EP

United Nations Environment Programme

Distr.
RESTRICTED

UNEP/WG.62/6
20 August 1981

Original : ENGLISH

First meeting of the Working Group on
Scientific and Technical Co-operation

Athens, 28 September - 2 October 1981

mediterranean action plan

POLLUTION MONITORING AND RESEARCH PROGRAMME

Mediterranean Environmental Quality Criteria

GE.81-02514

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1. INTRODUCTION

As part of the Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL - PHASE I) data were collected on the quality of the Mediterranean environment. In evaluating the data collected through pilot projects, in particular MED POL II : Baseline Studies and Monitoring of Metals, Particularly Mercury and Cadmium in Marine Organisms, and MED POL VII: Coastal Water Quality Control, the formulation of selected environmental quality criteria, applicable for the Mediterranean Sea, became possible.

In this connection the Intergovernmental Review Meeting of Mediterranean Coastal States and the First Meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution and its Related Protocols (Geneva, 5-10 February 1979) recommended that:[1/]

> "Work should be continued on the development of the scientific rationale for the criteria applicable to the quality of recreational waters, shellfish-growing areas, waters used for aquaculture, and seafood. Based on this rationale and taking into account existing national provisions and international arrangements and agreements, the criteria should be formulated on a scientific basis and submitted to the Governments and the EEC for their consideration."

Furthermore, the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources, adopted at the Conference of Plenipotentiaries of the Coastal States of the Mediterranean Region for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (Athens, 12-17 May 1980) stipulates[2/] that:

> "1. The Parties shall progressively formulate and adopt, in co-operation with the competent international organizations, common guidelines and, as appropriate, standards or criteria dealing in particular with:
> .....
>
> (c) the quality of sea-water used for specific purposes that is necessary for the protection of human health, living resources and ecosystems;
> .....

[1/] UNEP/IG.14/9, annex V, paragraph 13.

[2/] Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources, article 7.

2. Without prejudice to the provisions of article 5 of this Protocol, such common guidelines, standards or criteria shall take into account local ecological, geographical and physical characteristics, the economic capacity of the Parties and their need for development, the level of existing pollution and the real absorptive capacity of the marine environment."

In response to the cited recommendation and provision contained

in the Protocol the draft environmental quality criteria contained in this document have been prepared by:

- WHO for environmental quality criteria for recreational waters and for shellfish growing areas; and

- WHO, FAO and UNEP for environmental quality criteria for mercury in seafood.

This document, and particularly the rationale used in drafting the proposed criteria, the scientific evidence supporting this rationale and the applicability of the proposed criteria, should be revised by the Working Group for Scientific and Technical Cooperation before it is submitted to the Contracting Parties at their forthcoming meeting for their adoption and application.

2. ENVIRONMENTAL QUALITY CRITERIA FOR RECREATIONAL WATERS

In the light of the definitions put forward at the United Nations Conference on Human Environment in Stockholm 1972, the following definitions could be drawn up in the context of recreational water quality criteria.

Water quality criterion is defined as a quantifiable exposure-effects relationship between the density of an indicator in the water concerned and the potential human health risks involved in using that water. On this relationship a judgement on the water quality can be based.

Health effects water quality indicator is defined as a microbiological, chemical or physical parameter which indexes the potential risk of infectious disease coincident with man's use of the aquatic environment as a source of recreation. Ultimately the best indicator will be the one whose densities correlate best with associated health effects. It can be selected therefore only on the basis of epidemiological analysis.

Water quality standard is an acceptable maximum level for the density of the indicator in the water associated with unacceptable health risks. It derives from the water quality criterion. The concept of acceptability implies that social, cultural, economic and political, as well as medical factors are involved, and that these factors may vary in both time and space.

2.1 Existing national provisions and international arrangements and agreements relevant to the Mediterranean

While the need for water pollution control in the Mediterranean countries is being increasingly recognized, and specific legislation is under consideration in the majority of these countries, only a limited number of them have issued norms or standards on recreational water quality up until now.

Table I summarizes the available information on existing or proposed standards dealing with recreational water quality among individual Mediterranean countries.

As Table I illustrates, recreational water quality standards among Mediterranean countries show a considerable variation, as much in the type and numerical values of the microbiological indicator used, as in the specified frequencies considered for sampling and compliance with the standard. This disparity makes difficult, if not impossible, comparison between the obtained results and the quality of the relevant recreational waters.

An effort towards the development of an internationally harmonized approach has been made by the European Economic Community (EEC). In this context, the Council of the European Communities (EEC 1976) adopted in 1975 the Directive concerning the quality of bathing water. The Directive takes into consideration the physico-chemical and microbiological parameters applicable to bathing waters, the minimum sampling frequencies, and the reference methods of analysis for the proposed parameters.

EEC's Member States shall take all necessary measures to ensure that, within 10 years following the notification of the Directive, the quality of bathing waters conforms to the limit values set in accordance with Article 3 of the Directive. Furthermore, Member States shall, four years following the notification of the Directive, and at regular intervals thereafter, submit a comprehensive report to the Commission on their bathing water and the most significant characteristics thereof.

The microbiological parameters considered by the Directive are: total coliforms, faecal coliforms, faecal streptococci, Salmonella and enteroviruses. (Table II). Bathing water shall be deemed to conform to the relevant parameters:

TABLE I: MICROBIOLOGICAL WATER QUALITY STANDARDS FOR RECREATIONAL WATER OF SOME MEDITERRANEAN COUNTRIES

Country	Year of Proposal	Water Quality Indicator	STANDARD				Notes
			Analytical Method	Sampling Frequency	Compliance Frequency	Indicator Concentration per 100 ml	
France	1973	Total coliforms	-	-	100%	2000	
		Faecal coliforms	-	-	100%	500	
		Faecal streptococci	-	-	100%	100	
Greece	1965	Total coliforms	MPN	-	-	0-50	Safe for bathing
		Total coliforms	MPN	-	-	51-500	Acceptable
		Total coliforms	MPN	-	-	501-1000	Not recommended
		Total coliforms	MPN	-	-	>1000	Unsafe
Israel	1950	Faecal coliforms	MPN	Over 30 days	90%	1000	
Italy	1973	E. coli	MPN	-	100%	100	
Libya	1975	Total coliforms	MPN	-	100%	1000	
		Faecal coliforms	MPN	-	100%	100	
Malta		E. coli	MPN	-	100%	1000	
Spain	1977	E. coli	MPN or MF	Over 30 days	50% 90%	200 1000	
Yugoslavia	1967	Total coliforms	MPN	-	100%	20000	

if the samples of that water, taken at the same sampling point and at the intervals specified in Table II, show that it conforms to the parametric values for the quality of the water concerned, in the case of:

- 95% of the samples for parameters correponding to those specified in column "I" of Table II;

- 90% of the samples in all other cases with the exception of the "total coliform" and "faecal coliform" parameters, where the percentage may be 80%.

and if, in the case of the 5, 10 or 20% of the samples which do not comply:

- the water does not deviate from the parametric values in question by more than 50%, except for microbiological parameters, pH and dissolved oxygen;

- consecutive water samples taken at statistically suitable intervals do not deviate from the relevant parametric values.

France, Greece and Italy are members of the European Economic Community (EEC), and as such are bound to comply with the provisions contained in the EEC Council Directive concerning the quality of bathing water.

Considering the usefulness and the necessity to harmonize the evaluation of pollution in the Mediterranean, a similar effort was undertaken since the early stage of the MED POL VII Project.

To that end the World Health Organization (WHO), and the United Nations Environment Programme (UNEP), within the frame of WHO/UNEP pilot project on Coastal Water Quality Control in the Mediterranean (MED POL VII) convened a Group of Experts in Athens in 1977 to initiate a scientific study concerning health criteria and epidemiological studies related to coastal water pollution (WHO/UNEP, 1977a).

The purpose of the meeting was:

- to review the epidemiological factors and health criteria on which quality standards for recreational and coastal waters are based, and

- to develop a methodology for epidemiological research programmes intended to provide reliable data for practical application.

After examining the available evidence, the Working Group came to the conclusion that there was not as yet enough epidemiological basis for recommending changes in the conclusions reached by the WHO Working

TABLE II: MICROBIOLOGICAL QUALITY REQUIREMENTS FOR BATHING WATER OF THE EUROPEAN ECONOMIC COMMUNITY (EEC, 1976)

	Parameters		G (1)	I (1)	Minimum Sampling Frequency	Method of analysis and inspection
1.	Total coliforms	per 100 ml	500	10 000	Fortnightly (2)	Fermentation in multiple tubes. Sub-culturing of the positive tubes on a confirmation medium. Count according to MPN (most probable number) or membrane filtration and culture on a appropriate medium such as Tergitol lactose agar, endo agar, 0-4% Teepol broth, subculturing and identification of the suspect colonies. In the case of 1 and 2, the incubation temperature is variable according to whether total or faecal coliforms are being investigated.
2.	Faecal coliforms	per 100 ml	100	2 000	Fortnightly (2)	
3.	Faecal streptococci	per 100 ml	100	-	(3)	Litsky method. Count according to MPN (most probable number) or filtration on membrane. Culture on an appropriate medium.
4.	Salmonella	per litre	-	0	(3)	Concentration by membrane filtration. Inoculation on a standard medium. Enrichment - subculturing on isolating agar - identification.
5.	Entero viruses	PFU per 10 litres	-	0	(3)	Concentrating by filtration, flocculation or centrifuging and confirmation.

