species in the region.

As far as the specific parameters are concerned, they were selected on the basis of those considered of priority concern and taking into account the total number of samples and the geographical and temporal coverage. Thus, the selection included the trace metals Cd, Hg, Pb, Zn and Cu, and the families of DDTs and PCBs, as the more representative persistent organic pollutants (POPs). The Drin's (aldrin, endrin and dieldrin), HCB and lindane were also considered. In summary, after selection and harmonization of data, a total of 33,742 observations, corresponding to more than 400 stations monitored during the MED POL Phases III and IV (1999-2010) have been included in the present assessment.

The assessment is divided in two sections: i) occurrence and geographical distribution of trace metals (in sediments and biota) and chlorinated pesticides and PCBs (in biota); and ii) temporal trends. Special reference is made to the assessment of the four eco-regions in which the Mediterranean has been divided. In general, good data coverage is found for the Northern part of the Mediterranean basin while only a small number of sampling stations are defined in the Southern riparian countries, as shown in the Figure below. Therefore, data has been complemented with available information from the literature as well as other MAP reports. In comparing data, special use is made of the median concentration values because they constitute a better representation of the left-skewed populations studied.



Map of MED POL stations.

Trace metals in sediments

In general, Cd and Hg exhibit values several orders of magnitude lower than Zn, being Pb and Cu in an intermediate and similar position. Although the number of samples is far from being representative of the basin (the southern Central and Aegean-Levantine eco-regions are underrepresented) and the lithology of the continental shelf may influence the occurrence of trace metals in sediments, the values can be used as reference for comparison purposes. In general, the Western Mediterranean and the Adriatic are the regions where metal concentrations are higher as a result of the intense human activities that can cause chemical contamination of coastal areas. Besides urban and industrial inputs, rivers and streams are major contributors of metals of anthropogenic or natural origin to coastal areas. Moreover, land-based sources of specific trace metals are not only set down at coastal sediments but may end up deep in the marine canyons. Atmospheric deposition may also contribute to the contamination of deep sea sediments.

In the Western Mediterranean, major hotspots for metals, particularly Cd, Pb, Hg and Cu, are located in the areas of Marseilles-Fos and Toulon, in France, and Cartagena-Valle Escombreras-Portman, in Spain, holding important urban-industrial and mining areas, respectively. Sensitive areas are represented by the coastal lagoons (e.g. Berre, Thau and Mar Menor). The area influenced by the Rhone River discharges exhibited increased levels of all metals except Hg. The levels of Pb are important along the Italian coast, especially in areas around the Gulf of Genova (e.g. Savona, La Spezia, Genova, Livorno) that also show evidence of Zn accumulation, while high levels of Pb are found in Naples. These pollution sources can be related to industrial and domestic wastes and harbour activities. Mercury levels are also high in the area of Messina and Palermo and Regio Calabria. The contributions related to tectonic sources are important in volcanic and geothermal sources near as southern Tyrrhenian Sea. These contributions could explain natural important levels of mercury in some islands of the basin. Significant concentrations of Zn, Cu and particularly Cd have been reported on the coast of Morocco (Tangier-Martil and Nador), whereas higher levels of Hg were found in Algeria (Algiers).

The Central Mediterranean exhibits relatively elevated levels of Hg in the Gulf of Taranto and in both the Tunisian and Italian coasts of the Strait of Sicily. However, an extensive study in the Ionian Sea revealed that mercury levels were generally comparable to those from other Mediterranean areas. The Tunis and Bizerta Lakes (Tunisia) also also exhibits high contents of Pb. In the Greek coastal zone, the most elevated levels of such contaminants in sediments (e.g. Amvrakikos and Patraikos Gulfs) can be associated with the main sewage (domestic and industrial) outfalls.

Trace metals have been extensively monitored in the Adriatic Sea. The Po River, draining the most industrialized part of northern Italy, is an important pollution vector in the area. High levels of Cd, Hg, Pb and Zn are found in the northern Adriatic, including the Venice and Grado Lagoons. Mercury and Pb are also critical contaminants in the Gulf of Trieste and Rijeka Bay. The occurrence of some discrete stations with high levels of Hg, Pb, Cu and Zn are found in Croatia, such as at Kastela and Martinska Bays. In Albania, Hg contamination from a former inland chlor-alkali plant is evidenced in sediments of Vlora Bay.

The analysis of representative trace metals in sediments of the Aegean – Levantine basin revealed the occurrence of high values of Cd at Iskenderun Bay (Turkey). High levels of Cd, Pb, Zn and Cu have been found in Izmit Bay. Lead was also high in Izmir Bay. Most of the stations, particularly Izmir, Edremit and Candarli Bays, exhibited moderate levels of Cu and Zn. Low to moderate levels were found in Israel, with high values of Hg and Zn in some stations (e.g. Haifa Bay), whereas Cd was high in the northern coast of Syria. Conversely, relatively low values were found in Egypt, around the mouth of the Nile River. The distribution patterns reflect anthropogenic sources originating from point and diffuse land-based sources, providing useful information on the identification of hotspots in the area although not fully comprehensive. In Greece, monitoring of metals in sediments revealed a pollution gradient across the coastal areas, indicating different pollution fingerprints, with higher concentrations of Cu and Pb in the areas of influence of Thessaloniki and Athens and, particularly, in the Kavala Gulf.

Trace metals in bivalves and fish

The mussel *Mytilus galloprovinciallis* has been the most widely used sentinel organism in the region. In the case of fish, *Mullus barbatus* (red mullet) has been extensively used for monitoring but only in the Aegean-Levantine region. The metal accumulation in biota follows a similar trend than for sediments Cd < HgT < Pb < Cu << Zn. Here, the reported values are, excluding the hotspots. Like in the case of sediments, the median values can be used as a reference for a preliminary assessment of spatial trends and identification of hot spots.

The concentrations of trace metals in sediments and mussels exhibit a fair correlation except in the case of Zn, which can be attributed to a major influence of the sediment lithology. As it was observed for sediments, concentrations of trace metals in mussels are higher for the Western Mediterranean and the Adriatic Sea, although the data set is lacking information from several eastern and southern countries In most cases, low or moderate levels were found, in particular for Cd, Hg and Zn, and to a lesser degree, for Pb and Cu. In this respect, Cd, Hg and Zn display a rather even distribution along the coasts of the different eco-regions, with a few hotspots in Italy (Sardinia (Cd) and Naples (Cd, Hg and Zn)), and Turkey (Izmir Bay) (Cd). Mercury hotspots are also found in Croatia (Rijeka Bay) and Greece (Patras). A large number of stations exhibit high values of Pb, usually associated to urban areas (e.g. Barcelona, Marseille, Genova, Fiumicino and Naples) and mining spots (Portman, Spain). High levels of Cu have been found in the Ligurian (e.g. Genova) and Tyrrhenian Seas (e.g. Fiumicino and Naples) as well as in the coast of Sardinia.

Besides the MEDPOL monitoring, a large number of studies has been carried out in coastal enclosures and open areas of the Western Mediterranean, Adriatic and Aegean Sea. In the Western Mediterranean, some stations like those close to Genova, at the Ligurian Sea, and Naples are chronically polluted by all metals. In addition to these, certain sites can be considered as particular hot spots. High levels of Cd and Pb are found in the Sardinia coast (Portoscuso), Palermo and Cartagena-Portman. Higher levels of Hg and Pb were also found in coastal waters of the Tyrrhenian Sea (e.g. Fiumicino and Messina). All these stations are close to mining, industrial and/or urban areas. High levels of Cu have been found in the

Ligurian (e.g. Genova) and Tyrrhenian Seas (e.g. Fiumicino and Naples) as well as in the coasts of Calabria and Sardinia. High levels of Pb are usually associated to direct river/urban sewage inputs. This explains the levels found in mussels collected in the Marseille Gulf and Hyeres Bay (France), and the mouth of the Llobregat River (NE Spain), also influenced by the Barcelona metropolis, Malaga, Fiumicino, etc. Very high Hg concentrations were measured at five scattered sites along the Western Mediterranean basin (Portoscuso, Palermo and Maddalena-Sardinia Island, in Italy; Skikda in Algeria, and El Portus in Spain). There was also a predominance of high Hg values at Algiers Bay, along the north-west Italian coast (Piombino, Portoferraio) and in the French coast at Hyeres ouest. Finally, the levels of Zn are also high in the Alboran coast of Spain as well as in the southern coast of Italy (Calabria and Sicilia).

