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Task Group 8 Report

Contaminants and pollution effects

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PREFACE

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) requires that the European Commission (by 15 July 2010) should lay down criteria and methodological standards to allow consistency in approach in evaluating the extent to which Good Environmental Status (GES) is being achieved. ICES and JRC were contracted to provide scientific support for the Commission in meeting this obligation.

A total of 10 reports have been prepared relating to the descriptors of GES listed in Annex I of the Directive. Eight reports have been prepared by groups of independent experts coordinated by JRC and ICES in response to this contract. In addition, reports for two descriptors (Contaminants in fish and other seafood and Marine Litter) were written by expert groups coordinated by DG SANCO and IFREMER respectively.

A Task Group was established for each of the qualitative Descriptors. Each Task Group consisted of selected experts providing experience related to the four marine regions (the Baltic Sea, the North-east Atlantic, the Mediterranean Sea and the Black Sea) and an appropriate scope of relevant scientific expertise. Observers from the Regional Seas Conventions were also invited to each Task Group to help ensure the inclusion of relevant work by those Conventions. A Management Group consisting of the Chairs of the Task Groups including those from DG SANCO and IFREMER and a Steering Group from JRC and ICES joined by those in the JRC responsible for the technical/scientific work for the Task Groups coordinated by JRC, coordinated the work. The conclusions in the reports of the Task Groups and Management Group are not necessarily those of the coordinating organisations.

This report presents the findings of the task group addressing Descriptor 8 "Concentrations of contaminants are at levels not giving rise to pollution effects." The group met twice (06.-07.04.2009 in Ranco, Italy, and 20.-23.10.2009 in Amalfi, Italy) and had one web conference. Much of the work was carried out by correspondence. The group worked in a very interactive and efficient manner, both the experts and observers giving valuable input to the document.

Readers of this report are urged to also read the report of the above mentioned Management Group since it provides the proper context for the individual Task Group reports as well as a discussion of a number of important overarching issues.

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EXECUTIVE SUMMARY

We recommend that the assessment of achievement of Good Environmental Status (GES) under the Marine Strategy Framework Directive 2008/56/EC (MSFD) Descriptor 8 "Concentrations of contaminants are at levels not giving rise to pollution effects" should be based upon monitoring programmes covering the concentrations of chemical contaminants and also biological measurements relating to the effects of pollutants on marine organisms in each of the assessment regions. The combination of conventional and newer, effect based, methodologies, with the assessment of environmental concentrations of contaminants provides a powerful and comprehensive approach. As the occurrence of adverse effects at various levels of organisation (organism, population, community, and ecosystem) needs to be avoided, monitoring schemes should also indicate the approaching of critical values as early warning.

Therefore, for the purpose of implementing Descriptor 8 under the MSFD, three core elements of data assessment are recommended:

- Concentrations of contaminants in water, sediment and/or biota are below environmental target levels identified on the basis of ecotoxicological data;
- Levels of pollution effects are below environmental target levels representing harm at organism, population, community and ecosystem levels;
- Concentrations of contaminants in water, sediment and/or biota, and the occurrence and severity of pollution effects, should not be increasing.

Monitoring programmes should include the assessment of concentrations of contaminants in environmental matrices, i.e. water, sediment, and the tissues of biota. Monitoring programmes should also include the quantification of biological effects of contaminants at different levels of biological organisation. The selection of contaminants, monitoring species and biological effects measurements should be made for each assessment region by the Member States (MS) with responsibility for implementation of MSFD in each region. Therefore, the priority monitoring matrices, and chemical and biological measurements made may vary between assessment regions in response to regional concerns and environmental conditions. However, monitoring and assessment should be harmonised to the greatest possible degree between assessment regions eventually allowing comparison between regions.

Monitoring data should be interpreted against the objective described by Descriptor 8 through a series of environmental target levels, expressed as concentrations of chemical contaminants, or levels of biological response. In particular, monitoring data should be interpreted against environmental target levels that are designed to protect against the occurrence of pollution effects. Examples of suitable target levels include Environmental Quality Standards (EQSs) derived under the Water Framework Directive 2000/60/EC (WFD), Environmental Assessment Criteria (EACs) as defined within OSPAR for water, sediment and biota, and parallel target levels used by other Regional Conventions or MS for the interpretation of monitoring data. Biological effects should be assessed against environmental target levels of response that are indicative of significant harm to the organisms concerned. The aim is to prevent pollution effects occurring at the organism, population, community and ecosystem level.

In addition, monitoring data should be assessed against background concentrations of contaminants or levels of biological response to enable added-risk approaches to be used in the derivation of environmental target levels, to enable greater use to be made of monitoring data in interpreting the causative agents of pollution effects, and to give early warnings of potential developing problems.

Increasing contaminant concentrations increase the likelihood of pollution effects. In order to minimize the risk of deleterious effects, concentrations of contaminants in water, sediment and/or biota, and the occurrence and severity of pollution effects, should not be increasing. Regional Conventions have developed robust statistical approaches to the analysis of time series of monitoring data to detect significant trends over time. These should be applied to chemical and biological effects monitoring data.

The integration of the results of chemical monitoring programmes, and combination of data from chemical and biological effects monitoring, is an active area of science within the Regional Conventions (i.e. OSPAR, HELCOM, and MEDPOL). Current experience indicates that integration is greatly facilitated by coherent and consistent sets of environmental target levels (EQSs, EACs, etc). Further development work is necessary, through the EU, Regional Conventions or MS, to expand the range of target levels to include a greater number of contaminants and biological effects. Integrated monitoring programmes, data collation, interpretation and presentation schemes are being developed and applied by the Regional Conventions, and we recommend that this work continues and that MS apply the best international advice applicable to MSFD regions for which they have responsibility.

A core of both chemical analytical methods and biological effects methods exists which can be applied now. There are considerable benefits to be gained from the international experience in programme design, measurement methodology and data management and interpretation available from the Regional Convention programmes, and the EU (e.g. WFD). Detailed implementation of programmes for MSFD Descriptor 8 should build upon these, and upon existing data, to ensure that assessments against GES are as robust as possible. However, marine monitoring science continues to develop, and the implementation strategy for MSFD should allow for programmes and procedures to evolve with time so as to maintain and improve the level of protection for marine ecosystems.

LIST OF ABBREVIATIONS

AMAP	Arctic Monitoring and Assessment Program
BAC	Background Assessment Concentration (OSPAR)
BC	Background Concentration (OSPAR)
CEMP	Coordinated Environmental Monitoring Programme (OSPAR)
CEN	European Committee for Standardization
DGT sampler	Diffusive gradients in thin film (DGT) passive samplers
EAC	Environmental Assessment Criteria (OSPAR)
EEA	European Environment Agency
EQS	Environmental Quality Standards (WFD)
GES	Good Environmental Status
HELCOM	The Helsinki Commission Baltic Marine Environment Protection Commission
IAEA	International Atomic Energy Agency
ICES	International Council for the Exploration of the Sea
ISO	International Organization for Standardization
MEDPOL	The Programme for the Assessment and Control of Marine Pollution in the Mediterranean region
MS	EU Member States
MSFD	The Marine Strategy Framework Directive 2008/56/EC
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PFOS	Perfluorooctanesulfonic acid
POPs	Persistent organic pollutants
TBT	Tributyltin
TMF	Trophic magnification factor
UNCLOS	United Nations Convention on the Law of the Sea
WFD	The Water Framework Directive 2000/60/EC

1. INITIAL INTERPRETATION OF THE DESCRIPTOR

1.1. Interpretation of the key terms used in the descriptor

In Annex I of the Marine Strategy Framework Directive 2008/56/EC (MSFD), Descriptor 8 is formulated as "Concentrations of contaminants are at levels not giving rise to pollution effects". Contaminants are defined as substances (i.e. chemical elements and compounds) or groups of substances that are toxic, persistent and liable to bioaccumulate, and other substances or groups of substances which give rise to an equivalent level of concern. This definition is in line with the definition of hazardous substances used in the Water Framework Directive 2000/60/EC (WFD), and by OSPAR and HELCOM.

Pollution effects are defined as direct and/or indirect adverse impacts of contaminants on the marine environment, such as harm to living resources and marine ecosystems, including loss of biodiversity, hazards to human health, the hindering of marine activities, including fishing, tourism and recreation and other legitimate uses of the sea, impairment of the quality for use of sea water and reduction of amenities or, in general, impairment of the sustainable use of marine goods and services.

1.2. Coverage of the descriptor

The descriptor is concerned with the pressures exerted by chemical pollution onto marine ecosystems. All contaminant types and pollution effects other than those covered by other descriptors will be considered.

Therefore nutrients and the introduction of energy will not be covered in Descriptor 8, as they will be assessed within Descriptor 5 and Descriptor 11, respectively. Likewise, the significance of the concentrations of contaminants in fish and other seafood for the protection of the health of human consumers will be excluded from Descriptor 8 as this is the subject of Descriptor 9. Tar balls are excluded from Descriptor 8 as their impact is primarily aesthetic and so they should be covered by Descriptor 10 as litter, while a short paragraph on oil slicks has been added under the Descriptor 8 header. Marine algal toxins are excluded as they are natural products rather than contaminants.

1.3. Links with other descriptors

The various descriptors of Good Environmental Status (GES) are closely linked with each other. Descriptor 8, dealing with effects caused by contaminants, has its closest links with Descriptor 9 on seafood as contaminant concentrations in marine species may give rise to concern not only for human consumption, but also to broader aspects of ecosystem integrity.

Descriptor 10 on marine litter is related to Descriptor 8 as litter may release contaminants, or due to the interaction between pollutants and litter, and also as the distinction between contaminants and litter may not be immediately clear for certain types of waste. Chemical pollution may affect biodiversity (Descriptor 1), the integrity of food webs (Descriptor 4) and sea-floor ecosystems (Descriptor 6), which are therefore closely linked.

1.3.1. WFD and other relevant policies and conventions related to the descriptor

The Water Framework Directive (WFD) establishes, *inter alia*, requirements for good surface water chemical status. Surface waters with regard to chemical status are defined as inland waters, except groundwater; transitional, coastal and territorial waters. Chemical status is defined in terms of compliance with environmental quality standards (EQSs) established for chemical substances at European level. The Directive also provides a mechanism for renewing these standards and establishing new ones by means of a prioritization mechanism for hazardous substances. Directive

2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy (Environmental Quality Standards Directive) sets EQSs for the priority substances and certain other pollutants (which are neither priority nor priority hazardous substances) in accordance with WFD requirements. MS are required to take actions to meet those quality standards by 2015. The Commission Directive 2009/90/EC of 31 July 2009 laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status has been adopted and enters into force on 21 August 2009. The objective of this Directive is to establish common quality rules for chemical analysis and monitoring of water, sediment and biota carried out by MS. The Directive shall be transposed within two years from entry into force. The implementation of this Directive in MS is assisted through the WFD Common Implementation Strategy and a series of guidance documents, which include chemical monitoring of surface waters.

REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) is a recent European Community Regulation on chemicals and their safe use (EC 1907/2006). One of the main goals of REACH is to improve the protection of human health and the environment from chemical risks. Its authorization system aims to ensure that substances of very high concern are adequately controlled, and progressively substituted by safer substances or technologies or only used where there is an overall benefit for society of using the substance. Furthermore, EU authorities may impose restrictions on the manufacture, use or placing on the market of substances causing an unacceptable risk to human health or the environment.

European Regional Seas are managed by dedicated Marine Conventions. The Convention on the Protection of the Marine Environment of the Baltic Sea Area is governed by the Helsinki Commission - Baltic Marine Environment Protection Commission (HELCOM). The HELCOM Baltic Sea Action Plan is intended to restore the good ecological status of the Baltic marine environment by 2020, and applies an ecosystem approach with associated monitoring activities. The North-East Atlantic is managed by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). The objectives of both OSPAR and HELCOM with regard to hazardous substances are to continuously reduce discharges, emissions and losses of hazardous substances, with complete cessation by 2020, the ultimate aim being the achievement of concentrations in the marine environment near background values for naturally occurring elements and substances and close to zero for man-made synthetic substances. The Mediterranean is managed by the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (the Barcelona Convention). The Programme for the Assessment and Control of Marine Pollution in the Mediterranean region (MEDPOL) is the environmental assessment component of the Mediterranean Action Plan (MAP). The objectives of the monitoring activities implemented as part of MEDPOL Phase IV are to present periodical assessments of the state of the environment in hot spots and coastal areas, to determine temporal trends of some selected contaminants in order to assess the effectiveness of actions and policy measures, and to enhance the control of pollution by means of compliance to national/international regulatory limits. The Black Sea is covered by the Convention on the Protection of the Black Sea Against Pollution (the Bucharest Convention). In the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP), each country is obliged to carry out ecological monitoring on marine stations, with particular emphasis given to eutrophication.

Besides these, there are international conventions which deal with the sources of specific contaminant types. The International Maritime Organization IMO deals with direct pollution of the Seas by human activities through different protocols, such as the London Dumping Convention (1972/1996) and specific protocols for maritime activities. The objective of the Stockholm Convention on Persistent Organic Pollutants is to protect human health and the environment from persistent organic pollutants.

1.4. Spatial coverage

In accordance with the MSFD Article 3(1), marine waters are defined as (a) waters, the seabed and subsoil on the seaward side of the baseline from which the extent of territorial waters is measured extending to the outermost reach of the area where a Member State has and/or exercises jurisdictional rights, in accordance with the UNCLOS (United Nations Convention on the Law of the Sea), with the exception of waters adjacent to the countries and territories mentioned in Annex II to the Treaty and the French Overseas Departments and Collectivities; and (b) coastal waters as defined by the WFD, their seabed and their subsoil, in so far as particular aspects of the environmental status of the marine environment are not already addressed through that Directive or other Community legislation. See Annex 1 for detailed information on jurisdictional rights of MS and maritime jurisdiction in the Mediterranean Sea. The WFD defines coastal waters as surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.

1.5. Conceptual approach

The assessment of achievement of GES should be based upon monitoring programmes covering the concentrations of chemical contaminants and also biological measurements relating to the effects of pollutants on marine organisms in each of the assessment regions. The combination of conventional and newer, effect based, methodologies, with the assessment of environmental concentrations of contaminants provides a powerful and comprehensive approach to Descriptor 8. As the occurrence of adverse effects at various levels of organisation (organism, population, community, and ecosystem) needs to be avoided, monitoring schemes should also indicate the approaching of critical values as an early warning of the potential for effects. Where possible, this should also include effects which may be caused by synergistic or cumulative interactions between different contaminants.

Monitoring and assessment for Descriptor 8 should therefore combine chemical and biological assessment methods. Early warning of conditions that would fail to meet the requirements of the descriptor should be built into the assessment process through temporal trend analyses of monitoring data.

1.6. Overall ecosystem approach

In the marine strategies to be developed and implemented in respect of each marine region or subregion, an ecosystem-based approach to the management of human activities is to be used (MSFD Article 1(3)). This is to ensure that the collective pressure from human activities is kept within levels compatible with the achievement of GES and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations.

The Convention on Biological Diversity (www.cbd.int) defines the ecosystem approach as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Additionally, HELCOM and OSPAR have adopted a common vision of an ecosystem approach applied to their maritime areas defined as "the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity". The application of the precautionary principle is a central part of this ecosystem approach. In the Mediterranean region, the Contracting Parties of the Barcelona Convention have also decided (2008) to progressively apply the ecosystem approach to the management of human activities that may affect the Mediterranean marine and coastal environment for the promotion of sustainable development.

With regard to Descriptor 8, the ecosystem-based approach denotes that pollution effects need to be considered at various biological levels of organization, taking into account effects due to the interaction of contaminants with other abiotic and biotic factors.

2. REVIEW OF SCIENTIFIC LITERATURE AND EXISTING METHODS

Chemical contaminant concentrations are an aspect of the objective of achieving clean, safe, healthy, biologically diverse and productive seas in the MSFD context. A potential consequence of seas that are chemically contaminated is that organisms or biological processes may be adversely affected. In the following, two main approaches to studying pollution effects, i.e. measurements of biological effect parameters and contaminant concentrations, are presented. The need for quality control methodologies and procedures to underpin all of these techniques and to ensure that data are “fit for purpose” under MSFD cannot be overstressed.

The essence of Descriptor 8 is the avoidance of pollution effects arising from marine contaminants. Text below demonstrates the range of effects that can arise from exposure to contaminants, and the potential of contaminants to cause undesirable biological effects is reflected in the chemical monitoring programs undertaken through the Regional Conventions, under WFD, and in response to other drivers.

In order to interpret chemical monitoring data in terms of the consequential risk to marine organisms, various types of standards or assessment thresholds have been developed. These include standards/criteria that reflect background conditions and standards/criteria that are designed to protect the health of sensitive organisms. The former include Background Concentrations developed within OSPAR, for example, while the latter include EQSs developed through the WFD process, and Environmental Assessment Criteria (EACs) developed through OSPAR processes (as examples). The use of these standards/criteria, together with standards/criteria for biological effects, offers the potential of interpretation of monitoring data in a coherent and internally consistent manner.

While there are different terms in use for expressing the concept of an upper boundary limit for environmental concentrations not causing harm, such as threshold values, quality standards, assessment criteria, in this document a wording consistent with the MSFD definition (Article 3 (7)) has been used. Therefore such values/standards are referred to as “environmental target levels”,

2.1. Biological effects of contaminants

2.1.1. Review of chemical substance-related effects in the European marine environment

There is an overwhelming amount of evidence demonstrating that a wide range of chemicals in sediments and water are responsible for toxicological and undesirable effects in a large variety of marine organisms in many areas of the European marine environment (summarized in Annex 2). Such effects range from mortality, cellular and biochemical alterations, and histopathological lesions, to subtle impacts on reproduction and normal endocrine function, and are particularly marked in many urbanised estuaries and other semi-enclosed marine waters. Effects of persistent substances have also been observed in coastal and offshore organisms, particularly in those associated with sediments, or which occupy higher trophic levels where such contaminants tend to accumulate. There is growing evidence that contaminants may be partly responsible for the observed increase in disease outbreaks in marine organisms (e.g. marine mammals, fish) by adversely affecting their immune systems. Some of these effects are known to have caused population declines or resulted in impoverished communities. There are, however, only a limited number of clear cases of impacts at population, community or ecosystem level effects due to chronic contaminant exposure in marine wildlife. One important reason for this is the simple fact that effects underwater will be more easily overlooked than in terrestrial systems. If a fish or another marine organism is dead or dying it will not be sampled by the methods most commonly used and any impacts will tend to be underestimated.

There are indications for effects due to chemicals on benthic community structure, plankton communities and epifaunal assembles in European marine waters, but the links are not clear. It can be expected, however, that in most cases, where and if contaminants do contribute to population or higher levels effects, the quantitative contribution of contaminants to the observed population effect will remain unknown. A novel risk assessment approach that integrates measured tissue residue levels with dose-response relationships can predict the health risk and uncertainties in the associations of the predictions for top predators (Schwacke et al. 2002). Risk assessment of secondary poisoning by persistent organic pollutants (POPs) in top predators can be based on a diet-based and tissue-based approach (Leonards et al. 2009).

2.1.2. Detection and quantification of effects caused by exposure to contaminants

Although contaminants will affect processes from molecular to ecosystem level, the contaminant specificity of detection methods is inversely related to complexity. There is rarely a direct relationship between tissue levels of contaminants and their effects (except in special cases with high exposure levels), and there is limited understanding of the effects of mixtures of contaminants and of interactions between contaminants and other environmental stressors. Nonetheless, a range of methods that may be used to address contaminant effects on biological systems have been developed over the past decade and many of them validated through use in national and international monitoring activities (ICES 2007b).

An understanding of causal relationships between contaminants and any observed effects, but also the ability of methods to separate between contaminant effects and natural processes, is crucial in the effective monitoring/management and restoration of impaired marine ecosystems. Priority compounds may interact with each other or with as yet unknown or emerging toxic compounds. Although there is a wealth of information available from laboratory studies, our understanding of the ecological relevance of chemical pollutants and the extent to which contaminants may change the genetic composition of populations is limited. The same is true for the indirect effects caused by chemical pollutants. Thus, it is challenging to assess the full extent, nature and significance of contaminant-related effects in marine ecosystems. Additional ecological concerns of contamination in the marine environment include changes in species distributions and abundance, habitat alterations, and changes in energy flow and biogeochemical cycles. The toxic effects of chemical contaminants on marine organisms depend on their toxicity profile, bioavailability and/or persistence, as well as the ability of organisms to accumulate and metabolize specific contaminants. The transfer of toxic chemicals through marine food chains can result in bioaccumulation in commercial fishery resources and transfer to the human consumer (considered within Descriptor 9).

2.1.3. Methods of determination and assessment of biological effects of contaminants

The assessment of impacts of contaminants on organisms requires consideration of effects throughout the hierarchy of biological organization, from the molecular and cellular to the organismal, population, community and ecosystem levels. Ideally, the causal evidence of contaminant effects should be based on a weight of evidence approach using field studies and laboratory studies on field-collected material (including bioassays), taking into account statistical association and meta-analysis, consistency, temporal trends and specificity. Specificity to contaminant stress, some form of dose-dependency and feasibility for use in the field are three critical properties for any method to be used to address Descriptor 8. Some methods have been found to comply with these requirements and have been recommended by ICES (International Council for the Exploration of the Sea) working groups as suitable for use in marine monitoring programs.

Although many of the model species originally used in toxicity testing are freshwater species, such tests are now also available for marine species, and the knowledge base for sublethal effects of contaminants is increasingly becoming similar for both freshwater and marine species and ecosystems. The assessment of pollutant effects can, however, be expected to be more challenging for marine ecosystems than for freshwater or terrestrial systems as: (1) there are complex and large-scale hydrodynamic and sedimentary processes resulting in variable transport and differences in the spatial and temporal levels of chemicals at local and global scales; (2) there is a large dilution of contaminants, which is generally challenging to model adequately; (3) there are complex trophic webs; (4) sea-going research and monitoring require an expensive infrastructure; and (5) marine ecosystems are open and it is therefore difficult to interpret biological impacts, especially at the population level.

In the following, four main approaches to evaluate contaminant effects in marine ecosystems are presented with particular emphasis on the different characteristics of the approaches: (i) model exposure and use laboratory-based effect levels in assessment, (ii) estimate effects from tissue levels of contaminants, (iii) estimate effects through toxicity assessment of abiotic or biotic components of ecosystems, or (iv) estimate effects on ecosystem components directly.

(i) model exposure and use laboratory-based effect levels

The risk arising from environmental exposure to toxic chemicals can be estimated in a standardised framework based on the information available, mainly from laboratory toxicity tests. To reflect increased risk when there is limited information available, the models are constructed to reflect worst-case situations. In this approach, the potential for effects is assessed through comparisons of exposure concentrations of toxicants in the field with threshold concentrations or assessment thresholds derived from laboratory tests with selected organisms (the basis set comprises alga, crustacean, fish). The consequences of exposure may also be modelled on the basis of measured levels in abiotic media (water, sediments). Such estimated exposure levels will be predictable and reproducible, but in most cases imprecise due to complex processes which are present in the environment but which cannot be taken account of in models.

(ii) estimate effects from tissue levels of contaminants

There is a long tradition of measuring the concentrations of contaminants in selected marine organisms and such data have frequently formed the basis for environmental assessments. Such data are clearly required to address time trends, spatial distribution and the safety to consumers of marine organisms, so it would have been useful if there was also a relationship between contaminant levels in tissues and effects on that individual. Some strategies to this end have met with some success, e.g. the critical body burden approach (Franke 1996) and efforts made through a series of OSPAR workshops to develop appropriate criteria (Thain et al. 2008). There are some reasons why this approach has not been entirely successful: firstly, some contaminants may cause effects although they do not accumulate, particularly in vertebrates (e.g. most endocrine disrupting substances, polycyclic aromatic hydrocarbons, organophosphate insecticides, etc.); secondly, it is at present not possible to integrate effects from different contaminants on an individual and, finally, many species accumulate contaminants in e.g. fatty tissues with no apparent ill effects. In the latter case, effects may only become evident when contaminants are mobilised, e.g. in relation to reproduction or starvation.

(iii) estimate effects through toxicity assessment of abiotic or biotic components

Contaminants are known to be irregularly distributed in the environment, but methods exist by which samples representative of an area of e.g. water or sediment can be collected. The use of passive samplers is one strategy by which it is possible to obtain a time-integrated sample of an abiotic environmental component, and which has the potential to reflect the critically-important, freely dissolved, portion of the total contaminant loading. The toxicity of such a sample can then be determined in detail through a range of bioassays (see Annex 3). Such assessment will make it possible to clarify the possible modes of action of the substances present, even if no analytical method exists for their direct identification and quantification. Subsequent fractionation and analyses (e.g. by Toxicity Identification and Evaluation procedures) can then aid in identifying the substance(s) that contribute to environmental risk.

(iv) estimate effects on ecosystem components directly

Contaminants may affect levels of ecosystem organisation from individual to community level. Although there are obvious issues with representativeness and specificity (see below), such information is clearly the ultimate goal in an assessment of contaminant effects on marine ecosystems. The ability of biological effects methods to identify and quantify effects of contaminants is regularly reviewed by the ICES Working Group on the Biological Effects of Contaminants. Briefly, with few exceptions, it is not really feasible at this time to link community or population effects to contaminants in field studies. The main reason is the large natural variability and the influence of other factors, such as organic enrichment or physical disturbance. An added complication for population assessment is the difficulty in observing dead or moribund individuals in marine ecosystems. Methods by which to quantify more or less contaminant specific effects at the individual level have increasingly been developed over the past decades and have been used in national and international monitoring programmes since the 1980s (e.g. Thain et al. 2008). An integration of such methods and the quantification of chemical determinands in assessments of adverse effects on the individual health of marine organisms lies at the core of a recently developed OSPAR monitoring framework (in Annex 4).

2.1.3.1. Requirements for effect based methods

A range of publications have proposed requirements for methods with which to assess the environmental effects of contaminants (Viarengo et al. 2007, Thain et al. 2008), but two stand out as more critical than the rest: specificity and sensitivity. There are two types of specificity: the ability to separate contaminant effects from the influence of other factors, and the ability to identify effects due to a specific contaminant or group of contaminants. It is also clear that methods need to be sufficiently sensitive to detect and quantify effects that will have relevance for the functioning of that particular biological system.

A general issue with all approaches is the area described by the chosen approach(es). While some methods cover a well-defined, limited area (e.g. benthic community, effects on sessile organisms, caging studies), other methods will, of necessity, integrate over larger areas (e.g. fish monitoring). It is critically important to identify the area under study and ensure that selected methods actually cover the area of interest.

2.1.3.2. Interpretation — what is an effect?

The definition of “effect” is at the core of the current process. As will be evident from the above, there are methods available to detect toxicologically relevant contaminants in abiotic matrices and contaminant-related responses in individuals. There is some, although limited, understanding of whether, and to what extent, such individual responses (biomarkers) actually represent adverse effects and affect fitness in organisms.

Methods that identify effects in individuals can be divided into two categories: (1) methods that indicate contaminant-linked sublethal responses, but which cannot with current knowledge be used to predict adverse effects on individual health, and (2) methods that indicate sublethal responses, but for which there is a mechanistic basis to make a prediction for adverse health effects for individual organisms. Category (1) methods would include methods such as PAH metabolites in bile, cytochrome P4501A activity in tissues and metallothionein concentrations in tissues, whereas category (2) methods would include methods such as lysosomal membrane stability, some fish diseases and DNA damage. For category (1) methods there would only be one assessment criterion, i.e. to separate "normal" and "affected" Category (2) methods would have two assessment criteria, one to indicate "affected" (as for category (1)) and a second to indicate adverse health effects. Criteria have been set for a range of species and methods as a result of work within OSPAR (WKIMC, see next section).

2.2. Environmental target levels for biological effects measurements

Work is currently being undertaken through ICES/OSPAR to develop environmental target levels to aid interpretation for biological effects measurements. Combination of biological effects and chemical measurements (or additional effects measurements) will provide an improved assessment due to the ability to address effects that are potentially caused by a wide range of contaminants as well as those that are more clearly linked to specific compounds or groups of compounds. The JAMP Guidelines contain advice on the appropriate combinations of chemical and biological effects measurements in integrated monitoring programmes of fish and shellfish (mussels). Quantitative target levels are needed for effects data to be included in environmental assessment programmes (Sandström et al. 2005).

Biomarkers have been considered in two large groups; biomarkers of exposure to stressors including contaminants, and biomarkers of effect (see Annex 5). A main focus has been on developing an understanding of normal (or background) levels of the responses, such as are encountered in areas that are distant from sources of environmental contaminants. They can therefore be considered, to a degree, to be parallel to the Background Concentrations developed for chemical contaminant concentrations, and to address the first objective of the OSPAR Hazardous Substances Strategy. A distinction can be made between biological-effect methods for which it would be appropriate to establish a global background level, and hence the ability to derive a general assessment criterion (deviation from normal) and methods for which there would be a need for a reference location with which to compare populations at affected locations. The present view is that it may be possible to derive global values for all methods if a limited number of dominant external factors can be controlled for. Hepatic cytochrome P4501A activity (measured by EROD) is one example for which temperature and/or gonad development corrections may in fact be sufficient. The current proposals for environmental target levels are summarized in Table 1. Response levels above background, and where possible and relevant, elevated response range and high and cause for concern response are determined for some methods, but this list is currently expanded and updated through the WKIMON/SGICM process (see Annex 4).

However, both forms of environmental target levels (i.e. those analogous to BCs and to EACs) are not appropriate for all of the effects measurements recommended in the OSPAR integrated monitoring strategy. The parallel to an EAC in terms of biological effect might be an expression of a level of effect or response that correspond to the initiation of significant harm to the organism at organ, individual or population level. Unacceptable biological effects are likely to be observed at whole organism or tissue levels. Whole organism and tissue level responses are more likely than sub-cellular responses to be suitable for the establishment of environmental target levels corresponding to significant pollution effects, as well as to background conditions.

OSPAR has established an EcoQO for the effects of TBT on marine gastropods (*Nucella, Littorina, Buccinum* and *Neptunea*). Associated with this EcoQO is an assessment scale which includes background levels of effect, and levels of effect that are significant at individual and population levels. This classification scheme has been applied to international monitoring data and assessment reported by OSPAR MON and included in the OSPAR Quality Status Report to be published in 2010.

2.2.1. Recommended biological effect techniques

WGBEC (ICES 2007b) regularly reviews the status of biological effect techniques and recommends in its reports those techniques for fish and invertebrates that are in the research phase, those which look promising for use in the future but which require further development and analytical-quality control, and those which are now available for use and within national and international monitoring programmes. Biological effect techniques range from responses measured at the subcellular level (e.g. metallothionein and DNA-adducts) to whole-organism responses (e.g. scope for growth and fish disease). The most recent list, last updated in 2007, is presented in Annex 3. Some of the recommended methods have been included in OSPAR guidelines for contaminant-specific or general monitoring (JAMP 1998b, a) and have, after a process of quality assurance, been included within the CEMP 9 Coordinated Environmental Monitoring Programme). The OSPAR status of biological effect techniques for invertebrates and fish (within the JAMP) is given in Annex 3.

The exact methods by which the chemical concentrations and levels of biological effects will be integrated for assessment purposes are under development.

Table 1. Summary of current proposals for environmental target levels (ICES 2010).