(1) G = guide I = mandatory

(2) When a sampling taken in previous years produced results which are appreciably better than those in this Table and when no new factor likely to lower the quality of the water has appeared, the competent authorities may reduce the sampling frequency by a factor of 2.

(3) Concentration to be checked by the competent authorities when an inspection in the bathing area shows that the substance may be present or that the quality of the water has deteriorated.

Group on Guides and Criteria for Recreational Quality of Beaches and Coastal Waters (WHO, 1975). Thus the following interim water quality criteria were adopted: "Highly satisfactory bathing areas should, however, show E. coli counts of consistently less that 100 ml, and to be acceptable, bathing waters should not give counts consistenly greater than 1000 E. coli per 100 ml".

The Working Group felt that, while it may be justified that water quality control at existing recreational facilities be based on the more lenient criterion of 1000 E. coli per 100 ml limit, the more strict value of 100 E. coli per 100 ml should be considered for new recreational facilities, and for long-term decisions on water quality management involving large investments.

The Working Group felt that the above numerical limitation of 1000 E. coli should be more closely defined statistically, and recommended the following expression:

> No more than 10% of at least 10 consecutive samples collected during the bathing season should exceed 1000 E. coli per 100 ml.

2.2 Quality of recreational waters in the Mediterranean

Implementation of MED POL VII has been a main step in the effort by Mediterranean countries to study and evaluate the quality of their recreational coastal waters. The overall objective of MED POL VII was to obtain statistically significant data, scientific information and technical principles required for the assessment of the present levels of coastal pollution as it concerns human health.

A total of 30 collaborating centres from 14 Mediterranean countries have participated in the project, lasting from July 1976 to March 1981. Though a significant number of Mediterranean coastal areas devoted to bathing and swimming were included in the project, they cannot be considered as fully representative of all the coastal waters used for recreation. In this respect, the proposed Long-Term Pollution Monitoring and Research Programme (MED POL - PHASE II) should include coastal zones with a more representative geographical distribution, as well as with a larger coverage of the population concerned.

The general adoption by participating institutions of common microbial indicators, as well as of the sampling, analytical and interpretation techniques, has been a substantial step forward for promoting harmonization, reliability and comparison of results. Furthermore, the extensive exchange of views held on practical and methodological aspects of monitoring have undoubtedly contributed to increasing the degree of reliability and comparability of the results obtained.

More specifically, the proposed "interim water quality criteria for recreational waters" were considered as reference values with which to compare experimental results. In practice, E. coli concentrations were considered equivalent to faecal coliform concentrations. Considering that the faecal coliform group includes E. coli, and that preliminary results showed faecal coliform colonies grown on membrane filters as being E. coli colonies, the practical equivalence adopted was considered satisfactory.

The reports submitted by the Principal Investigators of the collaborating institutes participating in MED POL VII have provided an overall picture of the water quality of Mediterranean recreational areas. Available results indicate that the large majority of the areas monitored satisfy the proposed interim quality criteria for recreational waters.

However, a consistent application of the EEC microbiological requirements for the waters in two of the Mediterranean coastal areas studied showed little compliance. The limitation imposed by the 500 total coliforms per 100 ml not to be exceeded in 80% of the samples, and particularly the one imposed by the 100 faecal coliforms per 100 ml not to be exceeded in 80% of the samples, were the decisive factors which determined alone the classification of a water sampling station.

In the same areas, it was found that the standard deviations of the concentrations of the three indicators approach quite closely that implied by the "proposed interim quality criteria", while it is notably different to that implied by the EEC requirements.

Future experimental results gathered by the Mediterranean countries through the MED POL - PHASE II should be analysed, to further investigate and evaluate the possible reasons for the above differences in practical interpretations of microbiological data.

The statistical approach adopted for interpreting microbiological data from coastal waters has allowed a systematic evaluation of water quality with respect to the proposed interim criteria. Among the most interesting results derived from the use of this approach, is the validity of the applied hypothesis that microbiological water quality at a given sampling station, for a period of several weeks, follows a lognormal probability distribution with a range of standard deviations far more limited than initially expected. (Mujeriego, et al. 1980).

A detailed analysis of microbiological data collected at 250 sampling stations surveyed by 9 collaborating institutes shows that:

- a lognormal probability distribution provides an adequate interpretation of the experimental data;

- graphical adjustment of the model offers superior and more meaningful characteristics than a numerical treatment of the data, and

- standard deviation at a given sampling station, in terms of natural logarithms of concentrations, varies within the narrow range of 1 to 3, with most of the values ranging within the interval of 1.5 to 2.0.

The above statistical approach is applicable regardless of the microbial indicator used, the analytical method employed, or the season of the year covered.

Earlier observations on this statistical behaviour of microbiological water quality (WHO, 1975;WHO/UNEP, 1977b) has been further confirmed by experimental results reported by MED POL VII Principal Investigators as well as by researchers (Gameson, 1980) studying microbiological data from other coastal areas of the world. The available evidence emphasizes the great interest of this observation, particularly for the intrinsic implications it has on the water quality standard setting process.

2.3 Scientific rationale and relevant considerations for the establishment of quality criteria applicable to Mediterranean recreational waters

Studies carried out within MED POL VII have pointed out the need for a thorough analysis of the scientific and technical information available on which to base standards for coastal water quality. Accordingly, the attention of scientists participating in MED POL VII has been focused on discussing and elaborating the scientific rationale, and the relevant considerations needed for the establishment of water quality criteria applicable to Mediterranean coastal waters, specifically as regards public health protection.

Though the available literature in the field contains a considerable number of contributions, particularly dealing with the analytical methods and the adequacy of the various microbial indicators, their conclusions are sometimes contradictory, apparently due to the specific conditions in which the studies were done.

As a result, the discussion that follows has given great attention to experimental results reported by investigators working on Mediterranean coastal waters, while keeping in perspective the relevant information available in the literature.

The approach given today to the process of developing water quality criteria is that specific consideration be given, at least, to the following aspects:

- the type and nature of the quality indicator;
- the indicator concentration not to be exceeded;
- the analytical methods involved;
- the method and the frequency of sampling;
- the frequencies of compliance for a given indicator concentration;
- the interpretation method, and
- all additional factors peculiar to the water mass and to the beneficial uses considered.

A summary discussion of each of the above aspects is given below:

(i) Quality indicator

The assumption that discharges of animal and human faecal wastes into water bodies used primarily for recreational purposes, bathing and swimming, are a source of potential public health hazards, has developed historically into the search for a microbial indicator capable of characterizing the risk involved in the intended use of the water.

The coliform group was originally selected, in accordance with both analytical methodology and field experience available. Better understanding of the source and significance of the different components of the coliform group brought about the consideration of the faecal coliform group, and particularly of E. coli, as a better quality indicator for recreational waters. Development of analytical techniques as well as of knowledge on ecological behaviour of faecal microorganisms has shown the interest in considering other microbial indicators, among them some pathogens, such as faecal streptococci, Clostridium perfringens, Pseudomonas aeruginosa, Salmonella, and selected enteric viruses and bacteriophages.

Potential microbiological quality indicators, relevant to public health, should fulfil the following requirements:

- be consistent and exclusively associated with the source of pathogens of concern;
- be present in sufficient numbers to provide an accurate density estimate whenever the level of the pathogen is capable of producing a detectable effect;

- approach the behaviour and resistance, under disinfection and environmental stresses, of the most resistant pathogen expected to be present at significant levels in the source;

- be identifiable and quantifiable by reasonably easy and economical methods, with sufficient specificity, accuracy and precision.

As a practical compromise between the general conditions of most laboratories in charge of microbiological control of coastal water quality, and the alternative indicators available, faecal coliforms and particulary E. coli have been considered as the most sensitive indicators of the degree of sewage pollution (WHO, 1975), and have been subsequently proposed for routine monitoring of coastal water quality within MED POL - PHASE II (UNEP, 1981a).

Recent epidemiological studies carried out by the United States Environmental Protection Agency (USEPA, 1980) and by two MED POL VII collaborating institutes, Malaga and Tarragona, (UNEP, 1981b) have indicated a potential interest on faecal streptococci as an additional water quality indicator for public health protection.

The results of the epidemiological study conducted by the USEPA (1980) can be summarized as follows:

1. Gastrointestinal symptoms and, to a lesser extent, fever were found to be both swimming-associated and pollution related.

2. Faecal streptococci and, to a lesser degree, E. coli are the two quality indicators that best correlate with the morbidity rate of gastrointestinal symptoms.

The results from the study carried out at two MED POL VII pilot zones (UNEP, 1981b) can be summarized as follows:

- Skin, ear and eye ailments are the most frequently suffered by recreationists in coastal waters.

- The habit of immersing the head in the water while swimming follows a statistically significant association with the occurrence of ear and eye ailments.

- The fact that faecal streptococci predominates over faecal coliforms in waters considered satisfactory by the interim water quality criteria is consistent with the different inactivation behaviour of both indicators. The statistically significant

association obtained between morbidity rate for ear ailments and faecal streptococci concentrations can be used as a valuable additional quality criteria for recreational coastal waters.

In spite of the difficulties and shortcomings of epidemiological studies on public health effects derived from recreation in costal waters, and the difficulties to establish definite cause-effect relationships, the presently available information and results of MED POL VII justify the establishment of adequate criteria for coastal water quality management aimed at protecting efficiently public health.

(ii) Concentration limits for indicators

The essential component of a water quality criterion is the quantitative exposure-effect relationship between the density of the quality indicator and the level of protection provided for a given beneficial use. Though information presently available is far from complete, considerable progress has been achieved during the last few years. Summarized below are the more recent results.