Trace metals are extensively monitored throughout the Adriatic Sea using mussels as bioindicators, mostly confined in urban and industrial areas. Concentrations are moderate in Northern, NE and NW part of the basin. High concentrations of Pb and Cu were found in the Venice Lagoon and in the areas affected by the Po River discharges, consistent with urban/industrial discharges. The Central Eastern and Western Adriatic has also been extensively monitored. Concentrations of Pb and Hg are relatively high in the Mali Ston Bay (Croatia). High levels of Cd, Hg and Cu are found in the Kastela and Rijeka Bays, due to the discharge of untreated urban and industrial wastewaters.

In Albania, Pb and Cu contamination above the mean levels were found in mussels collected in Vlora Bay and close to Durres, a known dumping site of industrial residues. The Central Mediterranean is not well represented in the Database. A few samples from south Italy and Greece are available. High levels of Hg were found in the Gulf of Patras (Greece) and moderately high levels of Cu were also found at the Sicily coast.

Trace metal analysis in biota in the Aegean-Levantine region exhibited low values in the case of *Mytilus galloprovinciallis*, with the exception of Cd, Pb and Cu in Turkey (Akçay and Izmir Bays) and Cd and Zn in Greece (Piraeus). In Israel, *Mactra coralline* was used as indicator organism which exhibited relatively enhanced values of Cd and Cu in the northern coast (Haifa). Information is missing for the southern and eastern countries. The red mullet (*Mullus barbatus*) showed rather uniform metal accumulation through the region but certain stations exhibited high levels of Cd, Hg, Pb and Cu. High values of Hg and Pb were also found in Crete (Chania Bay) and Cyprus (Larnaca and Limassol Bays). The levels of Zn are also high in the Avramikos, Saronikos and Thermaikos Gulfs (Greece). The area of Mersin (Turkey) exhibit high values of Cu and the mullets collected in the northern coast of Syria exhibit high concentrations of Zn and Cu. However, the limited number of stations precludes any further consideration.

<u>Chlorinated compounds in bivalves and fish</u>

Chlorinated pesticides have been extensively analysed in Mediterranean biota since the inception of MED POL (UNEP, 1990). Mussels and mullets have been the most widely studied organisms in the whole basin as part of many case studies published in the literature and recently assessed on the occasion of the implementation of the Stockholm Convention (UNEP, 2002). However, it has been only since the last decade that they have been continually monitored, and data gathered in the MED POL Database, although data on mullets are limited to Cyprus and Turkey. An additional number of individual studies can be found in the literature. As it can be seen, the levels reported for samples collected during the 90s exhibit much higher values than the more recent ones. This may clearly reflect a decreasing trend resulting from the ban of this pesticide in the region but also that the assessment of the spatial distributions of chlorinated compounds in the Mediterranean should be based on published data around the last 5 years. Concentrations of aldrin, dieldrin, endrin, lindane and hexachlorobenzene in *Mytilus galloprovincialis* are in the low ng g-1 range. Concentrations of DDTs were one order of magnitude higher, with p,p'-DDE being, in general, the predominant component, although recent inputs of DDT in some areas cannot be ruled out.

Concentrations are higher in the Aegean-Levantine region for aldrin and dieldrin, and in the Western Mediterranean for HCB and lindane. However, the highest values of HCB and lindane are found in Turkey and Albania, with a number of important hot spots. In the case of DDTs, their median values are similar for the four eco-regions, around 10ng g-1 dw, but again very high values are found in the Adriatic, corresponding to Albania. Despite the similarity of the mean DDT levels for the four eco-regions, available data indicate that contaminants are not uniformly distributed throughout the sub-regions.

In the Western Mediterranean, areas of particular concern include estuaries (Rhône, Ebro), ports, bays and gulfs (Barcelona, Marseille-Fos, Bays of Algiers and Tunis, Naples, etc.). There is evidence that river inputs represent the most important source of pesticides entering the Western Mediterranean Sea. In the Southern part of the W. Mediterranean, significant accumulation values of DDT were recorded at the Nador Lagoon (Morocco) and in Algiers Bay.

Coastal waters of the Adriatic Sea belong to unpolluted areas of chlorinated pesticides, with the exception of some stations from Albania. Concentrations up to 9779 ng g-1 dw of total DDTs were found at the Durres and Vlora Bay, most probably due to the presence of stockpiles of obsolete pesticides in the country. Moderate concentrations of Lindane and DDTs were found in the Gulf of Trieste and the Marches region (Ancona), respectively.

Information on the Central Mediterranean is almost lacking, although the region seems relatively free of hotspots of chlorinated hydrocarbons in marine bivalves, at least according to the limited availability of data.

In the Aegean-Levantine eco-region, organochlorine compounds, mainly DDTs, were determined in mussels and red mullets across the Greek coastal waters and in some stations of Turkey and Cyprus. In all cases the concentrations of DDTs were quite low, although moderate concentrations of DDTs were present in a few stations of Turkey (Izmir Bay) and Greece (Amvrakikos Gulf). *Mullus barbatus* was also the indicator species used in the Aegean-Levantine Sea. The spatial distribution of DDTs revealed a homogeneous pattern (av. 12.4 ng g-1), indicating no point sources of pollution, in accordance with the banning of these compounds since the 70s. The values for Cyprus and Turkey can also be considered in the low range.

PCBs occur in the vicinity of industrial and urban sites, as well as in major river mouths. The geographical distribution of concentrations (7 ICES PCB congeners) in the indicator organism *Mytilus galloprovincialis* is shown in the following Table. The median values show the higher levels in the Adriatic where the Albania samples are well above the average, with values up to 1500 ng g-1 dw in one station of France.

In the Western Mediterranean, the baseline levels are high and the sites most affected are the areas of Barcelona, Marseille and the Ligurian Sea, from Livorno to Nice, including the Genova harbour, and at the mouths of Rhone and Ebro Rivers. It was clear that in western Mediterranean coastal areas, rivers and wastewater discharges are the major sources of PCBs.

Information on the Central Mediterranean is almost lacking but, apparently, it is relatively free of hotspots.

The Adriatic Sea has been extensively monitored for PCBs. It includes from unpolluted to moderately polluted coastal areas. Concentrations are low along the western coast, with areas with high concentrations in the eastern bank, along the coasts of Croatia and Albania.

In the case of Aegean-Levantine spatial analysis is limited to Cyprus (fish) and Turkey (mussels and fish). The concentrations in mussels (Turkey) were rather low. The values on *Mullus barbatus* in the MED POL database can also be considered in the medium-low range, taking into account the higher accumulation capacity of fish with respect to mussels. PCBs in marine biota across the Greek coastal environment, determined within the Greek monitoring system, were also low, the highest contamination being observed in mussels collected from the Saronikos Gulf (industrial and urban effluents). On the other hand, bioaccumulation in fish revealed a homogeneous pattern indicating no point sources of pollution.

<u>General temporal trends</u>

The detection of temporal trends in concentrations of contaminants in the marine environment has been one of the aims of the MED POL Programme. However, this was possible only in few selected sites, while in most sites the objectives preliminarily set, were not enough to achieve the temporal trend of any selected contaminant. The major reason for this was the difficulty in analysing data, especially when normalization was not intended for reducing the intrinsic variance by taking into account the differences in morphology (e.g. sediment grain size) or composition (e.g. tissue fat content) of the samples. Moreover, there are few countries with more than five years ongoing programmes to fulfil the requirements of a temporal trend assessment, and the situation is even less satisfactory in the case of sediments that require at least a 10yrs period for evidencing and assessing significant variations.