Biological Effect	Qualifying comments	Background Response Range	Elevated Response Range	High and Cause for Concern Response
VTG in plasma; µg/l	Cod	LOD to 2		
	Flounder	LOD to 2		
Reproduction in eelpout; mean frequency (%)	Malformed larvae	0 1	> 1-2	> 2
	Late dead larvae	0 2	> 2–3	> 3
	Growth retarded larvae	0 4	> 4–6	> 6
EROD; pmol/mg protein pmol/min/ mg protein S9 * pmol/min/ mg microsomal protein	Cod	≤ 151*	> 151*	not relevant
	Dab (males)	≤ 97	>97	not relevant
	Dab (females)	≤ 142	>142	not relevant
	Flounder	≤ 34	>34	not relevant
	Four-spotted megrim	≤ 13*	>13*	not relevant
	Plaice (males)	≤ 3.7	> 3.7	not relevant
	Dragonet	≤ 202*	> 202*	not relevant
	Red mullet (males)	≤ 208*	> 208*	not relevant
Bile metabolites; 1-OH pyrene (µg/ml; 341/383 nm fluorescence) *synchronous scan fluorescence	Dab	≤ 0.15*	> 0.15*	not relevant
	Cod	≤ 1.1	> 1.1	not relevant
	Flounder	≤ 1.3	> 1.3	not relevant
	Haddock	≤ 1.9	> 1.9	not relevant

Biological Effect	Qualifying comments	Background Response Range	Elevated Response Range	High and Cause for Concern Response
Bile metabolites; HPLC (fluorescence detection; ng/g)	Dab	≤ 13	> 13	not relevant
	Cod	≤ 13	> 13	not relevant
	Flounder	≤ 232	> 232	not relevant
	Haddock	≤ 10	> 10	not relevant
DR-CALUX	Sediment	< 10	>10 <40	> 40
DNA adducts; nm adducts mol DNA	Dab	≤1.0	> 1.0	(> 6)
	Flounder	≤1.0	> 1.0	(> 6)
	Cod	≤1.6	> 1.6	> 6
	Haddock	≤3.0	> 3.0	(> 6)
Bioassays; % mortality	Sediment, Corophium	0-30	> 30-< 60	> 60
	Sediment, Arenicola	0-10	> 10-< 50	> 50
	Water, copepod	0-10	> 10-< 50	> 50
Bioassays; % abnormality	Water, bivalve embryo	0-20	> 20-< 50	> 50
	Water, sea urchin embryo	0-10	> 10-< 50	> 50
Bioassay; % growth	Water, sea urchin embryo	0-20	> 20-< 50	> 50
Lysosomal stability; minutes	Cytochemical; all species	> 20	≤ 20-≥ 10	< 10
	Neutral Red Retention: all species	> 120	≤ 120-≥ 50	< 50
Fish Disease Index	Cutpoints of the FDI assessment statistic are the 2.5% and the 97.5% quantiles of the assessment statistic. Their numerical values depend on the amount of data and are determined by simulation. Values below the 2.5% quantile are considered as "desirable", values between and including the quantiles are considered as "indifferent", values above the 97.5% quantile are considered as "undesirable" (raising concern).	< 2.5% quantile	2.5-97.5 % quantiles	> 97.5% quantile

2.3. **Contaminants**

2.3.1. Review of chemical contaminants of concern for the marine environment

European Seas are affected by intense human activities, which constitute sources of chemical contamination and may cause degradation and a risk of serious damage in coastal and marine zones (EEA 1999, 2003). In the future, coastal areas are expected to face even greater pressures. The

JGOFS (Joint Global Ocean Flux Study) and IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) programs were intended to understand the factors governing the concentrations and fluxes of carbon and nutrients using a multidisciplinary approach involving biologists, physicists and geochemists. This approach has to be adopted in studies of the distribution and fluxes of chemical contaminants, since the behaviours, fates and budgets of the anthropogenic substances and elements is also influenced by the dynamics of the main biogeochemical cycles (C, N, P, Si, Fe) (Cossa et al. 2009). Because of the particular importance of atmospheric transport and air-water exchange, open waters are also of concern due to chemical contamination, especially through the processes of trophic transfer and bioaccumulation, provided that their study is integrated within a biogeochemical and ecosystem approach.

Our knowledge in terms of concentrations, input and output fluxes, behaviour within the water and sediment columns and toxicological impacts on ecosystems is very different, depending on the group of contaminants being considered. Chemical contaminants are generally separated into three groups: stable trace elements, organic substances, and radionuclides. For the first group, most of the elements considered should be those for which toxicity is known, such as Cu, Cd and Pb, as well as Hg and Sn and their organic forms. The organic contaminants include POPs as well as "novel" compounds such as hormones, veterinary medicines and pharmaceuticals.

Information on activities relating to chemical contaminants in the marine environment in preparation for the MSFD in meetings and dedicated workshops can be found on the European Commission CIRCA website: *http://circa.europa.eu/Public/irc/env/marine/library*. There is also info and documentation provided by the European Environment Agency EEA through a series of workshops from 2003-2007 in the European Marine Monitoring and Assessment group EMMA.

2.3.1.1. Trace metals

The inputs of trace metals into European Seas are largely dominated by atmospheric inputs (Bethoux et al. 1990, Migon et al. 2002, Migon 2005) which are characterised by a European background signature (which shows both natural and anthropogenic influences). In the Mediterranean Sea, Saharan dust signatures are superimposed upon this natural background signature (Chester et al. 1997, Guieu et al. 1997, Sandroni and Migon 1997, Guerzoni et al. 1999). Atmospheric fluxes of trace metals measured at coastal sites can be extrapolated to the basin scale (Migon et al. 1991) as the spatial variability of total atmospheric metal deposition appears to be relatively low, despite the variability of local meteorological and climatological conditions (rainfall, winds speeds, efficiency of the aerosol scavenging). The influence of major rivers is more important in coastal zone areas, and constitutes the major source for particulate metals on some continental shelves. For instance, in the Gulf of Lions (Western Mediterranean), Radakovich et al. (2008) demonstrated that atmospheric fluxes constituted less than 5% of the total (rivers + atmosphere) particulate inputs of Cr, Co, Ni, Cu and Pb, 17% of Zn and 35% of Cd.

Even if the influence of the rivers is less at the scale of the Mediterranean Sea (Martin et al. 1989, Guieu et al. 1997, Guerzoni et al. 1999), riverine particulate inputs have to be more precisely estimated for all the trace metals, and especially to take account of flood events which can transport 80 to 90% of the yearly average trace metal discharge into the marine environment (Radakovich et al. 2008).

The partitioning of atmospheric inputs between dissolved and particulate phases within the surface layer strongly determines the behaviour of trace metals and their involvement in biogeochemical cycles (Cossa et al. 2009). Basically, the assimilation of metals by biota may be constrained by their solubilisation, resulting from physico-chemical and biological processes (dissolution through zooplankton guts for example).

Some trace metals called "bioactive" are involved in the Redfield model of organic matter synthesis and deeper remineralisation (Bruland 1980, Frew 1995, Löscher et al. 1997, Hunter and Boyd 1999). During photosynthesis, phytoplanktonic organisms assimilate nutrients and trace metals in proportions following a Redfield ratio evaluated as: C:N:P:Fe:Zn:Cd, Cu, Mn, Ni = 106:16:1:0.005:0.002:0.0004 (Bruland et al. 1991). This ratio is an approximation and the relationships between trace metals and macronutrients can vary regionally (Saager et al. 1992). The specific seasonal trophic pattern (long stratification period in summer and autumn with nutrient-depleted surface waters) of the Mediterranean Sea induces the accumulation of trace metals in surface waters, leading to specific "nutrient-like" vertical profiles with depth in the water column.

Bioactive trace metals are likely to limit the growth of phytoplankton and heterotrophic bacteria due to their low concentrations in seawater, but their potential toxicity may also inhibit biological development. Bruland et al. (1991) pointed out possible antagonistic and competing interactions between nutrients and inhibitory trace metals, which are however difficult to evaluate due to severe analytical difficulties. Furthermore, the involvement of trace metals in uptake processes depends on factors such as redox speciation, complexation with organic ligands, photochemical reactions, etc. Phytoplankton is likely to accumulate trace metals (bioactive and/or inhibitory) by either assimilation or adsorption processes (Fisher 1986) before being ingested by zooplankton. Potentially toxic metals, even when they have a biological role, are likely to produce environmental harm through assimilation by planktonic species at high concentrations. The transfer of trace metals up the food chain and their accumulation in marine organisms have been addressed in experimental studies (e.g. Odzak et al. 1994, Wang and Fisher 1998). In the case of the Mediterranean Sea, field studies have shown effective accumulation in various species, from plankton (Roméo et al. 1987, Roméo et al. 1992) to species at the top of the marine food chain, e.g. dolphins and whales (Augier et al. 1993, Frodello et al. 2000). The scarcity of field data on trace metal accumulation in Mediterranean planktonic species calls into question any comparison of bioaccumulation state-of-the-art in the Mediterranean and in other regions.

More studies are carried out on the contamination of species under threat, such as cetaceans. The fact is that the concentrations of trace metals found in whale stomachs suggest that the food source is responsible for a significant proportion of the metal contamination to the whales (Frodello and Marchand 2001). During the 1970s, several papers pointed out the elevated Hg concentrations in the Mediterranean fishes, in which the concentrations were twice those found for the same species living in the Atlantic Ocean (e.g. Thibaud 1971, Bernhard and Renzoni 1977). Most of the mercury content of the fish muscle was as methylated species. Recent results of the MERLUMED project (http://www.ifremer.fr/medicis/EN/projets/merlumed.html) confirmed these findings. The occurrence of higher metal bioaccumulation in planktonic organisms in oligotrophic environments has already been suggested. This means that the key for the "Med-Hg anomaly" should originate from higher bioaccumulation of MeHg at the base of the food chains, especially in phytoplankton and bacterioplankton (Harmelin-Vivien et al. submitted). Moreover a difference in background levels of several metals exist between the western and eastern Mediterranean, as came out of the results of the MYTIMED project. This could be probably attributed to the more recent geological activities in the eastern Mediterranean in comparison with the western part, such as the alpine mountain range creation (Alpic Orogenesis) and the volcanic arc in the South Aegean Sea.

Variable patterns of trace metals accumulation occur among species. These include regulation of body concentrations of some metals by some species related to interacting influences of four factors on bioaccumulation: metal specificity, environmental/geochemical influences, exposure route, and species-specific characteristics (Luoma and Rainbow 2005).

2.3.1.2. Organic contaminants

In the last two decades, the progress in environmental science has provided evidence of the spread throughout the global environment of certain POPs, and a quantitative understanding of the processes controlling their distributions in the environmental reservoirs, including living organisms (including humans). The compounds of most concern in the marine environment are generally those that are persistent, toxic and bioaccumulative. In addition, compounds which undergo long-range atmospheric transport can contaminate remote areas far from sources. The results of recent research have shown that, at the global scale, the ocean is the main receptor environment for the POPs whereas residence in continental soils can slow down their transfer to the sea (Dachs et al. 2002, Dalla Valle et al. 2005). In spite of the regulations established since the beginning of the 1970s, certain POPs are now embedded in the natural biogeochemical cycles in the marine and continental ecosystems. Because of bioaccumulation and biomagnification processes in food webs, these compounds may attain dangerous concentrations, especially in top predators, including marine mammals and fish eating raptors.

On the other hand, with the improvements and development of analytical techniques, the identification and quantification of many previously undetected organic anthropogenic compounds in the marine environment has also progressed spectacularly in recent years. These are for instance: polybrominated diphenyl ethers PBDEs (Sellström and Jansson 1995, de Boer et al. 1998); perfluorochemicals: perfluorooctane sulfonates PFOS and perfluorooctanoic acid PFOA (e.g. Giesy et al. 2001); alkylphenolic compounds nonyl- and octylphenol; many pesticides ex. triazine and phenyl ureas herbicides (e.g. Tronczyński et al. 1993); veterinary medicines and human pharmaceuticals, biocides and bactericides, such as triclosan (Kolpin et al. 2002); and phthalate esters (Mackintosh et al. 2004) . Moreover, it has been found, that the detection of certain of these “novel/emerging” contaminants might be of environmental concern, because they have been shown to be mobile, persistent and toxic and some are also bioaccumulative. Few studies have also shown that the levels of certain of these chemicals have increased during recent decades and that their presence in the environment is widespread (e.g., PBDEs, (Ikonomou et al. 2002, Johansson et al. 2006)).

Finally, the scientific community had also gathered growing evidence of the biochemical reactivity and potential for biological effects (e.g. immunotoxicity, endocrine disruption and carcinogenicity) of various organic pollutants in animals, including humans (see Chapter 2.1). For a review on organic pollutants found in coastal waters see Annex 6.

2.3.1.3. Radionuclides

In order to support the evaluation of GES-related to contaminants and their effects, this section gives information concerning the activities of International Organisations in regard to the occurrence of radionuclides in the marine environment. The EURATOM treaty is the main EU Community–level tool for ensuring health and safety associated with the nuclear industry. At United Nations level, the International Atomic Energy Agency (IAEA) works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies.

Furthermore, the Marine Conventions OSPAR and HELCOM conduct assessments for their specific regional marine regions, the Northeast Atlantic and the Baltic Sea area, respectively. Within OSPAR, the objective with regard to radioactive substances, including waste, is to prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances. Therefore, a strategy has been implemented in accordance with the Programme for More Detailed Implementation of the Strategy with regard to Radioactive Substances, that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero by 2020 (OSPAR 2009b).

Within the HELCOM convention, there exists the working group MORS, which was established at the beginning of April 1986 to coordinate environmental monitoring of radioactive substances in the Baltic Sea area (Monitoring of radioactive substances: MORS; 2008-2011). This group collects data on discharges and environmental levels of radioactivity in the Baltic Sea, The data are submitted by the Contracting Parties to the HELCOM database and are compiled annually. A periodic assessment of radioactivity in the Baltic Sea covering data up to 2009 was undertaken. The assessment includes levels, inventories and trends for radioactivity in water, sediment and Biota of the Baltic Sea and assesses the radiological impact on man and the environment. Thematic reports were prepared on a number of issues: naturally occurring radionuclides in the Baltic Sea, releases of man-made radionuclides from non-nuclear activities (e.g. hospitals) and simple procedures for assessing doses to man from radioactivity in the Baltic Sea.

Under the Arctic Monitoring and Assessment Program AMAP, an assessment of the presence and effects of radioactive contaminants in the Arctic Environment has been prepared in 2002 (AMAP 2002).The European Commission Joint Research Centre (Institute for Transuranium Elements) has prepared in 2003 the report Marina II on radionuclides in the marine environment (Betti et al. 2004b, a). In 1994 a report on radionuclides in the Mediterranean Sea has been published (EC 1995). The cited reports can give a thorough overview about the presence of radionuclides in the marine environment during their coverage period and thus provide also information about the temporal and spatial trends involved.

Information about proposed guideline values for levels of radionuclides in food for used in international trade can be found under the Joint FAO/WHO Food Standards Programme of the Food and Agriculture Organization of the UN (Draft Guideline Levels for Radionuclides in Food for Use in International Trade, ALINORM 04/27/12; para. 204; Appendix XXII).

The EU Council Directive 96/29/EURATOM sets a limit value of 1 mSv/ year to members of the general public for additional radiation exposure resulting from man-made activities. However, it was shown by the reports mentioned that the real doses resulting from levels of man-made radioactivity in European Sea areas by consuming marine food or any other usage of the amenities of the sea are significantly below this limit (acknowledged contribution by Hartmut Nies, IAEA).

2.3.1.4. Hydrocarbon pollution

The release of hydrocarbons (as fuel, crude oil, or oil products) could in specific areas interfere with the environmental status of the marine ecosystem. The formation of oil slicks through accidental or continuous release of oil and oil products should be quantitatively assessed under an appropriate descriptor. Currently assessments are being carried out using aerial surveillance or satellite imagery rather than within traditional monitoring programmes. Constituents of the oil slicks, such as polycyclic aromatic hydrocarbons, are covered under the currently proposed criteria for Descriptor 8 whether arising from oil or combustion sources. Current environmental legislation (2005/35/EC, Ship-source pollution and on the introduction of penalties for infringements) obliges MS the monitoring of oil spills and their remediation. TG 8 and 10 considered oils (mineral and non mineral) and paraffins and concluded that they are not covered adequately by any existing GES descriptor.

2.3.2. Chemical contaminants of relevance for GES

Monitoring, in the form of repeated measurements of key aspects of the state of the marine environment at key locations, provides the basis for assessing progress towards GES and the evaluation of the effectiveness of actions being taken to protect the sea. An overview of priority substances identified by OSPAR, HELCOM, MEDPOL, the Black Sea Convention, AMAP, and the WFD is presented in Annex 7 with the aim of summarizing those substances which have been be taken into consideration so far and are therefore of prime concern when assessing GES of marine environments. For more detailed information on contaminant monitoring under these and other Regional Seas Conventions see Annex 8. In addition, there are substances of possible concern (identified in the OSPAR List of Substances of Possible Concern and in the EQS directive 2008/105/EC, Annex III) which should be reviewed for possible relevance under the MSFD. These substances include PFOS, dioxins and PCBs known to be relevant for the marine environment.

The selection of relevant chemical contaminants should be done by MS within their frameworks of Regional Seas Conventions. Harmonization between the marine regions should ensure an equal level of environmental protection.

2.4. **Currently used environmental target levels for chemical contaminants**

Criteria for assessing the quality of marine and freshwater habitats with regard to the concentrations of chemical contaminants have been developed under the WFD and marine conventions, particularly under OSPAR. Environmental quality assessments are generally dependent on comparisons with environmental target levels that represent either some threshold that should not be exceeded (e.g. EQSs for concentrations in water in a WFD context), or a long-term objective (e.g. concentrations close to background in OSPAR context). Such target levels will be necessary to enable interpretation of chemical or biological monitoring (2.2) data against the objective expressed in Descriptor 8 for MSFD.

2.4.1. Environmental Quality Standards

The Environmental Quality Standards Directive (2008/105/EC) lays EQSs for priority substances and certain other pollutants as provided for in Article 16 of the WFD, with the aim of achieving good surface water chemical status. The objective is to protect pelagic and benthic freshwater and marine ecosystems (transitional, costal and territorial waters), and human beings from adverse impacts of chemical contaminants. The directive sets EQS for 33 substances/groups of substances (listed in Annex 9). Currently the majority of EQSs are established for surface water only (with the exception of hexachlorobenzene, hexachlorobutadiene and mercury for which standards have been defined for biota), but MS are to arrange for the long-term trend analysis of substances that are likely to accumulate in sediment and/or biota, and take measures to ensure that their concentrations do not significantly increase in these matrices.

The methodological framework used in deriving these EQSs is described in (Lepper 2005). Currently a guidance document for derivation of EQSs within MS is about to be finalized (DRAFT Technical Guidance for deriving Environmental Quality Standards EQS-TGD under the Water Framework Directive, Working group E WFD Common Implementation Strategy). The assessment framework was based on deriving EQS values for water (protection of the pelagic community), sediments (protection of the benthic community), and biota (protection of predators against secondary poisoning). Additionally for human health related protection objectives, EQSs were derived for biota (fishery products; protection of humans against adverse effects upon consumption of fishery products), and water intended for drinking water purposes. The lowest of these values was set as the overall EQS. Water EQSs were derived for all priority substances, whereas for the other objectives only if certain triggers related to physico-chemical properties of the substances were met. Distinct EQSs were derived for freshwater and saltwater environments, unless there was sufficient data to conclude that both environments could be considered equally vulnerable.

The TGD Assessment Factor method (Technical Guidance Document on Risk Assessment in Support of Commission Directive 93/67/EEC on Risk Assessment for New Notified Substances and

Commission Regulation (EC) No 1488/94 on Risk Assessment for Existing Substances and Directive 98/8/EC of the European Parliament and the Council Concerning the placing of biocidal products on the market. Part II) was used as the standard approach to deriving EQSs for organic chemicals including plant protection products. Additionally if sufficient data and valid studies were available, the species sensitivity distribution (SSD) method or the results of simulated ecosystem studies were used. For metals, the Added Risk approach was used which enables natural background concentrations to be taken into account. This is generally of greater importance in freshwater that marine environments. In this approach, a maximum permissible addition (MPA) to the background level of a certain metal is calculated. The derivation methods used in deriving EQSs for organic substances generally apply for the derivation of MPAs. For marine waters, an additional assessment factor was used in cases where only data for freshwater or saltwater algae, crustaceans and fish was available, as it was considered that freshwater data may not fully reflect risk to marine communities. Annex 1 Part B of the EQS directive provides at Point 3 that MS may take account of natural background concentrations and hardness pH or other water quality elements that affect bioavailability of metals.

To cover both long-term and short-term chemical effects, two kinds of EQS were derived for each substance: (a) the annual average concentration (AA-EQS) referring to the annual arithmetic mean concentration providing protection against chronic exposure, and (b) the maximum acceptable concentration (MAC-EQS) for protection against acute toxic effects caused by short-term contaminant peaks. The MAC-EQS values are not to be exceeded at any time. The directive provides at Annex 1 Part B point 2 the option for MSs to use Statistical Methods, such as a percentile approach in their appraisal of compliance to MAC standards and thus the values may not be absolute values as stated. MAC-EQS were derived for water only on the basis that emissions to the aquatic environment normally occur in water first, and because changes in contaminant concentrations can occur more rapidly in water than the other matrices. In cases where an AA-EQS was deemed protective for both chronic and acute exposure, MAC-EQS were not derived.

2.4.2. Environmental target levels in OSPAR and HELCOM

The OSPAR Joint Assessment and Monitoring Programme (JAMP) includes extensive monitoring of the concentrations of contaminants in sediment and biota. To form the basis of assessment schemes, OSPAR has used two forms of assessment criteria in the interpretation of chemical monitoring data; (1) background concentrations (BCs) and associated Background Assessment Concentrations (BACs), and (2) Environmental Assessment Criteria (EACs). Comparisons against both types of criteria have been used to develop assessments of contaminant concentrations in sediment and biota for the QSR 2010 project (see Annex 10). Within OSPAR, the assessment criteria are agreed, but are subject to review and possible revision as more data become available. Such assessment criteria are not available as yet for all CEMP determinands in sediment and biota, and a review of assessment criteria will be undertaken as part of the development of the new JAMP post-2010.

A BC is defined as the concentration of a contaminant at a “pristine” or “remote” site based on contemporary or historical data. The BC for a man-made substance is therefore zero. Historical samples are not generally available for biota, and therefore background concentrations have generally been estimated from modern data from areas distant from sources of contaminants. BACs are derived mathematically from BCs to enable robust analysis of monitoring data in relation to the objective that concentrations should be “near background”. Details of the derivation of BACs (and BCs) in given in the CEMP Assessment Manual, published by OSPAR in 2008, and in Annex 11.

EACs are concentrations of contaminants in monitoring matrices, normally sediment or biota, below which unintended/unacceptable biological responses, or unintended/unacceptable levels of such responses, are unlikely to occur. Different approaches have been used over the years to derive these values, but the more recent attempts have followed the same principles as those used to derive EQSs in WFD contexts. In some cases, there are sufficient data on the direct toxicity of contaminants in sediment or biota to organisms, but in others it has been necessary to use partitioning coefficients to translate EQSs in water into EACs in sediment or biota.

Linked to comparisons with BCs and EACs have been analyses of time series data for temporal trends. The aim of this has been to determine whether conditions are deteriorating or improving. OSPAR MON has developed and employed robust time series analysis procedures for this purpose, as are outlined in the CEMP Assessment Manual and presented in Annex 12.

The hazardous substances section of the OSPAR QSR 2010 required that a consistent process be used to assess monitoring data for a range of hazardous substances in sediment and biota. The bulk of the data available in the ICES database was for priority substances, i.e. trace metals (particularly mercury, cadmium and lead), CB congeners, and PAHs, and therefore emphasis was given to ensuring that a coherent set of assessment criteria (BCs/BACs and EACs) were available for these substances.

In practice, background concentrations, and associated background assessment concentrations, were available for these priority substances, or could be developed in time for the QSR. However, this was not the case for all EACs, and some different approaches were necessary to complete the suite of assessment criteria. These approaches included the use of some ERL values for sediments, and the development of EACs for CBs in sediment that reflected new understanding of the availability of CBs in sediment derived from passive sampling studies. The resulting list of "EACs" was considered to reflect contaminant concentrations in sediment and biota that presented unacceptable risk, corresponding to the failure to achieve statutory targets or policy objectives for contaminants in these matrices (see Annex 10).

An outcome of this approach to data assessment was that data assessments could be described through a three colour "traffic light" scheme, in which the upper transition (green to red) indicates that the target/objective has been achieved; i.e. "red" indicates that environmental conditions represent an unacceptable risk. The lower transition (represented as a blue-green) refers to achievement of the OSPAR objective in relation to background concentrations. In the context of MSFD Descriptor 8, "red" would be considered as a failure to achieve GES, whole both "green" and "blue" would indicate achievement of GES.

In the current on-going HELCOM thematic assessment of hazardous substances in the Baltic Sea, HELCOM Contracting Parties are allowed to decide which environmental target levels to apply in their own coastal waters. HELCOM does not have its own target levels for contaminants in the Baltic Sea.

2.5. Monitoring programs related to contaminants and their effects under Marine Conventions and other international programs

Monitoring programs related to contaminants and their effects under Marine Conventions and other international programs have been reviewed. There are in total 18 Regional Seas Programmes focusing on the protection of coastal and marine habitats (http://www.unep.ch/regionalseas/legal/conlist.htm). These include the Antarctic, Arctic, Baltic Sea, Black Sea, Caspian Sea, Eastern Africa, East Asian Seas, Mediterranean, North-East Atlantic, North-East Pacific, North-West Pacific, Red Sea and Gulf of Aden, South Asian Seas, South East Pacific, Pacific, ROPME Sea Area, Western Africa, and Wider Caribbean. An overview of contaminant monitoring programmes established under/as a part of Regional Seas Programmes and other international programs is provided for in Annex 8.

2.6. Relevant EU research projects

A considerable number of research projects have been funded during the past Framework programs by the EU for topics related to contaminants in aquatic environment, marine research and others. These projects have been screened for possible relevance of their outputs to the Descriptor 8 working group. They cover a wide range of topics, including the relation of contaminants to effects in aquatic ecosystems and the involved environmental target levels, as well as large scale monitoring in the Mediterranean Sea. The projects are listed with a short summary in Annex 13.

2.7. Common understanding of key concepts

The assessment of achievement of GES under Descriptor 8 will be based upon monitoring programmes covering a range of chemical and biological measurements relating to the effects of pollutants on marine organisms. Monitoring programmes will include the assessment of concentrations of priority contaminants in environmental matrices, i.e. water, sediment, and the tissues of biota. Monitoring programmes will also include the quantification of biological effects of contaminants at different levels of biological organisation. The selection of priority contaminants, monitoring species and biological effects measurements may vary between assessment areas in response to local concerns and environmental conditions.

These monitoring data will be interpreted through a series of environmental target levels, expressed as chemical concentrations or levels of biological response. In particular, monitoring data will be interpreted against target levels that are designed to protect against the occurrence of pollution effects. Examples include EQSs and EACs for water, sediment and biota. Biological effects will be assessed against criteria of significant harm to the organisms concerned. In addition, monitoring data will be assessed against background concentrations or levels of biological response, to enable added-risk approaches to be used for target levels, to enable greater use to be made of monitoring data in interpreting the causative agents of pollution effects, and to give early warnings of potential developing problems.

Integration of the results of monitoring programmes will be facilitated by the coherent and consistent sets of environmental target levels (EQSs, BACs, EACs, etc) currently applied, and being developed further, under the WFD, Regional Seas Conventions, or at MS level.

The compliance regime for application by Member State level must be agreed at the European level. Clear provisions, which allow a harmonised implementation of the MSFD, are necessary. They should include technical details on compliance/non-compliance, considering also statistical issues of sampling and comparisons against target levels.

3. RELEVANT TEMPORAL AND SPATIAL SCALES FOR THE DESCRIPTOR

3.1. Temporal scale

The temporal scale selected for assessing against GES under Descriptor 8 should allow a representative evaluation, i.e. the sampling strategy should minimise bias through short term variations and natural variability and it should allow the observation of trends of contaminant concentrations over an appropriate time scale.

In marine regions and sub-regions, covering large areas and with contaminant inputs being buffered by large watersheds, changes can often only be observed on longer temporal scales. Detailed information about the statistical analysis of trends in environmental concentration is given in Annex 12.

Annual mean contaminant concentrations can be examined for possible time trends using appropriate statistical techniques. Power analysis should be conducted in order to establish the magnitude of a trend (upwards or downwards) that could be detected in a given time. When no trend can be seen, this may represent a stable situation (i.e. concentrations are remaining the same, within the level of variability, from year to year) or that the sampling strategy adopted does not have the ability to detect a trend which is, in fact, there (OSPAR 2009a). It is important to know which is the case, so that details of the design of monitoring programmes can be reviewed to ensure the most effective utilisation of resources, and to minimise the possibility of misleading conclusions being drawn. Further statistical analysis can indicate the confidence level in any trend detected. This involves adopting an appropriate sampling design and using analytical techniques which are sufficiently accurate and precise for the envisaged scope.

3.1.1. Seasonal

In many instances, there are variations in contaminant content by season due to several abiotic (temperature, lighting, waves, currents) and biotic (qualitative and quantitative changes in the available food, growth rate, reproduction) parameters. Particularly for lipophilic organic contaminants in biota, as an example, the lipid content. The lipid content of fish and shellfish increases as they prepare for spawning, with consequent changes in contaminant concentration. The additional lipid is lost when the animals spawn and, in bivalve shellfish for example, spawning may result in a loss of 50% of an individual's soft tissue weight. In order to minimise the impact of such changes, sampling of fish and shellfish should take place annually, at the same time each year and outside the spawning period. Further reduction in variance may be obtained by expressing concentrations on a lipid-weight basis. Depending on the selected matrix for monitoring, seasonal changes in hydrometeorology, such as effects arising through seasonal patterns of enhanced rainfall may need to be taken into account.

3.1.2. Annual variability

There can be substantial variability between contaminant concentrations in individuals of the same species, particularly when uptake is age- or size-related. In order to obtain robust estimates of the mean concentration of a contaminant and the variability, a number of individuals of a species should be taken from a single location to form a sample. Tissues from these can be analysed individually or pooled, homogenised, and a subsample analysed. For mussels, for example, OSPAR recommends taking and analysing 3 pools of 20 individuals. Variability can be further reduced by sampling within fixed, narrow, size or age ranges. For mussels under OSPAR again, this can be 1-2 years old or 3-6 cm body length (OSPAR 2009a). Annual means can then be compared with confidence.

3.1.3. Environmental Specimen Banks (ESB)

Annual variability implies that temporal trend detection requires several years of monitoring. For future analyses of new contaminants it is therefore essential to build storage capacity in ESBs and to store annual environmental samples to speed up retrospective trend detection in future.

3.2. **Spatial scale**

For all descriptors, the spatial scale of assessment and reporting of environmental status are of major importance. The scale may be different among the descriptors as the affected environmental compartments may differ. It will be important that the scale allows the observation of the functioning of ecosystems at the level where it might be compromised. Upscaling to larger areas might then show the extent of that problem. Assessing at a scale which is much larger than the impact scale might cause that either the impact is not observed or that causes cannot be assessed.

3.2.1. *Regional scale*

In accordance with Article 4 of the MSFD, the European Seas are divided into four marine regions (the Baltic Sea, the North-East Atlantic Ocean, the Mediterranean Sea, and the Black Sea) represented by respective marine conventions. Scale (here used as cross-width, approximate) at this level is between 500-3000 km. While there are also globally important issues, the regional scale will be the largest scale of assessment under the MSFD.