Morbidity rates for gastrointestinal symptoms approaching 1% are associated with both mean concentrations of approximately 10 faecal streptococci per 100 ml, and mean E. coli concentrations in the range of 10 to 100 E. coli per 100 ml. A 5% morbidity rate for the same symptoms is associated with mean concentrations of approximately 1000 faecal streptococci per 100 ml (USEPA, 1980).

Morbidity rates for ear ailments approaching 1% are associated with mean concentrations of 10 faecal streptococci per 100 ml, while a 2% morbidity rate was associated with a mean concentration of approximately 1000 faecal streptococci per 100 ml (UNEP, 1981b).

Studies carried out in the coastal waters of the Tyrhenian Sea (UNEP, 1981b) show that viruses were detected in all water samples exceeding 920 E. coli per 100 ml. A significant correlation was also found between the number of E. coli and those of enteroviruses.

Studies carried out at 3 beaches of Tel Aviv, Israel, (WHO/UNEP, 1980) show that enteroviruses were detected on all three beaches even when coliform levels were below the 1000 faecal coliform per 100 ml level contained in the proposed interim criteria.

Finally, results on relative survival of microbial indicators gathered at some MED POL VII pilot zones reveal that faecal streptococci are more persistent in sea-water than faecal coliforms and approach the resistance behaviour of some enteric viruses. Also, the gradual variation of the faecal coliforms to faecal streptococci ratio, as the faecal coliforms vary over a wide

range of concentrations, could explain the different regression lines obtained by investigators working within a short range of faecal coliform concentrations.

(iii) Analytical methods

Two basic methods can be used for the determination of microbial indicators:

- The multiple tube dillution technique, followed by the interpretation by the Most Probable Number (MPN), and

- The Membrane Filtration technique (MF).

Selective media and incubation procedures are available for the most common microbial indicators.

There has been a continous discussion on which of the above two methods give more accurate results. Strictly considered, the MPN method relies on the statistical hypothesis that the microbial concentration assigned to a given number is that which makes the observed combination of positive tubes the one with the highest probability of occurrence. The inclusion of the 95% confidence interval in the MPN method tabulation is precisely directed to inform the user that other microbial concentrations can result in the same combination of positive tubes. Though the MF method is based on the direct counting of visible colonies, there are also a series of working hypothesis that can reduce the number of viable organisms from those originally present.

There are two specific conditions of coastal water quality control that should greatly help in solving the existing discussion on analytical methodology. First, the degree of uncertainty with which microbial standards are presently fixed is not in proportion with the degree of accuracy and precision of both methods of analysis. Though this assertion should not be used as a ground for discontinuing further improvement and development of analytical techniques, it points out the need for a practical judgement when dealing with microbial concentrations measured in recreational coastal waters.

Second, results gathered both at the Mediterranean pilot zones, and at other coastal areas of the world, show that a statistical interpretation of microbiological quality is an adequate and powerful method for evaluating coastal water quality. The simultaneous consideration of microbial values obtained during several weeks allows for a balancing of the intrinsic spatial and temporal variation of coastal water quality. Furthermore, results

presently available indicate that overall evaluation of microbial quality of coastal waters by a statistical approach is practically the same, regardless of the analytical technique used for microbial estimations.

The wide application of a lognormal probability distribution method, as considered by some European countries (WHO, 1975) and recommended for use within the MED POL VII pilot project (WHO/UNEP, 1977b, 1979) should provide valuable information on its validity, as well as on its ability to overcome the dual methodology discussion.

(iv) Method and frequency of sampling

The overall objective of MED POL VII was specifically addressed to evaluate the public health implications of coastal water quality. The sampling methodology recommended for use by participants in MED POL VII was to obtain water samples in areas used by high numbers of recreationists. As a compromise between the accessibility of the sampling points and the coverage of the area more frequented by bathers, the recommended procedure was to collect a water sample from 10 to 20 cm below the surface at a point with 1.0 to 1.5 m depth.

Though operational difficulties were experienced by several participants, and some alternative procedures were used, there is no conclusive evidence to warrant a modification of the proposed procedure. Thus the Long-Term Programme (MED POL - PHASE II) gives specific attention to this point.

Water samples should be collected in sterilized wide-mouth bottles, and protected from sunlight and heat until the time of analysis. A maximum of 8 hours should elapse from the collection of the sample until the actual analysis. Water samples analysed after that period of time result in microbial concentrations with inadequate accuracy and precision.

An adequate evaluation of microbial quality for coastal waters, be it statistically or otherwise, requires a minimum number of samples to obtain a meaningful result. From the analysis of data collected at various pilot zones it appears that at least 10 consecutive samples should be collected during a given period to allow a meaningful interpretation of the results. This requirement translates into a one per week sampling frequency during the summer period, considering that the bathing season at most Mediterranean coastal areas is about three months.

It has to be pointed out that microbiological quality is but an element for judging the public health implications of recreation in coastal waters. A detailed technical inspection is also an

important and necessary complement for the evaluation of the sanitary conditions of recreational coastal areas.

Sampling should be carried out systematically, by observing a regular time interval between consecutive samples, and within the same hour interval of the day. Though the influence of sunlight and temperature have been documented as the main factors affecting the survival of microbial indicators, the selection of the sampling time is also dependent on the recreational pattern in the waters of concern, as well as on the means of sample collection, transportation and analysis. As a tentative schedule, the period between 10:00 and 13:00 h has been adopted by many laboratories.

(v) Frequencies of compliance

Quality control techniques rely quite frequently on statistical methods. The interest and validity of this approach, for the study of the microbiological quality of coastal waters, is reflected in the increasing number of national and international standards which include upper concentrations of indicators not to be exceeded in a given percentage of a set of consecutive samples.

A major outcome of the MED POL VII pilot project has been the verification that microbial concentrations in coastal waters can be adequately interpreted by a lognormal probability distribution model. Furthermore, standard deviations for most water sampling stations are within a short interval, regardless of the microbial indicators considered, which includes the standard deviation value implied by the proposed interim criteria.

The immediate consequences of this practical observation are that:

- two pairs of microbial concentration versus frequency of compliance completely define the water quality characteristics of a sampling station, since two parameters determine a lognormal distribution, and

- two pairs of microbial concentration versus frequency of compliance, whose implied standard deviation is not within the experimentally observed interval, are bound to be imbalanced, one of them becoming the most restrictive for all practical purposes, and the other becoming practically inoperative.

A further benefit from a balanced set of standards concerns the design of facilities for wastewater treatment and disposal at sea. A receiving water quality standard, defined by a pair of balanced limits, assures the designer that if the median limitation is met, it is most likely that the other limitation will also be met.

From the experimental results gathered in the Mediterranean coastal waters, studied under MED POL VII project, it appears that a 10-fold ratio between the concentration not to be exceeded in 90% of the time, and that not to be exceeded in 50% of the time, approaches quite well the naturally observed variation of microbial quality. Simple calculations will allow obtaining the ratio associated to a different pair of frequencies.

Detailed analysis of microbiological quality of coastal waters during the MED POL - PHASE II should provide very valuable information on which to validate and extend the above proposed criterion.

(vi) Interpretation methods

The ultimate purpose of the microbiological results gathered at a sampling station is to determine compliance with a proposed quality standard. The practical process results in a comparison of the set of values defined by the standard with the corresponding parameters of the experimental data.

A graphical interpolation of a straight line on the experimental points drawn on a lognormal probability paper seems to be a simple and powerful method for verifying the agreement of the data with the proposed model, as well as for the estimation of the water quality parameters concerned, (UNEP/WHO, 1977b). The graphical method is being suggested over the numerical method because of the better insight it provides, particularly on the possible discrepancies with the model and the values lying outside the general trend.

(vii) Additional factor

Among the additional factors to be considered in the development process of coastal water criteria and standards for the Mediterranean, the following should be mentioned:

Mediterranean coastal waters can be characterized by high salinity values, and low tide fluctuations. Current patterns, within the 3 km range from the coastline, follow a predominant direction parallel to the coast. Furthermore the summer season is characterized by high solar radiation levels and warm temperatures, both ambient and in the water.

Bathing and recreation in Mediterranean coastal waters is characterized by long periods of water contact intermixed with intensive sun exposure. Between 60 and 70% of the population visiting Mediterranean coastal areas stay at a given resort town up to 3 weeks, with almost daily recreation on the beach. Recreation in

coastal areas takes place mainly during July, August and September, and generally concentrates around widely known beaches, where high population densities are reached.

2.4 Proposed environmental quality criteria for recreational waters in the Mediterranean

Based on the results and experience gathered from the pilot phase of the joint WHO/UNEP project on Coastal Water Quality Control in the Mediterranean (MED POL VII), and in accordance with the above review of the scientific rationale presently available, the environmental quality criteria appearing in Table III are proposed for application to recreational coastal waters of the Mediterranean, as regards public health protection.

TABLE III: PROPOSED EVIRONMENTAL QUALITY CRITERIA FOR RECREATIONAL WATERS OF THE MEDITERRANEAN

Parameter	Concentrations per 100 ml not to be exceeded in 50% of the time	90% of the time	Minimum Number of Samples	Analytical Method	Interpretation Method
Faecal coliforms	100	1000	10	Membrane Filtration, m-FC broth or agar incubated at 44.5±0.2°C for 24 h	Graphical or analytical adjustment to a lognormal probability distribution
Faecal streptococci	100	1000	10	Membrane Filtration, M-Enterococcus agar incubated at 35±0.5°C for 48 h	

The proposed faecal coliforms criteria was unanimously adopted by the Principal Investigators of the collaborating institutes in the pilot phase of the MED POL VII project. However, not only faecal coliforms were investigated during the pilot phase, but total coliforms and faecal streptococci were also included in the faecal indicators compulsory list. In view of the experimental results gathered during

the pilot phase, faecal streptococci have also been included in the proposed quality criteria.