Taking into account the limited data available, trends are just preliminarily assessed. The analysis has been mainly focused on *Mytilus galloprovincialis* (MG) and *Mullus barbatus* (MB), with the exception of Israel, where the clam *Mactra corallina* (MC) has been considered. Moreover, a few available time series for sediments from Israel (Haifa Bay) and France (Gulf of Lions) have also been considered.

<u>Trace metals in sediments</u>

A general downward trend of concentrations of trace metals is observed in sediment samples from the Haifa Bay, except for Cu. In the Gulf of Lions, the French RNO monitoring system has shown an apparent decrease of metals, particularly for Pb. Unfortunately, there is no information about the most polluted area of Marseille-Fos. On the contrary, mercury, a critical contaminant in the Gulf of Trieste, do not show a decline of concentration even 10 years after the closure of the Idrija mercury mine. In the case of mussels, the country median values do not exhibit clear trends for metals, with the exception of particular situations like Cd in Slovenia and in Morocco.

However, in several cases there is an apparent decline of outlier values, such as in the case of Italy, which may reflect a general improvement on the hotspots. Individual trends for representative stations of the different sub-regions do not exhibit specific tendencies but it can be concluded that, in general, concentrations are relatively constant or declining. In the Western Mediterranean few stations, usually corresponding to those exhibiting the higher values (e.g. Marseille, Fos and Piombino), are slightly increasing, although those of Genova and Naples show evidence of a decline. Data on trace metals for samples of *Mytilus galloprovinciallis* collected in 21 stations along the period 1979-2006 within the French monitoring system (RNO) clearly show a general decline of concentrations during this time span. In the Adriatic, the levels are not showing significant changes along the time. However, general upward trends are observed in some stations holding high values, particularly for Cd (e.g. Rijeka and Kastela Bays in Croatia and Durres and Vlora Bay in Albania).

The coverage of Central Mediterranean and Aegean-Levantine regions is very limited. Levels of Cd, Hg and Pb in mussels decreased during the period 2001-2008 in the Bizerta Lake

(Tunisia). In Israel, the levels found in the clam *Mactra coralline* during the last 10 years in Haifa Bay show no statistical trend, while the concentrations of trace metals in sediments revealed a consistent decline. In Turkey an increasing trend was detected in Goksu station, while no clear trend was detected in other stations.

The levels of chlorinated pesticides in mussels clearly evidence a decline over time, which is consistent with the banning of production and use of these compounds. The median values in mussels from Croatia and France exhibit clear decreasing trends, as well as the outlier values in the latter. The only exception seems to be Albania (e.g. Durres and Vlora Bay) which may be related to stockpiles of obsolete chlorinated pesticides. In general, the decrease is faster for lindane and the other chlorinated pesticides than for DDT that appears to be consistent with the higher long-life of the latter.

<u>PCBs in sediments</u>

The assessment of PCBs is more difficult because the lack of long-term consistent data mainly due to the change in concentration units (from Aroclor to individual congeners). The profiles obtained do not allow deriving any conclusion. However, the temporal trends for some individual stations generally reveal conservative or even increasing trends, probably reflecting an inefficient management of the existing regulations concerning their use and stocking.

In the Western Mediterranean, the stations evidencing relatively high levels of PCBs are still exhibiting increasing trends whereas those more pristine seem to be stable or decrease. For the other regions there is limited availability of data to allow drawing precise conclusions. Decreasing trends were also observed in the French monitoring network of coastal pollution using bivalves as sentinel organisms (IFREMER, 2001). In general, it was found that during the period 1979-1998 the decreasing trends were in the order: SDDT > HCHs > PCBs, which may reflect that the regulation of the use of these chemicals and, consequently, of the contaminant inputs to the sea was more efficient for DDT and lindane than for PCBs. A recent assessment of the Mediterranean sediments contamination by persistent organic pollutants (Gomez *et al.*, 2007) has also concluded that a decreasing trend is more evident for DDTs than for PCBs, indicating a steady input of the latter in the Mediterranean Sea and the need for an improved management of their potential sources.

As a conclusion the MED POL monitoring database constitutes a relevant source of information for assessing the state of the Mediterranean Sea. The efforts made during the MED POL Phase III and Phase IV, have been successful in building up and improving this essential instrument of environmental policy. Although at the moment is hosting monitoring data of only 14 Mediterranean countries, and the portion of data for each component and country is uneven, it constitutes the most comprehensive record of monitoring data for the whole basin and, therefore, it should be consolidated.

However, from the above analysis, it must be stressed that there is a need to establish monitoring programs in many countries to fill the geographical data gaps, and ensure the continuation of existing temporal trend data. These programs must be able to generate comparable and accurate data, taking into account the intrinsic variability of the environmental matrices considered. For example, the adoption of normalization procedures which could account for the differences in sediment characteristics (organic carbon and/or Al contents), as well as, the implementation of quality assurance/quality control procedures, are considered essential. A useful outcome of the database can be the establishment of background concentrations for the target compounds in Mediterranean biota and sediments, which is necessary in order to have reference values for comparison with field data. Moreover, with the improvement and development of analytical techniques, the identification and quantification of emerging substances of potential concern for the marine environment because of their persistence, toxicity and bioaccumulation properties, is continuously increasing. They are believed to be ubiquitous but information on their occurrence in the Mediterranean is limited and should be improved. Finally, the conceptual approach of the MED POL Program, updated with the recent knowledge and experience generated by the scientific community needs to incorporate relevant assessment tools for hazardous substances in marine sediments and biota. Specifically, there is a need to establish environmental assessment criteria (EAC) for the hazardous substances included in the MED POL database: trace metals, chlorinated pesticides and PCBs.

5.2. Site-specific analysis for pollution trends

One of the major components of the MED POL Phase III monitoring activities was the monitoring of contaminants at Mediterranean hot spots and coastal waters, in order to attain site-specific temporal trends with appropriate and consistent monitoring strategy. The first evaluation of the data collected in the MED POL Database was made in 2003 to identify the sampling and analytical variances underlying each monitoring practise. In 2005 a second attempt was made mainly to identify the weakest parts of the adopted sampling strategy. In 2009 when the 10 years benchmark was reached, a draft detailed analysis of variances and trends – where possible - for each monitoring site were performed. Merging of MED POL Database with some national data sources was required to perform the trend tests with long-term time series of data. The use of QA data was also aimed in the evaluation. Finally, the site specific trends analysis, the dataset was updated in 2011, including more recent data and a detailed analysis of variances and trends – where possible - for each monitoring site were performed. The updated Trend analysis Report is presented as information document UNEP(DEPI)MED WG.365/Inf.4 “Analysis of the Trend Monitoring activities and data for the MEDOPOL Phase III and IV (1999-2010)”.

Inorganic and organic contaminants data collected for biota and sediments were both attempted to be evaluated for each sampling site included in the MED POL database. Due to the size of the database and the need to undertake time consuming steps of data preparation and analysis, complete statistical analysis is presented for the inorganic contaminants (Trace Metals) data. However, initial results will also be presented for trends in organic contaminant concentrations.