3.2.2. *Subregional scale*

In the North East Atlantic Ocean and the Mediterranean Sea, subregions have been declared, which may be used in the implementation of the directive (MSFD Article 4(2)). For the other marine regions, the MSFD gives MS the possibility to use subdivisions if they inform the Commission in accordance with article 4(2). At the sub-regional scale large estuaries and bays can be regarded separately, and the scale ranges from 100 to 1000 km.

In the Mediterranean Sea the subregions are the Western Mediterranean Sea, the Adriatic Sea, the Ionian Sea, the Central Mediterranean Sea and the Aegean-Levantine Sea. In the North-east Atlantic Ocean the subregions are the Greater North Sea, including the Kattegat, and the English Channel, the Celtic Seas, the Bay of Biscay and the Iberian Coast, and in the Atlantic Ocean, the Macaronesian biogeographic region, being the waters surrounding the Azores, Madeira and the Canary Islands. A suggestion prepared by the HELCOM Secretariat for the subdivision of the European Seas for the assessment of GES which for example could be applied to the Baltic Sea, is presented in Annex 14. Geographically the Black Sea consists of a Western and an Eastern part, and three gulfs can be regarded as subregions: the Karkinitskij bay, the Odessa bay, and the estuary of Dnepro-Bugsky.

3.2.3. *Local Scale*

While certain aspects of GES under Descriptor 8 are being affected at very large scales, as e.g. the pollution by long range transport of persistent pollutants, other impacts occur at a more local scale. It is well known that point sources of contamination exist in marine waters. Hot spots, e.g. drill cutting sites, mining sites, dredge spoil disposal sites, munition waste sites or other locally impacted areas will, due to their small spatial extension of typically no more than only few kilometres, not influence an assessment at subregional scale. Their assessment can be of importance in order to examine the pressures deriving from them at larger spatial scale.

MS should be encouraged to identify and remediate such hot spots under their national pollution control legislation, even if, due to spatial dilution effects arising from the large scale of regional assessment, a direct impact on the regional environmental status cannot be proven.

4. GENERAL FRAMEWORK FOR DESCRIBING ENVIRONMENTAL STATUS

The overall assessment of "Good Environmental Status" will be based on the integration of GES assessments against the 11 Descriptors described in the Marine Strategy Framework Directive. Descriptor 8 "*Concentrations of contaminants are at levels not giving rise to pollution effects*" considers the impact of contaminants on the marine environment. This should be achieved by measuring and assessing contaminants concentrations against relevant quality standards and guidelines; and by examining their effects on the organisms themselves.

4.1. **Relevant state and pressure indicators**

The pressures considered under Descriptor 8 are inputs of contaminants into the marine environment. These derive mainly from land-based sources via rivers and coastal run-off and/or from atmospheric sources. Contaminant inputs can also result from anthropogenic activities in the sea, which cause continuous and/or accidental release of contaminants. The pressures exerted through the input of contaminants can be quantified as loadings expressed in pollutant weight per time transferred into the marine environment. For environmental management purposes, the control of loads and thus pressures can be a useful tool to determine whether measures are having an effect.

To prevent pollution effects from rising, environmental target levels for contaminants and their effects have to be defined. These target levels can then be used to delineate the border of GES. The exceedance of these limits triggers investigations of causes and the development of appropriate remediation measures. The aim is to prevent pollution effects occurring at the organism, population, community and ecosystem level. Increased contaminant concentrations increase the likelihood of pollution effects. In order to minimize the risk of deleterious effects, concentrations of contaminants in water, sediment and/or biota, and the occurrence and severity of pollution effects, should not be increasing. Relevant pollutants have to be identified, their toxicological properties known and, if appropriate, their background concentrations in the marine environment should be estimated.

For the purpose of implementing Descriptor 8 under the MSFD the following environmental target levels are being recommended:

- **Concentrations of contaminants in water, sediment and/or biota are below environmental target levels identified on the basis of ecotoxicological data;**
- **Levels of pollution effects are below environmental target levelrepresenting harm at organism, population, community and ecosystem level;**
- **Concentrations of contaminants in water, sediment and/or biota, and the occurrence and severity of pollution effects, should not be increasing.**

There is a core of both analytical methods and biological effects methods which can be applied now, for which long-term experience in their application exists. These methods have been reviewed in Chapter 2.

As also reviewed in Chapter 2, there are different approaches of marine assessment methodologies, e.g. EQSs and EACs. There is, however, a need to increase their scope and harmonisation.

The environmental matrices and target levels used by MS may vary between different marine regions and possibly subregions reflecting the use of different species in monitoring, differences in the underlying geochemistry and/or oceanographic conditions in assessment areas, and differences in contaminant inputs. Adaptation to such conditions may result in different responses of species to contaminants. There is need for harmonization of the approaches used in order to ensure an equal level of environmental protection among the assessment regions.

4.2. **Indicator responses to a degradation gradient**

Contaminants can adversely impact organisms, populations, communities and ecosystems. Anthropogenic contaminants, e.g. industrial chemicals and biocides, do not occur naturally in the marine environment, and ideally their concentrations should be zero. Other pollutants, such as heavy metals and polycyclic aromatic hydrocarbons, occur naturally but their concentrations can be dramatically increased due to releases due to human activities. In these cases, background concentrations are expected to represent a level which does not harm ecosystems.

Current risk assessment methods assume that concentrations can be identified at which pollution effects do not occur, and in general, increased contaminant concentrations can be assumed to increase the risk of pollution effects. While the likelihood of these effects increases with the concentration, synergistic effects, threshold effects, mitigation effects, and others cannot be excluded.

The chemical indicators selected for Descriptor 8, i.e. concentrations in water, sediment and/or biota would be expected to increase in response to an increasing degradation gradient. Exceptions would include those chemical contaminants which are readily metabolised by some target organisms (mainly vertebrates). In such case, the degradation gradient may be only weakly reflected by some indicators.

The biological effects indicators available for Descriptor 8 will show a progressive change along a chemical degradation gradient (provided that the indicator is responsive to the chemical showing the gradient). The change in biological response may be either positive or negative, depending on the response concerned. For example, PAH exposure would lead to increases in EROD activity, but decreases in Neutral Red Retention Time.

4.3. Monitoring of state and pressure indicators

The monitoring of the environmental status of a marine area is performed by the sampling of water, sediment and/or biota and its subsequent chemical analysis or by quantifying the expression of contaminant effects. The primary assessment period will be the assessment cycle of the MSFD. Within that cycle, sampling will be designed to minimise the influence of seasonal variations in chemical concentrations and their effects. Data could initially be summarised as annual statistics. The applied methodologies for sampling, measurement and data evaluation must be harmonised, reliable, and robust and provide a data quality fit for the envisaged purpose. Harmonised mechanisms for data quality control and assurance must be in place as well as quality assurance.

While the measurement of contaminant levels and expression of pollution effects is the means of confirmation of GES, the determination of loads is a valuable tool for assessing the effectiveness of measures to reduce pressures.

4.4. Aggregation of indicators to assess Good Environmental Status for the descriptor

Chemical and biological effects monitoring data should be assessed and interpreted in an integrated manner. First it will be necessary to aggregate the results of single indicator parameters, as e.g. the measurement of a specific contaminant or a biological effect, across stations. Further steps can then include the aggregation of information after assessment against environmental target levels, as e.g. percentages of stations showing exceedance. This information can then be aggregated to the subregional level, and eventually, if appropriate, to the level of each marine region. Aggregation of monitoring results should provide an overview assessment, but inevitably results in loss of detail. Aggregation methods must therefore incorporate traceability to all the necessary underlying information. Methodologies for data aggregation are in use within marine conventions and should be harmonized at the European level. While most considerable experience on data aggregation for environmental assessments is available through OSPAR (Annex 15), even there data have not been aggregated between different indicator groups, nor have data been aggregated above MSFD subregional level. The aggregation to higher level, if required, is therefore a challenge which is faced during the implementation of MSFD.

5. MONITORING

5.1. Data needs for monitoring compliance to GES

Concentrations data for contaminants and data from biological effect measurements in an appropriate spatial and temporal distribution are needed in order to compare them against environmental target levels. The implementation of monitoring requirements under the MSFD should be such that it ensures an equal level of protection for all European Marine Waters.

Although there may be differences in the contaminants and biological effects studies applied within regions, due to differences in background characteristics, chemical usage and contaminant inputs, the approach taken needs to be harmonised. While methods might differ, specifically, the degree of quality control applied to both the chemical analytical and biological effects methods should be to the same high standard in all monitoring studies, so as to ensure that the data generated are "fit for purpose" in determining GES under MSFD. The implementation of monitoring requirements will need further efforts by MS and Regional Seas Conventions to share their knowledge, identify best practises and ensure a harmonised application across EU.

5.2. To which extent are data needs covered by national monitoring programmes?

In most European countries, the monitoring of concentrations of a range of chemical contaminants in water, sediments and biota is undertaken in response to international (e.g. WFD, and Regional Convention programmes) or national drivers. The scope and scale of this monitoring varies, but should be considered as a base from which to introduce a greater degree of harmonisation between MS, and to ensure that contaminants and matrices of importance within assessment regions are covered by appropriate monitoring programmes. Biological effects monitoring is generally less widely established in both national or international programmes, and the number of countries undertaking such studies (and the intensity of the coverage) is much smaller.

Coverage from current national programs is limited. Therefore, for pragmatic reasons, initial assessments of GES under Descriptor 8 will probably be based upon data of a relatively small number of contaminants and biological effects, reflecting the scope of current programmes and the availability of suitable agreed assessment criteria. Important development areas over the next few years will include harmonisation of monitoring targets (determinands and matrices) within assessment regions, development of wider suites of assessment criteria, and review of the scope of the monitoring programmes to ensure that those contaminants which are considered to be important within each assessment area are included in monitoring programmes. Through these, and other, actions, it will be possible to develop targeted and effective monitoring programmes tailored to meet the needs and conditions within each assessment region.

Marine Monitoring is currently to a large extent organised within the Marine Conventions for the Regional Seas. They have developed approaches for monitoring over decades, including the set-up of networks, logistic collaboration, quality control measures and expert fora. However, the extent and coverage of monitoring is still variable and requires further action at EU level. An overview of the current assessment programs is provided in chapter 2.5.

Certain major monitoring efforts have been performed within research or regional support projects which have a limited duration. For a sustainable and reliable monitoring scheme implementation, long term support needs to be ensured.

5.3. Are there existing methodological standards to cover data needs?

Although the use of standard methodologies such as those produced by CEN and ISO is generally not a requirement of current international marine monitoring programs, the chemical analytical methods which are used are standardized and subject to quality control procedures. Directive 2009/90/EC provides the data quality requirements under the WFD (see 5.6.4) (European Commission, 2009). For biological effect methods, a small number are currently fully validated and quality controlled, but many other methods have already been developed and are in the process of validation.

5.3.1. ICES TIMES series

An important source of advice on analytical methods for determination of concentrations of contaminants in marine matrices, and on the measurement of biological effects of contaminants, is the ICES TIMES (Techniques in Marine Environmental Sciences) series. This series has developed over the last 20 years, and the contents of the booklets are subject to detailed peer review through the relevant ICES Working Groups prior to publication, and are considered to be reliable and authoritative.

TIMES series documents are available from the ICES website (www.ices.dk). The complete list is given in Annex 16, classified according to the subject matter into biological effects methods, chemical analysis methods, benthic faunal community methods, quality assurance advice, and sampling and statistics. The series of documents on biological effects measurements has a particularly wide scope, covering a high proportion of the methods that might be employed in monitoring programs.

5.3.2. Methodological standards under OSPAR

Monitoring of the marine environment by OSPAR Contracting Parties under CEMP concentrates on concentrations of contaminants in sediment and biota, and on their biological effects. Coordination of the programme includes adherence to monitoring guidance and quality assurance procedures adopted by the OSPAR Commission. The aim is to ensure that comparable and quality assured datasets are available from across the OSPAR maritime area. This has led to the progressive development of a CEMP Monitoring Manual, which covers technical aspects of monitoring, particularly sample selection, preservation and analysis. For a contaminant to be considered for inclusion in the CEMP, a standard method of analysis must be available, supported by external international quality assurance and assessment criteria to allow interpretation of the monitoring data. It is also necessary for a background document to be prepared that reviews the properties and risks associated with the substance, makes a preliminary assessment of its potential importance as an environmental contaminant, and makes initial proposals for an appropriate monitoring strategy.

The part of the Manual concerned with monitoring practice is structured in the form of Guidelines for the monitoring of hazardous substances in biota and sediments, supported by a range of Technical Annexes which present details of technical aspects of sample handling and analysis. The Guidelines are formal agreements of OSPAR Contracting Parties. The monitoring guidance is regularly reviewed in collaboration with ICES and where necessary updated to take account of new developments including the inclusion of new monitoring parameters in the CEMP. The contents of the Guidelines for monitoring contaminants in biota, sediments are summarized in Annex 17.

5.3.3. Methodological standards under HELCOM

HELCOM has compiled available data on specific pollutants, their sources, pathways, markets, the legal situation and chemical analysis. The information on assessment methodologies is available in the COMBINE manual part B and Annexes (http://www.helcom.fi/groups/monas/CombineManual/en_GB/Contents/).

Guidance documents for specific pollutants are available among the HELCOM protocols (http://www.helcom.fi/groups/LAND/en_GB/publications/):

- Mercury
- Cadmium
- Short-chained chlorinated paraffins
- Nonylphenol and nonylphenolethoxylates
- Dioxins
- PCBs.

5.3.4. Methodological standards under UNEP/MAP-MEDPOL

In the framework of the Regional Seas Programme, UNEP is assisting Mediterranean participating countries in the assessment of the state of marine environment and of its resources, of the sources and trends of pollution and the impact of pollution on human health, marine ecosystems and amenities. In order to assist the countries and to ensure that the data obtained through this assessment can be compared on a world-wide basis and thus contributing to the Global Environmental Monitoring System (GEMS) of UNEP, a set of reference methods and guidelines for marine pollution studies, covering technical aspects of monitoring, sample selection, preservation and analysis, have been developed and recommended to be adopted by Governments participating in the Regional Seas Programme. The methods and guidelines have been prepared in cooperation with the relevant specialised bodies of the United Nations system (WHO, FAO, IAEA, IOC) as well as other organisations and are tested by competent experts. The Methods and Guidelines are periodically revised taking into account the development of our understanding of the problem, of analytical instrumentation and the actual need of the users. The Marine Environment Laboratory of the International Atomic Energy Agency (IAEA) in Monaco is responsible for the technical co-ordination of the development, testing and intercalibration of Reference Methods.

The Reference Methods for the analysis of pollutants in water, sediment and biota, in the framework of the UNEP/MAP-MEDPOL, can be found in www.unepmap.org (Document and publications; Library Resources; Reference Methods).

5.4. **How to make optimal use of existing monitoring information?**

A vast amount of monitoring data from the past decades is available through the Marine Conventions (see also Annex 8). These data have been used e.g. for the identification of significant marine contaminants, development of monitoring strategies and guidance, and the development of assessment criteria (see also Annex 10). With respect to implementing the requirements of the MSFD, there are considerable benefits to be gained from taking advantage of monitoring data and information developed through these programmes. Such actions include (1) the use of existing experience in the design of monitoring programmes, (2) the use of existing guidance on analytical etc. methods to inform technical aspects of MSFD monitoring, (3) the use of existing sampling station networks as a framework for MSFD sampling networks, (4) the use of existing statistical assessment tools and work on assessment criteria as the basis for assessments of MSFD data, (5) the use of existing data to describe the distributions of contaminants and effects in the sea, and (6) the use of existing time series as the basis of MSFD monitoring against a “no deterioration” objective. The availability of data with confirmed quality is of importance for the assessment of trends in pollutant concentrations.

The approach to regional scale assessments against GES for ranges of contaminants and effects can also be built on recent developments in the integration of monitoring data across assessment areas and contaminants/effects (see Annex 15). The integration with data deriving from the assessments performed under the WFD will also be important for the implementation of MSFD (the WFD covering the coastal waters (1 nm) and for selected priority pollutants also the territorial waters). In addition, existing data handling experience can be used in the development of centralised international data storage and handling facilities to enable rapid and reliable harmonised data analysis and presentation. The ICES Data Centre, for example, holds data on contaminant concentrations and biological effects on behalf of OSPAR.

5.4.1. Integration of monitoring data in environmental assessments

The purpose of chemical and biological effects monitoring data collected for MSFD purposes is to contribute to the determination of whether assessment areas have achieved GES. This requires summarizing large amounts of chemical and biological effects data at various scales, as discussed in Chapter 4.4. While techniques for aggregating spatially distributed data of similar types are available and straightforward, the aggregation of different data types, such as concentration data with biological effect data is more challenging.

There are approaches available within OSPAR (Annex 15), which have primarily been used to aggregate data for single contaminants across OSPAR regions and subregions. Similar methods could be used to aggregate across different parameters, but unavoidably include implicit or explicit weighting of these parameters against each other. The use of environmental target levels for different parameters that have been developed using consistent methodology provides a level playing field for the initial comparisons of field data against target levels. From this point, it would be possible to consider the application of weighting procedures, but such a process would involve socio-economic and other factors.

This subject needs to be further elaborated in the GES Management Group report combining the input of different descriptors.

5.5. **Identify where it is possible to make improvements by targeted and focused additional monitoring**

5.5.1. Spatial coverage of European Seas

Currently not all Regional Seas are covered to an equal extent by national or regional monitoring programs. Efforts should aim at improving this situation by extending the spatial coverage of efforts in order to achieve an equal level of protection across Europe. A close cooperation with EU neighbouring countries in marine monitoring is crucial for sound assessments, as most European marine regions are shared with non-EU countries. The regional conventions play an important role in this interface.

5.5.2. Open sea and off-shore environment

The coverage in monitoring of open sea and deep sea environments is generally less dense than in the coastal environment. While there are good reasons for this, e.g. the vicinity of coastal environments to land based direct sources, data from the open sea environment is needed in order to assess the oceans as final contaminant sinks and as receiving waters for atmospheric input and off-shore emissions.

5.5.3. Screening for emerging pollutants

The application of screening techniques and surveys for the identification of novel contaminants is encouraged. New contaminants are entering the environment all the time, and screening techniques and surveys allow concentration data to be compiled for these new contaminants and for their likely significance to be assessed.

5.5.4. Passive sampling

Passive sampling is a rapidly developing area of marine science. Various different samplers have been developed for metals, hydrophilic and lipophilic contaminants. The method offers a powerful approach to direct measurement of the active concentrations of contaminants in water and in sediment. In the case of lipophilic contaminants, such measurements are impossible by classical methods, and yet are the key to environmental quality assessment, and to risk assessment in marine management. Passive samplers can provide integrated data over periods of days to months and therefore are very useful in areas where access may be difficult or infrequent.

5.6. Existing quality assurance guidelines and assessment of guidelines which need to be developed

In marine areas within Europe, quality assurance guidelines are provided for monitoring within Convention areas and national programmes, underpinned by Laboratory Proficiency Schemes such as QUASIMEME and BEQUALM. As new methods are developed and begin to be used, appropriate quality control measures need to be developed and applied.

For the implementation of MSFD monitoring requirements, there will be a need for a forum at EU level harmonising the details of approaches in order to ensure an equal level of environmental protection at community level. Guidelines for the application of both chemical and biological effects methods and appropriate quality control measures for both types of methods should be developed in a collaborative effort.

5.6.1. BEQUALM

The Biological Effects Quality Assurance in Monitoring Programmes (BEQUALM) project was initiated in 1998 as an EU funded research programme. This project aimed to develop appropriate quality standards for a wide range of biological effects techniques and devise a method for monitoring compliance of laboratories generating data from these techniques for national and international monitoring programmes. This has developed into a self-financing Quality Assurance (QA) system for biological effects techniques.

The main effects measurements that have been covered recently are:

- EROD, CYP 1A and protein in fish liver microsomes
- External fish disease and liver histopathology
- Corophium 10 day acute toxicity test
- Luminescent Bacteria Toxicity Assay
- Benthic faunal community analysis and supporting measurements of sediment particle size methodology, and biomass estimation
- Phytoplankton community analysis enumeration and identification

For some aspects BEQUALM routinely organises training workshops on techniques and/or taxonomy.

5.6.2. QUASIMEME

QUASIMEME (Quality Assurance of Information in Marine Environmental Monitoring) was founded in 1992. The project was initiated with EU funding (1992-1996) and continued by subscription of the participating institutes. The QUASIMEME Project Office at Wageningen University and Research Centre, The Netherlands, operates under the guidelines provided in the ISO/IEC guide 43-1: 1996 (E) for the development and operation of proficiency testing schemes and in the Guidelines for the Requirements for the Competence of Providers of Proficiency Testing Schemes: ILAC-G13: 20002.

The QUASIMEME LP studies provide external quality assurance (QA) for national and/or international monitoring programmes, individual or collaborative research and for contract studies. The QUASIMEME LP studies support quality management and quality measurement in the participating laboratories.

QUASIMEME collaborates with the following organisations: AMAP, EEA, HELCOM, ICES, MEDPOL, NORMAN, OSPAR, national marine monitoring programs of member countries, and PT-WFD network. For a summary of the scope of the QUASIMEME PTS see Annex 18. As the need arises, QUASIMEME organises Development Exercises for the determination of emerging contaminants, and holds training workshops to improve to overall quality of analyses by participating laboratories.

5.6.3. IAEA

The Marine Environmental Studies Laboratory of the international Atomic Energy Agency (IAEA - MESL) has the responsibility to provide assistance to Member State Laboratories in Mediterranean region in maintaining and improving the reliability of analytical measurement results. IAEA - MESL has the responsibility of running data quality assurance programme for chemical contaminants for UNEP/MAP-MEDPOL for the last 30 years. MESL undertakes a quality assurance programme involving:

1) Organization and evaluation of Intercomparison exercises and Proficiency tests for organic contaminants and Trace Elements in marine samples
2) Training courses on inorganic and organic contaminants analysis in marine samples and good laboratory practice
3) Provision of Certified Reference Materials (CRM) to Mediterranean Laboratories
4) Expert services for procurement of analytical instrumentation
5) Split-sample analyses for Mediterranean countries participating in the MED POL Monitoring Programme and confirmatory analysis.

The sampling matrices for the intercalibration exercises include surface sediment and biota (Bivalves, Demersal Fish, Pelagic Carnivore Fish, Pelagic Plankton Feeding Fish, Crustaceans), while the contaminants analysed include:

- Total and methyl mercury in sediment and biota
- Cadmium in sediment and biota
- Total arsenic in biota
- Zinc in sediment and biota
- Copper in sediment and biota
- Lead in sediment and biota
- Petroleum hydrocarbons, including polycyclic aromatic hydrocarbons in sediment and biota
- Polychlorinated biphenyls (PCBs) in sediment and biota
- Organochlorine pesticides in sediment and biota.

IAEA/MESL conducts interlaboratory studies in which laboratory performance and the potential source of errors are highlighted.

5.6.4. Water Framework Directive data quality

The requirements for data quality deriving from chemical monitoring under the WFD are provided in the Commission Directive 2009/90/EC laying down, pursuant to Directive 2000/60/EC of the European Parliament and of the Council, technical specifications for chemical analysis and monitoring of water status (European Commission, 2009). CEN and ISO standard methods are available or being developed for WFD monitoring. Additionally, a network comprised of organisers of proficiency tests, the PT-WFD network (http://www.pt-wfd.eu/), has been set-up. It seeks to ensure that the demands of the WFD are met through the organisation of high-quality proficiency tests which are performed in a harmonised and comparable way.

5.6.5. Guidelines to be developed

Additional guidance, specific for the implementation of the MSFD requirement will have to be developed in selected cases. The eventual need for such documents will arise during the harmonisation process at EU level.

5.7. **Emerging contaminants and effects**

The development of products and applications of industrial origin is continuously ongoing, implying the production of new chemical compounds which can be released into the environment. When detected in environmental samples at potentially toxicologically significant concentrations or by general biological effects techniques, further targeted monitoring will be required.

The NORMAN network of laboratories for the monitoring of emerging contaminants (www.norman-network.net) is an independent expert forum which acts as an early warning tool in the identification of new emerging risks from chemical substances. As part of its activities, NORMAN systematically collects information on the occurrence and biological effects of chemical compounds of potential concern. This information is channelled via NORMAN to the national authorities and the European Commission in support to the implementation of EU legislation. Moreover, it forms the basis for the formulation of common views of the scientific community on research needs and priorities for future legislation.

5.8. **New monitoring approaches**

While some monitoring approaches have been developed a long time ago and have been applied regularly since decades, the field of marine environmental monitoring continues to develop. Currently methodologies which have been recently developed are being implemented in large scale monitoring programs. These include e.g. methods for the quantification of specific biological effects caused by pollutants.

In addition there are methodologies which are part of research programs or pilot studies. Some of them have potential for use in environmental status assessments and are therefore listed here. While not being complete, this listing should show that the possibilities for environmental assessments and data evaluation change with the upcoming of new technologies and that new developments should be considered. In addition, information on techniques which are ready to be employed can be found in chapter 5.5 on targeted and additional monitoring. As new techniques usually need further research for development and implementation, also chapter 6 on research needs contains relevant information.

5.8.1. New sampling and observation techniques

5.8.1.1. Passive sampling

The use of passive samplers allows chemicals to be extracted and concentrated *in situ*, so reducing the difficulties of applying ultra-trace techniques and the associated high analytical costs. The DGT-passive sampler (Diffusive Gradients in Thin films) yields semi-quantitative results for common heavy metal ions in water (Pb, Cd, Cu, Zn, Ni, Co) (Zhang and Davison 1995). As these devices collect mainly labile ions (plus inorganic complexes), it is considered to be a good tool for use in the prediction of effects. DGTs can therefore be used to evaluate water quality on the basis of timeaveraged concentration data. However, the existing passive sampling systems require validation of the obtained data and further standardisation.

Various integrative devices have already been described for monitoring POPs (e.g. (Huckins et al. 1993, Pekol and Cox 1995, Petty et al. 1995, Verhaar et al. 1995), for screening new compounds (Lebo et al. 1992, Lebo et al. 1995, Smedes et al. 2007), for assessing diffusive flux at the benthic interface (Tixier et al. 2007). Semi permeable passive samplers, such as POCIS (Polar Organic Chemical/Compounds Integrative Sampler) can also be used to estimate the biologically available fraction of the POPs. Polyester sulfone membranes with adsorbents have been developed for the sequestration of more hydrophilic compounds (log K_{ow} < 3) (Alvarez 2004), whereas SPMDs (semi-permeable membrane devices) and silicone rubber samplers have been applied to more hydrophobic substances. Based on initial experience (Alvarez 2004, Jones-Lepp et al. 2004) , the capability of these devices at the concentration levels expected to be found in coastal waters needs to be investigated.

Also, when new biological effects assay techniques are developed such surveys represent an opportunity for trial and gaining of experience in their deployment and use. An effective way to conduct screening studies, whether using passive samplers or bioassays, can be to combine them with routine monitoring, as the samples are being collected anyway and the additional results represent "added value" to the routine studies. There are advantages to be gained from combining the use of extracts from passive samplers and specific bioassays to form an important linkage between the WFD and MSFD. In this connection, the application of integrated bioanalysis (a small set of cheap and fast bioassays representing various taxonomic groups and/or modes of action (e.g. estrogenicity) applied to water, suspended matter or sediment extracts) extended with toxicity identification evaluation (TIE) procedures, novel sensors and micro-arrays (when they become available) and instrumental methods to identify causal compounds should also be considered.

The ability to use passive samplers to make these measurements in water and sediment opens new opportunities in environmental quality assessment and pollution control. The Task Group anticipates that the use of passive samplers will increase rapidly in both the monitoring and research fields, and encourages the application of passive sampling techniques for better identification of dissolved concentrations and available fractions of contaminants in the water column and in sediment.

In specific areas elevated concentrations and biological effects are being observed due to local contamination. A dedicated monitoring targeting such hot spots areas should be highly encouraged as this will help to identify causative chemicals and help in reducing overall pollution load through remediation. Passive sampling is particularly appropriate for Descriptor 8 in that the data obtained reflect the fraction of the total load of each contaminant in water or sediment that is available to organisms and can lead to pollution effects.

5.8.1.2. Multi-sensor buoys and marine stations

Multi sensor buoys and marine stations can provide complete data sets in a continuous way independent from dedicated cruises. A Europewide network of such devices could deliver comparable data from different regions and therefore serve as a tool for intercalibration and quality control of monitoring programs. They can be equipped with sensors for basic oceanographic data and specific sensors such as e.g. voltametric electrodes for trace metal quantification (5.8.1.4) or passive sampling devices (5.8.1.1). Continuous deployment can improve trend analysis by collecting data of high temporal resolution. Ships-of-Opportunity can serve as platforms for cost effective, specific measurements. Such ship-based measurements can include transects which provide spatially integrated data for large scale assessments.

5.8.1.3. Benthic stations

While buoys and cruising ships can provide data from the sea surface, dedicated devices can be deployed in the deep sea and automatically record data otherwise not available. Application can be useful e.g. in specific areas, such as the Mediterranean Sea, where physical forcing, such as storms, waves and extreme meteorological events, act on the dynamics of water masses and the resuspension of sediments (e.g. Ulses et al. 2008). Therefore, the distributions of some contaminants, those preferentially associated with particulate matter, are affected, with their possible remobilization from the solid phase into the water column. For measuring the amplitude of such phenomena a prototype benthic device has been developed (Gonzalez et al. 2007) . This *in situ* instrumentation allows the continuous recording of salinity, temperature, pressure, turbidity, current velocity and direction, wave height, and sediment erosion and deposition. These parameters allow for the detection and characterization of meteorological events and, when controlled by a pre-programmed mechanical device, the passive sampling of hydrophobic chemical contaminants using DGT (Zhang and Davison 1995) and SBSE (Stir Bar Sorptive Extraction) (Roy et al. 2005).

5.8.1.4. In situ voltammetry

Electrode based sensors have been used in aquatic environments for a long time and micro-electrodes were developed a decade ago. Based on this technology, a voltammetric *in situ* profiling system has been proposed by (Tercier et al. 1998) using an Ir-based electrode and developed recently as a “multi-physical chemical profiler” (Tercier-Waeber et al. 2005) . This technology allows *in situ* monitoring of trace metal speciation at trace and ultra-trace concentrations. It has a strong potential for use in association with mobile platforms, such as floats, gliders or autonomous underwater vehicles (AUVs).

5.8.2. Application of modelling techniques

5.8.2.1. Biogeochemical modelling

The pathways of chemical contaminants within the European Sea could be investigated by the construction of complete biogeochemical models based on various emissions scenarios and environmental changes. This requires increasing our knowledge regarding (i) flux data at sources and sinks and their temporal variations, and (ii) biogeochemical behaviour models based on the specific properties of chemical contaminants and their integration within the biogeochemical cycles of major elements, including transfer processes at physical and biological interfaces (exchanges, bioaccumulation, etc.). This requires the coupling of biogeochemical, ecological, sedimentary, hydrodynamic and atmospheric models, and would support further policy making.