Other quality indicators studied during the pilot phase of the MED POL VII project, such as Salmonella and several enteric viruses, should be investigated during the MED POL - PHASE II, to improve the present approach and to develop more reliable, consistent, representative, simple and economical water quality indicators of human faecal pollution.

The proposed quality criteria represent a main step in ensuring an appropriate level of protection for recreationists in the coastal waters of the Mediterranean. However, they should not be considered as rigid limitations, but instead requirements that can be amended as further scientific and technical information becomes available. Results from the MED POL - PHASE II should be of great value in this respect.

Experience gathered during the pilot phase of the MED POL VII project should be used for establishing the monitoring network included in the MED POL - PHASE II, so it can provide the additional information needed for a better assessment of the quality of the recreational waters of the Mediterranean.

Among the specific aspects to be considered for further improvement of the proposed quality criteria, the following can be mentioned:

(i) epidemiological studies should be carried out among recreationists of Mediterranean coastal waters to appraise the public health implications of bathing and their potential association with water quality;

(ii) further studies should be conducted on the inactivation processes of faecal microorganisms in the sea, to better understand the parameters governing these processes and the technical principles available to promote them;

(iii) further studies should be carried out on the adequacy and efficacy of analytical methods for detecting microbial indicators;

(iv) a quality control programme should be established and implemented by all the participating laboratories in order to ensure the accuracy, precision, and comparability of the results of the microbiological analyses; and

(v) a systematic evaluation of microbiological data should be conducted, preferably by graphical adjustment of a lognormal probability distribution, to achieve a better understanding of the factors influencing the quality of Mediterranean coastal waters.

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3. ENVIRONMENTAL QUALITY CRITERIA FOR SHELLFISH GROWING AREAS

The major health hazards associated with shellfish are those caused by the consumption of raw shellfish polluted by human faecal material. The pollution of shellfish growing waters by pathogenic micro-organisms may occur whenever the water is contaminated by human faeces, sewage outfalls, discharges from polluted rivers or drainage from polluted areas. Sewage outfalls constitute the major pollution source for shellfish growing areas.

It is important to consider the marine environmental factors which affect the sanitary quality of shellfish. These factors may be divided into two broad groups: physical and biological.

The extent to which shellfish growing areas are affected depends mainly on the following physical factors:

- the location of the sewage discharge relative to the shellfish growing areas;
- the quantity and concentration of the sewage effluent;
- the type and degree of treatment of the sewage before discharge;
- the dilution and dispersion characteristics of the receiving waters.

The degree of contamination of shellfish growing waters and of shellfish depends on the following biological factors:

- the microbiological contents of the sewage discharge;
- the viability of the different microorganisms in the sea;
- the biological processes of shellfish;
- the development of toxic algae.

The present document deals only with the environmental quality criteria applicable to shellfish growing waters, in those aspects relevant to the protection of human health.

3.1 Existing national provisions and international arrangements and agreements relevant to the Mediterranean

To ensure the production and distribution of safe shellfish, an elaborated system of control, with ad hoc support services, is required. However, such systems are justifiable and should be provided mainly whenever there is a substantial shellfish industry.

An adequate control system should cover all aspects of production, from the growing area to the processing facilities, and to the wholesale and retail market. This is the case in a limited number of Mediterranean States, where such efficient control systems have been evolved, or where a similar approach is justifiable and should be developed.

In some countries, emphasis is placed upon categorization of shellfish growing areas as approved or otherwise, based on detailed investigations of both the topography and the water quality itself. In other countries, more emphasis is placed on the quality of shellfish taken from an area. However, when an assessment is made of the suitability of an area for shellfish production, both the topographical factors and the bacteriological quality of the water are taken into account.

One of the difficulties in assessing the suitability of an area for the production of shellfish, by examining the quality of the shellfish growing waters, is the lack of a direct relationship between the bacterial content of the water and that of the shellfish grown in them. However, effective control has been exercised in some countries through an assessment of shellfish growing waters as the main basis of sanitary control.

Very few countries in the Mediterranean have appropriate legislation or have developed quality criteria for shellfish growing waters and for shellfish flesh. Furthermore, existing legislation and quality criteria are quite different among countries.

In France, for example, the quality of shellfish growing areas is determined on the basis of the faecal coliforms content of shellfish living in the respective area. The evaluation of the contamination is expressed as the MPN of faecal coliforms per 100 ml of flesh smashed and diluted following a given methodology. The evaluation is based on 26 samplings spread over 12 consecutive months.

Shellfish growing areas are classified as "sanitary" when the MPN of shellfish flesh does not exceed 300 faecal coliforms per 100 ml.

This standard is considered to be met when the number of samples with a MPN higher than 300 faecal coliforms per 100 ml does not exceed five during a period of twelve consecutive months. However, the MPN of three out of the five samples should not exceed 1000 faecal coliforms per 100 ml, the remaining two not exceeding 3000 faecal coliforms per 100 ml.

Waters where the above standards are not met are classified as unsuitable for shellfish growing. Collection of shellfish is forbidden in such areas, except in cases where purification of shellfish is intended to be undertaken. To this effect, relevant approval should be issued by the responsible authorities.

When the MPN of shellfish flesh exceeds 10 000 faecal coliforms per 100 ml in 25% of the samples, the relevant approval needs confirmation by the departmental Direction of the sanitary and social action.

In Italy, the quality of shellfish growing areas is determined on the basis of the MPN of E. coli present in the water itself.

Approval for shellfish growing requires that water samples taken over 12 consecutive months do not exceed 2 E. coli per 100 ml in 90% of the samples, and that they do not exceed 6 E. coli per 100 ml in 10% of the samples.

In Spain, protection of shellfish growing waters requires that E. coli concentrations do not exceed 15 E. coli per 100 ml in 50% of the samples, and that they do not exceed 50 E. coli per 100 ml in 90% of the samples.

Similarly, as in the case of shellfish growing waters, the standards for shellfish, where they exist, do also differ from one country to another.

In France, for example, the microbiological criteria relevant to shellfish for human consumption are as follows:

- Aerobic microorganisms, 30°C — 100 000 per gramme
- Faecal coliforms — 300 per 100 ml
- Faecal streptococci — 2 500 per 100 ml
- Staphylococcus aureus — 100 per gramme
- Anaerobic Sul. reducing bacteria, 46°C — 10 per gramme
- Salmonella — absent in 25 grammes

The interpretation of the results provides three categories of contamination, namely:

- the contamination does not exceed the above described criteria "m";
- the contamination is between the above criteria "m" and an upper level "M" equal to 10 times the criteria "m", when the enumeration of microorganisms is made on solid media, or a level equal to 30 times the criteria "m" when the enumeration is made on liquid media;
- the contamination exceeds the level "M".

Provided that any of the results included in a given sampling exceeds "M", the quality of the sampling is considered:

- satisfactory, when the observed values are:

  $\leqslant$ 3m for solid culture media, or

  $\leqslant$ 10m for liquid culture media;

- acceptable, when the observed values are:

  between 3m and 10m for solid culture media, or

  between 10m and 30m for liquid culture media, and

  $\frac{c}{n} \leqslant \frac{2}{5}$, where "c" is the number of units composing the sample, which give results between m and M, and "n" is the number of units per sample, depending on the adopted interpretation plan.

- unsatisfactory, when:

  $\frac{c}{n} > \frac{2}{5}$, for the values specified above, or

  whenever a value above the "M" criteria is observed.

In Italy, the quality criteria for shellfish from approved growing areas requires that samples taken during 12 consecutive months do not exceed a MPN of 160 E. coli per 100 ml of shellfish in 90% of the samples, and that they do not exceed a MPN of 500 E. coli per 100 ml of shellfish in 10% of the samples.

Few additional Mediterranean countries have also developed standards for shellfish growing water as well as for shellfish, being generally different from country to country.

While the quality criteria developed by each Mediterranean country may fulfil its relevant needs, no harmonization or coordinated action may be promoted under the present conditions. As a result, a relevant assessment of the quality of shellfish growing areas and a rational control of pollution sources for the Mediterranean as a whole will be deficient.

At present, the great majority of Mediterranean countries are concerned with shellfish production without having the adequate facilities for treatment and handling of polluted shellfish. In those cases, an appropriate surveillance of shellfish production areas can

be a critical measure for ensuring that shellfish leave the production area in a safe and wholesome state. In these circumstances, a sanitary control of the shellfish could then be carried out by national public health officers, by appropriate inspections of shellfish after they leave the growing areas, through normal food hygiene control procedures.

The shellfish quality control component of the joint WHO/UNEP MED POL VII pilot project on Coastal Water Quality Control was aimed at applying and assessing the above simplified approach, while at the same time promoting the necessary harmonization in the Mediterranean area. With this objective, a monitoring programme of both water quality in growing areas and shellfish was organized and carried out for the Mediterranean countries. For the needs of this pilot monitoring programme common interim criteria for growing waters and for shellfish were investigated and agreed upon by the Principal Investigators participating in the MED POL VII pilot project (see 3.4).