Site-specific pilot trend monitoring programmes were initiated in many countries, but after ten years only few were adequately implemented in order to perform a statistically meaningful evaluation. Therefore, the trend evaluation can be performed only on countries with more than five years of ongoing programmes and the analysis was done only for data series that fulfil this requirement. For the trend detection, the software suite PIA was used. PIA is a computer program for analysing trends in time-series datasets by applying a standard statistical analysis that has been adopted by the Arctic Monitoring and Assessment Programme (AMAP) for use in its temporal trend assessment activities. PIA© was developed by Anders Bignert (anders.bignert@nrm.se). *Investigation of within year variances*

A variety of tests are available to analyze data record. Each one has its own capabilities and underlying assumptions and therefore considerable judgement is needed to select the appropriate one. OSPAR proposed three trend detection methods in a suite. The idea is to take the benefits of all methods, because there is not only one method which always offers the best analysis. The three methods (Mann-Kendall, linear regression, lowess smoother) are amongst the most commonly used in this field. The order is from the simplest to the more complex method. Mann-Kendall is the most robust to outliers, but in case of a linear trend, the linear regression has more power and therefore is selected first. Since nature is not always linear, the smoother is taken to detect a non-linear trend. Based on above, the trend analysis was performed at a 5 % significance and 90 % power and the log-normal distribution was used, because log-concentration has often been found to be approximately normally distributed with constant variance. The basic statistical methodology applied when running

PIA is a robust regression-based analysis to detect trends in time-series datasets (Nicholson et al., 1995).

Analysis of the database showed that there were not enough data to apply the statistical test in stations from Albania, Croatia, Cyprus, Greece and Morocco. In the sites where the test could be applied, the results showed in most cases either non-significant or decreasing trends:

In Israel, no significant trends were found for Cd and HgT in *Mullus barbatus*, while measured values are very close to the detection limit. Also no statistical trends were found for HgT in the bivalve *Mactra corralina* at stations in the Haifa Bay for the period 2001-2009.

In Morocco data suggests a decreasing trend for Cd, HgT and Pb in *Mytilus galloprovincialis* at the coastal zone in front of the Oued Laoud, but the important data variance doesn't permit to draw a statistically sound conclusion.

In Slovenia a statistically significant decreasing trend was detected for Cd at one station, while HgT didn't show any trend and its values oscillated around a low concentration.

In Tunisia at two stations, data series show a statistically significant decreasing trend for Cd and HgT in the bivalves *Mytilus galloprovincialis* and *Ruditapes decussatus*.

In Turkey in most stations, no significant trends were detected for Cd in fish (*Mullus barbatus),* while data presented small variations around a certain value. For HgT, no significant trends were found in most stations, with the exception of Goksu station, where a statistically increasing trend was detected.

The results of the statistical analyses are presented in detail in the information document UNEP(DEPI)MED WG.365/Inf.4. From the successful implementation of the trend monitoring pilot programme at specific sites, it can be concluded that the analysis of data can detect statistically significant trends of trace metals concentrations in biota and therefore, it can be used for the assessment of a change with time in the levels of chemical contaminants in the marine environment. Therefore, trend monitoring, if properly planned and implemented, can be an important tool for the assessment of the effectiveness of control measures taken at the pollution hot spots and also for the assessment of state of marine environment.

6. Development of an new integrated monitoring programme of MAP in the framework of the Ecosystem Approach for the management of human activities in the Mediterranean (ECAP)

6.1. Introduction

The Contracting Parties of the Barcelona Convention at their 15th meeting held in 2008, Almeria, Spain, decided that UNEP/MAP should gradually apply the ecosystem approach in order to achieve the ecological vision for the Mediterranean which corresponds to "a healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations' (Decision IG 17/6). Parties have also agreed to a seven step process, which includes 1) determining an overarching vision for the Mediterranean as a whole; 2) elucidating strategic objectives for achieving that vision; 3) undertaking a preliminary assessment of the environmental condition of the Mediterranean; 4) determining ecological objectives; 5) determining operational objectives and related targets and indicators; 6) revising monitoring programmes for periodic assessment, regular updating of targets, and guiding changes necessary for an ecosystem approach to management; and 7) developing relevant action plans and programmes.

Steps 1 and 2 of the ECAP process have been completed and the integrated assessment (step 3) has been reviewed by the countries, peer-reviewed by GESAMP and is now being finalized to be presented in the next COP meeting (January 2012). The next steps during the current phase of the ECAP (and also of the implementation of the MSFD) are the development of Ecological Objectives, Operational Objectives, relative Indicators to be used, and the targets for GES in the different water bodies and the revision of MAP monitoring programme.

6.2 Ecological Objectives, Operational Objectives and Indicators

The Ecological Objectives should reflect the ecosystem approach vision and goals as well as a basic understanding of ecosystem condition, values, pressures and impacts. They are meant to be illustrative, not proscriptive, and serve as a starting point for regional and sub-regional cooperation and discussions among the Contracting Parties on how to move the EA process forward in a timely manner.

After several meeting with technical and Government designated experts (Rome 8-9 April 2010, Barcelona 6-7 July 2010, Istanbul 10-11 March 2011 and Durres 2-3 June 2011) 11 Ecological Objectives for the Mediterranean were agreed, in harmony with the EU MSFD Descriptors but tailored for the scale and circumstances of moving towards an ecosystem approach within the Mediterranean region. The resulting Ecological Objectives take into account the geographical scope of the application of the Barcelona Convention and its Protocols, the issues emerging from the finalized Integrated Assessment Report, socio economic considerations, Integrated Coastal Zone Management (ICZM) and cumulative impacts.

Ecological Objectives

1. *Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions*
2. *Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem*
3. *Populations of select commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock*
4. *Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability*
5. *Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.*
6. *Sea-floor integrity is maintained, especially in priority benthic habitats (coastal lagoons and marshes, intertidal areas, seagrass meadows, coralligenous communities, sea mounts, submarine canyons and slopes, deep-water coral and hydrothermal vents)*
7. *Alteration of hydrographic conditions does not adversely affect coastal marine ecosystems*
8. *The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved*
9. *Contaminants cause no significant impact on coastal and marine ecosystems and human health*
10. *Marine and coastal litter do not adversely affect coastal and marine environment*

11. *Noise from human activities cause no significant impact on marine and coastal ecosystems*

Ecological Objectives 5, 9 and 10 are directly linked with pollution and will be monitored and assessed by MED POL. Also, part of Ecological Objective 6 (related to dumping) and part of Ecological Objective 7 (related to the discharge of brine form desalination plants) could also be directly monitored and assessed by MED POL. Furthermore, due to the expertise of MED POL in organizing and implementing monitoring programmes on pollution sources and the quality of the marine environment, the MED POL Focal Points during their last meeting in Rhodes, Greece, "requested MED POL to coordinate the process of preparing the new MAP integrated monitoring programme, in line with the ecosystem approach and in cooperation with relevant MAP components and other relevant organizations, as appropriate".

A set of Operational Objectives, and their corresponding Indicators, for each of these draft proposed Ecological Objectives was also developed according to the methodology which included consideration to the pertinence of the Operational Objective as it relates to the Ecological Objective, to the feasibility of collecting information across the region, and to the potential importance of the management response that could flow from the adoption of Operational Objectives and Target. The Ecological Objectives developed in the framework of ECAP, the Operational Objectives and the relevant indicators are presented in information document UNEP(DEPI)MED WG.365/Inf.5).

This set of Ecological Objectives, Operational Objectives and Indicators will guide the work of the Contracting Parties during the first cycle of the application of the Ecosystem Approach and could be reviewed and amended as necessary towards subsequent cycles. It is important to emphasize here that this inherent cyclical character of the Ecosystem Approach will make possible that, after iterations, the information gathered for the different indicators constitutes trends that will illustrate at what rate ecosystems are approaching thresholds, or moving closer or away from the (later) agreed-upon target levels. Besides the iterative character of the compilation of data for the indicators it is important to mention that the spatial monitoring strategy should be adapted to each of the indicators in order to optimize monitoring efforts.

6.3. Capacity of the MED POL monitoring programme to generate data and data gaps

MED POL monitoring programme (MED POL Phase IV) is already generation data for most of the indicators of EO5 and EO9, while no monitoring data exist on EO10 and EO11.