5.8.2.2. Bioaccumulation and bioamplification modelling

A biodynamic view of metal bioaccumulation processes combines knowledge on how and why chemical contaminants bioaccumulation differs among contaminants, species, food chains and environments. Using kinetic parameters of uptake, transfer and excretion, a bioenergetic-based (DEB) kinetic bioaccumulation models can be built as an efficient bio-monitoring tool to be applied to various environments (Luoma and Rainbow 2005, Casas and Bacher 2006, van der Meer 2006, Bodiguel 2008). An integrated vision of the bioaccumulation process, with its spatial and temporal variations, can provide an evaluation of the chemical contamination of sites with different trophic conditions and differences in physiological response. The successful reconstruction of Hg and Pb concentrations in the surrounding water at different sites, with concentrations in tissues and the measurement of growth, encourage the implementation of the DEB-based model in scenario simulation studies for management purposes (Casas and Bacher 2006). Bioenergetic processes play a major role in the uptake and elimination of chemical contaminants and interspecific variation in bioaccumulation depend how species feed, digest, and allocate energy. De Bruyn and Gobas (2006) derived a model to predict the biomagnification factor for nonmetabolizable, slowly eliminated, chemicals. This kind of approach is quite well adapted to studies of the Mediterranean Sea food webs (Bodiguel 2008).

6. RESEARCH NEEDS

The purpose of assessments under Descriptor 8 is to determine whether this aspect of GES is being achieved within assessment regions. The task is essentially descriptive, and the approach described in this document (measurements of contaminant concentrations and effects followed by comparisons against numerical target levels) reflects that philosophy. Ongoing research is vital for a better understanding of the underlying fundamental principles and for the further development of monitoring approaches.

6.1. Level of maturity of our understanding of the descriptor

MSFD GES target setting implies understanding of the processes affecting contaminant cycling and availability, the responses of marine organisms to contaminants, the identification of sources and the availability of appropriate monitoring tools. Our scientific knowledge of the functional relationships between pressures and impacts, and the consequent responses contains significant gaps. Effective utilisation of MSFD to improve marine environmental quality will be greatly enhanced by improvements of knowledge in key areas. The implementation of measures to ensure the Good Environmental Status as described under Descriptor 8 requires a combination of several assessment tools which are at different levels of maturity. While some elements have already been used for a long time, other aspects have been introduced only recently. Still fundamental knowledge is lacking in some areas as listed below.

6.1.1. Understanding of the ecosystem responses to pollution

There is a general lack of understanding of causal relationships and of mechanistic processes between contaminants and their effects on biota. This includes mixture effects or interactions between contaminants and other environmental stressors, and the extent to which contaminants change the genetic composition of populations. Of special importance are genotoxic contaminants that may affect the genetic background of marine biota, in addition to the introduction of genetic alternations. Continuing research should be encouraged to fill the before mentioned gaps and to quantify the effect and impact of contaminants at the population level and higher levels of biological organisation. As well as the conduct of detailed field surveys in hot spot areas, the use and application of mesocosm experiments and modelling tools to further improve our knowledge should be encouraged. At the same time, studies on the cellular level may supplement the vital background for better understanding of future changes on the population and mesocosm levels.

Specially important is to further investigate methodologies to assess the effects of real complex mixtures of inorganic and organic pollutants to organisms and ecosystems, since the number of organic pollutants described in any single assessment or research study is small in comparison to total number of known pollutants in marine waters (Annex 6), and the latter is also small to the total number of marine potential pollutants (Dachs and Méjanelle 2010).

In general one of the challenges for MSFD GES implementation will be to establish relationship between pressures and GES of European seas. The knowledge of this relationship is essential for pertinent and efficient measures in order to achieve and maintain GES in marine ecosystems. The diversity of direct and indirect pressures especially in coastal areas, imbrications of biological, chemical and physical processes, operating at different scales, render complex characterization of causative links between particular pressure and observed status of a entire ecosystem or one it compartments. In this context, research support is expected for a better understanding of this relationship between pressures, their effects and impacts on the marine environment. The progresses are also necessary for deriving pertinent and operational indicators for GES assessments for the Descriptor 8. These developments are in particular now needed for the Mediterranean region.

Research is also needed on the relationship between the mechanisms of entry of pollutants (riverine, atmospheric, etc.) into marine waters and their availabiltity and potential effects on organisms and ecosystems. Marine ecosystems have been, presumably, subject for increasing anthropogenic pressures due to pollutants during the last decades, as it has happened for many other anthropogenic pressures (nutrients, carbon, etc.) (Dachs and Méjanelle 2010). The knowledge of how ecosystems are responding to these long terms trends is unknown and research is need on long time series that relate pollutant exposure and cycling to effects to organisms and ecosystem functioning at all levels and scales.

6.1.2. Knowledge on the marine foodwebs with regard to contaminants

Ideally, environmental target levels should take into account the processes of bioaccumulation, biomagnification, and the possibility of additive, synergistic and antagonistic effects. The transfer of contaminants through the food chain needs to be better understood and (when possible) quantified, in order to explore the use of trophic magnification factors within the ecosystem-based approach.

The toxic effects of chemical contaminants on marine organisms are dependent on bioavailability and persistence, the ability of organisms to accumulate and metabolize contaminants, their interactions with the organisms' DNA, and the interference of contaminants with specific metabolic or ecological processes. The transfer of toxic and genotoxic chemicals through marine food chains can result in bioaccumulation in commercial fishery resources and so to transfer to the human consumers of seafood.

Little is known about contaminant uptake in the first trophic levels (plankton and benthos), and how different biogeochemical statuses of marine ecosystems (e.g. oligotrophy vs. eutrophy) favour the bioaccumulation and cycling of contaminants. Even more challenging are the questions on how the bacterial loop may deal with genotoxicants or how the bacterial loop may enhance the bioaccumulation of contaminants and enrich the base of food webs. For hydrophobic organic contaminants and some heavy metals, such as mercury, it is important to get better knowledge of the relative importance of their pelagic versus benthic food web transfers. Finally, the coupling of bioavailability and chemical kinetics is still not well developed, although it is essential for a better understanding and modelling of the bioavailability of vital and detrimental compounds for marine biota.

6.1.3. Contaminant uptake and effects in marine top predators

Biota on the top of the trophic chain are most affected by bioaccumulation and biomagnification. They are often highly mobile and thus difficult to relate to environmental conditions in specific regions. Investigations on their state, number and exposure to contaminants require multidisciplinary studies. This includes baseline studies, aiming at developing reliable time trend series.

6.1.4. Source identification and quantitative apportionment

Data for better quantification of contaminants fluxes and inputs into European Seas and their sea/air and water/sediments interfaces exchanges is lacking. These data are also essential for predictive and mass balance modelling of contaminants fates in the marine systems. Such source apportionment provides the necessary basis for effective measures in emission reduction.

6.1.5. Development of methods for the monitoring of pollutants

The current knowledge of environmental processes and effects of organic pollutants is limited by the methodologies available for quantitative determination of concentrations of pollutants at ultra trace level. The measurement of contaminant concentrations in the marine environment requires therefore the ability for a cost-effective analysis of a high number of chemical compounds at relevant concentration levels. Besides the development of (e.g. mass spectrometric) analytical detection techniques this should include also the techniques for sample preparation (e.g. extraction) and introduction (e.g. injection techniques). There is a need of tools for non-target analysis and identification of pollutants, sampling techniques allowing assessments of 3D spatial distribution and high temporal resolution in order to gain new knowledge on fate and effects of pollutants in the marine environment. These techniques should cover all pollutant types and include emerging pollutants.

6.1.6. Deep Sea Research

Approaches for a cost-effective sampling in the deep sea environment should be developed. They should cover the needs for an assessment of the final sinks for pollutants, including different environmental matrices, such as biota and sedimenting material. This includes the further development of platforms, such as benthic stations (5.8.1.3) and sampling tools or *in-situ* analytical tools. The use of sensors on board of Autonomous Underwater Vehicles AUVs can provide high resolution 3D data which are necessary for the understanding of contaminant behavious in complex oceanographic conditions.

6.1.7. Passive sampling techniques

The application of passive sampling devices should be further developed. A variety of passive sampling devices offers the potential for temporally-integrated sampling of a number of priority pollutants and emerging substances, including brominated flame retardants and perfluorinated substances, in water and the assessment of their availability in sediments, and these should be deployed where possible. OSPAR is currently considering the use of some of these tools (e.g. passive sampling using silicone rubber) for application within its monitoring programmes. In addition, *in vitro* studies (like the comet assay) employed on water and sediment samples offer additional facets for the generic toxicity and genotoxicity of the environment.

There are advantages to be gained from combining the use of extracts from passive samplers and specific bioassays to form an important linkage between the WFD and MSFD. Both methods are generic and can be applied to a wide variety of environments. In this connection, the application of integrated bioanalysis (a small set of cheap and fast bioassays representing various taxonomic groups and/or modes of action (e.g. estrogenicity) applied to water, suspended matter or sediment extracts) extended with toxicity identification evaluation (TIE) procedures, novel sensors and micro-arrays, when they become available, and instrumental methods to identify causal compounds should also be considered.

6.1.8. Biological effects techniques

Current biological effects techniques used in environmental health assessment are an assemblage of bioassays, assays for specific inhibition of enzymes, induction of proteins, pollutant metabolites, DNA adducts, physiological responses and pathology. However, generally lacking are methods to assess the effects of immunotoxic compounds. Therefore, there is a specific need to develop biological effects methods to monitor the harmful effects of immunotoxic contaminants on the immune system of organisms. This need is underlined by the disease epizootics in populations of mammals and fish that have been reported and that can be attributed (at least in part) to a decreased disease resistance (e.g. weakened immunocompetence) caused by exposure to contaminants such as PCBs.

New biological effect techniques for certain priority and emerging substances (e.g. PFOS, certain brominated flame retardants, pharmaceuticals) need to be developed, validated and internationally standardized, and existing monitoring programmes should then be augmented to include their study. Several new techniques are either published in the recent literature or under development in national and international research programmes. For example, for brominated flame retardants, thyroid hormone receptor assays in fish blood are relevant in terms of their mode of toxicity, but have not yet been tested in the field and currently remain at the laboratory stage.

There is a need to further explore the potential application of Omics (*genomics*, metabolomics) technology to chemical and biological effects monitoring. The current consensus of opinion is that Omics data can usefully contribute to a weight of evidence approach, but used alone are not sufficient for risk assessment in regulatory toxicology. Omics tools enable simultaneous analysis of a wide range changes in gene expression, protein (e.g. enzyme) and physiological metabolite (e.g. lipid, aminoacid) profiles within the cells of an organism. When applied to animals exposed to toxic chemicals, these can provide a "fingerprint" which can be used to identify the underlying biochemical mechanisms of pathology and toxicity. In environmental toxicology, analysis of gene expression profiles (transcriptomics) is the only procedure that is sufficiently well developed at present to be considered in environmental health or risk assessments. Gene expression profiles (or "fingerprints") associated with chemical exposure and the ensuing toxicity and pathology can be determined by use of DNA microarrays.

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ANNEX 1. JURISDICTIONAL RIGHTS OF MEMBER STATES

MS of the EU are obliged to apply nature legislation in waters under their jurisdiction and, outwards, in waters where they exercise sovereign rights. As defined in UNCLOS (United Nations Convention on the Law of the Sea), the sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea. Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles. The outer limit of the territorial sea is the line every point of which is at a distance from the nearest point of the baseline equal to the breadth of the territorial sea. The UNCLOS determination for the exclusive economic zone (EEZ) is an area beyond and adjacent to the territorial sea in which the coastal state has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds. Additionally, coastal States have jurisdiction with regard to the establishment and use of artificial islands, installations and structures, marine scientific research, and the protection and preservation of the marine environment. The EEZ may not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

The continental shelf of a Member State is distinct from the EEZ, and it is defined in the UNCLOS as the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance. The continental shelf may not extend beyond 350 nautical miles. The rights of the coastal State over the continental shelf do not affect the legal status of the superjacent waters or of the air space above those waters.

In the Annex to Council Conclusions on the Integration of Environmental Concerns and Sustainable development into the Common Fisheries policy (Luxembourg, 2001), the Council of the EU encouraged the implementation of Habitats (92/43/EEC) and Bird (79/409/EEC) Directives in the EEZs of MS to guarantee the protection of the marine ecosystem. Furthermore, case law of the European Court of Justice has confirmed that EC law applies throughout EEZs of MS in European waters. As MS are obliged to apply Community law, it is expected, as for the implementation of Birds and Habitats Directives, that the MSFD will be applied to the above-mentioned maritime areas, i.e. to territorial seas, EEZs, and continental shelves.

Maritime jurisdiction in the Mediterranean Sea

The UNCLOS has not been fully implemented in the Mediterranean Sea largely due to regional geopolitical issues. Most coastal states of the Mediterranean have established territorial seas (Table 1). Greece and Turkey have adopted territorial waters of only 6 nautical miles in the Aegean Sea. The continental shelf legal regime has also been widely implemented. However, EEZs have been adopted in an inconsistent manner and in few countries (Table 1) meaning that in the Mediterranean, the areas of water under national jurisdiction are smaller than in EU’s other marine regions. The same applies to Fisheries Protection Zones (FPZs) and ecological protection zones.

In the Communication from the Commission to the Council and the European Parliament of 9 October 2002 laying down a Community Action Plan for the conservation and sustainable exploitation of fisheries resources in the Mediterranean Sea under the Common Fisheries Policy, the declaration of FPZs of up to 200 nautical miles was advocated. To achieve this, a common approach should be agreed upon by MS.

Marine Protected Areas (MPAs) have been established in the EU as part of the Barcelona Convention, OSPAR and HELCOM. For the Mediterranean Sea, the 1995 Protocol of the Barcelona Convention Concerning Mediterranean Specially Protected Areas and Biological Diversity in the Mediterranean provides for the establishment of a List of Specially Protected Areas of Mediterranean Interest (SPAMI List). Natura 2000 areas designated as part of Birds and Habitats directives in marine habitats are also MPAs. Also the International Convention for the Prevention of Pollution from Ships (MARPOL) defines certain special areas in which mandatory methods for pollution control are required and MARPOL also provides the legal basis for the declaration of Particularly Sensitive Sea Areas (PSSAs).

Table 1. Claims to maritime jurisdiction by states bordering the Mediterranean Sea (modified and updated from (Cacaud 2005).

State	UNCLOS ratification, accession	Territorial sea (nautical miles)	EEZ (nautical miles)	Ecological and fisheries protection zones (nautical miles)	Continental shelf (outer limit)
Albania	23 June 2003	12			n/a
Algeria	11 June 1996	12		32 or 52 (Fishing zone is 32 mi. between western maritime boundary and Ras Ténés, and 52 mi. from Ras Ténés to eastern maritime boundary, Legislative Decree No. 94-13, 28 May 1994, setting General Rules for Fisheries, art. 6)	del
Bosnia and Herzegovina	12 January 1994				n/a
Croatia	5 April 1995	12		3 October 2003	del
Cyprus	12 December 1988	12	Yes		depth of exploitability
Egypt	26 August 1983	12	200 (Feb 2003 established EEZ coordinates between Cyprus and Egypt)		n/a
France	11 April 1996	12	200 (not applicable in the Mediterranean)	8 January 2004	depth 200 m or exploitability
Greece	21 July 1995	6[1]			depth 200 m or exploitability
Israel		12			depth of exploitability
Italy	13 January 1995	12		Agreements on outer limits with opposite or adjacent states pending[2]	depth 200 m or exploitability
Lebanon	5 January 1995	12			n/a
Libyan A. J.	Signatory	12		62	n/a
Malta	20 May 1993	12		25	depth 200 m or exploitability
Monaco	20 March 1996	12	Halfway to Corsica (1985)		n/a

State	UNCLOS ratification, accession	Territorial sea (nautical miles)	EEZ (nautical miles)	Ecological and fisheries protection zones (nautical miles)	Continental shelf (outer limit)
Morocco	31 May 2007	12	limit not specified in the Mediterranean		depth 200 m or exploitability
Serbia and Montenegro	12 March 2001	12			del
Slovenia	16 June 1995	12			n/a
Spain	15 January 1997	12	200 (not applicable in Mediterranean)	49 (applicable only in Mediterranean)	n/a
Syrian A. R.		35			depth 200 m or exploitability
Tunisia	24 April 1985	12	June 2005	12 or 50 (12 mi from Algero Tunisian border to Ras Kapoudia parallel; 50 mi between Ras Kapoudia parallel and Libyan border)	n/a
Turkey		6 in Aegean Sea, 12 mi in Mediterranean and Black Sea	200 (in Black Sea)		n/a

n/a: No information available

del: Up to delimitation with neighbouring states

[1] The extent of the territorial sea is fixed at 10 nautical miles for the purpose of regulating civil aviation (see Decree No. 6 of 18 September 1931).

[2] Pending negotiations and the subsequent entry into force of such agreements, the outer limits of the zones are to follow the median line, every point of which is equidistant from the nearest points on the baselines of the territorial sea of Italy and of the neighboring state.

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ANNEX 2. REVIEW OF CHEMICAL SUBSTANCE-RELATED EFFECTS IN THE MARINE ENVIRONMENT

This is a summary of available evidence for effects of chemical substances on wildlife in marine ecosystems. We present and discuss the evidence for effects of chemical substances using key studies and examples mainly from the maritime regions of Europe (Table 1 with observed effects). Some relevant studies of contaminant-related effects in marine organisms outside Europe have also been used.

Documented field effects attributed to chemical contaminants

A number of toxic effects in marine mammals, seabirds, fish and invertebrates have been associated with exposure to chemical pollutants. The observed abnormalities vary from subtle changes to permanent alterations, including perturbed sex differentiation with feminised or masculinised sex organs, changed sexual behaviour, or altered immune function. Such sublethal effects have been thought to have contributed to population level impacts including reproductive failure and outbreaks of disease. The best evidence for chemical pollution-related population effects has been linked to chemicals with endocrine disrupting properties (EDCs) (e.g. (Vethaak et al. 2006), but there is also evidence for e.g. relationships between levels of chlorinated compounds in tissues and increased prevalence of damaged embryos or reduced fertilisation success (von Westernhagen et al. 1989, Petersen et al. 1997) and tissue changes in areas affected by offshore activities (Hylland et al. 2006a, Hylland et al. 2006b). Impaired reproduction and development causally linked to EDCs have been documented in a number of species and have caused local or regional population changes.

Perhaps the best example of population level effects by specific endocrine disrupting contaminants is masculinisation (imposex) in female marine gastropods by tributyltin (TBT), a biocide formerly used in anti-fouling paints. A large number of studies have shown that the presence of very low concentrations of TBT (ng/L) will induce imposex or intersex in a range of gastropod species (e.g. dog whelks and netted dog whelks: for a review see (Matthiessen and Gibbs 1998, Oehlmann et al. 2007). These contaminant effects have in the past caused (local) populations to decline, but nowadays these effects have alleviated as a consequence of policy measures, i.e. progressive banning of the substance in antifouling formulations (e.g. (Waite et al. 1991, Laane and de Voogt 2006, Morton 2009). TBT-associated imposex is however still reported for gastropods in the Mediterranean and Black Seas, in and near harbours, marinas or in coastal bays, as well as in waters off the coast of the United Kingdom (Morton 2009). A recent field study has suggested the presence of DNA damage associated with the development of imposex in the dog-whelk *Nucella lapillus* collected from sites in southwest England and other sites throughout Europe (Hagger et al. 2006).

Endocrine disruptive compounds have been shown to have had adverse effects on a variety of fish species. Estrogenic effects (increased vitellogenin, a yolk precursor protein, and/or ovotestis in males) occur frequently in organisms inhabiting European estuaries and coastal waters, especially at the vicinity of point sources or highly polluted areas. Such effects could have implications e.g. for fish populations (Matthiessen 2003). Several studies have observed estrogenic effects in marine fish, including large pelagic predators evident in male fish in areas away from point sources (Fossi et al. 2002, Kirby et al. 2004, Scott et al. 2006, Scott et al. 2007). The causes of these phenomena are not yet fully understood (Matthiessen 2003, Vethaak et al. 2006), but bioaccumulation of unknown substances, possibly through feeding, is a possible explanation for estrogenic exposure for at least some of these species. There is also increasing evidence of compromised reproductive capacity in female fish which could potentially have an impact on populations (Jobling et al. 2002). This hypothesis is supported by the evidence from a Canadian whole lake study that demonstrated the collapse of a fish population after exposure to a synthetic estrogen at ng/L levels (Kidd et al. 2007).

There have been a couple of studies indicating demasculinisation of crustaceans as a possible impact of environmental contamination however, so far, comprehensive studies of this type have been few and far between (Ford et al. 2005, ICES 2009).

In mammals, the best evidence comes from the field studies on Baltic grey and ringed seals, and from the feeding experiments with Wadden Sea harbour seals, where both reproduction and immune functions have been impaired by PCBs in the food chain (Reijnders 1986, Ross et al. 1995, Ross et al. 1996, Bergman 1999). Numerous cases refer to mass mortalities by infectious diseases, poor reproductive performance, immunosuppression, thyroid abnormalities and other non-reproductive disorders in marine mammals (polar bear, seal, dolphin: see Table 1) and fish-eating birds (Giesy et al. 2003). Such effects have been to some extent been associated with the presence of POPs (e.g. organochlorine compounds, brominated flame retardants and certain metabolites) and other endocrine disrupting and/or immunotoxic compounds in the body fat (Fisk et al. 2005). An increasing disease susceptibility in different whale and dolphin populations has led to speculation about a possible negative influence of contaminants on the immune system (Beineke et al. 2009). In most of these cases, however, it was not possible to confirm a cause-and-effect relationship between a specific chemical or group of chemicals and individual or population level effects.

Outbreaks of (infectious) diseases and cancer associated with chemical pollutants have been documented especially in marine mammals and fish. For example suppression of immune function have likely contributed to the mass mortalities due to morbillivirus infections (Aguilar and Borrell 1994). Another more recent study reported significant negative relationships between high blood levels of PCBs and serum immunoglobulins in polar bears (*Ursus maritimus*) and a significant negative relationship between PCB exposure and cell-mediated immunity (Lie et al. 2005).

There is evidence for a link between exposure to carcinogenic/genotoxic compounds such as PAHs and the development of liver tumours and other liver lesions in flatfish (Vethaak et al. 2006, Vethaak et al. 2009). Liver neoplasms and a series of liver cancer normally develop over a number of years, so it is unlikely that liver tumours add significantly to fish mortality in the marine environment. PAHs are possibly also involved in the etiology of high prevalences of cancer observed in beluga whale (*Delphinapterus leucas*) from St Lawrence estuary in Canada (Martineau et al. 2002). This hypothesis has to some extent been supported by the observations that the human population living in proximity of the habitat of the St. Lawrence beluga has higher rates of cancer than rates found in people in the rest of Québec and Canada. Some of these cancers have been epidemiologically related to PAH exposure. A significant decrease towards natural background level has been reported for PAH-related liver tumours and major skin diseases in Dutch flatfish populations in the past 15 to 20 years. Although not having a direct impact on the population of flatfish, the improved health status of fish has been attributed to improved water quality in this region, including a decrease in carcinogenic and other toxic contaminants (Vethaak et al. 2009). Liver tumours in dab (*Limanda limanda*) and flounder (*Platichthys flesus*) are still observed in other regions of the North Sea such as some UK estuarine waters (Hylland et al. 2006a). In addition, other diseases such as skin ulcers and hyperpigmentation (a new emerging disease in dab) are increasing and evident (Lang et al. 2006, ICES 2007c, Vethaak et al. 2009). There is no evidence that contaminants are directly responsible for external fish disease outbreaks. However, reduced disease resistance as a result of exposure to immunotoxic contaminants may have contributed to infectious and non-infectious disease outbreaks in fish. There is growing evidence from laboratory studies that support this hypothesis (Zelikoff 1993, Wester et al. 1994, Beineke et al. 2009). For example, current levels of tributyltin contamination in coastal and estuarine environments are also still likely to negatively affect the immune response and ultimately the general health status of estuarine flatfish in heavily polluted environments in Europe (Grinwis et al. 2009). Other recent studies report that arsenic even at very low concentration is immunotoxic to freshwater catfish *Clarias batrachus* (Datta et al. 2009), and that concentrations of produced water in the North Sea containing polycyclic aromatic hydrocarbons, alkylated phenols, metals and production chemicals, close to the discharge point cause modulation to cellular immunity in blue mussels (*Mytilus edulis*) (Hannam et al. 2009).

High levels of malformed fish eggs and larvae have been correlated to high levels of pollutants, i.e. chlorinated organic contaminants, detected at sites in the North Sea (Detlefsen et al., 1996). Environmental factors such as temperature are also known to influence egg viability, so it has not been possible to establish conclusively whether pollutants are responsible. Recent findings, however, indicate a stabilisation of malformation rates at natural background levels (von Westernhagen et al. 2006), in correspondence with decreasing concentrations of chlorinated substances.

Several studies suggest that the decline in eel populations (*Anguilla anguilla*) may be at least in part due to the exposure to chemical compounds, including dioxine-like compounds (Robinet and Feunteun 2002, Palstra et al. 2006, van Ginneken et al. 2009). This hypothesis is supported by an experimental study that demonstrated a clear inverse relationship between the TEQ level and the survival period of the fertilised eggs, which in turn strongly suggests that the current levels of dioxin-like compounds seriously impair the reproduction of the European eel (Palstra et al. 2006, van Ginneken et al. 2009).

Numerous studies have demonstrated effects of contaminants on lower level of organisation in individual marine organisms, ranging from sponges, phyto and zooplankton to marine mammals (see Table 1). However, the ecological significance of these effects remains often unclear. Several of these studies demonstrate a long-term decline in biochemical and morphological responses to contaminants in different marine organisms in coastal and offshore areas. An example is the observed decline in estrogenic effects (measured by vitellogenin and ovotestis occurrence) in UK estuarine flounder (Matthiessen 2006). However, by contrast, a recent study on long-term biomarker data from pearch in the Baltic Sea indicates increasing exposure to environmental pollutants (Hanson et al. 2009).

As referred briefly to above, a monitoring study using haddock (*Melanogrammus aeglefinus*) in the North sea observed a range of effects in this species linked to the presence of populations in or near areas with offshore activity (Hylland et al. 2006a). There were substantially increased levels of DNA damage and changes in the lipid composition of membranes in haddock collected in areas with high activity. The effects were corroborated by other biomarkers and comprised a total picture of a population with increased DNA damage due to predominantly PAH exposure (documented through elevated PAH metabolite concentrations), but also increased oxidative stress resulting in changed lipid composition (Hylland et al. 2006a).

Effects measured in sediment and water bioassays

There has been an increasing emphasis on the use of toxicity bioassays to identify and qualify the toxicity of estuarine and coastal environments. Numerous studies have demonstrated toxic responses in vivo and in vitro sediment and water. In vivo bioassay responses are only rarely observed in real field samples, with the exception of most polluted estuaries and harbour sediments. However, high in vivo sediment toxicity was found close to industrial sites and harbours, but also in open sea areas in Swedish waters (Dave and Nilsson 1999).Toxicity measured in vitro and in vivo bioassays using environmental extracts, concentrates, or sediment elutriates have been commonly reported but the ecological relevance of the results remain often unclear. For example, results of toxicity tests show dioxin-like, estrogenic and genotoxic activity in coastal and offshore sediment and suspended matter extracts by known and yet unknown contaminants (Klamer et al. 2005). Several mechanism-based (AhR and ER agonist) in vitro bioassays were able to detect dioxin-like and estrogenic activity at most surface water sites in the German Bight and in the direct vicinity of offshore oil production platforms in the North Sea (Hylland et al. 2006b).

In several studies a combination of target chemical analyses and Effect Directed Analysis (EDA)/Toxicity Identification Evaluation (TIE) procedures were used to elaborate on the pollution problems in the chosen sites. EDA and TIE are powerful techniques for identifying effects and compounds responsible for the observed effects. Examples include the identification of estrogenicity resulting mainly from isomeric mixtures of C1 to C5 and C9 alkylphenols in produced water extracts (Hylland et al. 2006b).

Using a newly developed early life stage (ELS) test by (Foekema et al. 2008), adverse effects are reported for the dioxin-like PCB 126 on the early development of the marine flatfish sole (*Solea solea*). The test includes metamorphosis of the symmetric larvae into an asymmetrical flatfish. Results reveal that exposure for only 4 days, covering only the egg stage, was sufficient to cause adverse effects during a critical developmental phase two weeks later. Used concentrations were within the same order of magnitude as levels found in fish from highly polluted areas. This study indicates that ELS fish tests that are terminated shortly after the fish becomes free-feeding, underestimate the toxic potential of compounds with low acute toxicity such as PCBs. Prolonged ELS with this native marine flatfish suggests that reproductive success of fish populations at contaminated sites can be affected by persistent compounds that are accumulated by the female fish and passed on to the eggs (Foekema et al. 2008).

Pollution of the aquatic environment by human and veterinary waste pharmaceuticals is an increasing area of concern but little is known about their ecotoxicological effects on wildlife. In particular the interactions between pharmaceuticals and natural stressors of aquatic communities remains to be elucidated. (Thomas and Langford 2007) showed that very few data were available for pharmaceuticals, personal care products and veterinary medicines in the marine environment. Occurrence data are available from Norway, Germany and UK with the target compounds typically being detected at low ng/L concentrations if present. A recent experimental study showed that Baltic sea key species (blue mussel *M. edulis*, *Gammarus spp*, and the macroalgae *Fucus vesiculosus*) exhibit negative effects when exposed to human pharmaceuticals at environmentally relevant concentrations of propranolol, diclofenac, and ibuprofen (Ericson et al., 2009). Other recent experimental work demonstrated that the pharmaceutical clotrimazole can affect marine microalgal communities at picomolar concentrations, but the true impact on marine primary producers has not been established (Porsbring et al. 2009). Another emerging field of concern relates to nanoparticles. At present, however, there are few data on the effects of nanoparticles on marine organisms (Moore 2006, ICES 2009).

Recent concern has developed over the potential chronic and transgenerational effects of environmental contamination, and the changes in genetic variability and allele frequencies of populations that result from induced mutations, population bottlenecks, and selection caused directly or indirectly by contaminant exposure. There is evidence that contaminant exposure often leads to change in the genetic attributes of natural populations (Bickham et al. 2000, Belfiore and Anderson 2001).

Table 1. Summary of field effects attributed to chemical contaminants.