International arrangements and agreements satisfactorily covering the Mediterranean as a whole do not exist. However, some international arrangements have been or are being developed, concerning the quality of shellfish growing waters and the sanitary requirements for shellfish intended for human consumption. These arrangements are as follows:

(i) The Council of the European Communities adopted in 1979 the Directive on the quality required in shellfish growing waters (EEC,1979). The Directive takes into consideration the physico-chemical and microbiological parameters to be applicable to shellfish growing waters, the relevant (G) guide values, the (I) mandatory ones, the reference methods of analysis, and the minimum sampling and measuring frequencies.

The requirements established by the Directive, as far as the microbiological parameters of shellfish growing waters are concerned stipulates, as its guide value, a MPN concentration of less than or equal to 300 faecal coliforms per 100 ml of shellfish flesh and intervalvular liquid. However, pending the adoption of a Directive on the protection of consumers of shellfish products, the present Directive states that it is essential that the above value be observed in waters in which shellfish directly edible by man live.

EEC Member States shall, initially within a two year period following the notification of the Directive, designate shellfish growing waters. Further provisions are made for additional designations and for revisions. Member States shall establish programmes to ensure the designated waters conform, within six years following designation, to both the values set by the Member States and the comments contained in columns G and I of the Annex of the Directive.

Designated waters shall be deemed to conform to the microbiological provisions of the Directive if samples of such waters, taken at a minimum quarterly frequency, at the same sampling point, and over a period of 12 months, show that they conform to both the values set by the Member States and the guide value described above, as regards 75% of the samples.

The Directive on the quality required for shellfish waters concerns at present three Mediterranean countries: France, Greece and Italy. Under this condition the Directive does not help to avoid the shortcomings experienced in the Mediterranean and due to the different criteria of individual countries.

(ii) A proposed draft code of hygiene practice for molluscan shellfish has been prepared by the Codex Alimentarius Commission (1978).

The draft code in its Appendix III provides general environmental sanitation recommendations. These concern:

- Sanitary disposal of human and animal wastes;
- Determination of pollution types and sources;
- Classification of the shellfish growing areas;
- Control of the shellfish growing areas;
- Reclassification of shellfish growing areas;
- Animal, plant, pest and disease control.

Moreover in an Annex to the Appendix III of the Code, current laboratory procedures and standards are given. This is a list of bacteriological standards and methods currently employed in several developed countries. Among the Mediterranean countries, only France and Italy are included in the above list.

The Committee on Food Hygiene considered that:

(a) successful shellfish control programmes have been in operation in a number of member states for many years, using a wide range of bacteriological standards and methods, and

(b) that it was virtually impossible to reach agreement at this time on any specific set of standards and methods.

The Committee concluded that a listing of bacteriological standards and methods currently in force in several developed countries would serve a useful purpose.

The Code of Hygienic Practise for moluscan shellfish has a universal character and therefore also concerns the Mediterranean area. However, it is of a general nature and does not provide, at this stage, valuable possibilities to cover the specific needs and conditions of the Mediterranean as a whole. In this respect it does not alleviate the shortcomings that the national criteria and the Directive of the European Communities present.

3.2 Quality of the shellfish-growing areas in the Mediterranean

It is evident that with the existing various national criteria which are applied in few Mediterranean countries, it is not possible to make an assessment of the quality of the shellfish growing areas in the Mediterranean as a whole, and to take appropriate concerted action. However, in countries where national quality criteria exist and are applied, satisfactory results as far as health protection is concerned are usually experienced.

As mentioned in 3.1 above, a coordinated assessment of the quality of the shellfish growing areas in the Mediterranean was undertaken on a pilot basis, through the establishment of a monitoring programme of shellfish growing areas as part of the MED POL VII pilot project. To this end common quality criteria for both growing waters and shellfish flesh, as well as similar methodology were applied (see 3.4).

The results of the monitoring showed that the great majority of the shellfish growing waters studied conformed to the established criteria, and that the related shellfish flesh was also meeting the relevant quality criteria. In the few cases where these standards were not met, the influence of detrimental physical factors was easily detected.

However, in view of the relatively small number of shellfish growing areas monitored, the above results do not apply to all the prevailing conditions in the Mediterranean as a whole. Further investigation is necessary in order to attain an appropriate assessment and control of pollution in shellfish growing areas. In this respect, it would be advisable to continue the work already initiated by the MED POL VII pilot project, and to expand the network of monitoring shellfish growing areas, to better cover both the Mediterranean as a whole, and

its important growing shellfish areas. In addition, the value of the indicators, as far as health effects are concerned, should be evaluated. This is best achieved by means of epidemiological studies which should be undertaken at an early stage.

3.3 Scientific rationale for the criteria applicable to Mediterranean shellfish-growing areas

The development of criteria applicable to Mediterranean shellfish growing areas should be based on indicators, which are:

- consistently and exclusively present in human faecal wastes at reasonably high densities;

- capable of survival, during sewage treatment and various types of transport, to an extent comparable to that of the pathogens potentially contained therein.

Moreover, considering that such criteria should be applicable to the Mediterranean as a whole, they should be based on:

- a minimum number of indicators;

- a simplified and limited number of analytical methods;

- the possibilities and facilities available in each of the Mediterranean States.

Various indicators are being applied in one country or another where shellfish growing areas are routinely monitored. These indicators include E. coli, faecal coliforms, faecal streptococci, Cl. perfringens and Salmonella. However, in certain circumstances, such as those occurring after a disease incident with shellfish, the range of tests should be expanded to include pathogens likely to be implicated. Among them are Salmonella typhi, other salmonella spp., V. parahaemolyticus and V. cholerae.

Considering the universality of faecal coliforms, these indicators are being retained for routine monitoring. However, the study of other practical indicators as well as new ones should be included in any monitoring exercise, with the aim to further improve results by selecting better indicators, simplified methods, and more economic procedures.

The methods usually applied include the MPN method, the MF method and the total plate count method. Similarly the media used for recovery of the indicators are various. Here again the aim is to apply appropriate reference methods which will be used by all

those concerned in the Mediterranean area, and will provide more satisfactory results.

In addition to simplification and applicability all over the Mediterranean, the proposed harmonization of quality criteria and methodology is aiming at promoting comparability, uniform evaluation, exchanging of knowledge and experience, gradual improvement of approach and of results, development of control methods, and certification and recognition of results. Gradually the quality criteria may be subject to refinement and additions, in order to meet the requirements defined by different species of shellfish and/or conditions in the Mediterranean.

Purification of shellfish may also be expanded in the Mediterranean in the future. In this respect, quality criteria should be developed and applied for sea water in storage basins and in purification plants. There also, quality criteria for shellfish flesh will be needed.

In view of the absence of epidemiological studies to back any criterion, the proposed criteria for shellfish growing waters are based on the available experience in European countries and in the U.S.A. Such quality criteria are proposed to be evaluated by appropriate epidemiological studies, which should be conducted in one of the following ways (WHO/UNEP, 1977a):

- Predictive models;

- Retrospective epidemiological studies of case reports and disease outbreaks; and

- Prospective controlled epidemiological and microbiological studies.

Following such evaluation, the proposed criteria may be adjusted as required.

The next step will be the establishment of standards based on the criteria. At that stage a decision should be made as to the "acceptable risks" of symptoms of varying degrees of severity, or of specific diseases. This decision should be influenced by social, economic, political and health factors.

3.4 Proposed environmental quality criteria for shellfish-growing areas in the Mediterranean

Based on the results and experience gathered from the joint WHO/UNEP pilot project on Coastal Quality Control in the Mediterranean (MED POL VII), and in accordance with the above review

of the scientific rationale presently available, the environmental quality criteria appearing in Table I are proposed for application to shellfish growing waters in the Mediterranean.

The proposed faecal coliforms criteria were unanimously adopted by the Principal Investigators of the institutes collaborating in the MED POL VII project. However, not only faecal coliforms were investigated during the pilot phase, but also total coliforms, faecal streptococci and total heterotrophic bacteria were included in the list of compulsory indicators. Moreover, Vibrio parahaemolyticus, Salmonella, and enteric viruses were also investigated on a voluntary basis as potential faecal indicators (WHO/UNEP, 1977b, 1980; UNEP 1981a).

In reviewing the results obtained from the shellfish monitoring programme, the participating Principal Investigators agreed that the compulsory microbiological parameters to be used for shellfish monitoring should be limited to faecal coliforms and faecal streptococci (WHO/UNEP, 1980). On the other hand, other potential indicators, such as Salmonella and enteric viruses should be further investigated.

The proposed criteria represent a main step in ensuring an appropriate level of protection for human consumption of shellfish grown in coastal areas of the Mediterranean. However, they should not be considered as rigid limitations, but instead requirements that can be amended as further scientific and technical information becomes available. Results from the MED POL - PHASE II should be of great value in this respect (UNEP, 1981b).

Experience gathered during the pilot phase of the MED POL VII pilot project should be used for establishing the monitoring network included in the MED POL - PHASE II, so it can provide the additional information needed for a better assessment of the quality of the shellfish growing waters in the Mediterranean.