EO5 Eutrophication

Indicators	*Data collected (MED POL Phase IV)*	*Additional Data needed*
5.1.1 Concentration of key nutrients in the water column	*NO3, NO2, NH4, PO4 (or Total N, Total P), SiO4 (occasionally*)*	*None (improve geographical coverage)*
5.1.2 Nutrient ratios (silica, nitrogen and phosphorus), where appropriate	*Possible if ALL nutrient data are collected*	*None*
5.2.1 Chlorophyll-a concentration in the water column	*CHl-a*	*None (improve geographical coverage)*
5.2.2 Water transparency where relevant	*None*	*Secchi disk*
5.2.3 Number and location of major events of nuisance/toxic algal blooms caused by human activities	*None*	*Record of location and frequency of toxic algal blooms*
5.3.1 Dissolved oxygen near the bottom, i.e. changes due to increased organic matter decomposition, and size of the area concerned	*None*	*DO measurements in bottom waters at selected locations*

*Not all countries provide data for all nutrients

EO9 Pollution

Indicators	*Data collected (MED POL Phase IV)*	*Additional Data needed*
9.1.1 Concentration of key harmful contaminants in biota, sediment or water	*Hg, Cd, Hg, PCBs, halogenated pesticides, PAHs, in sediment and biota**	*Contaminants may be added following countries specificities Aluminum (Al) and Organic Carbon (OC) measurements in sediments for normalisation purposes*
9.2.1. Level of pollution effects of key contaminants where a cause and effect relationship has been established	*Lysosome membrane stability for general effect (pilote). No cause and effect relationship established for specific contaminants*	*Development of biomarkers (such as lipofuscin accumulation, neutral lipid accumulation, micronuclei frequencies, oxidative stress, metallothionein content, acetyl cholinesterase activity, peroxisome proliferation, lysosome to cytoplasm ratio, and stress on stress) Imposex (for TBT)*
9.3.1 Occurrence, origin (where possible), extent of significant acute pollution events (e.g. slicks from oil, oil products and hazardous substances) and their impact on biota affected by this pollution	*None (REMPEC is following shipping accidents involving oil slicks)*	*REMPEC to develop oil slick tracking system Method to evaluate impact on biota*
9.4.1. Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood	*None*	*To be developed*
9.4.2. Frequency that regulatory levels of contaminants are exceeded	*None*	*To be developed*
9.5.1 Percentage of intestinal entorococci concentration measurements within established standards	*Intestinal entorococci concentration measured*	*None*
9.5.2. Occurrence of Harmful Algal Blooms within bathing and recreational areas	*None*	*To be developed*

*Not all countries provide data on all contaminants in all matrices
For EO10 and EO11, monitoring methods have to be developed and applied to generate data.

6.4. Towards a new integrated monitoring programme of MAP in line with ECAP requirements

The MED POL Phase IV ends in 2013, therefore during the next biennium a new MED POL Phase has to be discussed and agreed. Regarding monitoring requirements, the implementation of the Ecosystem Approach roadmap will imply the establishment of a regional holistic integrated monitoring programme that takes into account the ecological objectives, operational objectives and appropriate indicators and targets for Good Environmental Status (GES). The holistic integrated monitoring programme of MAP will be prepared during the biennium 2012-2013 and MED POL is the key component to provide assistance using its long expertise on the development and implementation of marine pollution monitoring programmes in the Mediterranean region. The philosophy underlying the holistic approach is that all monitoring activities are integrated in a single, well-defined aim – that of achieving a particular level of environmental quality in a specified ecosystem. This means that common practices have to be adopted across all types of monitoring activities and data management.

The key features of a holistic integrated monitoring programme are:

- building on and further developing the values of the current UNEP/MAP MEDPOL monitoring programme
- extending the scope of monitoring along the lines of ecological objectives to a wider spectrum of issues (including marine pollution and biodiversity) and focusing both on coastal and open sea waters
- monitoring threats from land based sources as well as from other sources, and recognize the interaction among the threats
- build synergies with EU MSFD and other monitoring programmes implemented in the region with a view to sharing data and enhancing the effectiveness of environmental monitoring in the MED on the regional and country levels
- build synergies with the Regular Process of the UN
- take into consideration cumulative and combined effects of pollution and other kind of pressures (i.e. fisheries)

The new holistic integrated monitoring programme of MAP will be developed during the biennium 2012-2013 in a participatory approach with the involvement of experts from all Mediterranean countries.

One of the priority issues for discussion during the next biennium during the preparation of the new monitoring programme of MAP, is the establishment of threshold values (boundaries) in order to asses achievement of Good Environmental Status (GES). In relation to pollution-related Ecological Objectives, the threshold values are concentrations of specific pollutants (hazardous substances) or the results of pollution (chl-a) corresponding to the achievement, or failure to achieve, statutory targets or policy objectives for contaminants in these matrices.

MED POL has already made some preparatory work to provide initial background information on methodologies for the establishment of threshold values for Eutrophication (Ecological Objective 5) and Contaminants (Ecological Objective 9). These issues will be further discussed during national expert meetings, which will be organized by MAP during 2012-2013.

6.4.1. Eutrophication (chlorophyll-a)

In the framework of the Common Implementation Strategy for the Water Framework Directive (2000/60/EC) and intercalibration exercise was undertaken in order to ensure the compatibility among EU Member States in relation to biological monitoring results and to the adopted National classification systems for the state of the water bodies. The Intercalibration process was done on geographical basis, ie groups of EU Member States that share the same water typology and included many Biological Quality Elements (BQE) including the BQE Phytoplancton. In the Mediterranean region , the Geographical Intercalibration Group (MED-GIG) has reviewed the methods, criteria and limit values fort the assessment of BQE "Phytoplancton" and prepared relevant reprots that could assit the work on the determination of GES in coastal water bodies in relation to the Ecological Objective 5, "Eutrophication", of the ECAP.

A more detailed technical analysis of the work and conclusions of the MED_GIG Work Group on the BQE Phytoplancton is presneted in the document "Review of the methods, criteria and limit values for the assessment of Eutrophication (Biological Quality Element "Phytoplankton") as developed in the framework of the Intercalibration Exercise of the MED GIG (Mediterranean Eco-region), Water Framework Directive 2000/60 EC" (UNEP(DEPI)MED WG.365/Inf.7).

In brief, for the ecological classification of coastal water quality by means of this BQE, the following parameters were requested: phytoplankton biomass and abundance, specific composition, bloom frequency and intensity. The wide range of hydrological (Salinity, Temperature, Transparency), physico-chemical (Dissolved Oxygen, pH, etc.), chemical (nutrients in their various forms) and biological (Chlorophyll *a*) parameters, were also strongly recommended as supporting elements. However, after many years of work it was concluded that there is no consensus on which parameter is useful and if this parameter has some added value for the assessment of BQE Phytoplankton. There are different approaches among Member States (from fully compliant methods, up to methods that includes only one parameter), such as only chlorophyll-a (with the exception of France) in the Mediterranean Sea. It was recommended that methods that consider only the chlorophyll will be accepted only when a common position within the GIG will be agreed and scientific supporting documentation will be improved, including the reliability of the Good/Medium boundary based on the chlorophyll as unique parameter.

On that issue, the MED-GIG has concluded on classification criteria for chlorophyll-a, depending on the type of coastal water directly or indirectly affected by the freshwater inputs from the continent (contribution of large and minor rivers, industrial and urban settlement discharges and so on). This is in agreement with the salinity/dilution factor approach.

<u>Conceptual framework and strategies</u>

Concerning the coastal water body and its trophic level, the Mediterranean experience shows that coastal waters are those directly or indirectly affected by the freshwater inputs from the continent (contribution of large and minor rivers, industrial and urban settlement discharges and so on). This is in agreement with the salinity/dilution factor approach. (See Figure 6.1 below).