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
Biodiversity	Reductions in species richness and evenness of marine habitats	Strong associations with anthropogenic contaminants (no specific class)	Marine environment (Literature review and meta-analysis of 216 studies)	(Johnston and Roberts 2009)
Benthic community	Significant reduction in phytoplankton biomass and primary productivity	Benthos health (i.e. BI) showed negative correlation with sedimentary PAHs and TBT; acutely toxic effects are expected for TBT	Barcelona harbour, Spain	(Martínez-Lladó et al. 2007)
Benthic community, nematode assemblages	Reductions in species diversity	Significant correlations between certain nematode species and concentrations of environmental contaminants i.p. Cu	Tourist marinas, Mediterranean Sea	(Moreno et al. 2009)
Benthic community	Reductions in species diversity or other changes in community structure	Discharges of oil-based drilling fluids (halted in 1996)	North Sea offshore (oil and gas industry)	(Gray et al. 1999)
Benthic community	Changes in the species composition	Seawater quality including sewage contaminants	Swansea Bay, Wales, UK	(Smith and Shackley 2006)
mammals				
Polar bear (*Ursus maritimus*)	Masculinisation	Endocrine disrupting pollutants (e.g. PCBs) may be responsible	Spitsbergen	(Wiig et al. 1998)
Polar bear (*Ursus maritimus*)	Cell-mediated immunity	Negative relationships between high blood levels of PCBs and serum immunoglobulins against a range of pathogens	Arctic	(Lie et al. 2005)
Polar bear (*Ursus maritimus*)	Histology of selected immunological organs	Organohalogen contaminants (PCBs, DDTs, HCHs, CHLs, HCB, Dieldrin and PBDEs). No clear evidence, although some POPs were related to increased	East Greenland	(Kirkegaard et al. 2005)

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
		secondary follicle counts in the spleen		
Polar bear (*Ursus maritimus*)	Population effects, e.g. reproductive impairment, increased mortality, lower survival rates of cubs	Organochlorines (blood) Suggestion of contaminant-related population level effects	Svalbard, Norwegian Arctic	(Derocher et al. 2003)
Steller sea lion (*Eumetopias jubatus*)	Population decline	Butyltins, mercury, PCBs, DDTs, chlordanes and hexachlorobenzene. Insufficient data to reject the hypothesis that contaminants play a role in the continued population decline	Alaska	(Barron et al. 2003)
Ringed seals (*Phoca hispida baltica*) and Grey seals (*Halichoerus grypus*)	Effects on cytochrome P4501A activity, vitamin E levels, Arylhydrocarbon receptor-mediated chemical-activated luciferase gene expression (CALUX) response, and vitamin A (in liver, blubber or plasma)	PCBs, DDT. Several parameters/biomarkers showed a clear correlation with the individual contaminant load	Baltic Sea	(Nyman et al. 2003)
Ringed seals (*Phoca hispida*)	Uterine stenosis, occlusions, resulting in a depressed reproductive capacity	DDE-/PCB methylsulfones	Baltic Sea, German Wadden Sea	(Bergman 1999)
Harbor seals (*Phoca vitulina*)	Lowered immunocompetence	TCDD-like	Wadden Sea, Netherlands	(de Swart et al. 1996, Ross et al. 1996)
Harbor seals (*Phoca vitulina*)	Decreased fecundity, implantation failure	PCBs and metabolites	Wadden Sea, Netherlands	(Reijnders 1986)
Harbor porpoise (*Phocoena phocoena*) (strandings)	Increased risk of mortality from infectious disease possible through immunosuppression	PCBs (blubber)	UK coastal waters; case control study	(Hall et al. 2006)
Grey seals (*Halichoerus grypus*)	Effects on concentrations serum proteins, minerals and thyroid hormones. Cholesterol and albumin concentrations were also	A link is suggested between thyroid hormones and exposure to PBDEs in grey seals during their first year	Farne Islands, UK	(Hall et al. 2003)

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
	positively related to blubber PBDEs	of life		
Harbour seals (*Phoca vitulina*)	Disruption of vitamin A and its receptor (retinoic acid receptor)	PCBs	Coastal British Columbia, Canada, and Washington State, USA	(Mos et al. 2007)
Striped dolphins (*Stenella coeruleoalba*)	Mass mortality due to morbillivirus epidemic	PCBs (blubber)	Mediterranean Sea	(Aguilar and Borrell 1994)
Beluga (*Delphinapterus leucas*)	Cancer in 27% of examined adult animals found dead	PAHs produced by the local aluminium smelters	St. Lawrence estuary (SLE)	(Martineau et al. 2002)
birds				
Numerous species	Egg shell thining	DDE	Europe, North America	See (Vos et al. 2000)
Numerous species	Reprouctive impairment	PCDDs, PCDFs, PCBs	US, Europe	See (Vos et al. 2000)
Caspian terns (*Sterna caspia*) (young)	Altered Immune Function suppressed T cell function and enhanced antibody production	Organochlorine contamination (e.g. PCBs en DDE)	Lake Huron, Canada	(Grasman and Fox 2001)
fish				
Bluefin tuna (*Thunnus thynnus thynnus*), Swordfish (*Xiphias gladius*) and Mediterranean spearfish (*Tetrapturus belone*)	Increased levels of VTG (blood or liver) in males. High prevalence in swordfish (25% oocystes)	Xeno/estrogens most likely obtained through the food chain	Mediterranean Sea	(Fossi et al. 2002, De Metrio et al. 2003)
Perch (*Perca fluviatilis*)	Elevated blood vitellogenine in male fish	Pulp mill effluents; unknown chemicals	Baltic Sea, Sweden	(Forlin et al.

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
				1995)
Perch (*Perca fluviatilis*)	Decreased gonad weight and increased hepatic EROD activity	Pollutants may be partly responsible	Baltic Sea, Swedish coast	(Hansson et al. 2006)
Cod (*Gadus morhua*)	Elevated levels of hepatic EROD, bile 1-OH pyrene, DNA adducts, Inhibition of acetylcholinesteras	Lipophilic xenobiotics, incl PCB congeners and organochlorine pesticides in liver. Indications for exposure to mixtures of organic toxic substances including genotoxic substances and organophosphates, carbamates, or certain heavy metals	Baltic Sea	(Schnell et al. 2008)
Roach (*Rutilus rutilus*)	Intersex, reduced fertility	Mixtures of endocrine-disrupting substances	UK rivers	(Jobling et al. 1998, Jobling et al. 2002)
Roach (*Rutilus rutilus*), Caspian starred goby (*Benthophilus stellatus*) and various sturgeon species	Elevated induction of CYP1A. No evidence of contaminant-related histopathologies	Hydrocarbon exposure	Caspian Sea, Lake Balkhash, and the Ily River Delta, Kazakhstan	(Moore et al. 2003)
Mullet (*Mugil soiuy*)	Elevated EROD activity, glutathione S-transferase and catalase activities	PAHs and related contaminants	West Black Sea Coast of Turkey	(Bozcaarmutlu et al. 2009)
Eelpout (*Zoarces viviparus*)	Impaired larval development (50% up to a maximum of 90%)	Different sources of chemical pollutants	German and Swedish Baltic coastal waters	(Gercken et al. 2006)
Eelpout (*Zoarces viviparus*)	Developmental malformations, AChE (muscular) and GST (liver) activity of females	Heavy metals, PCBs, HCHs and DDT. No clear associations were found.	Polish coastal waters (southern Baltic Sea)	(Napierska and Podolska 2006)
Eelpout (*Zoarces*	Developmental defects in the broods of	Hazardous substances (e.g. teratogens)but also	Danish coastal waters	(Strand et al.

Ecosystem/community/ species	**Effect**	**Associated contaminants**	**Location**	**Reference**
Ecosystem function/ biodiversity/ community				
viviparus)	females	eutrophication-effects may play a role		2004)
Grass goby (*Zosterisessor ophiocephalus*)	Effects on somatic liver index and gonadal somatic index, cytochrome P450 enzymes, acetylcholinesterase activity and ovarian morphology	HCB, DDTs and PCBs and p-nonylphenol (NP) and lower ethoxylate (NPE1–2). Results suggest contaminant effects	Orbetello lagoon (southern coast of Tuscany, Italy), receiving sewage effluent	(Corsi et al. 2003)
Viviparous blenny (*Zoarces viviparous*)	A shift in sex ratio in favour of females	Near an outlet of a sewage treatment plant	Baltic Sea	(Gercken and Sordyl 2002)
Shanny (*Lipophrys pholis*)	Vitellogenin gene expression in males	Exposure to endocrine disrupting compounds	Portuguese coast	(Ferreira et al. 2009)
Solea senegalensis, juvenile	Histopathological lesions in liver and gills	Semi-field study using contaminated sediments collected from a Portuguese estuary/ 28 days	Several metals and organic contaminants (PAHs, PCBs and, dichloro-diphenyl-trichloroethane plus its metabolites),	(Costa et al. 2009)
Sand goby (*Pomatoschistus minutus*,Pallas)	Increased adult mortality and female Zrp and Vtg mRNA expression, weakening of male nuptial coloration, but no induction of male vitellogenesis	Semi-field exposure, 7 months	Sewage effluent containing known xeno-oestrogens (alkylphenol polyethoxylates	(Robinson et al. 2003)
Flounder (*Platichthys flesus*)	Reduction in muscle cholinesterase (ChE) activity	Contaminant-mediated and that OP and C pesticides were probable contributors	UK estuaries (Humber, Mersey, Tamar, Tees and Tyne)	(Kirby et al. 2000)
Flounder (*Platichthys flesus*), Goby	Histopathological biomarkers (liver tumors	Contaminants, incl PAHs	UK estuaries (the Tyne, Tees, Mersey	(Stentiford et al.

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
(*Pomatoschistus minutes*) and Eelpout (*Zoarces viviparous*)	and associated lesions), intersex in males		and Alde)	2003)
Flounder (*Platichthys flesus*)	Prevalences of liver lesions (early toxicopathic non-neoplastic, pre-neoplastic and neoplastic lesions)	Indications of contaminant effects	Baltic Sea	(Lang et al. 2006)
Flounder (*Platichthys flesus*)	EROD and AChE activities, multixenobiotic resistance (MXR) protein and intersex in males	No specific associations, but results are suggestive for chemical pollutant effects	Seine Bay, France	(Minier et al. 2000)
Two demersal fish species (*Lepidorhombus boscii* and *Callionymus lyra*)	EROD and other enzymatic Biomarker (liver)	Lowering of biomarker activity two and three-years after the oil spill, indicating a decreasing level of exposure of the fish to residual hydrocarbons associated with the spillage to baseline levels existing before the accident	Galician coast (NW Spain)	(Martínez-Gómez et al. 2009)
Haddock (*Melanogrammus aeglefinus*)	Increased exposure and DNA adduct concentrations	Oil and gas production activity	North Sea offshore	(Hylland et al. 2006a)
Dab (*Limanda limanda*), flounder (*Platichthys flesus*)	Temporal trends in prevalence of liver tumours and skin diseases (epidermal hyperplasia/papilloma, lymphocystis, ulcers)	PCBs, HCB, metals (liver), PAHs (sediment). Clear association between contaminant exposure and liver tumors. Results suggest that immunotoxic compounds contributed to elevated prevalences of infectious and non-infectious disease	Dutch coastal and offshore waters	(Vethaak et al. 2009)
Flounder (*Platichthys flesus*)	Elevated blood vitellogenin in male fish	(Xeno)estrogens	UK, estuaries and coastal waters	(Allen et al. 1999)
Dab (*Limanda limanda*)	Elevated EROD activity	Planar compounds e.g. PAHs and some PCBs possibly associated with Elbe flood 2002 event	North Sea, German Bight	(Kammann et al. 2005)

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
Various fish species	Embryonic malformation in pelagic eggs	Unknown	North Sea coastal waters, Baltic Sea	(von Westernhagen et al. 2006)
Flounder (*Platichthys flesus* L and Blue mussel (*Mytilus edulis*)	Effects on lysosomal membrane stability, biotransformation enzymes, and cellular changes in livers and digestive gland (lysosomes)	Organochlorines, PCBs associated with Elbe flood 2002 event	Wadden Sea, Germany	(Einsporn et al. 2005)
Red mullet (*Mullus barbatus)* and mussel (*Mytilus galloprovincialis*)	Reduced AChE activities	Contaminants related to urban and agriculture activities, e.g. heavy metals, pesticides	Italian coast, Salento Peninsula	(Lionetto et al. 2003)
European eel (*Anguilla anguilla*)	Impairement of reproduction	Dioxine-like compounds	East Atlantic	(van Ginneken et al. 2009)
Blue mussel (*Mytilus edulis*) and eelpout (*Zoarces viviparus*)	Effects on. lysosomal membrane stability, AChE activity, micronuclei (mussels), DNA adducts, EROD induction and PAH-metabolites (eelpout)	PCBs, DDTs. Clear evidence for pollution effects	Southwestern Baltic Sea, Wismar Bay	(Schiedek et al. 2006)
invertebrates				
Brown shrimp (*Crangon crangon*)	Effects on enzymatic biomarkers, e.g. AChE, lactate dehydrogenase, glutathione Stransferases, and AChE-like ChE in the cephalotorax	Agricultural, industrial or urban, effluent contamination	Iberian Atlantic coast	(Quintaneiro et al. 2006)
Shore crabs (*Carcinus maenas*) (transplanted)	Effects on DNA integrity and enzymatic biomarkers as indicators of general stress	Mixture of contaminants, e.g. metals and PAHs	Ria Formosa Lagoon, Portugal	(Maria et al. 2009)

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
Harpacticoid copepods	Intersex	Sewage	Scotland	(Moore and Stevenson 1994)
Hexaplex trunculus	Imposex in females (widespread occurrence)	Tributyltin (TBT) -based antifoulants	Adriatic Sea, Croatia, Kaštela Bay	(Stagličić et al. 2008)
Periwinkle (*Littorina littorea*), Blue mussel (*Mytilus edulis*)	Intersex (snails), DNA, damage (mussel gills)	Heavy metals (Cd, Cu, Pb and Zn), butyltin compounds (TBT, DBT and MBT), PCBs and PAHs.	Highly contaminated harbour in Denmark	(Rank 2009)
Nassarius reticulatus (L.)	Imposex	Organotin contamination	Portuguese coast	(Sousa et al. 2005)
Blue mussel (*Mytilus edulis*)	Elevated lysosomal responses and metallothionein induction	Organometals, POPs and PAHs	South-west coast of Iceland incl. Reykjavik harbour	(Da Ros et al. 2007)
Mussels (*Mytilus Galloprovincialis*) (caged)	Many biomarkers, incl. lysosomal stability, and biomarkers of genotoxic damages	Trace metals and PAHs associated with remobilization of chemicals from dredged sediments	Harbour of Piombino (Tuscany, Italy)	(Bocchetti et al. 2008)
Mya arenaria (a bivalve species)	Disruption of reproductive activity	Organotins, metals	St. Lawrence Estuary (Quebec,Canada) Odense Fjord (Denmark)	(Gagné et al. 2006)
Scrobicularia plana (a bivalve species)	Intersex	Endocrine disrupting compounds	Southern UK coast, Avon estuary	(Chesman and Langston 2006)
Echinogammarus marinus (Leach)	Reduced quality of sperm	Industrial pollution, e.g. EDCs	North and eastern coasts of Scotland	(Yang et al. 2008)

Ecosystem/community/ species	Effect	Associated contaminants	Location	Reference
Ecosystem function/ biodiversity/ community				
(Crustacea)				
Sea star (*Asterias rubens*)	Spatial patterns cytochrome P450 level, benzo[a]pyrene hydroxylase (BPH) activity, acetyl-cholinesterase (AChE) activity and DNA integrity	Unknown pollutants	North Sea	(den Besten et al. 2001)
Blue mussels (*Mytilus edulis*)	Scope for growth	Contaminants associated with urban/industrial development,including PAHs, TBT, DDT, Dieldrin, g-HCH, PCBs, and a few of the metals (Cd, Se, Ag,Pb)	Irish Sea	(Widdows et al. 2002)
Sponges *Crambe crambe*	Inhibition of growth, fecundity and survival	Cu and Pb	Mediterranean Sea, Spain	(Cebrian et al. 2003)

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ANNEX 3. OSPAR STATUS OF BIOLOGICAL-EFFECT TECHNIQUES FOR INVERTEBRATES AND FISH (JAMP)

Method	In JAMP	CEMP category	Rec. by WGBEC	QC
Mussels				
Whole sediment bioassays	Yes	II	Yes	B
Sediment pore water bioassays	Yes	II	Yes	B
Sediment seawater elutriates	Yes	II	–	–
Water bioassays	Yes	II	Yes	B
In vivo bioassays	No	–	Yes	B (some)
In vitro bioassays	No	–	Yes	–
Lysosomal stability	No	–	Yes	B-a
Multidrug resistance (MXR/MDR)	No	–	Yes	–
Scope for growth	No	–	Yes	B-a
AChE	No	–	Yes	–
Metallothionein (MT)	No	–	Yes	B-a
Histopathology	No	–	Yes	–
Imposex/intersex in gastropods	Yes	I (M)	Yes	Q
Benthic community analysis	Yes	–	Yes	B
Fish				
AChE in muscle	No	–	Yes	–
Lysosomal stability	Yes	II	Yes	B-a
Externally visible diseases	Yes	I (V)	Yes	B
Reproductive success (eelpout)	Yes	II	Yes	B-a
Metallothionein	Yes	II	Yes	B-a
ALA-D	Yes	II	Yes	B-a
Oxidative stress	Yes	II	–	–
CYP1A-EROD	Yes	II	Yes	Yes
DNA-adducts	Yes	II	Yes	B-a
PAH metabolites	Yes	II	Yes	Q
Liver neoplasia/ hyperplasia	Yes	I (V)	Yes	B
Liver nodules	Yes	I (V)	Yes	B
Liver pathology	Yes	I (V)	Yes	B
Vitellogenin in cod	No	–	Yes	Yes
Vitellogenin in flounder	No	–	Yes	–
Intersex in male flounder	No	–	Yes	B-a

CEMP category: II, method suitable for marine monitoring purposes; I, method suitable and analytical-quality control (AQC) is available; M, mandatory method in place, with AQC and assessment criteria established. Quality control: V, voluntary method in place, with AQC but conducted voluntary. Recommendations for inclusion by WGBEC (ICES, 2007a) and information on existence of quality control (QC: B, Biological Effects Quality Assurance in Monitoring Programmes (www.bequalm.org); B-a, available online at http:\\www.bequalm.org; Q, Quality Assurance of Information for Marine Environmental Monitoring in Europe, available online at http:\\www.quasimeme.org).

Source: Thain, J.E., Vethaak, A.D. and Hylland, K., 2008. Contaminants in marine ecosystems: developing an integrated indicator framework using biological-effect techniques. 65(8): 1508-1514.

ANNEX 4. THE WKIMON APPROACH

Over the last few years, ICES/OSPAR WKIMON and associated groups have progressively developed an integrated approach to the use of biological effects measurements in environmental monitoring and assessment to meet the objectives of the OSPAR Strategy for Hazardous Substances. This approach has been described in more detail in various reports of ICES (e.g. (ICES 2006, 2007a, 2008, Thain et al. 2008)).In relation to hazardous substances, the OSPAR Joint Assessment and Monitoring Programme seeks to addresses the following questions:

- What are the concentrations in the marine environment, and the effects, of the substances on the OSPAR List of Chemicals for Priority Action ("priority chemicals")? Are they at, or approaching, background levels for naturally occurring substances and close to zero for man made substances?
- Are there any problems emerging related to the presence of hazardous substances in the marine environment? In particular, are any unintended/unacceptable biological responses, or unintended/unacceptable levels of such responses, being caused by exposure to hazardous substances?

The primary means of addressing these questions on an OSPAR wide basis is the Coordinated Environmental Monitoring Programme (CEMP; OSPAR Agreement 2005 – 5). Guidelines for the Integrated Monitoring and Assessment of Contaminants and their Effects were presented to ASMO 2007 (ASMO 07/6/8).

The integrated approach described in the Guidelines is been based around recommendations of sets of measurements that could be used to investigate the effects of contaminants on either fish or shellfish (mussels). These reflect the wide experience of the monitoring of the concentrations of priority contaminants in sediment and biota, and the benefits of combining this with the developing experience of the use of biological effects measurements in monitoring programmes. The fish (Figure 1) and shellfish (Figure 2) integrated monitoring schemes are reproduced below (Figures 1 and 2) from the JAMP Guidelines for the Integrated Monitoring and Assessment of Contaminants and their Effects.

As indicated in the Guidelines, the contribution made by an integrated programme, involving both chemical and biological effects measurements, is primarily that the combination of the different measurements increases the interpretive value of the individual measurements. For example, biological effects measurements will assist in the assessment of the significance of measured concentrations of contaminants in biota or sediments. When biological effects measurements are carried out in combination with chemical measurements (or additional effects measurements) this will provide an improved assessment due to the possible identification of the substances contributing to the observed effects.

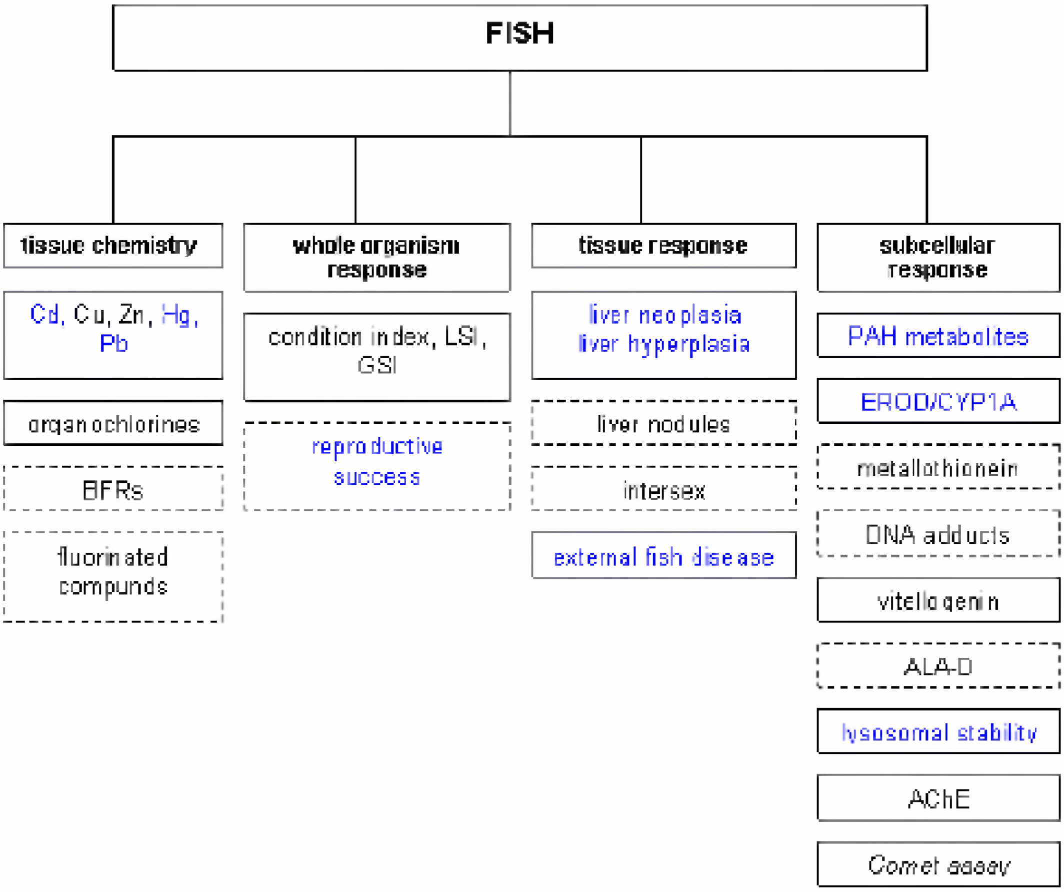

Figure 1. Overview of methods to be included in an integrated program for selected fish species. (Blue: included in CEMP; solid-line boxes: prioritised components (only applies to tissues and subcellular responses); italics: ICES WGBEC promising method.

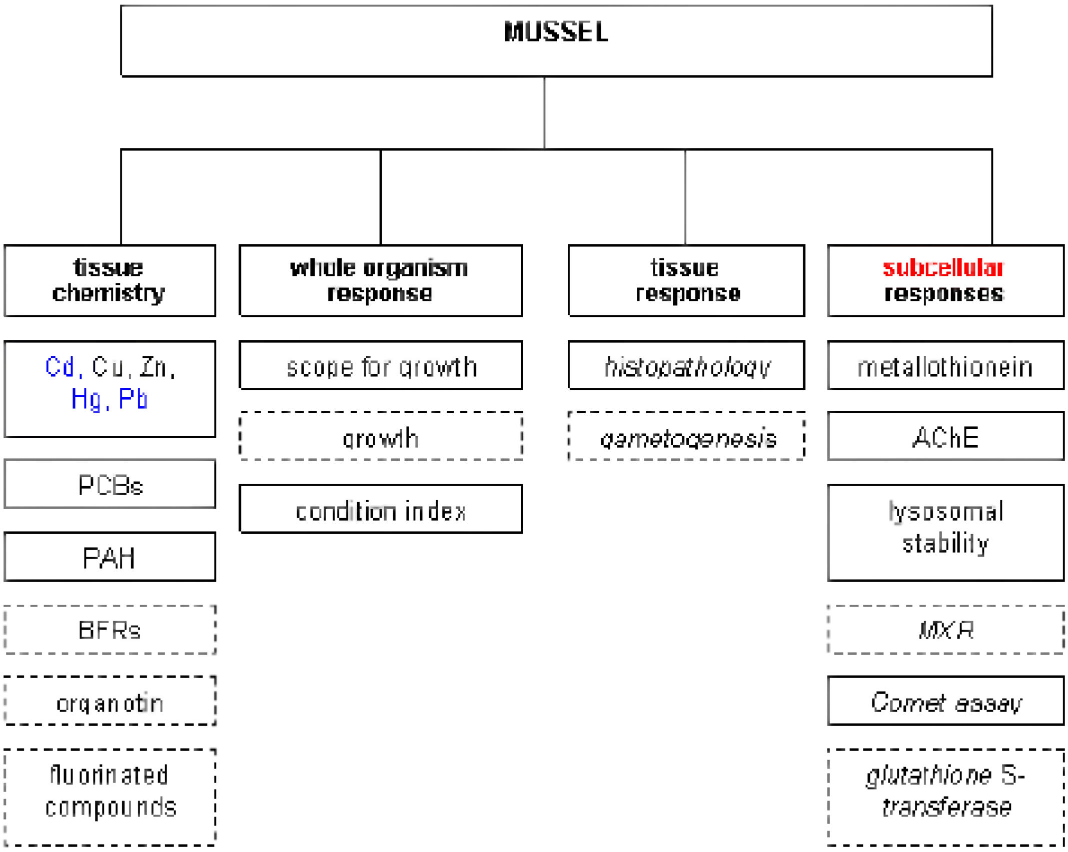

Figure 2. Overview of methods to be included in an integrated program for selected blue mussel. (Blue: included in CEMP; solid-line boxes: prioritized components (only applies to tissues and subcellular responses); italics: ICES WGBEC promising method.

The structure of each of the schemes recognizes that a full integrated assessment requires the integration of a variety of chemical measurements (concentrations of contaminants in the fish or mussels) and biological effects data.

It is well recognized that some particular contaminants or groups of contaminants can have characteristic biological effects. The classic example of a highly specific response to a contaminant is that of the effects of tributyltin (TBT) compounds in inducing imposex or intersex in gastropod mollusc species. These responses have been widely used as an assessment of the environmental significance of tributyltin compounds. While it is theoretically possible for other substances to disrupt the hormonal systems of snails in a similar way, it is generally accepted that TBT is the primary marine contaminant responsible for the effects.

There is clearly great attraction in the recognition of a highly specific response to a particular narrow class of contaminants, particularly if chemical analysis at concentrations known to be associated with the effects is difficult. However, generally such close relationships are rare. For example, a range of effects measurements have been applied to the effects of planar organic contaminants in the sea, ie

- the concentration of PAH-metabolites in fish bile;
- CYP1A/EROD induction;

- Indices of genotoxicity (e.g. DNA adducts of PAH, COMET assay, micronucleus assay etc)
- liver (microscopic) neoplasms
- liver histopathology.

However, these effects show varying degrees of specificity for PAH as opposed to other planar organic contaminants such as planar CBs, or dioxins. The concentration of PAH-metabolites in fish bile is clearly specific to the PAH compounds detected, but CYP1A/EROD induction is a property of a range of groups of compounds.

In general, it is found that while subcellular responses can commonly be linked to a substances that have the potential to induce the response, measurements of whole organism effects are much less contaminant-specific. However, they are often more closely linked to the potential to cause effects at population level, through reduction in survival or reproductive capacity. This gradation is reflected in the grouping of the effects measurements in Figures 1 and 2 under the headings of sub-cellular responses, tissues responses and whole organism responses. Sub-cellular responses such as EROD, bile metabolite concentrations and metallothionein are recognized as biomarkers of exposure to contaminants, while whole organism and tissue level responses are more clearly markers of effect.

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ANNEX 5. ENVIRONMENTAL TARGET LEVELS FOR BIOLOGICAL EFFECTS MEASUREMENTS

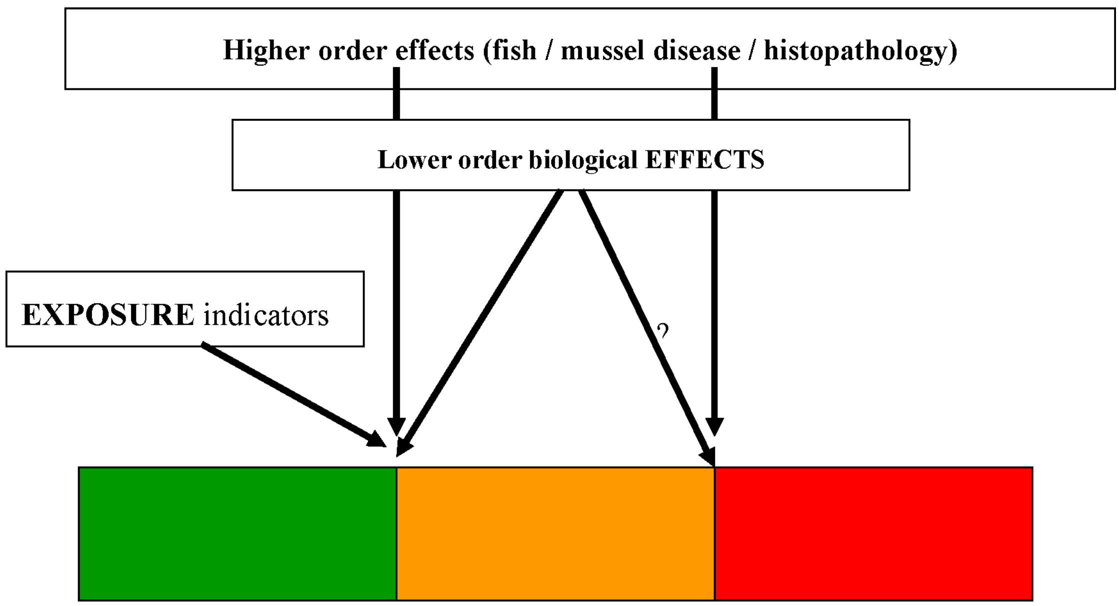
ICES WGBEC has noted that some biological measurements are indicators of exposure to contaminants, while others are more clearly indicators of effect. In most cases, a background response level has been found to be applicable to both categories of measurements, but the higher level assessment criterion may only be applicable to indicators of effect. Examples of the latter include the imposex response of marine snails to tributyltin, and lysomal stability. Background degrees of imposex (VDSI) are very low (<<1), whereas clear indications of inhibition of reproduction arte present if VDSI is >4. The OSPAR EcoQO structure for TBT effects in snails recognises the significance of differing degrees of induction of imposex for snail populations. Lysosomal stability measurements (by two methods) can also be interpreted using two assessment criteria, as illustrated below:

Lysosomal Stability Assessment Criteria

NRR	**>/= 120 mins**	**<120 - >/= 50 mins**	**< 50 mins**
Cvt Ch	**>/= 20 min**	**<20 - >/= 10 mins**	**<10 mins**

By contrast, some biological measurements are more appropriately viewed as biomarkers of exposure. Reasons for this differentiation can include that the response is rather transitory and unlikely to persist, or that there is no clear implication of the biomarker for tissue or whole organism level responses, or that the response is adaptive. Examples include the induction of metallothionein as a detoxification system for some metals, or the presence of metabolites of PAHs in fish bile. In these cases, while a background level of response may be recognisable, it may be difficult or impossible to define a higher level of response corresponding to unacceptable harm at higher levels of organisation.