Among the specific aspects to be considered for further improvement of the proposed quality criteria, the following can be mentioned:

(i) epidemiological studies should be carried out among permanent and seasonal populations of the Mediterranean coastal areas to appraise the public health implications of shellfish consumption;

(ii) studies should be conducted on the influence of the natural self-purification processes of shellfish on the accumulation of faecal microorganisms, to understand the parameters governing these processes, and to evaluate the relationship between growing water quality and shellfish flesh quality;

TABLE I: PROPOSED ENVIRONMENTAL CRITERIA FOR SHELLFISH GROWING AREAS OF THE MEDITERRANEAN

1. GROWING WATERS

Parameters	Concentration per 100 ml not to be exceeded in 80% 20% of the time	Minimum Sampling Frequency	Analytical Method	Interpretation Method
Faecal coliforms	10 100	In Winter: monthly In Summer: fortnightly	Membrane Filtration m-FC broth or agar incubated at 44.5±0.2°C for 24 h	Graphical or analytical adjustment to a lognormal probability distribution

2. SHELLFISH FLESH

Parameters	Concentration per gramme of flesh	Minimum Sampling Frequency	Analytical Method	Interpretation Method
Faecal coliforms	< 2 Sale permitted Between 3 & 10 temporary prohibition of sale > 10 Sale prohibited	In Winter: monthly In Summer: fortnightly	Multiple tube fermentation and counting according to MPN (Most Probable Number) MacConkey broth incubated at 35±0.5°C for 24 h and then at 44.5±0.2°C for 24 h	By individual results, histograms. or graphical adjustment of a lognormal probability distribution

(iii) further studies should be carried out on the adequacy and efficacy of analytical methods for detecting microbial indicators, as well as on the influence of intervalvular liquid on analytical results;

(iv) a quality control programme should be established and implemented by all the participating laboratories in order to ensure the accuracy, precision, and comparability of the results from microbiological analyses; and

(v) a systematic evaluation of microbiological data, from both shellfish growing waters and shellfish flesh, should be conducted preferably by graphical adjustment of a lognormal probability distribution, to attain a better understanding of the factors influencing the quality of both the shellfish flesh and the shellfish growing waters of the Mediterranean.

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4. ENVIRONMENTAL QUALITY CRITERIA FOR MERCURY IN SEAFOOD

4.1 Existing national provisions and international arrangements and agreements relevant to the Mediterranean

The mercury poisoning which occurred in Minamata and Niigata in Japan, in Iraq, and in other similar incidents, stimulated the concern of governments for the hazards of the ingestion of mercury by humans.

In this context various efforts were undertaken to investigate sources and levels of mercury in the environment, especially in relation to food contamination, and to establish regulatory action for the control of mercury in the environment, as a health measure irrespective of occupational exposure to mercury that is not dealt with in this context.

Fish and fish products were found to be the major if not the only source of intake of mercury for most people. Therefore, much of the regulatory approach is primarily directed to limit levels of mercury in fish and fish products fit for human consumption, and secondly emission of mercury in the environment being considered of secondary importance. The present limited knowledge of the cause and effect relationship of mercury in the physical environment and in living organisms implied the need of a significant safety margin for ensuring human health protection.

Nominal marine catch in the Mediterranean amounted to 1.2 million metric tons in 1978 (Table I), 300 000 tons caught by vessels from countries outside the Mediterranean. The most important single groups of species by weight were the clupeids and the engraulids, with about 350 000 tons each. Landings were highest in Italy, Spain and Turkey (GFCM/CGPM, 1980). Total net imports of countries with major fisheries operating within the Mediterranean peaked in Italy and Yugoslavia.

In studying the need for setting maximum levels for mercury in food, a number of countries conducted surveys of the dietary intakes of their populations. Particular studies relating mercury levels and the amount of fish consumed by populations in the Mediterranean area were conducted in France and Italy.

Average annual per capita consumption of fish and shellfish (in kg) in Mediterranean countries amounts to [1]:

Albania (1.8)	Algeria (2.3)	Cyprus (6.6)
Egypt (4.2)	France (22.2)	Greece (15.7)
Israel (11.1)	Italy (12.5)	Lebanon (3.4)
Libya (4.1)	Malta (13.3)	Monaco (4.6)
Morocco (4.6)	Spain (35.2)	Syria (1.5)
Tunisia (5.3)	Turkey (4.5)	Yugoslavia (3.0)

[1] Source: Standardized Food Balance Sheets, FAO, Rome, Fisheries Department, Policy and Planning Division (unpubl.).

TABLE I

Marine catch (in metric tons) in the Mediterranean (1978) by country by major species or species groups B/
(Source: GFCM, Statistical Bulletin, No. 3. Nominal catches 1968-1970. 1980. 124 p., Table 3.00)
(Source for net import: FAO, 1979 Yearbook of fishery statistics. Fishery commodities, vol. 49. 1981) 170 p., Table A1-5)

Country	Total catch (net import C/)	Tuna and Bonitos	Sharks, rays, chimaeras	*Xiphias gladius*	*Nephrops norvegicus*	*Sardina pilchardus*	*Engraulis encrasicolus*	Carangidae (*Trachurus*)	Sparidae (*Boops*)	Gadiformes (*Merluccius*)	Cephalopods (*Sepia*, *Loligo*, Octopuses)
Albania	4 000F/										
Algeria	34 143 (9 019F/)	216	546	120	33	19 707	2 734	1 368	3 613	1 192	
Cyprus	1 245 (4 602)		16	91				8	262	3	128
Egypt A/	11 636 (79 779)		224					81	1 502	1	560
France A/	42 400 (326 852)	1 597	287			11 412	2 122	552	1 782	2 131	1 622
Greece	69 753* (27 308)	500				12 234	7 387	7 188	6 630	2 564	2 154
Israel	3 550 (20 811)							100	200	100	
Italy	336 699** (279 341)	2 555	4 576	4 031	2 905	53 522	53 794	8 459	12 993	16 132	27 408
Lebanon	2 400F/ (5 500F/)										
Libya	4 803 (262F/)	634	1 000						634	130	
Malta	1 044 (2 519F/)	61	53	121				174	188	8	38
Monaco											
Morocco A/	31 410 (-82 651)	356	151	4		15 272	7 523	2 908	1 801	35	48
Spain A/	153 876 (433)	2 909		806	533	41 460	26 820	15 832	9 804	10 135	8 092
Syria	1 361 (7 223)							68	123	95	
Tunisia	35 665* (-6 186)	791	968			8 337	211	917	3 596	605	4 579
Turkey	125 227* (-5 169)	2 947				1 417	79 883	20 159		3 913	61
Yugoslavia	37 464 (99 162)	1 111	480		355	22 246	2 769	714	1 055	646	781
MED TOTAL	1 200 945***	13 854	11 063	5 373	3 839	185 607	342 831	60 543	45 063	39 594	45 471

* Provisional figures ** 74 021 metric tons of unidentified marine fishes *** Including about 300 000 metric tons caught by other nations

A/ Countries fishing to a great extent outside the Mediterranean

B/ Selection criteria: high proportion of total catch and/or high average mercury level

C/ Net import equals total import minus export; might give a first indication of flows of fishery commodities into the Mediterranean countries from within or outside the region

F/ FAO estimate

In the Mediterranean the countries which establish regulations mainly place an overall limit on mercury concentration in fish. Here below is a summary of current maximum permissible levels of mercury in fish applied in Mediterranean countries where action levels have been set.

France, 0.7 mg/kg (ppm)	This limit is for fish expected to have a high level. For other fish 0.5 mg/kg applies.
	There is no legislation in force but random tests are made on imported fish and fish exceeding these limits are barred from the market.
Greece, 0.7 mg/kg	This is the limit for all seafood caught in Greek waters or imported and intended for local consumption.
	Legislation is still being drafted and the intention will be to change the limit to 0.5 mg/kg. In general, see Presidential Decree No. 786 on the veterinary inspection of fish, frozen and other preserved edible fish products of 19 October 1978.
	Studies with the scope or target of specifying the mercury pollution and content of fish and shellfish are under way.
Israel, 0.5 mg/kg	Maximum level for both domestic and imported fish; tuna receives special attention.
	New legislation is being prepared.
Italy, 0.7 mg/kg	There are no recommendations made regarding sizes and quantities per head per week. See Ministerial Decree of 28 January 1980 on maximum level of mercury for fish.
Spain, 0.5 mg/kg	-
Yugoslavia	See in general the Regulations on the quality of fish of 3 February 1978

At the international level, FAO, WHO and the OECD, have been periodically involved in studying the problem of food contamination by mercury. In 1967 the Joint FAO/WHO Expert Committee on Food Additives first considered the problem and recommended that "any use of mercury compounds that increases the level of mercury in food should be strongly discouraged". In 1972, the same committee met again and recommended a provisional tolerable weekly intake (PTWI) of 0.3 mg total mercury per person of 70 kg, of which no more than 0.2 mg should be present as methylmercury (expressed as weight of mercury) (Joint FAO/WHO Expert Committee on Food Additives 1972).

The Commission of the European Communities has transmitted to the Council the proposals for a directive concerning the upper limits for mercury discharges and the quality objectives for the aquatic environment in which mercury is discharged from the chloralkali electrolysis industry (26/6/79 J.O. No. C169 dated 6/7/79).

Within the frame of the proposed directive on quality objectives points 1 and 2 of Annex I respectively provide that the concentration of mercury in the waters must not be more than 0.5 ug/l within the fresh water limit. It must not be more than 0.05 ug/l beyond that limit. The mercury content in the flesh of fish living beyond the limit of fresh waters should not exceed 0.3 mg/kg of wet weight.

Since fish eating habits may vary from one population or subgroup to another and mercury levels in fish and shellfish differ according to species, the problem should be tackled with respect to intake levels of mercury, although it is understood that it may be very difficult to change taste, preference patterns, particularly where fish may be a readily accessible source of protein for certain populations for which there is no easy substitute.

4.2 Mercury in Mediterranean seafood

The two principle pathways for mercury intake by aquatic organisms are via the ingestion of organisms containing mercury and by direct uptake of mercury from the water.