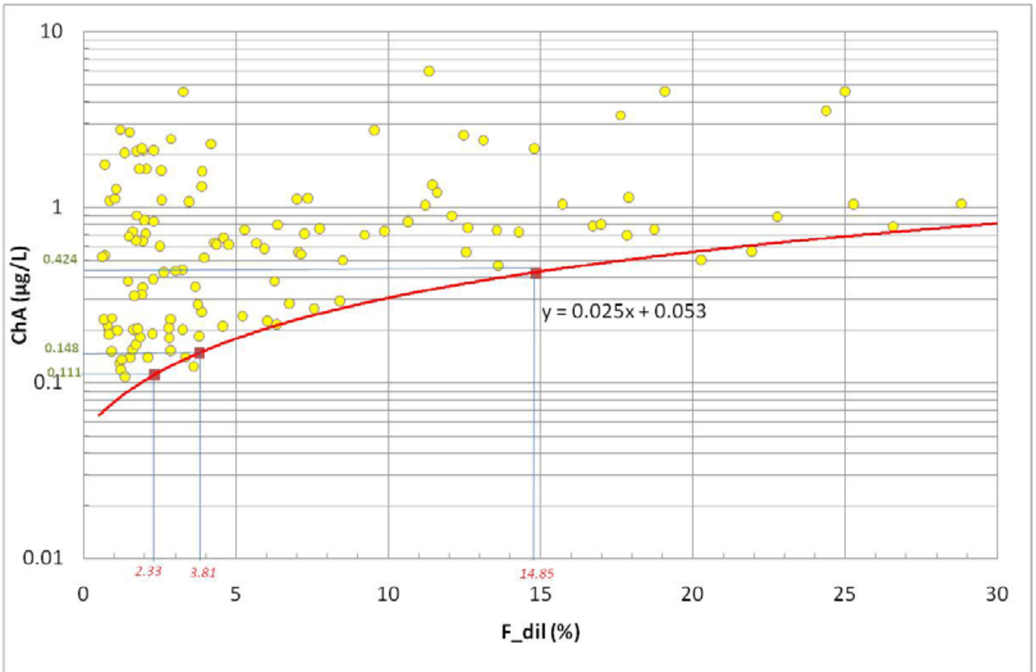


Figure 6.1: Chl vs F_dil relationships, for the identification of the Chl reference values

In this regard, it is important to treat the question of the trophic levels in the light of an integrated systems conception, which considers both scientific and socio-economic issues as interrelated. Accordingly, coastal waters, their connected hinterland and related human activities, the catchment areas with the related nutrient loads, represent the total system, of which the natural and socio-economic components are the respective subsystems.

This is the conceptual framework that has guided and still guides the approach to the problem of the control of trophic levels, against the risk of the Eutrophication. (UNEP(DEC)/MED WG 231/14 (2003) and UNEP/MAP-MEDPOL (2005) "Sampling and analytical techniques for the eutrophication monitoring strategy of MED POL", MAP Technical Reports Series No. 163.

"Management approach" and/or "Ecosystem approach".

At the MED GIG level, the choice of the Chlorophyll to build up a classification criterion for the BQE Phytoplankton still reflects a "Management Approach" more than an "Eco-system approach".

We had to keep in mind that Chl *a* isn't a true state parameter of the system, but rather a roughly estimator of biomass. The real indicators are the phytoplankton species and the related abundances, as on the other hand has been stated by the WFD 2000/6 for the EQB Phytoplankton.

It must admit however that, at the current state of knowledge (even also on the basis of the availability of data of taxonomic kind), an approach that privileges Phytoplankton taxonomic composition is still premature. Preliminary studies about the effects of trophic level increase on the biodiversity expressed by Phytoplankton, have shown promising results. They have been in fact identified the ranges of variation of the main indexes in use (Shannon-Weaver Index, Margalef Index, etc..), and these ranges are in good agreement with the values provided by the literature for coastal waters more or less impacted by the human activities. Nevertheless much remains to understand about the strategies and the dynamics of phytoplankton algal growth. E.g., in recent years are becoming more and more frequent blooms of phytoplankton species characterized by small size (<3 µm), with a large number of cells/L. We encounter difficulties not only of taxonomic kind, but also in the understanding the causes of these blooms, which apparently occur in a totally random way and lead however to a rapid decay in diversity.

<u>Chlorophyll as a variable statistically distributed</u>
Due to the particular nature of Chlorophyll *a* data, functionally related to phenomena of exponential type like biomass growth and nutrient uptake and release, decimal log transformation of the available Chlorophyll data must be adopted, considering this preliminary transformation proper and sufficient to normalize each Chl statistical distribution. Consequently, in order to characterize each sampling station, we have adopted the annual geometrical means (to say the arithmetic mean of the logarithms, re-converted into numbers), as the main metrics actually accounting for the trophic levels of the areas under consideration. Take note that, once the normal conditions are achieved by means of 10Log-transformation, all the distribution parameters are automatically set, including the theoretical maximum values (eg 90th% ile).

<u>Water body types definition: Type I and Type IIA</u>
In the MED GIG, the criterion adopted to identify different typologies of coastal water bodies, (see the Decision of the Commission EU - 2008/915/CE), is currently based on seawater density, as Sigma_t annual mean values: Type I: Sigma_t < 25. Type IIA: 27> Sigma_t >25. Type III(W&E): Sigma_t >27. (Note! Alternatively the salinity annual means [inside or outside the following range: 34.5-37.5], can be utilized). The whole NW Adriatic Sea area, affected by the Po River inputs (i.e. the Emilia Romagna coast), belongs to Type I. No other part of the Mediterranean coasts (among the EU countries belonging to the Mediterranean Eco-region), is classified as Type I, with rare exceptions, to be however referred to transitional water bodies. Similarly, the coastal stretches belonging to Type IIA, are mainly located in the Adriatic Sea and some coastal stretches also in the Tyrrhenian Sea. In the latter case however, the response of the Tyrrhenian coastal system is quite different, in trophodynamic terms (see the Figure 6.2), because of a noticeable change in the relationship between chlorophyll and total phosphorus, which reflects a greater efficiency of the Adriatic system to use nutrients to produce biomass. For these reason, MED GIG identifies two different categories of Type IIA, the Adriatic and the Tyrrhenian.

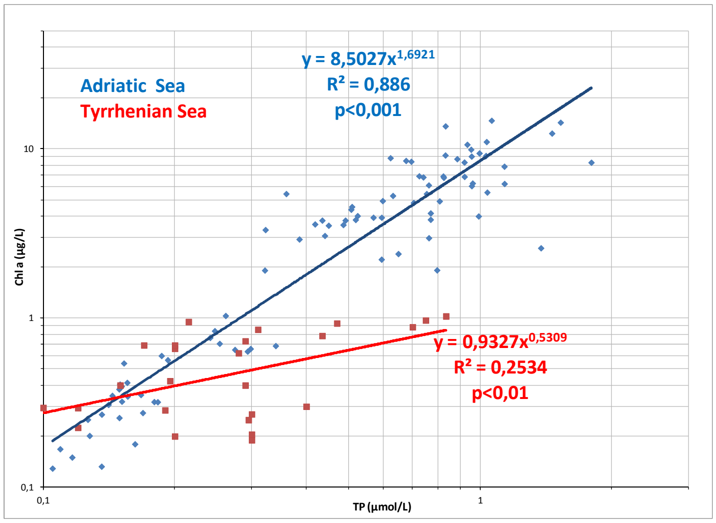


Figure 6.2: Chlorophyll a (Chl *a* geom. avg) vs. Total Phosphorous (TP geom..avg) concentrations (per sampling stations), in Adriatic and Tyrrhenian Seas. (From: Technical note on the classification criterion based on Chlorophyll *a,* as support to the MED GIG Milestone 5 report. (R. Precali, F.Giovanardi, J. Francé, S. Russo and C. Mazziotti)

Type III (West & East)
When designing a classification scheme, with the aim of comparing different trophic levels, the question that arises is how many samples are needed to obtain a reliable estimate of the difference between two contiguous Chl *a* means. Obviously this Discrimination Limit (i.e., the resolution power of a *t* test on the differences), depends on the sample size.
The annual geometric means of chlorophyll for sampling stations belonging to type III, usually do not exceed concentration values of 0.2 µg/L, with maximum seasonal peaks that are unlikely to exceed 1 µg/L. Therefore, with an yearly monitoring programme with a routinely sampling frequency, monthly or even bi-weekly, we would reach a discrimination level between two geometric means of Chl not indeed favourable for a status classification, that surely does not provides an acceptable level of uncertainty. In conclusion, we think that for this type of waters, the Chlorophyll is not a suitable indicator, but in consistency with the WFD, the EQB Phytoplankton should be tested against the biodiversity decay. We have to take into account that these coastal environments are particularly vulnerable and sensitive to the trophic levels increase and in general to the human-induced pressures, which may result in a considerable reduction of the phytoplankton diversity.