This can be illustrated as below:



Biological effects indicators of exposure therefore typically can be assessed against a background activity or response criterion, i.e. in relation to the green/orange boundary. Higher order effects can typically be assessed against both a background criterion and also against a criterion that represents unacceptable levels of biological effect, i.e. against both green/orange and orange/green boundaries. There may be a set of lower order measures of biological effect that are assessable against either both types of environmental target levels, or just a background level of response.

ANNEX 6. REVIEW OF ORGANIC POLLUTANTS FOUND IN COASTAL WATERS

Chemical family	Historical or current use application	References of occurrence, fate or toxicity
Polychlorinated biphenyls(PCBs)	Industrial, various	(Yang et al. 2008)
DDTs (1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane)	Insecticide	(Garcia-Flor et al. 2009, Roche et al. 2009)
Hexachlorbenzene (HCB)	Insecticide	(Garcia-Flor et al. 2009)
Aldrin	Insecticide	(Roche et al. 2009)
Dieldrin	Insecticide	(Roche et al. 2009)
Endrin	Insecticide	(Roche et al. 2009)
Toxaphene (polychlorinated bornanes)	Insecticide	(Maruya and Lee 1998)
Chlordane	Insecticide	(Offenberg et al. 2004)
Heptachlor	Insecticide	(Roche et al. 2009)
Polychorinated dibenzodioxins and furans (PCDD/Fs)	Combustion byproduct	(Ishaq et al. 2009)
Hexachlorocyclohexanes (HCHs)	Herbicide	(Roche et al. 2009)
Polycyclic aromatic hydrocarbons (PAHs)	combustion byproduct, fossil fuels	(Gigliotti et al. 2005, Echeveste et al. 2010)
Polybrominated biphenyl ethers (PBDEs)	Flame retardant	(Johnson-Restrepo et al. 2005, Mizukawa et al. 2009)
Hexabromocyclododecane	Flame retardant	(Smolarz and Berger 2009)
Nnonylphenol polyethoxylates (NPEO)	Surfactant	(Bester et al. 2001, Xie et al. 2006)
Nonylphenols (NP)	Degradation product of NPEO	(Van Ry et al. 2000)
Octylphenols (OP)	Degradation product of NPEO	(Dachs et al. 1999, Xie et al. 2006)
Bisphenol A	Plasticizer, antioxydant	(Kang et al. 2006)
Phthalates (phtalate esters)	Plasticizer	(Mackintosh et al. 2004, Xie et al. 2007b)
Alkanes and other hydrocarbons	Fossil fuel, combustion byproduct	(Dachs et al. 1999, Melbye et al. 2009)
Non resolved hydrocarbons (UCM)	Fossil fuel	(Dachs et al. 1999, Melbye et al. 2009)
Chlorinated alkanes	Industrial (lubricants, flame retardants, etc)	(Tomy et al. 2000)
Organotins (Tributiltin, triphenyltin, etc)	Antifouling agent	(Díez et al. 2002, Sousa et al. 2009)
Atrazine	Herbicide	(Clark et al. 1999, Jones and Kerswell 2003, Rohr and Crumrine 2005)
Simazyne	Herbicide	(Clark et al. 1999, Jones and Kerswell 2003, Lewis et al. 2009)

Chemical family	Historical or current use application	References of occurrence, fate or toxicity
Diuron	Herbicide	(Haynes et al. 2000, Jones and Kerswell 2003)
Hexazinone	Herbicide	(Magnusson et al. 2008)
Endosulfan	Pesticide (Insecticide/acaricide)	(Rohr and Crumrine 2005, Roche et al. 2009)
Linear alkylbenzene sulphonates (LAS)	Surfactant	(Bester et al. 2001)
Linear alkylbenzenes	Byproduct of LAS	(Gustafsson et al. 2001, Ni et al. 2009)
***Bis*(4-chlorophenyl) sulphone**	Plasticizer, byproduct of pesticide synthesis	(Olsson and Bergman 1995)
Glyphosate	Herbicide	(Tsui and Chu 2003)
Irgarol	Antifouling agent	(Okamura et al. 2000, Hall et al. 2009, Lenwood et al. 2009)
methyl tertiary-butyl ether (MTBE)	Gasoline additive	(Rossell et al. 2006)
Benzotriazoles	UV stabilizers, pharmaceuticals and others	(Nakata et al. 2009)
Trialkylamines (TAM)	Surfactant byproduct	(Maldonado et al. 1999)
2-ethylhexyl 2,3,4,5-tetrabromobenzoate (TBB)	Flame retardant	(Lam et al. 2009)
***bis*-(2-ethylhexyl)-tetrabromophthalate (TBPH)**	Flame retardant	(Lam et al. 2009)
Perfluorinated compounds (PFOS, PFOA and others)	Industrial and other	(Nakata et al. 2006)
polychloronaftalenes	Industrial and other	(Corsolini et al. 2002)
Drugs of abuse (cocaine, etc)	Illicit drugs	(Postigo et al. 2009)
Pharmaceuticals (various)	Pharmaceuticals	(Fent et al. 2006, Gros et al. 2007)
Veterinary antibiotics	antibiotics	(Managaki et al. 2007)
Musk fragances	Fragances, day care products	(Xie et al. 2007a)
Sucralose	Sweetener	(Mead et al. 2009)
Estrone	Natural estrogen, pharmaceutical	(Braga et al. 2005, Sumpter and Johnson 2005, Kidd et al. 2007)
17β-estradiol	Natural estrogen, pharmaceutical	(Braga et al. 2005, Sumpter and Johnson 2005, Kidd et al. 2007)
17α-ethynylestradiol	Pharmaceutical	(Braga et al. 2005, Sumpter and Johnson 2005, Kidd et al. 2007)

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ANNEX 7. HAZARDOUS SUBSTANCES OF PRIORITY CONCERN FOR THE EUROPEAN MARINE ENVIRONMENT

Contaminants	Black Sea Covention	HELCOM	OSPAR (substances in bold are under obligatory monitoring)	Mediterranean Action Plan MEDPOL	WFD
Heavy metals and their compounds	Mercury, cadmium and lead and their compounds	Mercury, cadmium, lead, copper	**Cadmium, mercury and lead in biota and sediment**	Heavy metals (Hg, Cd and Pb) organomercuric compounds, organolead compounds: tetramethyllead (TML) and tetraethyllead (TEL)	Mercury, cadmium, lead, nickel and their compounds
				Zinc, copper and chrome and their compounds	
Organotin compounds	Organotin compounds	Tributyltin compounds (TBT)	**TBT in sediment and TBT-specific biological effects**	Organotin compounds: trialkyltin compounds (e.g. tributyltin oxide, tributyltin fluoride, triphenyltin hydroxide)	Tributyltin compounds
			TBT in biota as an alternative to monitoring TBT in sediments		
		Triphenyltin compounds (TPhT)			Tributyltin-cation
Chlorobenzenes				Mono-, di- and trichlorobenzenes	Trichlorobenzenes, pentachlorobenzene, hexachlorobenzene
PCB´s, dioxins and dioxin-like polychlorinated biphenyls	PCBs	Dioxins (PCDD), furans (PCDF), dioxin-like polychlorinated biphenyls & PCB congeners CB 28, CB 52, CB 101, CB 118, CB 138, CB 153, and CB 180	**PCB congeners CB 28, CB 52, CB 101, CB 118, CB 138, CB 153, and CB 180 in biota and sediment**	PCBs (polychlorobiphenyles) and hexachlorobenzene; dioxins and furans	PCBs and dioxins are under review.
			Pplanar PCB congeners CB 77, 126 and 169 in biota. Monitoring of those congeners in sediment should be undertaken only if levels of marker PCBs are e.g. 100 times higher than the Background Assessment Concentration		

Contaminants	Black Sea Covention	HELCOM	OSPAR (substances in bold are under obligatory monitoring)	Mediterranean Action Plan MEDPOL	WFD
VOC´s				Chlorinated solvents: dichloromethane (methylene chloride);1,1,1-trichloroethane; trichloroethylene; and tetrachloroethylene (perchloroethylene)	Dichloromethane, 1,2-dichloroethane, Trichloromethane (chloroform), Carbon tetrachloride, tetrachloroethylene, trichloroethylene
					Benzene
BFR		Pentabromodiphenyl ether (pentaBDE)	**HBCD and PBDEs 28, 47, 66, 85, 99, 100, 153, 154 and 183 in biota and sediment, and BDE 209 in sediment**	Polybrominated diphenyl ethers (pentaBDE) and polybrominated biphenyls	Pentabromodiphenylether (congener numbers 28, 47, 99, 100, 153 and 154)
		Octabromodiphenyl ether (octaBDE)			
		Decabromodiphenyl ether (decaBDE)			
		Hexabromocyclododecane (HBCD)			
PFC		Perfluorooctane sulfonate (PFOS) Perfluorooctanoic acid (PFOA)	PFOS in sediment, biota and water		PFOS is under review for possible identification as PS or PHS
Nonylphenol		Nonylphenols (NP)			Nonylphenol
		Nonylphenol ethoxylates (NPE)			
Octylphenol		Octylphenols (OP)			Octylphenol
		Octylphenol ethoxylates (OPE)			
Short-chain chlorinated paraffins		Short-chain chlorinated paraffins (SCCP or chloroalkanes, C_{10}-C_{13})		Chlorinated paraffins (CP) with carbon chain lengths of C10 to C30	Chloroalkanes, C10-13 (4)
		Medium-chain chlorinated paraffins (MCCP or chloroalkanes, C_{14}-C_{17})			

Contaminants	Black Sea Covention	HELCOM	OSPAR (substances in bold are under obligatory monitoring)	Mediterranean Action Plan MEDPOL	WFD
PAHs			**PAHs: anthracene, benz[*a*]anthracene, benzo[*ghi*]perylene, benzo[*a*]pyrene, chrysene, fluoranthene, ideno[1,2,3-*cd*]pyrene, pyrene and phenanthrene in biota and sediment**	PAHS. fluoranthene, benzo[*a*]pyrene, benzo[*b*]fluoranthene, benzo[*k*]fluoranthene, indeno[1,2,3.*cd*]pyrene and benzo[*ghi*]perylene	PAHs: naphthalene, anthracene, fluoranthene, benzo(a)pyrene), σbenzo[*b*]fluoranthene)/benzo[*k*]fluoranthene), σbenzo[*ghi*]perylene)/indeno[1,2,3-*cd*]pyrene),
			Alkylated PAHs C_1-, C_2-, and C_3-naphthalenes, C_1-, C_2- and C_3-phenanthrenes, and C_1-, C_2- and C_3-dibenzothiophenes and the parent compound dibenzothiophene in biota and sediment		
			Polychlorinated dibenzodioxins and furans in biota and sediment		
			PAH- and metal-specific biological effects		
Organophosphorus compounds	Persistent organophosphorus compounds				Chlorfenvinphos, Chlorpyrifos (Chlorpyrifos-ethyl)
Organochlorine pesticides and other pesticides	Organohalogen compounds, e.g. DDT, DDE, DDD	Hexachlorocyclohexane (HCH), DDTs & hexachlorobenzene		Organohalogenated pesticides: gamma isomer of hexachlorocyclohexane (HCH), chlorophenoxy acids,(2,4 D and 2,4,5 T)	Hexachlorocyclohexane

Contaminants	Black Sea Covention	HELCOM	OSPAR (substances in bold are under obligatory monitoring)	Mediterranean Action Plan MEDPOL	WFD
Organochlorine pesticides and other pesticides continued				Pesticides: DDT; aldrin, dieldrin, endrin; chlordane; heptachlor; mirex; toxaphene; and hexachlorobenzene	Aldrin, dieldrin, endrin, isodrin, DDT, p,p'-DDT
		Endosulfan			Endosulfan
					Herbicides: alachlor, trifluralin, atrazine, isoproturon, diuron, simazine. Under review for PS or PHS: AMPA, bentazon, dicofol, glyphosate, mecoprop, quinoxyfon
				Polychlorinated naphtalenes	
Chlorinated phenolic compounds				Chlorinated Phenolic Compounds, mainly pentachlorophenol	Pentachlorophenol
	Radioactive substances and wastes, including used radioactive fuel	Radioactive substances		Radioactive substances	
					Hexachlorobutadiene, DEHP, bisphenol A. Under review PS or PHS: EDTA, free cyanide, musk xylene.

ANNEX 8. MONITORING PROGRAMS RELATED TO CONTAMINANTS AND THEIR EFFECTS UNDER MARINE CONVENTIONS AND OTHER INTERNATIONAL PROGRAMS

Baltic Sea

The Convention on the Protection of the Marine Environment of the Baltic Sea Area was agreed in 1992. The governing body of the Convention is the Helsinki Commission - Baltic Marine Environment Protection Commission (HELCOM). The HELCOM Baltic Sea Action Plan (BSAP), which was adopted in November 2007, is a programme to restore the good ecological status of the Baltic marine environment by 2021. The ecological objectives set out in BSAP are to reach concentrations of hazardous substance close to natural levels, to ensure that all Baltic fish are safe to eat, to safeguard the health of wildlife, and to reach pre-Chernobyl levels of radioactivity. The HELCOM Recommendation with regard to hazardous substances comprises a list of 42 hazardous substances for immediate priority action. The selected substances for immediate priority action are listed below (Rec. 19/5, Attachment, Appendix 3). Almost all pesticides/ biocides selected for immediate priority action have been phased-out for long time (or have never been used) in the Baltic Sea region (HELCOM 2001) and they are not anymore regarded as dangerous substances for the Baltic marine environment. Most substances selected for immediate priority action are not included to HELCOM monitoring program as indicated below. The revision of HELCOM Recommendation 19/5 is currently on-going and expected to be finalized by May 2010.

Hazardous substances for immediate priority action	Included to the current HELCOM monitoring program
Chlorinated paraffins, short chained (SCCP)	no
Chloroform (Trichloromethane)	no
Nonylphenolethoxylate & degradation/transformation products	no
Nonylphenol, 4-	no
Musk xylene	no
Diethylhexylphthalate	no
Dibutylphthalate	no
Cadmium	yes
Lead	yes
Mercury	yes
Selenium	no
1,2-Dibromoethane	no
2,4,5-T	no
Acrylonitrile	no
Aldrin	no
Aramite	no
Chlordane	no
Chlordecone (Kepone)	no
Chlordimeform	no

Hazardous substances for immediate priority action	Included to the current HELCOM monitoring program
DDT	yes
Dieldrin	no
Endrin	no
Fluoroacetic acid and derivates	no
HCH	yes
Heptachlor	no
Hexachlorobenzene	yes
Isobenzane	no
Isodrin	no
Kelevan	no
Lindane	yes
Mirex	no
Nitrophen	no
Pentachlorophenol	no
Quintozene	no
Toxaphene	no
Organotin Compounds	no
Hexabromobiphenyl	no
PCB	yes
PCT (mixtures)	no
TCDD, PCDD, PCDF (Dioxins & Furans);	no
PAH	no

HELCOM adopted the Baltic Sea Action Plan (BSAP) in November 2007, which selected 11 hazardous substances/substance groups of priority concern. Currently the following hazardous substances or substances groups are of specific concern to the Baltic Sea, however all of them are not yet included to the HELCOM monitoring program:

1. Dioxins (PCDD), furans (PCDF) and dioxin-like polychlorinated biphenyls
2. Tributyltin compounds (TBT) and triphenyltin compounds (TPhT)
3. Pentabromodiphenyl ether (pentaBDE), octabromodiphenyl ether (octaBDE), and decabromodiphenyl ether (decaBDE)
4. Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA)
5. Hexabromocyclododecane (HBCDD)
6. Nonylphenols (NP) and nonylphenol ethoxylates (NPE)
7. Octylphenols (OP) and octylphenol ethoxylates (OPE)
8. Short-chain chlorinated paraffins (SCCP or chloroalkanes, C10-13) and medium-chain chlorinated paraffins (MCCP or chloroalkanes, C14-17)
9. Endosulfan
10. Mercury

11. Cadmium

The BSAP actions focus on restricting and substituting the use of the above mentioned substances in important sectors within an agreed timetable in the whole Baltic Sea catchment area.

The HELCOM Monitoring and Assessment Group (HELCOM MONAS) looks after one of HELCOM's key tasks by assessing trends in threats to the marine environment, their impacts, the resulting state of the marine environment, and the effectiveness of adopted measures. Monitoring of hazardous substances under HELCOM in the Baltic Sea has been ongoing since the end of 70´s whereas the monitoring of radioactive substances began already in 1984. The HELCOM COMBINE programme aims to identify and quantify effects of anthropogenic discharges/activities in the Baltic Sea, and the changes in the environment as a result of regulatory actions. Variables measured and matrices used are listed in Table2. Monitoring of radioactive substances (MORS) quantifies the sources and inputs of artificial radionuclides, as well as the resulting trends in the various compartments of the marine environment (water, biota, sediment). HELCOM also coordinates the surveillance of deliberate illegal oil spills around the Baltic Sea, and assesses the numbers and distribution of such spills on an annual basis. More specifically the aims of COMBINE for contaminants monitoring are

- To compare the level of contaminants in selected species of biota (including different parts of their tissues) from different geographical regions of the Baltic Sea in order to detect possible contamination patterns, including areas of special concern (or ´hot spots´)
- To measure levels of contaminants in selected species of biota at specific locations over time in order to detect whether levels are changing in response to the changes in inputs of contaminants to the Baltic Sea
- To measure levels of contaminants in selected species of biota at different locations within the Baltic Sea, particularly in areas of special concern, in order to assess whether the levels pose a threat to these species and/or to higher trophic levels, including marine mammals and seabirds
- To carry out biological effects measurements at selected locations in the Baltic Sea, particularly at sites of special concern, in order to assess whether the levels of contaminants in sea water and/or suspended particulate matter and/or sediments and/or in the organisms themselves are causing detrimental effects on biota (e.g., changes in community structure).

The assessment of quality of seafood with regard to the human consumption is not included. All parts of the Baltic Sea are not covered by the contaminant monitoring programme. However, the core variables are studied over the entire area and provide the best available comparable information on time trends as well as spatial distribution. Biological effect studies have been sporadic in the Baltic Area.The species chosen so far for the chemical analysis programme have, to a large extent, been selected on the basis of experiences from pilot studies.

Table 2. Variables and matrices to be measured in the HELCOM contaminants programme by the Contracting Parties in open sea.

Species	Matrix	Variable	DK	EE	FI	DE	LV	LT	PL	RU	SE
Core programme											
Herring	liver	Cu, Cd, Pb, Zn		+	+	+		+	+		+
		PFC's									+
	muscle	Hg;		+	+	+		+	+		+
		DDTs;		+	+	+		+	+		+
		CBs (IUPAC Nos.28, 52, 101,118,138, 153 and 180);		+	+	+		+	+		+
Herring	muscle	HCB; alpha + gamma HCH		+	+	+		+	+		+
		PCDD/F's									+
		PBDE's, HBCDD									+
Main programme											
Cod	liver	Cu, Cd, Pb, Zn;		+	+	+		+	+		+
		DDTs;		+	+	+		+	+		+
		CBs (IUPAC Nos.28, 52, 101,118,138, 153 and 180);		+	+	+		+	+		+
		HCB; alpha + gamma HCH				+		+			
	muscle	Hg		+	+	+		+	+		+
Macoma baltica	homogenized soft tissue	Hg, Pb, Cd, Cu;		+			+ (metals)	+			
		DDTs;		+				+			
		CBs(IUPAC Nos. 28, 52, 101, 118, 138, 153 and 180);		+				+			
		alpha + gamma HCH		+				+			
Saduria entomon	homogenized whole organism	Hg, Pb, Cd, Cu;		+							
Guillemot	egg content	Hg, Pb, Cd, Cu;									+
		DDTs;									+
		CBs(IUPAC									+

Species	Matrix	Variable	DK	EE	FI	DE	LV	LT	PL	RU	SE
		Nos. 28, 52, 101, 118, 138, 153 and 180);									
		HCB; alpha + gamma HCH									+
		PCDD/F's									+
		PBDE's, HBCDD									+
		PFC's									+
Sea water	dissolved phase	Cu, Cd, Pb, Zn				+		+			
	particulate matter	Cu, Cd, Pb, Zn				+					
	total water	Hg, DDTs;				+		(+)			
		CBs(IUPAC Nos.28, 52, 101, 118, 138, 153 and 180); HCB; alpha-,beta-, gamma-HCH, PAHs				+		(+)			
Supporting programme											
Herring	different age classes	Hg, Pb, Cd, Cu;			+						
		DDTs;			+						
		CBs (IUPAC Nos. 28, 52, 101, 118, 138, 153 and 180);			+						
		HCB; alpha + gamma HCH;			+						
Blue mussel	homogenized soft tissue	DDT, DDE, DDD, CBs, HCH		+							+
		PAHs									+
Sea water		tot. oil hydrocarbons (fluorom.)		+	+	+	+	+			

HELCOM environmental Indicator Fact Sheets provide information on the recent state of and trends in the Baltic marine environment. With regard to chemical contaminants the fact sheets cover

- Trace metal concentrations and trends in Baltic surface and deep waters , 1993-2007
- TCDD-equivalents in herring muscle and guillemot egg
- PCB concentrations in fish muscle
- Hexabromocyclododecane (HBCD) concentrations in herring muscle and Guillemot egg (only from Swedish waters)
- Perfluorooctane sulfonate (PFOS) concentrations in fish liver and guillemot egg (only from Swedish waters)
- Predatory bird health - white-tailed sea eagle (only from Swedish and German waters)
- Health assessment in the Baltic grey seal (Halichoerus grypus)
- Cadmium, lead, and mercury concentrations in fish liver

Currently the indicator fact sheets concerning contaminants do not yet cover the whole Baltic Sea but include regions reported to the ICES data base. The aim is to expand them to cover the whole Baltic Sea.

Mediterranean

The Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (Barcelona Convention) was adopted in 1976 and came into force in 1978. The Programme for the Assessment and Control of Marine Pollution in the Mediterranean region (MED POL) is the environmental assessment component of the Mediterranean Action Plan (MAP). It was initiated in 1975 and is now in Phase IV. It is responsible for the implementation of the Land-Based Sources, Dumping, and Hazardous Wastes Protocols. It assists Mediterranean countries in the formulation and implementation of pollution monitoring programmes (trend, compliance and biological effects monitoring) and pollution control measures, and in the drafting of action plans aiming to eliminate pollution from land-based sources. The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (LBS Protocol) was amended in 1996 and entered into force in June 2008. The LBS Protocole includes a list of compounds for which action plans,programmes and measures have to be prepared in order to be implemented. The substances and compounds identified are: organohalogen compounds with priority given to Aldrin, Chlordane, DDT, Dieldrin, Dioxins and Furans, Endrin, Heptachlor, Hexachlorobenzene, Mirex, PCBs and Toxaphene; organophosphorus compounds; organotin compounds; PAHs; heavy metals and their compounds (priority is given to mercury, cadmium, lead and their compounds); used lubricating oils; radioactive substances; biocides and their derivates; pathogenic microorganisms, crude oil and petroleum hydrocarbons, cyanides and fluorides; non-biodegradable detergents and surfactants; nitrogen and phoshorus compounds which may cause eutrophication; litter; thermal discharges; acid or alkaline compounds which may impairthe quality of water; non-toxic substances that have an adverse effect on the oxygen content of the marine environment; non-toxic substances that may interfere with any legitimate use of the sea; and non-toxic substances that may have adverse effects on the physical or chemical characteristics of seawater. The Strategic Action Plan (SAP MED) is an action-oriented initiative of the MED POL Programme identifying priority target categories of polluting substances and activities to be eliminated or controlled by the Mediterranean countries through a planned timetable (up to the year 2025) for the implementation of specific pollution reduction measures and interventions.

After the entry into force of the amended LBS Protocole (June 2008) in the framework of its Article 15, three Regional Plans have been decided by the Contracting Parties of the Barcelona Convention in their meeting in Marrakesh (November 2009): (i) the reduction of BOD from urban wastewater,(ii) the elimination of Aldrin, Chlordane, Dieldrin, Endrin, Heptachlore, Mirex and Toxaphene and (iii) the phasing out of DDT. More Regional Plans to control other substances and compounds of the list of the LBS Protocole are under preparation.

The objectives of the monitoring activities implemented as part of MED POL Phase IV are:

- to present periodical assessments of the state of the environment in hot spots and coastal areas (needed to provide information for decision makers on the basic environmental status of the areas which are under anthropogenic pressures);
- to determine temporal trends of some selected contaminants in order to assess the effectiveness of actions and policy measures, and
- to enhance the control of pollution by means of compliance to national/international regulatory limits.

Trend monitoring is used for the detection of site-specific temporal trends of selected contaminants (see Land-Based Sources Protocol, Annex IC) at hot spots and coastal/reference areas (Table 3). Biological effects monitoring (monitoring with biomarkers) has been included in the monitoring programmes as a pilot activity to test the methodology to be used as an early-warning tool to detect any destructive effects of pollutants to the organisms at the initial stage of exposures. Compliance monitoring, referred to health-related conditions in bathing and shellfish/aquaculture waters, effluents and hot spots, supports the pollution control component. Countries are encouraged to prepare compliance reports by comparing the results of the monitoring with the existing limit values of their national and/or the international and regional legislations. Some parameters, however, are not regularly reported by all countries to the MED POL database.More data may exist at national level in the EU countries Monitoring Agreements prepared with these objectives are based on the following monitoring criteria:

Table 3. Trend (and State) Monitoring Criteria for MED POL Phase IV.

	Coastal / Reference areas and Hot Spots		**Loads (from point sources)**	**Biological effects**
Parameters (Matrices)	*Mandatory*	*Recommended*	*Mandatory*	*Pilot studies*
	Total Hg and Cd (in biota and sediment) Basic oceanographic parameters (in sea water)	Other heavy metals, HH+, PAH+ ,other organic pollutants (in biota and sediment) Nutrients, dissolved oxygen, chlorophyll-a, phytoplankton (in sea water)	Information on loads of BOD5, nutrients and hazardous compounds discharged from urban and industrial land-based sources are collected through national reporting system (National baseline Budget – NBB)	DNAx EROD MT LMS (in biota)

Sampling Frequencies	Annually for biota at the pre-spawning period	Semi-annually, seasonally or more often depending on the matrix	Every 5 years	Quarterly or semi-annually
	Coastal / Reference areas and Hot Spots		**Biological effects**	
Species (Tissue)	*Mandatory*	*Recommended (if the mandatory species are not available)*	*Mandatory (pilot)*	
	MG (whole soft tissue) MB (fillet)	ME, PP, DT or MC (whole soft tissue) MS or UM (fillet)	EROD, DNAx	MT, LMS
			MB, if not available Mugil sp., DL for caging (Liver)	MB, if not available Mugil sp., DL for caging (Liver) *Mytilus* sp. if not available *Patella* sp. (digestive gland, hepatopancreas for limpets)
Number of samples/ specimen	Recommended (pilot); depends on the statistical design of the trend monitoring programme		Recommended (pilot)	
	Min. 5 parallel samples for the selected species. Min. 15 specimens to be pooled in each sample for MG		Min. 5 parallel samples for the selected species	

Compliance Monitoring Criteria for MED POL Phase IV

	Bathing waters	Shellfish waters	Hot spots
Parameters(1)	MB (TC, FC, FS)	MB (TC, FC, FS)	Nutrients (TP, TN), TSS, HH+, PAH+
Sampling frequency	Fortnightly (Spring-summer)	Monthly (or) Seasonally	(2)
Sampling matrix	Sea water	Sea water	Sea water and sediment

(1) depends on national legislation requirements and analytical capabilities

(2) according to the existing national legislation

North-East Atlantic

The convention for the Protection of the Marine Environment of the North-East Atlantic of 1992 (OSPAR Convention) entered into force in 1998. The OSPAR Convention contains a general obligation to collaborate in regular monitoring and assessment of the state of the marine environment in the North-East Atlantic. The objective with regard to hazardous substances is to prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. The OSPAR

Joint Assessment and Monitoring Programme has interpreted this objective in the form of two main questions:

- What are the concentrations in the marine environment, and the effects, of the substances on the OSPAR List of Chemicals for Priority Action ("priority chemicals")? Are they at, or approaching, background levels for naturally occurring substances and close to zero for man made substances?
- Are there any problems emerging related to the presence of hazardous substances in the marine environment? In particular, are any unintended/unacceptable biological responses, or unintended/unacceptable levels of such responses, being caused by exposure to hazardous substances?

The first question is related to testing for the achievement of near background concentrations, while the second question is related to testing whether hazardous substances are causing pollution. The condition of the maritime area and the overall effectiveness of the measures taken are reviewed by the Environmental Assessment and Monitoring Committee (ASMO). It also arranges for the implementation of the Joint Monitoring and Environmental Assessment Programme (JAMP). Regular activities under the JAMP Strategy include the Co-ordinated Environmental Monitoring Programme (CEMP), the Comprehensive Atmospheric Monitoring Programme (CAMP), and the Comprehensive Study on Riverine Inputs and Direct Discharges (RID).

The core marine environmental monitoring activity under the OSPAR Joint Assessment and Monitoring Programme is the OSPAR CEMP. Some of the hazardous substances are to be measured on a mandatory basis (see Annex 6), but the CEMP also covers components which the Contracting Parties are preparing to monitor in a co-ordinated manner through the development of monitoring guidance, quality assurance procedures and/or assessment tools. These include e.g. general biological effects and they are currently to be measured on a voluntary basis (see Annex 6). In addition, there is the OSPAR List of Substances of Possible Concern, which was adopted in 2002. It is a dynamic working list and is regularly revised as soon as new information becomes available. There are currently 315 substances on the list that might merit action by OSPAR due to their persistency, liability to bioaccumulate and toxicity or other equivalent concern. Following substance groups are covered: aliphatic hydrocarbon, aromatic hydrocarbon, drug, hormone, metallic compound, organic ester, organic nitrogen compound, organohalogen, organometallic compound, organophosphate, PAH, pesticide, phenol, phthalate ester, and synthetic musk.

Contracting Parties' commitments under the CEMP are set out in detail in the CEMP agreement which is updated on an annual basis. Monitoring by Contracting Parties under the CEMP is coordinated through adherence to jointly agreed guidance on monitoring and quality assurance procedures, which provides a basis for the collection of comparable and quality assured data throughout the OSPAR maritime area. This guidance is compiled in the CEMP Monitoring Manual.

Black Sea

Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention) came into force in 1994. In the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP) each country is obliged to carry out ecological monitoring on marine stations approved by the Black Sea Commission. In all countries, except Ukraine, these stations are located in territorial waters. The program of monitoring of Ukraine includes also stations in the open sea in northwest area and round a southern extremity of

Crimea. In the program of marine ecological monitoring, special attention is given to eutrophication, which is the main problem of the Black sea. Detailed studies are carried out in three polygons: Danube, Dnestrovsky, and on the estuary of Dnepr -Bug border.

Annex I of the Convention on the protection of the Black Sea against Pollution the following hazardous substances or groups of substances are listed:

1. Organotin compounds.
2. Organohalogen compounds, e.g. DDT, DDE, DDD, PCB's.
3. Persistent organophosphorus compounds.
4. Mercury and mercury compounds.
5. Cadmium and cadmium compounds.
6. Persistent substances with proven toxic carcinogenic, teratogenic or mutagenic properties.
7. Used lubricating oils.
8. Persistent synthetic materials which may float, sink or remain in suspension.
9. Radioactive substances and wastes, including used radioactive fuel.
10. Lead and lead compounds.