The concentrations of total mercury in fresh tissue of fish, of which usually the greater part is present in the organic form, may show marked variation according to the geographical area and the age or size of the fish.

Irrespective of the area, some species (tuna, swordfish, elasmobranchs and norway lobster) constituting about 3% of the total fish caught in the Mediterranean, tend to have higher mercury levels per unit fresh weight than others caught in the same area. All of these average around or above 1 mg/kg wet weight. The individual analyses range between 0.05 and 6.3 mg/kg in tuna, 0.05 and >2.0 in swordfish, 0.06 and well above 2.0 in dogfish, sharks and rays, and 0.04 and 3.0 mg/kg in Norway lobster.

Still, interspecific comparison yields some remarkable differences between mercury levels in specimens caught in the Mediterranean and those from the Atlantic with usually lower concentrations in the latter. For hake, Merluccius merluccius for example, the International Council for the Exploration of the Sea (ICES) baseline study in the North Atlantic gave mean concentrations between 0.03 and 0.13 mg/kg and a total range between 0.02 and 0.22 mg/kg (ICES, 1977a), whereas Mediterranean specimens analysed had a much broader range of concentrations with an upper limit of 0.85 mg/kg and an average of about 0.34 mg/kg (FAO/UNEP, 1981).

Bluefin tuna (Thunnus thynnus thynnus) caught off the French coast in the Mediterranean displayed average levels of mercury 1.10 mg/kg with a range in 176 samples of 0.02 to 6.29 mg/kg (FAO/UNEP, 1981). Equivalent samples from the Bay of Biscay ranged from 0.02 to 0.8 mg/kg with the bulk of the data around 0.5 mg/kg. The same has been found in other tuna species ie. Thunnus alalunga in which mercury levels are about three times higher in the Mediterranean (Cumont et al., 1975).

In the Mediterranean itself two populations of bluefin tuna can be distinguished: one with a high body burden of mercury and positive correlation with the length (and/or weight) and another with a lower concentration of mercury and no evident correlation with the size of the animals. The mercury content of tuna collected in the Atlantic (just before entering the Mediterranean through the Strait of Gibraltar) instead is relatively low and is in the same range of values of those of the second population caught in the Mediterranean Sea, i.e. the population with low levels; this finding suggests that the two groups present in the Mediterranean during the reproductive season are (1) specimens that have spent their entire life in this sea, and (2) those that migrate from time to time from the Atlantic Ocean into the Mediterranean (Renzoni et al., 1978).

Mercury levels are not higher in all species of fish caught in the Mediterranean than they are in fish caught elsewhere. Average levels in Trachurus mediterraneus, the Mediterranean horse mackerel, are between 0.093 and 0.345 mg/kg, excluding an outlier of 0.705 mg/kg in area II (Fig. 1) based only on 3 samples. They are similar to the mean values between 0.17 and 0.33 mg/kg reported for Trachurus trachurus, the common horse mackerel, in the North Sea (ICES, 1977). The anchovy Engraulis encrasicolus shows levels around 0.16 mg/kg in 223 samples, and 46 analyses on the pilchard, Sardina pilchardus averaged 0.25 mg/kg (FAO/UNEP, 1981). Boops, Dicentrarchus, and other sparids of commercial relevance in the Mediterranean have moderate mercury levels throughout, averaging 0.20 mg/kg, though it should be noted that occasionally elevated values up to 0.85 mg/kg have been found. The same holds for cephalopods, such as Loligo and Sepia, with mean mercury levels of about 0.25 and peak values up to 1.3 mg/kg (Nauen et al., 1980)

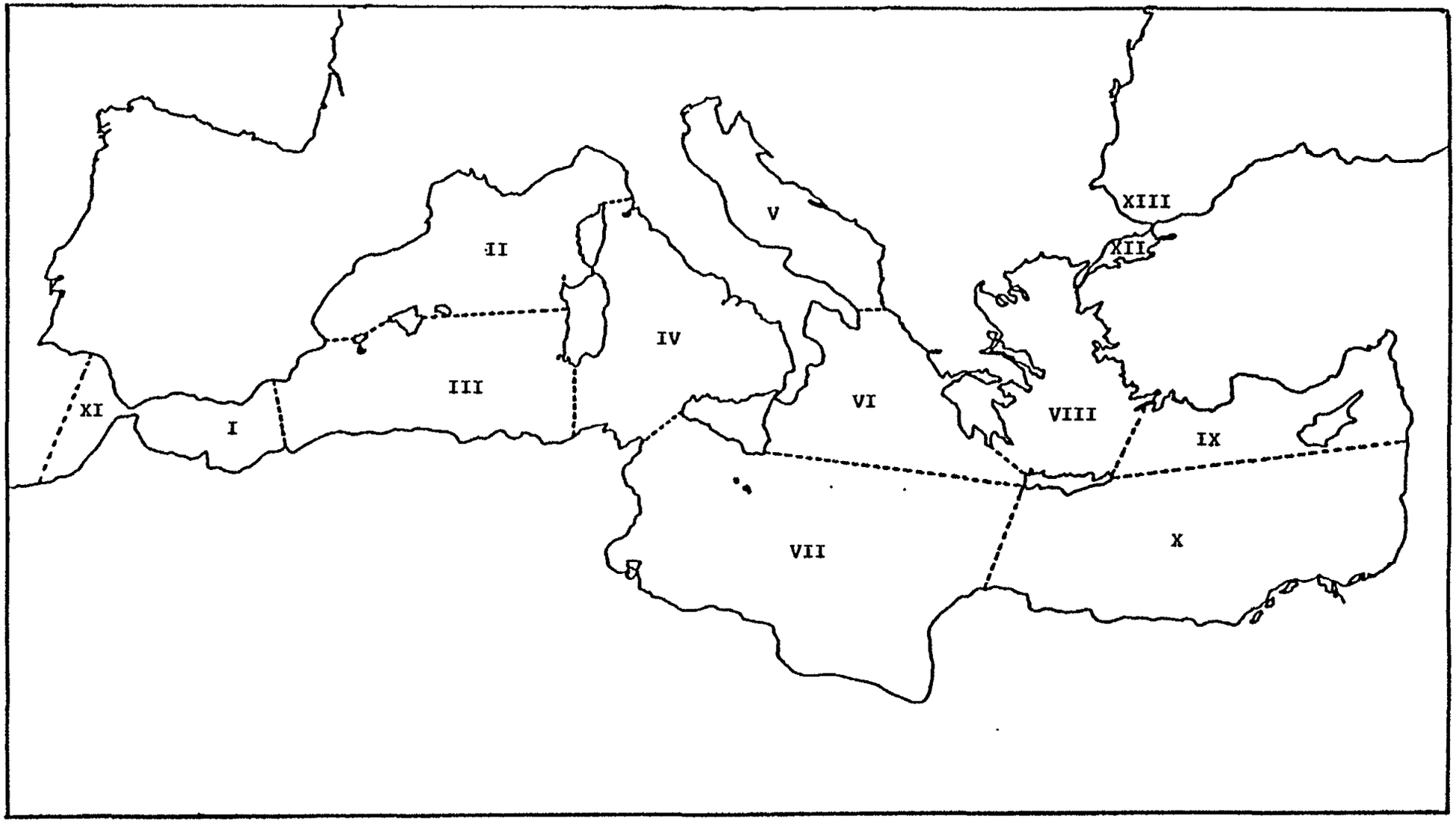

Figure 1. Sampling areas for MED

I	Alboran	V	Adriatic	IX	N. Levantin	XII	Black Sea
II	North-Western	VI	Ionian	X	S. Levantin		
III	South-Western	VII	Central	XI	Atlantic		
IV	Tyrrhenian	VIII	Aegean	XII	Sea of Marmara		

All the above mentioned species do migrate to some extent at least within the Mediteranean. Contamination levels can therefore be considered as an integration over space, though even in such species mercury levels tend to be higher in specimens caught adjacent to major industrial sites. This is even more so in the more sedentary species such as the striped mullet, Mullus barbatus, with mercury levels generally around 0.2 mg/kg or less. Particularly in MED POL areas II, IV and V (Fig. 1), however, values are reported to be considerably increased (FAO/UNEP, 1981). In area II (Fig. 1), where the bulk of the samples were collected from the Gulf of Lions 492 samples of striped mullet have not only an average of 0.59 mg/kg, about three times higher than that from the Aegean but also a much wider range of 0.02 to 7.9 mg/kg (FAO/UNEP, 1981). Bacci et al. (1980) showed highly increased mercury levels in the mullet caught in the Tyrrhenian, where cinnabar rich bedrock of the Mount Amiata region supports mercury extracting industries eventually draining their waste water into the sea. The average mercury concentration in area IV (Fig. 1) in 405 samples of mullet was 1.3 mg/kg ranging from 0.06 to 7.05 mg/kg.

Species that are virtually sedentary or even sessile, such as the Mediterranean blue mussel, Mytilus galloprovincialis, are more likely to reflect the 'local situation'. Consequently, levels in mussels sampled at 'hot spot' areas will be higher than the average. Mussels collected in rather polluted sites in the Adriatic generated an outstanding mean value of 1.1 mg/kg with a maximum of 8.04 mg/kg. Other high values are reported from the Tyrrhenian averaging 0.52 mg/kg in 109 samples. All other results are below 0.2 mg/kg fresh weight. These local differences are reflected in high standard deviations sometimes even exceeding the average (FAO/UNEP, 1981).