Pressures
In the frame of the MED GIG IC exercise, it was requested to test the sensitivity of the Chlorophyll variability against the human-induced pressures. The following pressures indicators were identified: nutrient concentrations, Oxygen % saturation (expressed as aD_O, absolute % deviation from the saturation), Dilution factor F%, etc. Multiple Linear Regression analysis (Linear Models) was applied to a common data set.

The results showed that Total Phosphorus accounts for the maximum weight in determining the variability of Chlorophyll; and this result was obtained for both type I and type II. The other regressors (i.e. the other pressure indicators) showed a negligible effect. For Type III sampling stations this procedure could not be applied, due to a too small sample size.

Boundary setting procedure for common IC types
After understanding that most of the Chlorophyll a concentration changes in coastal waters can be explained by Total Phosphorus variation, the Chl - TP relationship curves were built, in order to recognize specific distinctions of a trophic kind between types. Concerning the Adriatic Sea, the data points of Type I and Type IIA surely belong to the same statistical universe, not so for the stations of the Tyrrhenian Sea, which showed a significantly different Chl – TP relationship.

Taking into account this difference between types, the boundaries (or thresholds) were set applying a combination of expert judgement and statistical approach. As it is well known, the TRIX Index, due to its formulation encompasses the main characteristics of a phytoplanktonic community, but in addition it contains also the nutrients as pressure indicators, that allow to fix objectives and to adopt strategies and policies for correct sanitation plans. TRIX has been therefore used as a common metric to evaluate the corresponding values of Chl *a* (on which the classification criterion for BQE Phytoplankton is built up) and the related TP concentration, as the most relevant pressure indicator.
From the relationships TRIX - Chl and TRIX – TP, the different boundaries, as expressly required by the WFD, were set. These boundaries are therefore in agreement with the TRIX scale, the validity of which comes from more than 20 years of experience in monitoring and management of coastal waters. The boundaries are than calculated from the relationship curves for TRIX vs Chl *a* and TRIX vs TP (Figure 6.3, Table 6.1).

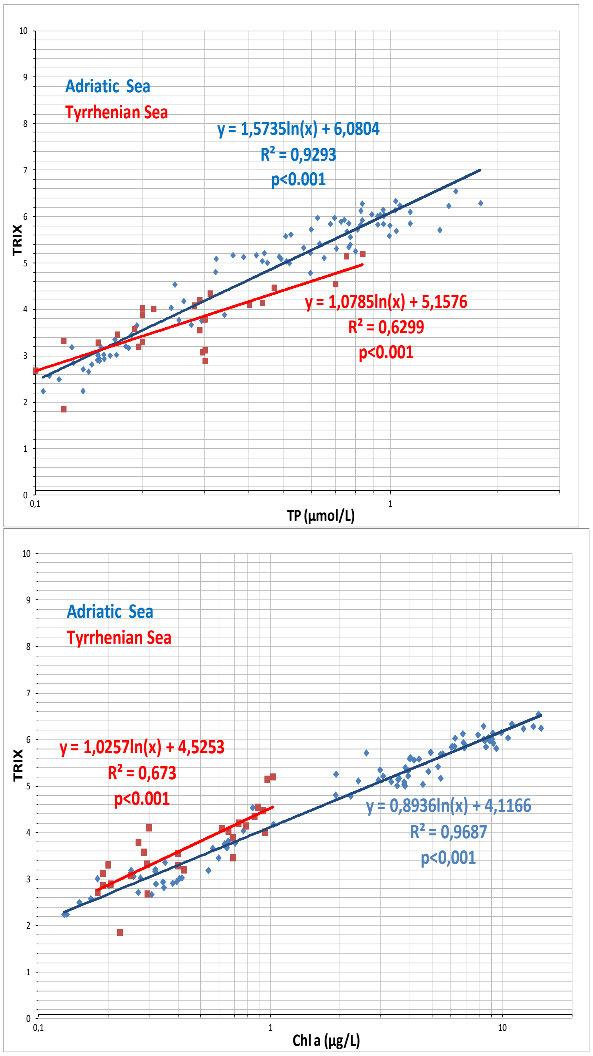


Figure 6.3 TRIX vs TP and Chl *a* for the various typologies. (From: Technical note on the classification criterion based on Chlorophyll *a,* as support to the MED GIF Milestone 5 report. (R. Precali, F.Giovanardi, J. Francé, S. Russo and C. Mazziotti)

Table 6.1: Boundaries for TRIX, Chl a (g. Mean and 90th %ile), Total Phosphorous (TP) and EQR (real and normalized) by Type.

Type I

Boundaries	TRIX	Chl a annual g.means (µg/L)	Chl a 90th percentile (µg/L)	EQRs real	EQRs normalized	TP annual g.means (µM/L)
Ref. Values	-	0.8	2.3	1	1	0.24
H/G	5.0	2.5	7.0	0.32	0.8	0.4
G/M	5.7	6.2	17.3	0.13	0.6	0.6
M/P	6.4	15.1	42.5	0.05	0.4	0.9
P/B	7.1	37.1	104.4	0.02	0.2	1.6

Type IIA- Adriatic Sea

Boundaries	TRIX	Chl a annual g.means (µg/L)	Chl a 90th percentile (µg/L)	EQRs real	EQRs normalized	TP annual g.means (µM/L)
Ref. Values	-	0.15	0.36	1	1	-
H/G	3.7	0.65	1.58	0.230	0.8	0.23
G/M	4.5	1.57	3.81	0.095	0.6	0.37
M/P	5.3	3.79	9.20	0.040	0.4	0.61
P/B	6.1	9.14	22.17	0.016	0.2	1.01

Type IIA- Tyrrhenian Sea

Boundaries	TRIX	Chl a annual g.means (µg/L)	Chl a 90th percentile (µg/L)	EQRs real	EQRs normalized	TP annual g.means (µM/L)
Ref. Values	-	0.15	0.36	1	1	-
H/G	3.7	0.4	1.06	0.34	0.8	0.26
G/M	4.5	0.9	2.19	0.17	0.6	0.54
M/P	5.3	1.9	4.51	0.08	0.4	1.14
P/B	6.1	3.8	9.30	0.04	0.2	2.40

Concluding remarks

Although they are well provided for 5 classes of ecological status, in the spirit of the WFD the boundaries truly important are in practice two, the H / G (High/Good) and the G/M (Good/Moderate). The reasons are the following: the H/G boundary represents the limit beyond which we have a pristine naturalness status or, better said, a status not affected by the anthropogenic pressures. The G/M boundary represents, instead, the limit below which the clean up actions are mandatory. In the middle there is something like a region of “acceptability” or “permissibility”. I think that, in agreement with you, if we move to the MSFD lexicon, we can consider the G/M boundary as the required threshold for a GES, in the spirit of the MSFD.