Arctic

The Arctic Council was established in 1996 to provide a means for promoting cooperation, coordination and interaction among the Arctic States (Canada, Denmark/Greenland, Finland, Iceland, Norway, Russia, Sweden, and the United States). The scientific work of the Arctic Council is carried out in six expert working groups, of which the Arctic Monitoring and Assessment Programme (AMAP) is responsible for issues relating to threats to the Arctic region caused by pollution. AMAP implements the AMAP Trends and Effects Monitoring Programme, which monitors pollutant levels and pollution impacts in the atmospheric, terrestrial, freshwater and marine environments, and human populations. Priorities include the following contaminant groups and issues:

- Persistent organic contaminants (POPs)
- Heavy metals (in particular mercury, cadmium, and lead)
- Radioactivity
- Acidification and Arctic haze (in a subregional context)
- Petroleum hydrocarbon pollution (in a subregional context)
- Climate change (environmental consequences and biological effects in the Arctic resulting from global climate change)
- Stratospheric ozone depletion (biological effects due to increased UV-B, etc)
- Effects of pollution on the health of humans living in the Arctic (including effects of increased UV radiation as a result of ozone depletion, and climate change)
- Combined effects of pollutants and other stressors on both ecosystems and humans.

Antarctic

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) came into force in 1982. Effects of fishing on harvested species and dependent species is monitored nder the CCAMLR Ecosystem Monitoring Program (CEMP). This program aims to distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological. Although the program includes monitoring of environmental parameters, chemical contaminants are not included.

Caspian Sea

The Caspian Environment Programme (CEP) is a regional programme which aims to halt the deterioration of environmental conditions of the Caspian Sea and to promote sustainable development in the area. Under the auspices of the CEP, a monitoring programme At Sea Training Programme (ASTP) was carried out from October 2000 to September 2001. It studied sediment quality in the coastal zone of the Caspian Sea focusing on the following contaminants: petroleum hydrocarbons, PAHs, organochlorinated compounds (DDT-related compounds, lindane and other hexachlorocyclohexanes, other chlorinated pesticides, PCBs), and metals.

Eastern Africa

The Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention) was adopted in 1985 and came into force in 1996. The work programme for the convention 2008-2012 aims to promote an ecosystem-based, multi-sector approach in policy and management, and an ecosystems approach will be used in the management of marine and coastal resources. An agreement has been achieved in June 2009 on the final text on a new Protocol for the protection of the coastal and marine environment from land-based sources and activities in Eastern and Southern Africa (LBSA Protocol). The agreement is accompanied by a Strategic Action Programme (SAP) for addressing pollution and degradation of the Western Indian Ocean from land-based sources and activities. The SAP contains a set of activities that countries in Southern and Eastern Africa have agreed to undertake in order to reduce or control the degradation of the ecosystems of the Western Indian Ocean from the pollution and other human activities that are degrading the coastal and marine ecosystems.

Regional Guidelines for Environmental Quality Objectives and Targets have been developed under the Regional Working Group on Water, Sediment and Biota Quality, which is part of the WIO-LaB project (Addressing land-based activities in the Western Indian Ocean).Western Africa

The Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (Abidjan Convention) was adopted in 1981. The Convention and its protocol concerning cooperating in combating pollution in cases of emergency came into force in 1984.

South Asian Seas

The South Asian Seas Action Plan (SASAP) was adopted in March 1995. It focuses on integrated coastal zone management, oil-spill contingency planning, human resource development and the environmental effects of land-based activities. Although there is no regional convention yet, SASAP follows existing global environmental and maritime conventions and considers Law of the Sea as its umbrella convention. A UNEP funded project Development of Harmonised National Environmental Quality Criteria for Seawater for the South Asian Seas (SEAQUAL) with the Norwegian Institute for Water Research (NIVA) has been going on for three years (2006 onwards?). The objective of the project is to develop harmonised national environmental quality criteria for seawater as a management tool for promoting sustainable development and for ensuring adequate quality for uses of seawater resources in the region.

East Asian Seas

There is no regional convention for this region. However, the Action Plan for the Protection and Development of the Marine and Coastal Areas of the East Asian Region was approved in 1981 and was initially sub-regional, involving only five countries of ASEAN with five more welcomed in 1994. The Action Plan is steered from Bangkok by its coordinating body, COBSEA. During the implementation of the International Mussel Watch Project, IOC/WESTPAC (The Intergovernmental Oceanographic Commission Sub-commission for the Western Pacific) initiated a pollutant (e.g. heavy metals, pesticides) monitoring programme in the WESTPAC region. Due to technical difficulties, monitoring activities were only carried out in a few participating countries.

North-East Pacific

In February 2002, the Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the North-East Pacific (The Antigua Convention) was signed. The governments also approved an Action Plan detailing how the countries concerned will improve the environment of the North-East Pacific for the benefit of people and wildlife. Key parts of the plan included: addressing issues of sewage and other pollutants, physical alteration and destruction of coastal ecosystems and habitats, overexploitation of fishery resources, and the effects of eutrophication. The Inter-American Tropical Tuna Commission (IATTC) is responsible for the conservation and management of fisheries for tunas and other species taken by tuna-fishing vessels in the eastern Pacific Ocean.

North-West Pacific

The North-West Pacific Action Plan was adopted in 1994. NOWPAP has four Regional Activity Centres established of which the Pollution Monitoring Regional Activity Center (POMRAC) is located at the Pacific Geographical Institute of the Far Eastern Branch of Russian Academy of Sciences (Vladivostok, Russian Federation). The center maintains two reference databases on contaminants, one on atmospheric deposition of contaminants and the other on river and direct contaminant inputs into marine and coastal environments. In 2007, POMRAC started a new project on integrated coastal zone and river basin management and compiled the state of marine environment report. Within the region there also exists the Pacific Northwest Aquatic Monitoring Partnership (PNAMP), which aims at providing a forum for coordinating state, federal, and tribal aquatic habitat and salmonid monitoring programs.

South-East Pacific

The South-East Pacific Action Plan was adopted in 1981 together with the Convention for the Protection of the Marine Environment and Coastal Zones of the South-East Pacific (Lima Convention) and its associated protocols. Asia-Pacific mussel watch: monitoring contamination of persistent organochlorine compounds in coastal waters of Asian countries.

Pacific

The Secretariat of the Pacific Regional Environment Programme (SPREP) is the primary regional organization concerned with environmental management in the Pacific. The Pacific Regional Environment Programme SPREP is a regional organization established by the governments and administrations of the Pacific region aiming to protect and manage the environment and natural resources.

Red Sea and Gulf of Aden

The Action Plan for the Red Sea and Gulf of Aden was established in 1976, and the Convention for the Conservation of the Red Sea and Gulf of Aden Environment (Jeddah Convention) and the Protocol concerning Regional Cooperation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency in 1982 which entered into force in 1985. The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERGSA) is an intergovernmental body responsible for the implementation of the Jeddah convention and Protocol. It has put in place a biological habitat and resource monitoring programme, and is developing a Regional Environmental Monitoring Programme (REMP) with the aim of developing a minimum, common set of monitoring parameters/requirements to be undertaken by all MS as an integral part of their national monitoring programmes. The primary objectives of the REMP are to ensure that adverse trends are detected in sufficient time to implement remedial action, and to provide an objective test of the effectiveness of existing environmental management practices (on a local, national and regional scale). Also, the REMP should address priority transboundary and common pollution issues rather than simply national issues.

ROPME Sea Area

The Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution (Kuwait Convention) was adopted in 1978 and came into force in 1979. The objective of the Regional Organization for the Protection of the Marine Environment (ROPME) is to coordinate the MS efforts towards protection of the marine environment of the ROPME Sea Area and prevent the reasons of pollution. The ROPME Sea Area is the sea area surrounded by Bahrain, I.R. Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. Several states in the region monitor levels of heavy metals (mercury, cadmium, copper, lead and vanadium) in the marine environment (in fish, bivalves, water and sediment) as part of national monitoring programmes. There is limited data on the production, use and environmental distribution of POPs in the marine environment of the ROPME Sea Area. The ROPME Council have approved funds for a pilot study to determine types 23 and amounts of POPs manufactured in the region and their significance to the marine environment (UNEP 1999).

Wider Caribbean

The Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) was adopted in 1983, and came into force in 1986. An Assessment and Management of Environmental Pollution Programme (AMEP) has been established under the Caribbean Environment Programme (CEP). It also provides regional co-ordination for the implementation of the protocol concerning Pollution from Land-based Sources and Activities as well as the protocol concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region (Oil Spills Protocol). Currently, an update of a regional overview of land-based sources (LBS) of pollution in the Wider Caribbean Region is ongoing. Two workshops have bee organized to discuss and approve methodologies to determine pollutant loads from land-based point sources and non-point sources. A survey is now underway to obtain information from member countries concerning land-based pollutant loads draining into the Caribbean Sea. Contaminants proposed for marine and coastal water quality indicators include oil and grease, heavy metals, PAHs, and pesticide residuals.

Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants is a global treaty to protect human health and the environment from persistent organic pollutants (POPs). The global monitoring plan is an important part of the effectiveness evaluation of the convention providing a framework for the collection of monitoring data or information on the presence of POPs from all regions, in order to identify changes in levels over time, as well as to provide information on their regional and global environmental transport. In support of the effectiveness valuation, a POPs Global Monitoring Programme (GMP) has been launched by UNEP Chemicals. GMP activities will include inter alia developing guidance on sampling and analysis of POPs, QA/QC procedures, data treatment and communication and data assessment.

Ambient air, human milk and / or human blood have been chosen as core matrices by the Conference of the Parties to the Stockholm Convention for global monitoring. Data from regional programs using other media can be used to complement data from the core matrices in helping to establish trends using a weight of evidence approach. The first monitoring report, using data collected over the period 1998-2008 of priority POPs (aldrin, chlordane, DDT, dieldrin, dioxins, endrin, furans, heptachlor, hexachlorobenzene (HCB), mirex, polychlorinated biphenyls (PCBs), and toxaphene), provides a baseline upon which concentrations in the core matrices will be studied over the long-term. The report was published in 2009 (http://chm.pops.int/Portals/0/Repository/COP4/UNEP-POPS-COP.4-33.English.PDF). Additionally the UNEP GMP guidance document discusses issues related to sampling and sampling preparation methodology of other matrices, i.e. bivalves, marine mammals, fish and bird’s eggs (http://www.chem.unep.ch/gmn/GuidanceGPM.pdf).

EMEP

The EMEP programme (Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air pollutants in Europe) has been established to regularly provide governments and subsidiary bodies under the LRTAP Convention with qualified scientific information to support the development and further evaluation of the international protocols on emission reductions negotiated within the Convention. EMEP's measurement programme includes analyses of benzo(a)pyrene, PCBs (IUPAC 28 52, 101, 118, 138,153 , 180), hexachlorobenzene (HCB), chlordane (gamma and alpha), lindane, hexachlorocyclohexane (HCH), DDT/DDE in precipitation and gas particles.

Others

Endocrine disruptive compounds in East Asia

Since 1999, United Nations University (UNU) has been managing a network of water pollution monitoring in coastal areas of China, Korea, Indonesia, Japan, Malaysia, Singapore, Thailand, and Viet Nam. Its focus is on endocrine disruptive substances, particularly organochlorine pesticides, alkylphenols, bisphenyl-A, and phthalates. The main focus of the project is on monitoring of these substances in rivers and fresh water bodies close to the coastal areas. The objective is to develop an early-warning system to counter and minimize environmental pollution, which is to be achieved through periodic and systematic monitoring.

USA

CCMA Center for Coastal Monitoring and Assessment addresses pollution through the National Status and Trends Program (NS&T), through which long-term monitoring of toxic chemicals and environmental conditions is conducted at more than 350 sites along U.S. coasts. The program also documents the nature and severity of the biological effects associated with toxic chemicals in 25 coastal ecosystems. The program was begun in 1984 and is the only nationwide source of long-term data on toxic contaminants in U.S. coastal waters and estuaries. Outcomes include a status of contaminant concentrations around the U.S. including Alaska, Hawaii, the Great Lakes, and Puerto Rico. The program's data information products are available to the public via publications and the Internet. The NS&T is comprised of two programs, Mussel Watch and Bioeffects. Parameters monitored in the Mussel Watch Program include sediment and bivalve tissue chemistry for over 100 organic and inorganic contaminants; bivalve histology; and Clostridium perfringens (pathogen) concentrations. This project regularly quantifies PAHs, PCBs, DDTs and its metabolites, TBT and its metabolites, chlorinated pesticides and toxic trace elements. Bioeffects Assessment Program identifies and assesses biological effects associated with contaminant exposure. Over forty intensive regional studies have been conducted since 1986 using the Sediment Quality Triad approach which utilizes a stratified random sampling method to determine the areal extent of contaminated sediments. The data include: sediment chemistry, toxicity, and species diversity and quantity for the same suite of organic contaminants and trace metals as the Mussel Watch Program.

Canada

The Canadian Wildlife Service (CWS) is the Canadian agency responsible for managing migratory birds and other wildlife of federal interest. Monitoring activities have taken place since the. There are two types of monitoring programs in use: (i) baseline trend monitoring, which monitors stressors, and (ii) programs designed to monitor stressed populations. CWS has maintained long-term chemical monitoring of Herring Gulls Larus argentatus in the Great Lakes as well as a variety of seabird species on the Atlantic and Pacific coasts and, more sporadically, seabirds and polar bears in the Arctic. There are three marine seabird egg monitoring programs, one for each of Canada's marine environments: Atlantic, Pacific, and Arctic. CWS has regularly monitored chemicals in eggs of Double-crested Cormorants, Leach's Storm Petrels Oceanodroma leucorhoa, Atlantic Puffins Fratercula arctica and Herring Gulls on Canada's Atlantic coast since 1968. Additionally, Northern Gannets Sula bassanus have been monitored on Bonaventure Island in the Gulf of St. Lawrence since 1968. On Canada's Pacific coast, CWS has monitored chemicals in eggs of Double-crested Cormorants, Pelagic Cormorants Phalacrocorax pelagicus, Leach's Storm Petrels and Rhinoceros Auklets Cerorhinca monocerata since 1985, although some Pacific collections were made starting in 1970. In the Arctic, CWS has monitored chemicals in eggs of Thick-billed Murres Uria lomvia, Northern Fulmars Fulmaris glacialis and Black-legged Kittiwakes Rissa tridactyla since 1975. In 1993, the Glaucous Gull Larus hyperboreus and Black Guillemot Cepphus grylle were added as Arctic monitoring species to facilitate comparisons with Scandinavian monitoring programs.

ANNEX 9. WFD - ENVIRONMENTAL QUALITY STANDARDS INCLUDED IN THE DIRECTIVE 2008/105/EC

	AA-QS Inland surface waters [µg/l]	AA-QS Other surface waters [µg/l]	MAC-EQS Inland surface waters [µg/l]	MAC-EQS Other surface waters [µg/l]	EQS in Biota [µg/kg]
Alachlor	0.3	0.3	0.7	0.7	
Anthracene	0.1	0.1	0.4	0.4	
Atrazine	0.6	0.6	2.00	2.00	
Benzene	10	8	50	50	
Pentabromodiphenylether	0.0005	0.0002	not applicable	not applicable	
Cadmium and its compounds (depending on water hardness)					
Class 1: < 40 mg/l $CaCO_3$	≤ 0.08	0.20	≤ 0.45	≤ 0.45	
Class 2: 40 to < 50 mg/l $CaCO_3$	0.08		0.45	0.45	
Class 3: 50 to < 100 mg/l $CaCO_3$	0.09		0.6	0.6	
Class 4: 100 to < 200 mg/l $CaCO_3$	0.15		0.9	0.9	
Class 5: ≥ 200 mg/l $CaCO_3$	0.25		1.5	1.5	
Carbontetrachloride	12	12	not applicable	not applicable	
C_{10}-C_{13}-chloroalkanes	0.4	0.4	1.80		
Chlorfenvinphos	0.1	0.1	0.3	0.3	
Chlorpyrifos (-ethyl, -methyl)	0.03	0.03	0.1	0.1	
Cyclodiene pesticides:	∑ = 0.01	∑ = 0.005	not applicable	not applicable	
Aldrin					
Dieldrin					
Endrin					
Isodrin					
DDT total	0.025	0.025	not applicable	not applicable	
para-para-DDT	0.01	0.01	not applicable	not applicable	
1,2-Dichloroethane	10	10	not applicable	not applicable	
Dichloromethane	20	20	not applicable	not applicable	
Di(2-ethylhexyl)phthalate (DEHP)	1.3	1.3	not applicable	not applicable	
Diuron	0.2	0.2	1.8	1.8	
Endosulfan	0.005	0.0005	0.01	0.004	
Fluoranthene	0.1	0.1	0.6	0.6	

	AA-QS Inland surface waters [µg/l]	AA-QS Other surface waters [µg/l]	MAC-EQS Inland surface waters [µg/l]	MAC-EQS Other surface waters [µg/l]	EQS in Biota [µg/kg]
Hexachlorobenzene	0.01[a]	0.01[a]	0.05	0.05	10
Hexachlorobutadiene	0.1[a]	0.1[a]	0.6	0.6	55
Hexachlorocyclohexane	0.02	0.002	0.04	0.02	
Isoproturon	0.3	0.3	1.0	1.0	
Lead and its compounds	7.2	7.2	not applicable	not applicable	
Mercury and its compounds	0.05[a]	0.05[a]	0.07	0.07	20
Naphthalene	2.4	1.2	not applicable	not applicable	
Nickel and its compounds	20	20	not applicable	not applicable	
Nonylphenols	0.30	0.3	2.0	2.0	
Octylphenols	0.1	0.01	not applicable	not applicable	
Pentachlorobenzene	0.0070	0.0007	not applicable	not applicable	
Pentachlorophenol	0.4	0.4	1	1	
Polyaromatic Hydrocarbons (PAH´s)	not applicable	not applicable	not applicable	not applicable	
Benzo[*a*]pyrene	0.05	0.05	0.1	0.1	
Benzo[*b*]fluoroanthene	∑ = 0.03	∑ = 0.03	not applicable	not applicable	
Benzo[*k*]fluoroanthene					
Benzo[*ghi*]perylene	∑ = 0.002	∑ = 0.002	not applicable	not applicable	
Indeno[1,2,3-*cd*]-pyrene					
Simazine	1	1	4	4	
Tetrachlorethylene	10	10	not applicable	not applicable	
Trichloroethyene	10	10	not applicable	not applicable	
Tributyltin compounds	0.0002	0.0002	0.0015	0.0015	
Trichlorobenzenes	0.4	0.4	not applicable	not applicable	
Trichloromethane	2.5	2.5	not applicable	not applicable	
Trifluralin	0.03	0.03	not applicable	not applicable	

[a] If Member States do not apply EQS for biota they shall introduce stricter EQS for water in order to achieve the same level of protection as the EQS for biota set out in Article (3) of this Directive. They shall notify the Commission and other Member States, through the Committee referred to in Article 21 of Directive 2000/60/EC, of the reasons and basis for using this approach, the alternative EQS for water established, including the data and the methodology by which the alternative EQS were derived, and the categories of surface water to which they would apply.

Annex 10. Assessment Criteria used for assessing CEMP Monitoring Data for the Concentrations of Hazardous Substances in Marine Sediments and Biota in the Context of QSR 2010

Adapted from OSPAR ASMO 09/07/3

Lynda Webster, Rob Fryer, Ian Davies, Patrick Roose and Colin Moffat

1. Considerations around generic definitions for blue, green and red within a 'traffic light' assessment tool

1. There are several cases in the QSR 2010, and the reports used to compile it, where a traffic light system has been put forward to indicate the status of different aspects of the marine environment. This is sensible from a presentational perspective, as it can give the reader a clear and immediate picture of where environmental conditions are acceptable, i.e. where statutory targets and policy objectives are met, and where this is not the case.

2. The primary objective of this document is to explain the assessment criteria and a data presentation framework used by the OSPAR MON Working group in preparing 2008/2009 assessment of CEMP data on contaminant concentrations in sediment and which will is the basis for a the material in Chapter 5 of the QSR 2010 on concentrations of contaminants in the marine environment. The aim was to support a consistent use of colours in the presentation of these assessments across matrices and contaminants.

3. As Contracting Parties are intending to use the QSR 2010 as part of the Initial Assessment required under the Marine Strategy Framework Directive in 2012 it would seem to be prudent to ensure that the use of "green" has a relationship to "Good Environmental Status" to the extent that it is currently possible to assess this. The basic principle is that the transition from red to green implies a transition from an unacceptable risk to a state which is acceptable and where there is little or no risk.

4. The interpretation of the proposed blue/green/red scheme in relation to hazardous substances is summarised in Table 1, which explains what this means in the context of contaminants. Table 1 further summarises the type of management activity which may be possible for each colour.

2. Use of Environmental Assessment Criteria (EACs) and Effects Range (ER) values as assessment criteria

5. The primary assessment threshold used in the assessment of contaminant concentrations in sediment and biota corresponds to the achievement, or failure to achieve, statutory targets or policy objectives for contaminants in these matrices. The outcomes of these assessments should be described by the transition in a traffic light scheme between green and red. Green indicates that the target/objective has been achieved; red that it has not.

6. In the OSPAR CEMP assessment context, OSPAR Environmental Assessment Criteria (EACs) should provide the green/red transition point. EACs, which represent the contaminant concentration in the environment below which no chronic effects are expected to occur in marine species, including the most sensitive species, continue to be developed for use in data assessments. EACs for a range of contaminants were proposed in 2004 and updated PAHs and PCBs were proposed in 2008. Concentrations below the EACs are considered to present no significant risk to the environment, and to that extent may be considered as being related to the EQSs applied to concentrations of contaminants in water, for example under the Water Framework Directive. Concentrations below the EAC are unlikely to give rise to unacceptable biological effects. EACs have been developed for a range of matrices and contaminants through a combination of work by OSPAR and ICES groups. In some cases, these have been recommended or accepted for use in data assessments. ICES recommends that the EACs for all ICES7 CBs in sediment and PAHs in shellfish may be

used for OSPAR assessments. EACs are therefore used as the green/red transitions for CBs in sediment and PAHs in shellfish[1] (Figure 1A; Table 6).

7. As implied above, some EACs have not been used in, mainly because the proposed EACs are less than the OSPAR BACs. For example, EACs for three of the parent PAHs (benz[*a*]anthracene, benzo[*ghi*]perylene and indeno[1,2,3-*cd*]pyrene) in sediment are below the BACs. For trace metals, EACs for Cd and Pb in sediment, Hg in mussels and Hg and Cd in fish are also below the corresponding BACs. It is also noted that for trace metals in sediment, BCs and BACs are normalised to 5% aluminium whilst proposed EACs are normalised to 1% organic carbon. It has been concluded that EACs for PAHs or trace metals in sediment and for metals or CBs in biota cannot be used to describe the green/red (T_1) transition. Therefore, in cases where the EACs have not been recommended, alternative approaches to appropriate criteria for the assessment of data on contaminant concentrations in sediment and biota need to be considered.

8. In order to maintain consistency, wherever possible, when filling these gaps in the suite of assessment criteria, it is helpful to employ as few alternatives as possible to the EACs. The use of alternatives needs to be consistent across groups of contaminants so that the output from the assessment process is readily understandable and features in the assessment may be interpretable.

2.1 Assessment at the green/red transition in sediments

9. EACs are available and recommended for use for CBs in sediment. However, this is not the case for PAHs or for metals in sediment, and an alternative approach is required. The US EPA have developed Effects Range (ER) values to be used to assess the quality of coastal and estuarine environments and the ecological significance of the concentrations of hazardous substances found in sediment(7,8). ER values were established as sediment quality guidelines to be used to predict adverse biological effects on organisms. In summary, the derivation of ER values involved the collation of a large amount of information on the concentrations of contaminants in sediments in which biological effects (for example on the benthic infauna) where found to be occurring. Two main assessment criteria are then calculated from this data collation. The ER-Low (ERL) value is defined as the lower tenth percentile of the data set of concentrations in sediments which were associated with biological effects, and the ER-Median (ERM) as the median of the concentrations associated with biological effects. Adverse effects on organisms are rarely observed when concentrations fall below the ERL value, and the ERL therefore has some parallels with the philosophy underlying the OSPAR EACs and WFD EQSs. The ways in which the criteria are derived are very different, and so precise equivalence should not be expected.

10. ERL values are available for individual PAHs and trace metals (including the 3 CEMP metals Hg, Cd and Pb) (Table 2)[2]. ERL values are also available for "total PAHs", but it is not clear to the authors to what this total refers. Therefore, an ERL was calculated for total PAHs by summing the relevant individual ERLs, where available. The totals are shown in Table 2, based on the sum for selected parent PAHs (including the CEMP 9) and may be amended to include alkylated PAHs by adding the individual ERL values for the alkylated PAHs. The ERL values are higher than the BACs for the parent PAHs (Table 2), though the difference is small for the 6-ring PAHs. Compared to the proposed, but not used, EACs the ERL values for some PAHs are lower, and others are higher. The ERLs for Hg, Cd and Pb are greater than the BACs (Table 2).

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[1] The ICES advice refers specifically to mussels and does not comment on oysters. However the pragmatic approach is to use the figures for both mussels and oysters.

[2] ER values are also available for total CBs (Aroclor equivalents) but not for individual CBs. Aroclor equivalents are approximately equivalent to 2 x ΣICES7 CB concentrations.

11. Although BCs and BACs are normalised to 5% aluminium for trace metals and 2.5% organic carbon for organic contaminants, no normalisation is made for sediment type when deriving ER values. For the purpose of CEMP data assessment, ERLs have been used in most cases (see section 5 below) as the green/red transition for PAHs and trace metals in sediment (Figure 1A; Table 6), and normalised concentrations have been compared to the ERLs.

2.2 Assessment at the green/red transition in biota

2.2.1 CBs in fish and shellfish

12. There are no recommended EACs for CBs in biota, and therefore an alternative approach to assessment criteria is required. Recent work on the bioavailability of hydrophobic contaminants in sediment using silicone rubber passive samplers has generally shown that the complete burden of CBs in sediments has the potential to be mobilised into the sediment pore water, i.e. to be potentially bioavailable[(9)]. Therefore, partitioning theory can be reliably applied to calculate the concentrations of CBs in lipid in biota that would be in equilibrium with the CBs in the sediment.

13. The biota sediment accumulation factor (BSAF) can be expressed as the ratio between the contaminant concentration in sediment (expressed on the basis of organic carbon) and the concentration in biological material (expressed on a lipid basis). In cases where the total concentration of a contaminant in sediment is potentially bioavailable, the value of BSAF is close to unity.

14. The EACs for CBs in sediment are expressed for sediment of 2.5% organic carbon. It is possible therefore to calculate lipid-normalised concentrations of CBs in fish liver and mussel tissue in equilibrium with sediment containing CB concentrations equal to the EACs in sediment (Tables 3, 4). These calculated values (termed $EAC^{passive}$) have been used as the green/red boundary for CBs in biota (Figure 1A and Table 6).

2.2.2 Metals in fish and shellfish

15. There are no recommended EACs for metals in biota and equivalents to Effects Range values are not available for fish and shellfish. Therefore an alternative approach to assessment criteria was required, which needed to be coherent across the range of species addressed in the CEMP programme. Two possible approaches were considered.

16. The first approach considered was the use of an added risk approach. This requires the use of the sum of the BCs and the EACs that have been proposed to derive a maximum permissible concentration (MPC). The advantages of this approach include that the derived MPC involves the use of the OSPAR BCs and EACs, and that the process is described in Moffat *et al.* (2004)[(10)] and has been discussed in WFD contexts. The disadvantages include that the EACs were not recommended for use in this way, and that the EACs are in some case only a small proportion of the BC/BACs so that the derived MPCs would not differ greatly from the BACs. The absence of proposed EACs for oysters prevents the derivation of MPCs for this species.

17. The second approach considered was an assessment of the contaminant concentrations in fish and shellfish with respect to their human health risk. The Commission Regulation (EC) No 1881/2006 (and subsequent additions and amendments) sets maximum concentrations for contaminants in foodstuffs to protect public health, i.e. to ensure that contaminant concentrations are toxicologically acceptable. This regulation includes maximum levels for Pb, Hg and Cd in bivalve molluscs and fish muscle (Tables 3 and 4) on a wet weight basis. Advantages of this approach are that the dietary standards are firmly established within EC statute, and that they can be used to fill the gaps for metals in both fish and shellfish species. Disadvantages include that standards are not directly available for all the matrix/contaminant combinations required for the assessment. Standards for shellfish exist, and for application in assessments of concentrations in mussels and oysters, the standards were converted to a dry weight basis by multiplying by 5 (Table 3). Standards exist for mercury in fish muscle, but, the EC Regulation does not address Cd and Pb in fish liver (as are required in the CEMP). It is recognised that Cd and Pb concentrations in fish liver are

naturally greater than in fish muscle (and this is reflected in dietary limits for bird and mammal muscle and liver tissue), and therefore that fish muscle standards cannot be used. The statutory dietary limits for Cd and Pb in bivalve mollusc tissue have therefore been used as a boundary for the assessment of Cd and Pb concentrations in fish liver.

18. Clearly, both of these approaches are not fully satisfactory. It was considered that the advantages of having assessment criteria that covered all three metals in both fish and shellfish greatly outweighed the consequences of not having any criteria for the green/red transition for metals in biota. Without criteria, all assessments would default to red, and this would result in very significant loss of information.

19. As an interim position, until a more appropriate approach to assessment criteria for metals in biota becomes available, the EC dietary limits, as described above, have been used for the purposes of the QSR 2010 assessment as a coherent suite of assessment criteria for trace metals in biota at an amber (replacing the green)/red transition (Figure 1B; Table 6). The use of amber rather than green takes account of concerns over the relevance of the EC dietary limits as criteria for environmental effects. Thus the colour scheme used to classify against these criteria should be red/amber/blue to reflect the larger risks and uncertainties. Exceeding the food standard, results in red. Concentrations below the BAC result in blue. Concentrations in between, result in amber, to indicate the uncertainty in the classification due to lack of information, as shown in Figure 1B. OSPAR looks to continue efforts in future years to derive a reliable series of EACs that address the ecological risk of metals in fish and shellfish.

3. Background Concentrations (BCs) and Background Assessment Concentrations (BACs) within OSPAR and their use as a transition point

20. In addition to assessment criteria corresponding to statutory limits, or to policy objectives aimed at avoiding unacceptable biological effects arising from contaminants in the environment, the OSPAR Hazardous Substances Strategy has "the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances". It is therefore appropriate, where possible, that assessment of contaminants data in an OSPAR context should take account of this additional policy aim.

21. In order to assess progress towards near background or zero concentrations, OSPAR has developed Background Concentrations (BCs), the definition for which is "the concentration of a contaminant at a 'pristine' or 'remote' site based on contemporary or historical data"[(10)]. For naturally occurring substances, such as polycyclic aromatic hydrocarbons (PAHs) and trace metals, BCs are the typical concentrations found in uncontaminated locations in the OSPAR maritime area (North-East Atlantic). For man-made synthetic substances such as chlorobiphenyls (CBs), OSPAR has adopted a BC of zero. In order to facilitate precautionary assessments of data collected under the OSPAR CEMP against BCs, OSPAR has developed Background Assessment Concentrations (BACs). Observed concentrations are said to be 'near background' if the mean concentration is statistically significantly below the corresponding Background Assessment Concentration (BAC) (see Tables).

22. BCs and BACs, developed using criteria as outlined above, have been recommended for use throughout the OSPAR maritime area. It is recognised that natural processes such as geological variability or upwelling of oceanic waters near the coast may lead to significant variations in background concentrations of contaminants, for example trace metals. The natural variability of background concentrations should be taken into account in the interpretation of CEMP data, and local conditions should be taken into account when assessing the significance of any exceedence. This needs to be explained where it is a relevant factor in data interpretation.