4.3 Scientific rationale for the criteria applicable to the mercury in Mediterranean seafood

It is recognized that an evaluation of health hazards through the consumption of Mediterranean seafood is difficult due to the very limited data for those populations considered likely to have an increased mercury intake. However, it is agreed that the intake of methylmercury in seafood may constitute a health hazard.

Table II sets out some comparative analytical figures for the mercury content of fish muscle sampled from various seas around the world. There is no doubt that in general levels of mercury are higher in Mediterranean fish. However, the following hypothetical calculations based on Table II suggest that the bulk of the population probably has a low methylmercury intake and is thus at negligible risk. An unknown factor that will reduce intake is the extent to which consumers include fish from outside the Mediterranean in their diet.

TABLE II

Range of published* approximate average values of mercury expressed in mg/kg wet weight in muscle tissue of various marine species modified after Piotrowski and Inskip (1980). It is understood that up to 100% of total mercury in fish is in the form of methylmercury.

Fish Species	Ocean/Sea			
	Atlantic	Pacific	Indian	Mediterranean
Mackerel	0.07 - 0.24	0.16 - 0.25	0.005	0.20
Sardine	0.03 - 0.06	0.03	0.006	0.16 - 0.25
Unspecified number of edible (non-predatory) spp.	0.08 - 0.27	0.07 - 0.09	0.02 - 0.16	0.10 - 0.30
Tuna	0.30 - 0.80	0.30	0.06 - 0.40	1.20
Swordfish	1.30	0.80 - 1.60	-	1.20**
Shark) Dogfish) spp. Ray)	1.00	0.70 - 1.10	0.04 - 1.50	0.06 ->2.0

*See also IRPTC (1980)
**Based on very few data

(i) For the majority of seafoods (excluding certain species of tuna, swordfish and elasmobranchs, for example) an average methlymercury content of up to 300 ug/kg wet weight is assumed; one meal of 150 gr would be equivalent to a methylmercury content of 45 ug. For a 70 kg body weight of an adult this would mean that with an intake of less than four fish meals per week, the PTWI would not be exceeded. (10-20 per cent of the PTWI should be allowed for methylmercury intake from other sources).

(ii) For certain marine species (including tuna, swordfish, elasmobranchs, Norway lobster and various other species) caught adjacent to anthropogenic mercury discharges, an average methylmercury content of up to 1 800 ug/kg is assumed; one meal of 150 g would be approximately equivalent to a methylmercury intake of 270 ug. In this case, therefore, fish consumption would have to be less than one meal per week to give an intake below the PTWI.

Although the above tentative calculation suggests a low methylmercury intake for the general population, it is considered that the following groups of the population have high methylmercury intake which may, in some cases, exceed the PTWI;

(i) Fishermen and their families

(ii) Employees of the fish industry and their families

(iii) Employees of fish restaurants and their families

(iv) Consumers of seafood with especially high concentration of methylmercury

Within the above groups special attention should be paid to women of child-bearing age as pre-natal life is considered as the most sensitive stage of the life cycle to methylmercury.

There are very limited data available on the level of methylmercury intake by the above groups. Data from Italy suggest that some intakes may be up to 3.5 ug/kg body weight per day i.e. 1.7 mg/week/70 kg.

Actual measurements by biological monitoring of mercury in blood of such populations in Italy have ranged up to 400 ug/l of red blood cells. This corresponds to levels of up to 200 ug/ml of whole blood. Some additional data from other Mediterranean countries may be available but they are not published. The few studies undertaken have not detected health effects due to methylmercury intake through seafood. However, this does not exclude the possibility of cases of mild methylmercury poisoning in the studied areas.

In summary, it is clear that there are serious gaps in the knowledge needed for an appropriate evaluation of health hazards and protection of the possible populations at risk.

Some suggestions for future studies needed to supplement existing knowledge in order of priority are:

(i) The accumulation of more extensive data about the mercury content of various species and sizes of fish sampled from specific consumption areas. Countries and islands with an entirely Mediterranean coastline and a high per capita fish consumption would be suitable. "Hot spot" areas could be selected and studied in depth.

(ii) Parallel to the above study, the eating habits in a few selected populations , covered for a full cycle of fish stocks (i.e. possibly for 1 year) should be undertaken.

(iii) When definite data concerning a population, the fish they actually consume and its mercury content becomes available, some biological monitoring should be undertaken in selected population, possibly commencing with the analysis of hair samples by internationally agreed compatible methods.

(iv) Studies should be undertaken to accumulate data on infantile mortality and morbidity in the areas under investigation.

(v) Surveys should be undertaken to identify anthropogenic sources of mercury and other selected pollutants and their contribution to the contamination of fish.

4.4 Proposed environmental quality criteria for mercury in Mediterranean seafood

The Consultation to re-examine the WHO environmental health criteria for Mercury (Geneva 21-25/4/80) and subsequent studies, acknowledged that the WHO Provisional Tolerable Weekly Intake of 200 ug methylmercury for a person of 70 kg body weight remains a valid recommendation in the light of presently available data. Based on present data on fish consumption in the Mediterranean area and concentration of methylmercury reported in fish, as mentioned in paragraph 3 above, it is considered that the major part of the population has an intake well below the PTWI, and that there seems to be little risk of not imposing an upper limit to the mercury level in marine organisms used for human consumption.

However, since a part of the population in the Mediterranean area have an intake of methylmercury through seafood which exceeds the PTWI, it should be recommended that the total intake of methylmercury through seafood be limited to protect such segments of population. It is realized that any such action may be contingent upon the availability of adequate data. In such situations the following courses of action could be considered:

(a) Advice on dietary intake, including:

(i) choice of the species and/or the size of fish allowed for consumption;
(ii) frequency and number of fish meals;
(iii) diversified sources of protein.

(b) The establishment of environmental quality criteria for mercury in other parts of the marine ecosystem which might end up in the banning or limitation of fishing, and/or the limitation of anthropogenic mercury discharged in certain areas with exceptionally high environmental mercury levels.

The advantages and disadvantages of various administrative actions are set out in Table III.

Since almost all marine species fit for human consumption are likely to have greatly elevated levels of methylmercury when caught in areas adjacent to anthropogenic mercury discharges it is clearly important to reduce as far as possible such sources of contamination. However, in the light of the natural sources of mercury found in the Mediterranean Basin this is unlikely to be an effective measure for the general Mediterranean mercury problem unless taken together with other steps. Any health effects will be the result of the total intake of mercury which is itself a function of the levels in the seafood, the quantity ingested per meal and the frequency of such meals. As has been indicated, the complete elimination of methylmercury from dietary fish is not feasible. However, where there is evidence of intakes of mercury above the recommended WHO Provisional Tolerable Weekly Intake this should be reduced by the recommendation of suitable dietary modifications.

Finally it should be noted that at the WHO Consultation held to re-examine the WHO Environmental Health Criteria for Mercury held in Geneva, 21-25 April 1980, it was concluded that "the fetus and possibly the pregnant woman are at greater risk than the non-pregnant adult population and, though not at present prepared to make a firm estimate of increased risk the group feels that the situation should be kept under close observation pending further evidence". In the light of this recommendation it is clearly adviseable to pay particular attention to pregnant women in any survey.

TABLE III

Advantages and disadvantages of various administrative actions that could be taken to reduce mercury intake by populations at risk

Administrative measures	Advantages	Disadvantages
I. Measures addressed to the fishery (indirect)		
- Establishment of standards in all seafood	Equal handling of all seafood; rejection of commodities with contaminant levels higher than the action level from the market according to enforcement.	High costs of monitoring system as prior condition of enforcement; little chance of enforcement for those with direct access to the resource, such as fishermen; thus, little protective effect and negative on the fishery and the marketing of fish products in general or of selected species.
- Establishment of standards in selected species	More specific towards only some of few species; reducing enforcement costs.	
- Restriction on the size of fish allowed for consumption for certain species in which mercury concentrations are known to be a function of size	Reduction of amount of commodities that need to be rejected from the market or discarded from the catch; reduction of enforcement costs; could partly be achieved through mesh size regulation.	Difficult to enforce due to high appreciation of big specimens.
- Ban or limit fishing in certain areas	Selective exclusion or reduction of availability of seafood species from 'hot spot' areas to consumers.	Difficult and costly to enforce if many large areas are affected; possible negative side effect of reduced fishing pressure could be increased in average size of the specimens and of the total fish population with subsequent migration due to increased intraspecific competition.
II. Measures addressed to the anthropogenic mercury discharge (indirect)		
- Limit anthropogenic discharges of mercury	Reduce the number of anthropogenic 'hot spots' in which seafood tend to have elevated mercury levels because of contaminant discharge.	Since anthropogenic discharge of mercury accounts for a minor part of total mercury in the Mediterranean, control measures towards the sources alone cannot solve this problem.
III. Measures addressed to seafood consumption (direct)		
- Advice on dietary intake: Choice of species	No necessity to reject any fish or shellfish with relation to mercury levels, but spread the distribution of species with known high mercury levels, substitute them by species with lower levels as much as possible.	Food consumption patterns are generally very conservative and taste preferences are particularly difficut to change: requires costly information campaigns, if large populations have to be addressed.
- Advice on dietary intake: Frequency of fish meals and other available sources of protein	As above; reduce the frequency of consumption especially of species with high mercury load and substitute by other sources of protein. Feasible method for sub-populations particularly at risk.	In view of easy and cheap accessibility, a reduction in total seafood consumption or in some species is difficult to achieve unless the message convincingly comes across and either low level fish species or other protein sources become as readily available.

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