On the other hand, as already mentioned for the BQE Phytoplankton, we have not yet developed methods of ecological kind, to decide if a value of chlorophyll that exceeds the proposed G/M boundary for G/M, actually involves a damage of "ecological" nature. Clearly in the case of Type I, the G/M boundary should be a limit of safety against the risk of anoxia in the deep layers, but this is not clear for Type II Type III.

In summary:

- the classification criterion (or the criterion to identify the GES) based on Chlorophyll concentration in coastal waters, utilizes, as metric, the annual geometric means: 6.2, 1.57 and 0.9 µg/L for Type I, Type IIA Adriatic and Type IIA Tyrrhenian, respectively. The corresponding 90th %iles are automatically defined.
- to the boundaries H/G and G/M for Chl, corresponding Total Phosphorus concentration values are identified, to be meant as the pressure levels that determine those Chl values;
- for Type III, for both Western and Eastern Mediterranean basins, no criteria have been defined. In any case Cyprus and Greece propose to maintain the classification criterion as defined during 1st phase of the IC exercise (i.e. 0.4 µg/L of Chl as 90th %ile).

- the use of annual averages of chlorophyll in order to define the ecological status, clearly obliges member countries to plan monitoring frequencies and number of sampling stations suitable for statistical significance. On the other hand there is also an evident necessity to have valuable information about the taxonomic composition of the Phytoplankton (Specific composition and abundances), as stated by the WFD, together with the broad array of the supporting parameters as T, Sal, nutrients and so on; see the cited manual on "sampling and analysis techniques…", already provided by UNEP) in order to improve our knowledge on the ecology of this Biological quality element and, in the same time, develop and test more adequate indices, more consistent with the definition of the ecological status (or GES) and with an ecosystem approach.

6.4.2. Hazardous substances

Two main conceptual approaches are usually used to define EACs, the OSPAR and NOAA/EPA approaches. The OSPAR approach uses an ideal approach to derivation of environmental assessment criteria for any given substance based on its policy for achieving concentrations in the environment near background values for naturally occurring substances and close to zero for man-made synthetic substances, and based on dose-response relationships.

The NOAA (not as official policy) and Canadian Environmental Quality Guidelines approaches uses benchmarks, based upon a database primarily of synoptic marine sediment chemistry and sediment toxicity bioassay data. For a given contaminant, the samples which were categorized as toxic by the original principle investigator is excerpted, and that subset is then ranked by increasing contaminant concentration and the 10^{th} (Effect Range-Low, ERL) and 50^{th} (Effect Range-Medium, ERM) percentiles determined. As such, these benchmarks are not analogous to the dose-response relationships, i.e. LC10s or LC50s. Based on similar database compilation but using different calculations, Threshold Effect Levels (TELs, geometric mean of the 15^{th} percentile) and Probable Effects Levels (PELs, geometric mean of the 50^{th} impacted samples and the 85^{th} of the non impacted) are calculated. The ERL is calculated as the lowest 10^{th} percentile concentration of available sediment toxicity data which has been screened for only those samples which were identified as toxic by the original investigator. The ERL is at the low ranges of levels at which effects were empirically observed it represents the value at which toxicity may begin to be observed in sensitive species.

In the information document "Methodology for the development of Environmental Assessment Criteria (EACs) for selected toxic metals (Hg, Cd, Pb) and hazardous organic substances in sediments and biota in the Mediterranean region" (UNEP(DEPI)MED WG.365/Inf.8), the methodologies for the development of Assessment Criteria is presented, along with an initial presentation of the requirements for a possible application of this methodology in the Mediterranean region

OSPAR has developed a traffic light scheme between green and red, green indicating that the target/objective has been achieved; red that it is not (OSPAR, 2009). These assessment criteria (called also Environmental Assessment Criteria – EACs) are intended to provide the green/red transition point: i.e "the concentration in the environment below which no chronic effects are expected to occur in marine species including the most sensitive species" (OSPAR, 2009). EACs have been proposed by OSPAR for 7CBs in sediments and PAH in shellfish, while alternative approach was used to define thresholds between acceptable/unacceptable levels of metals (Cd, Hg, Pb) in sediment and biota, PAHs in sediment and CBs in biota (OSPAR 2009).

A green assessment for a particular contaminant means that the environmental concentrations meet relevant statutory limits or policy objectives, and are satisfactory in that they present little or no risk. A red assessment means that the relevant limit or objective had not been met. The statistical aspects of the comparisons are on a precautionary basis.

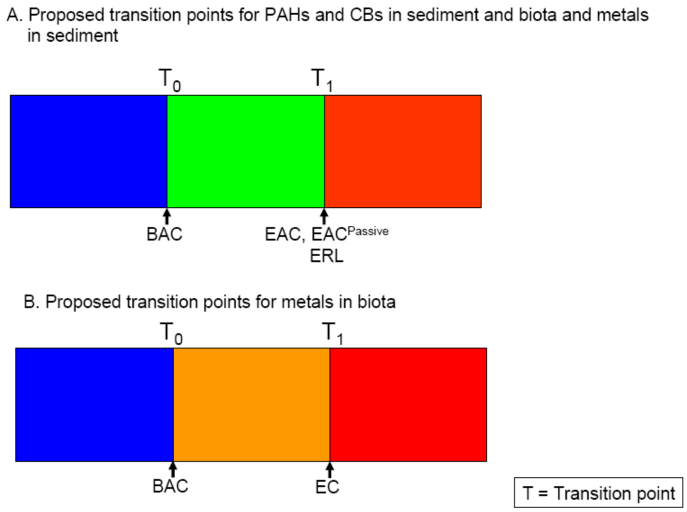


Figure 6.4: Illustration of the proposed traffic light system and the relevant transition point criteria for: A. PAHs and CBs in sediment and biota and metals in sediments, and B. metals in biota. The green/red boundary corresponds to the achievement of a statutory target (in WFD terms) or a policy objective (in OSPAR terms)

The interpretation of the proposed blue/green/red scheme (Figure 6.4.) in relation to hazardous substances is summarised below, as well as, the type of management activity which may be possible for each colour:

i. Below the T_0 value, measured contaminant concentration should not give rise to any biological effects. No immediate management action would be required, the monitoring frequency could be reduced or monitoring ceased.
ii. Between the T_0 and T_1 values, biological effects are possible (e.g. biomarker response, impaired growth, reproduction). Management actions could be to identify the reasons for elevated level(s), the use of expert judgement to assess significance, check trends and variability or the introduction of additional monitoring.
iii. Above T_1, long-term biological effects are likely (e.g. impaired growth, reproduction and survival), and acute biological effects (survival) are possible. Appropriate management actions could involve additional analysis to verify findings, identification of the reason(s) for elevated level(s), re-design of monitoring strategies for specific elevated contaminants and consider resource or emission management issues.

The establishment of the transition points T_0 and T_1, involves the definition of a series of reference concentrations, particularly of Background Assessment Concentrations (BACs), derived from the Background Concentrations (BCs), and the Environmental Assessment Criteria (EACs). This requires specific statistical analysis of the database and additional information. For instance, the definition of T_1 for each pollutant concerned requires ecotoxicological information for the key species to be used for such a purpose.

The development of Assessment Criteria for the Mediterranean is a way to implement Mediterranean-wide Environmental Quality Objectives (EQO) and standards (EQS) in the framework of the gradual application of the Ecosystem Approach (ECAP) in the Mediterranean. The adoption of specific Mediterranean EQOs and EQSs are essential for the risk assessment of the pollution.

The development of Assessment Criteria for hazardous substances will be undertaken by MED POL with the full participation of Mediterranean countries. In the information document (UNEP(DEPI)MED WG.365/Inf.8), background information is provided on the methodology to be followed for the definition of the above criteria and offers the first estimates of background concentrations for trace metals in sediments and biota, and PAHs in sediments. Recommendations are also made for improving the MEDPOL monitoring programme in order to overcome sediment size variability. These refer to the compulsory determination of Al content in sediments for normalization of trace metal data and the OC percentage for normalizing the PAHs concentrations.

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