Sediment

23. BCs and BACs have been previously adopted (OSPAR Agreement 2005-6) for 10 parent PAHs (9 CEMP PAHs[3] plus naphthalene) in sediment (Table 2). BCs for parent PAHs were derived through determining pre-industrial concentrations of PAHs in deep sediment cores. In 2008, the ICES Working Group on Marine Sediments proposed BCs for alkylated PAHs and DBT, again using deep core data from France, Norway and Scotland[(11)] (Table 2). BCs and BACs for PAHs are expressed in µg/kg dry weight normalised to 2.5% organic carbon (Table 2). The BC for total PAHs is the sum of the individual BCs. However, the corresponding BAC is not the sum of the individual BACs and is yet to be calculated.

24. As noted above, the BCs for CBs are zero. However, to calculate the BAC, a positive low concentration (LC) needs to be chosen that is both measurable and 'close to zero'. For individual CBs, 2 x QUASIMEME constant error is used as a low concentration (LC) and for the ΣICES7, the value used is 8 x QUASIMEME constant error (Table 2). BACs have been calculated for the ICES7 CBs in sediment (Table 2). Concentrations are expressed in µg/kg dry weight normalised to 2.5% organic carbon.

25. BCs and BACs have been previously adopted for cadmium, lead and mercury in sediments. The values (Table 2), derived from deep sediment cores, are normalised to 5% aluminium.

Biota

3.2.1 PAH compounds in shellfish

26. In 2008, the ICES Marine Chemistry Working Group (MCWG) proposed low concentrations (LCs) for PAHs in shellfish (mussels and oysters)[(12)]. The MCWG suggested that natural background concentrations would be lower than the proposed LCs. The MCWG used the limited available dataset from areas identified as pristine (mussel data from Spain and Scotland, and mussels and oysters from France) to estimate LCs as the 10th percentile of the data (Table 3). LCs were initially derived as µg/kg wet weight, but were converted to a dry weight basis by multiplying by 5 since OSPAR MON undertakes the assessment of mussel data on a dry weight basis. LCs could not be proposed for naphthalene, anthracene, dibenzothiophene and alkylated naphthalenes due to the limited dataset and because the concentrations of some PAHs were commonly below limits of quantification.

3.2.2 Metals in shellfish

27. The MCWG 2008 also reviewed information on the concentrations of metals in mussels from pristine areas in Spain, Greenland, Shetland/Faroe, Norway and Ireland. Median values for each of the regions were calculated. LCs proposed by MCWG (median of regional medians) are shown in Table 3 and were similar to those proposed by MON in 2006. With respect to oysters, conversion factors proposed by France at ASMO 08[(3)] have been used to calculate LCs for oysters (Table 3). It is recognised that natural processes, such as run-off from mineralised areas, or upwelling of deep oceanic water, may lead to enhanced natural concentrations of some metals in coastal shellfish. It is appropriate that the consideration of the significance of these processes, as well as of other processes such as anthropogenic inputs of metals, should be part of the interpretation of temporal trends and geographical patterns in monitoring data.

3.2.3 Metals in fish

28. The MCWG could not recommend BCs or LCs for trace metals in fish, due to the limited dataset. MCWG 2008 suggested that for fish, OSPAR MON should use a statistical approach to derive proxy BACs as illustrated in the MON 2007 Summary Record.

3.2.4 CBs in fish and shellfish

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[3]The 9 CEMP parent PAHs are anthracene, benz[*a*]anthracene, benzo[*ghi*]perylene, benzo[*a*]pyrene, chrysene, fluoranthene, indeno[1,2,3-*cd*]pyrene, pyrene, phenanthrene.

29. The BC for CBs in fish liver and shellfish is zero. For individual CBs, 2 x QUASIMEME constant error is used as a LC and for the ΣICES7 CBs, 8 x QUASIMEME constant error (Tables 3 and 4) is used. This follows the protocol used for CBs in sediment.

30. As discussed above, it is appropriate that the assessment of contaminants data for the QSR 2010 should include comparisons against BCs/BACs. This is as a second stage of assessment, to be carried out after the comparisons related to the green/red transition (see section 2 above). Concentrations which have been assessed as below the green/red transition boundary (amber/red transition boundary for metals in biota) are compared against the relevant BAC. Concentrations determined to be significantly below the BAC (as determined by the assessment methods adopted by OSPAR MON for the assessment of CEMP data (see CEMP Assessment Manual (OSPAR Publication 379/2008) are assigned the colour blue. The authors consider that this approach takes account of the desire for a generic description of the three primary traffic light colours and of the view that OSPAR's assessment work should lead to results which are, if at all possible, consistent with assessments under the Water Framework Directive and the Marine Strategy Framework Directive. The BAC may be considered conceptually as a transition point between what might be termed 'high' status and 'good' status (Figure 1), although this degree of discrimination is not required in Chemical Status assessments for WFD purposes. BAC are therefore used in the CEMP Assessment, but provide a second transition point (T_0) between blue and green (or amber for metals in biota) (Figure 1) and allow specific reporting in the context of the OSPAR Hazardous Substances Strategy.

4. Sediment normalisation

31. During the development of these approaches, it became clear that both Spain and Portugal have reservations concerning aspects of the application of normalisation procedures to contaminant concentrations in sediment. The procedure that has been used to date in CEMP data assessments by MON is based upon the frequent observation that, within a localised survey area, contaminant concentrations are generally higher in muddy sediments than in sand. Furthermore, the contaminant concentrations are often linearly related to expressions of the bulk properties of the sediment, such as the particle size distribution or organic carbon content. The geochemical normalisation used by MON is based upon these linear relationships, and seeks to use the normalisation process to express contaminant concentrations in sediments of different bulk properties in terms of the equivalent concentrations in a "typical" muddy sediment, considered to contain 5% aluminium (mainly from clay minerals) and 2.5% organic carbon.

32. The composition selected for this "typical" sediment has been found to be generally appropriate for sediments in and around the North Sea and Celtic Seas. However, it is less applicable to muddy sediments in the Iberian area. Information from Spain and Portugal indicates that typical aluminium concentrations in muddy sediments are around 2%, and that organic carbon concentrations are generally less than 2.5%.

33. To take into account the specific typical bulk composition of muddy sediments in the Iberian area, sediment data from Portugal was normalised to 2% aluminium and 2.5% organic carbon prior to comparison with ERLs at the green/red transition and BACs at the blue/green transition. BACs for metals was adjusted to reflect normalisation to 2% aluminium. Concentrations of organic contaminants were normalised to 2.5% organic carbon for comparisons at both the green/red and blue/green transitions.

34. Concentrations of contaminants in sediment from Spain were not be normalised, and were compared directly to ERL values (including the ERL for ΣICES7 CBs in Table 2), and with non-normalised BACs to be derived from appropriate low concentrations, to be developed prior to MON 2008. Appropriate explanatory text would be included in the proposal for the values of low concentrations. The reasons for different treatment of data from Spain and Portugal are set out in the CEMP assessment report (OSPAR Commission 2009).

5. Summary of Approach used in the QSR CEMP assessment

35. A three colour traffic light system has been used for assessing hazardous substances data for marine sediments and biota for the purposes of the QSR 2010. The initial assessment of data was made in relation to a green/red or amber/red transition. 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.

36. To report against the ultimate aim of the OSPAR Hazardous Substances Strategy that concentrations should be at, or close to, background concentrations, a second comparison has been made for a blue/green or blue/amber transition, against the relevant BAC. Concentrations that are significantly below the BAC, i.e. the OSPAR ultimate aim has been achieved, have been coloured blue. Concentrations that did not meet this precautionary statistical test remain green or amber.

5.1 Green/Red and Amber/Red Transitions (T1)

5.1.1 Sediment:

37. Concentrations of contaminants in sediment were normalised to 2.5% organic carbon for organic contaminants and 5% aluminium for metals (with the exception of the situations discussed in section 4 above) before comparing to assessment criteria. The assessment criteria for the green to red transitions were the ERLs for PAHs and trace metals in sediment, and the EACs for CBs in sediment. Mean concentrations needed to be significantly below the ERL (PAHs and trace metals) or EAC (CBs) to be classed as green (Figure 1; Tables 5 and 6).

5.1.2 Biota:

38. The assessment criteria for PAHs in mussels at the green/red transition were the EACs. This followed the recommendation by ICES.

39. The assessment criteria used for CBs in shellfish (mussels and oysters) and in fish were derived from the sediment EACs on the basis that the biota sediment accumulation factor (BSAF) is close to unity for CBs (Table 5). This has been termed the 'EACpassive'. Mean concentrations needed to be significantly below the EAC (PAHs) or EACpassive (CBs) to be classed as green (Figure 1; Tables 5 and 6).

40. As an interim position, until a more appropriate approach to assessment criteria for metals in biota becomes available, the EC maximum acceptable dietary levels (Commission Regulation (EC) No 1881/2006) were used, as described in Section 2 above, as a coherent suite of assessment criteria for trace metals in biota at an amber/red transition (Figure 1B; Tables 5 and 6) for the purposes of the QSR 2010 assessment.

5.2 Blue/Green Transition (T0)

41. The purpose of the blue/green transition is to represent assessment against the ultimate aim of the OSPAR Hazardous Substances Strategy that concentrations should be at, or close to, background concentrations. A comparison with BCs was therefore appropriate using the BACs that have been developed by MON, and calculating new BACs where they are required (for example, for metals in oysters). Some additional calculations were required, including the conversion of BACs for CBs in fish to a lipid weight basis using the appropriate conversion factor for the fish species. Furthermore, BACs for CBs and selected PAHs in shellfish were required, and the BACs for some PAHs in shellfish needed to be recalculated.

5.3 Dealing with a lack of assessment criteria

42. Where there are no potential green/red assessment criteria available, e.g. no EACs are available for chrysene or indeno[1,2,3-cd]pyrene, determinands were assessed for ancillary information (e.g. for trends, and for reference to such relevant assessment criteria that do exist).

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Figure 1. 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 (c.f. EQS in WFD terms) or a policy objective (e.g. EAC in OSPAR terms).

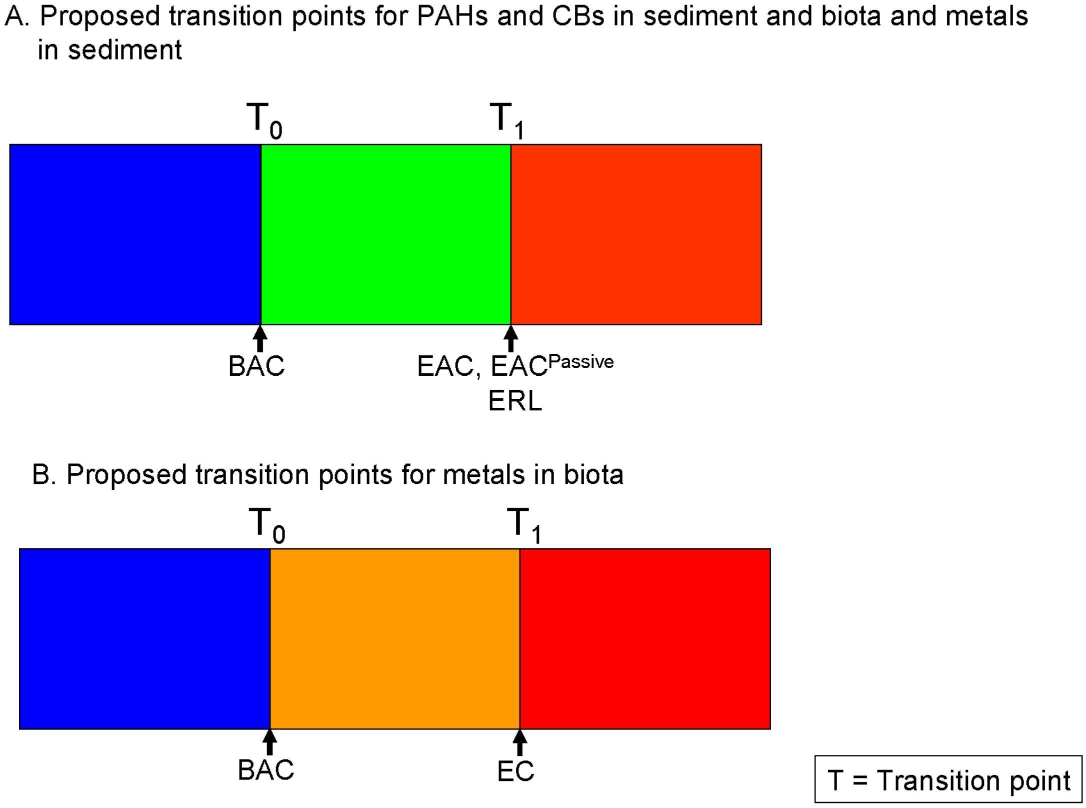

Table 1. Descriptors for a red, green, blue 'traffic light' system.

Traffic light colour	**Understanding of what the traffic light colours mean**		**Possible types of management activity**
RED	Status is unacceptable. Concentrations of contaminants are at levels where a risk to the environment and its living resources at the population or community level should be assumed. Potential for significant adverse effects to the environment, or to human health.		Measures in place or under consideration to address the cause. Regular monitoring to determine status and trends.
GREEN	Status is acceptable. Concentrations of contaminants are at levels where it can be assumed that little or no risks are posed to the environment and its living resource at the population or community level. No significant risk of adverse effects to the environment, or to human health.		Measures generally are not necessary to improve status, but may be required if there is a trend towards a deterioration in status. Appropriate monitoring regime to ensure that there is no deterioration.
BLUE	Status is acceptable. Concentrations are close to background or zero, i.e. the ultimate aim of the OSPAR Strategy for Hazardous Substances has been achieved.		Measures not required. Appropriate monitoring regime to ensure that there is no deterioration.
AMBER	Concentrations are lower than EC dietary limits for fish and shellfish and above background but the extent of risks of pollution effects is uncertain		

Table 2. Assessment Criteria for PAHs, CBs and trace metals in *sediment*. BCs and BACs are normalised to 2.5% organic carbon for PAHs and CBs, and to 5% aluminium for trace metals. Grey shaded cells show where there are no data. Purple shaded cells show where the EACs are below the BACs.

PAHs (µg/kg dry weight)				
Compound	**BC normalised to 2.5% TOC**	**BAC normalised to 2.5% TOC (T_0)**	**EAC normalised to 2.5% TOC**	**Effects Range-Low (ERL) (T_1)**
Naphthalene	5	8	43	160
Phenanthrene	17	32	1250	240
Anthracene	3	5	78	85
Dibenzothiophene	0.6[b]	[a]		190
Fluoranthene	20	39	250	600
Pyrene	13	24	350	665
Benz[*a*]anthracene	9	16	1.5	261
Chrysene/ Triphenylene	11	20		384
Benzo[*a*]pyrene	15	30	625	430
Benzo[*ghi*]perylene	45	80	2.1	85
Indeno[1,2,3-*cd*]pyrene	50	103	1.5	240
C_1-Naphthalene	2.7 [b]	[a]		155
C_2-Naphthalene	6.7 [b]	[a]		150
C_3-Naphthalene	3.3 [b]	[a]		
C_1-Phenanthrene/ Anthracene	2.7 [b]	[a]		170
C_2-Phenanthrene/ Anthracene	3.7 [b]	[a]		200
C_3-Phenanthrene/ Anthracene	2.2 [b]	[a]		
C_1-DBT	1.0 [b]	[a]		
C_2-DBT	0.7 [b]	[a]		
C_3-DBT	0.4 [b]	[a]		
Total PAH (11 parent PAH (CEMP 9 +	188.6[c]	[a]		3340[c]

PAHs (µg/kg dry weight)				
Compound **naphthalene and DBT)**	**BC** **normalised to 2.5% TOC**	**BAC** **normalised to 2.5% TOC** **(T_0)**	**EAC** **normalised to 2.5% TOC**	**Effects Range-Low (ERL)** **(T_1)**
Total PAH **(As for parent + alkylated PAHs)**	212[d]			

CBs (µg/kg dry weight)				
Compound	**LC**	**BAC** **normalised to 2.5% TOC** **(T_0)**	**EAC** **normalised to 2.5% TOC** **(T_1)**	**Effects Range-Low (ERL)**
CB28	0.05[e]	0.22	1.7	
CB52	0.05[e]	0.12	2.7	
CB101	0.05[e]	0.14	3.0	
CB118	0.05[e]	0.17	0.6	
CB138	0.05[e]	0.15	7.9	
CB153	0.05[e]	0.19	40	
CB180	0.05[e]	0.10	12	
Total CB (Aroclor Equivalents ~ = 2 x ICES7CBs)				23 (ERL)
ΣICES7CBs	0.20[f]	0.46		11.5 (ERL)[g]

Trace metals (µg/kg dry weight)				
	BC **normalised to 5% Al**	**BAC** **normalised to 5% Al** **(T_0)**	**EAC** **Normalised to 1% TOC**	**Effects Range Low (ERL)** **(T_1)**
Hg	50[h]	70[h]	220[i]	150
Cd	200[h]	310[h]	60[i]	1,200
Pb	25,000[h]	38,000[h]	2,200[i]	47,000

[a] to be defined in relation to adopted BC assuming sufficient data in ICES database

[b] proposed at the ICES Working Group on Marine Sediments in Relation to Pollution (WGMS) in 2008

[c] sum of individual BCs or ERLs for 11 parent PAHs

[d] sum of individual BCs for specified parent and alkylated PAHs

[e] LC = 2 x QUASIMEME constant error

[f] LC = 8 x QUASIMEME constant error

[g] ER values for total CB concentration/2

[h] normalised to 5% aluminium

[i] normalised to 1%TOC

Table 3. Assessment criteria for PAHs, CBs and trace metals in *mussels and oysters*. For CBs, EACs were estimated from sediment EACs and biota sediment accumulation factors (BSAF). Purple shaded cell are where EACs were not recommended for use by ICES (CBs) or are below the LC. EC - Commission Regulation No 1881/2006 sets maximum concentration for contaminants in foodstuffs to protect public health. $EAC^{passive}$ - calculated on the basis of BSAFs and sediment EACs.

Compound	LC (µg/kg dry weight)	BAC (µg/kg dry weight) (T_0)	EAC (µg/kg dry weight) (T_1)	EC (µg/kg dry weight) (T_1)	$EAC^{passive}$ (µg/kg dry weight) (T_1)
PAHs					
Naphthalene		81.2 [b]	340		
Phenanthrene	4.0[a]	12.6 [b]	1700		
Anthracene		2.7 [b]	290		
Fluoranthene	5.5[a]	11.2 [b]	110		
Pyrene	4.0[a]	10.1[b]	100		
Benzo[*b&j*]fluoranthene	3.0 [a]	[b]			
Benzo[*k*]fluoranthene	1.0 [a]	[b]	260		
Benz[*a*]anthracene	1.0[a]	3.6 [b]	80		
Chrysene	4.0[a]	21.8 [b]			
Benzo[*e*]pyrene	2.5[a]	[b]			
Benzo[*a*]pyrene	0.5 [a]	2.1[b]	600	50 (10 ww[h] X 5)	
Benzo[*ghi*]perylene	1.5 [a]	7.2 [b]	110		
Indeno[1,2,3-*cd*]pyrene	1.0 [a]	5.5 [b]			
C_2-Phenanthrene/ Anthracene	7.0 [a]	[b]			
C_3-Phenanthrene/ Anthracene	6.5 [a]	[b]			
C_1-DBT	1.0 [a]	[b]			
C_2-DBT	3.5 [a]	[b]			
C_3-DBT	3.5 [a]	[b]			
Total PAH (11 Parent PAH)	28.0[c]	[b]			

Compound	LC (µg/kg dry weight)	BAC (µg/kg dry weight) (T_0)	EAC (µg/kg dry weight) (T_1)	EC (µg/kg dry weight) (T_1)	EAC^passive^ (µg/kg dry weight) (T_1)
Total PAH (11 Parent + alkylated PAH with LCs)	56.5[d]	[b]			
CBs					
CB28	0.25[e]	[b]	13.5		3.2
CB52	0.25[e]	[b]	80		5.4
CB101	0.25[e]	[b]	5.0		6.0
CB118	0.25[e]	[b]	1.0		1.2
CB138	0.25[e]	[b]	100		15.8
CB153	0.25[e]	1.1[b]	1790		80
CB180	0.25[e]	[b]	26.5		24
ΣICES7CBs	1.0[f]	4.6[b]			
Trace metals (µg/kg dry weight) – mussels					
Hg	50[g]	140[h]	10	2,500 (500 ww[i] x 5)	
Cd	600[g]	1,940[h]	280	5000 (1,000 ww[i] x 5)	
Pb	800[g]	1,520[h]	8,500	7,500 (1,500 ww[i] x 5)	
Trace metals (µg/kg dry weight) – oysters					
Hg	100[j]	[k]		2,500	
Cd	1,800[j]	[k]		5,000	
PB	800[j]	[k]		7,500	

[a]low concentrations (LC) proposed at MCWG 2008 from the 10th percentile of datasets (Scotland, Spain and France)

[b]BACs used in the 2005/6 MON assessment to be defined/re-defined for updated BCs or LCs

[c]includes 8 of the 9 parent CEMP PAHs, benzo[*bj*]fluoranthene, benzo[*k*]fluoranthene and benzo[*e*]pyrene.

[d]includes 11 parent PAHs and selected alkylated PAHs. LCs were not proposed for anthracene or naphthalene nor for the alkylated naphthalenes due to a high proportion of samples in the datasets for which the values were below the limits of quantification for these PAHs

[e]LC = 2 x QUASIMEME constant error

[f]LC = 8 x QUASIMEME constant error

[g]low concentrations (LC) proposed at ICES MCWG 2008, median of regional medians

[h]BACs used in 2006/7 MON assessment to be redefined for new LCs

[i] ww, wet weight

[j]calculated using conversion factors proposed at ASMO 08 by France[(3)]

[k]To be calculated

Table 4. Assessment Criteria for CBs and trace metals in *fish*. For CBs EACs were estimated from sediment EACs and biota sediment accumulation factors (BSAF). Purple shaded cells are where EACs were not recommended for use by ICES (CBs) or are below the BAC. EC - Commission Regulation No 1881/2006 sets maximum concentration for contaminants in foodstuffs to protect public health. EAC^{passive} - calculated on the basis of BSAFs and sediment EACs.

CBs					
Compound	**LC (µg/kg wet weight)**	**BAC (µg/kg wet weight) (T_0)**	**EAC (µg/kg wet weight)**	**EC (µg/kg wet weight) (T_1)**	**EAC^{passive} (µg/kg lipid weight) (T_1)**
CB28	0.05[a]	0.6[e]	27[f]		64
CB52	0.05[a]	0.2[e]	163[f]		108
CB101	0.05[a]	1.9[e]	3.2[f]		120
CB118	0.05[a]	1.3[e]	0.65[f]		24
CB138	0.05[a]	0.2[e]	80[f]		316
CB153	0.05[a]	0.2[e]	53[f]		1600
CB180	0.05[a]	0.5[e]	126[f]		480
ΣICES7	0.2[b]	1.2[e]			

Trace Metals					
Determinand	**LC** **(µg/kg wet weight)**	**BAC** **(µg/kg wet weight)** **(T_0)**	**EAC** **(µg/kg wet weight)**	**EC** **(µg/kg wet weight)** **(T_1)**	**EAC^{passive}** **(µg/kg lipid weight)** **(T_1)**
Hg (muscle)	[c]	35[d]	3.5	500 (fish muscle)	
Cd (liver)	[c]	26[d]	7	1000 (bivalve tissue)	
Pb (liver)	[c]	26[d]	300	1500 (bivalve tissue)	

[a]LC = 2 x QUASIMEME constant error

[b]LC = 8 x QUASIMEME constant error

[c]The MCWG was unable to recommend BCs for metals in fish due to the limited dataset

[d]proxy BACs derived at MON in 2007

[e]based on UK data: to be re-estimated from CEMP data and with updated LCs; to convert to lipid weight, these should be multiplied by 5 for megrim, 9 for flounder and plaice, and 7 for common dab.

[f]whole fish

Table 5. Summary of assessment criteria used in the 2008/9 CEMP Assessment for (a) sediment, (b) mussels and oysters and (c) fish. (Orange shaded boxes correspond to non-CEMP parent PAHs). (a) Sediment

PAHs (µg/kg dry weight normalised to 2.5% TOC)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Green < ERL (T_1)**
Naphthalene	5	8	160
Phenanthrene	17	32	240
Anthracene	3	5	85
DBT	0.6	[a]	190
Fluoranthene	20	39	600
Pyrene	13	24	665
Benz[*a*]anthracene	9	16	261
Chrysene/ Triphenylene	11	20	384
Benzo[*a*]pyrene	15	30	430
Benzo[*ghi*]perylene	45	80	85
Indeno[1,2,3-*cd*]pyrene	50	103	240
CBs (µg/kg dry weight, normalised)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC (T_1)**
CB28	0.0/0.05	0.22	1.7
CB52	0.0/0.05	0.12	2.7
CB101	0.0/0.05	0.14	3.0
CB118	0.0/0.05	0.17	0.6
CB138	0.0/0.05	0.15	7.9
CB153	0.0/0.05	0.19	40
CB180	0.0/0.05	0.10	12
Trace Metals (µg/kg dry weight, normalised)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Green < ERL (T_1)**
Hg	50	70	150
Cd	200	310	1,200
Pb	25,000	38,000	47,000

Table 5. (b) Mussels and oysters

PAHs (µg/kg dry weight)			
Assessment	**LC**	**Blue < BAC (T_0)**	**Green < EAC (T_1)**
Naphthalene		81.2[a]	340
Phenanthrene	4.0	12.6[a]	1700
Anthracene		2.7[a]	290
Fluoranthene	5.5	11.2[a]	110
Pyrene	4.0	10.1[a]	100
Benzo[*bj*]fluoranthene	3.0	[a]	
Benzo[*k*]fluoranthene	1.0	[a]	260
Benz[*a*]anthracene	1.0	3.6[a]	80
Chrysene/ Triphenylene	4.0	21.8[a]	
Benzo[*a*]pyrene	0.5	2.1[a]	600
Benzo[*ghi*]perylene	1.5	7.2[a]	110
Indeno[1,2,3-*cd*]pyrene	1.0	5.5[a]	

CBs (µg/kg dry weight)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC (T_1)**
CB28	0.0/0.25	[a]	3.2
CB52	0.0/0.25	[a]	5.4
CB101	0.0/0.25	[a]	6.0
CB118	0.0/0.25	[a]	1.2
CB138	0.0/0.25	[a]	15.8
CB153	0.0/0.25	1.1[a]	80
CB180	0.0/0.25	[a]	24

Trace Metals (µg/kg dry weight) - mussels			
Assessment	**LC**	**Blue < BAC (T_0)**	**Amber< EC maximum food level (T_1)**
Hg	50	140	2,500
Cd	600	1,940	5,000
Pb	800	1,520	7,500
Trace Metals (µg/kg dry weight) - oysters			
Hg	100	[b]	2,500
Cd	1,800	[b]	5,000
Pb	800	[b]	7,500

Table 5. (c) Fish

CBs (µg/kg wet weight)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC^{passive} (µg/kg lipid weight) (T_1)**
CB28	0.0/0.05	0.6	64[d]
CB52	0.0/0.05	0.2	108 [d]
CB101	0.0/0.05	1.9	120 [d]
CB118	0.0/0.05	1.3	24 [d]
CB138	0.0/0.05	0.2	316 [d]
CB153	0.0/0.05	0.2	1600[d]
CB180	0.0/0.05	0.5	480 [d]
Trace Metals (µg/kg wet weight)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Amber < EC maximum food level (T_1)**
Hg (muscle)	[e]	35	500
Cd (liver)	[e]	26	1000 (bivalve tissue)
Pb (liver)	[e]	26	1500 (bivalve tissue)

[a]to be defined/redefined in relation to adopted BC during Autumn 2008

[b]to be calculated by MON during Autumn 2008

[c]dry weight basis, assuming 5% dry weight lipid concentration (equivalent to 1% wet weight lipid concentration)

[d]lipid weight basis

[e]The MCWG was unable to recommend BCs for metals in fish due to the limited dataset

Table 5. (c) Fish

CBs (µg/kg wet weight)			
Assessment	**BC/LC**	**Blue < BAC (T_0)**	**Green < EAC[passive] (µg/kg lipid weight) (T_1)**
CB28	0.0/0.05	0.6	64[d]
CB52	0.0/0.05	0.2	108 [d]
CB101	0.0/0.05	1.9	120 [d]
CB118	0.0/0.05	1.3	24 [d]
CB138	0.0/0.05	0.2	316 [d]
CB153	0.0/0.05	0.2	1600[d]
CB180	0.0/0.05	0.5	480 [d]
Trace Metals (µg/kg wet weight)			
Assessment	**BC**	**Blue < BAC (T_0)**	**Amber < EC maximum food level (T_1)**
Hg (muscle)	[e]	35	500
Cd (liver)	[e]	26	1000 (bivalve tissue)
Pb (liver)	[e]	26	1500 (bivalve tissue)

[a]to be defined/redefined in relation to adopted BC during Autumn 2008

[b]to be calculated by MON during Autumn 2008

[c]dry weight basis, assuming 5% dry weight lipid concentration (equivalent to 1% wet weight lipid concentration)

[d]lipid weight basis

[e]The MCWG was unable to recommend BCs for metals in fish due to the limited dataset

Table 6. Summary of transition points for assessing contaminants in sediment and biota for the OSPAR CEMP Assessment. T_0 = blue/green transition; T_1 = green/red or amber/red transition.

Contaminant	Transition Point	Sediment	Biota
PAH	T_0	BAC	BAC
	T_1	ERL	EAC
CB	T_0	BAC	BAC
	T_1	EAC	$EAC^{passive}$
Metal	T_0	BAC	BAC
	T_1	ERL	EC

Where suitable assessment criteria are not available, values will default to the lower status class.

ANNEX 11. INFORMATION ON THE DERIVATION AND USE OF BACKGROUND ASSESSMENT CONCENTRATIONS (BACS)

Interpretation of monitoring data from the OSPAR CEMP requires that statistical tests are used to determine whether the concentrations of a contaminant, derived from monitoring data, comply with background concentrations. The method used involves the use of the Background Concentrations (BCs) and it adopts a precautionary statistical approach to the comparison of monitoring data with BCs. The method adopted requires the establishment of a secondary concentration level, the Background Assessment Concentration (BAC). The BAC is a concentration near to the background and its value for a particular contaminant will depend, for contaminants with non-zero BCs, on the value of the BC and the residual variance in temporal trend series at the BC. The BC for xenobiotics is zero, and in this case the variance used to derive BACs is the variance at a low concentration that is small but detectable by common analytical methods. The use of BACs is considered to be:

- being statistically sound and based on a precautionary approach;
- having a potential for wide applicability covering all contaminants, natural and man-made in all regions of the Convention Area (providing BCs are available), and potentially more widely in European waters;
- being applicable to sediment and biota, and also potentially to water
- having application as a strategic management tool
- allowing OSPAR to test against its policy objectives.

BACs are used to determine whether the concentrations observed in monitoring programmes are "*near background values for naturally occurring substances and close to zero for man-made synthetic substances*". This is achieved through comparisons with BACs. The test is precautionary, in that the mean concentration is considered to be greater than "near background" (i.e. [c] > BAC) unless there is statistical evidence to show that it is near background (i.e. [c] ≤ BAC). The null and alternative hypotheses are therefore:

H_0: [c] > BAC (i.e. concentrations above background)

H_1: [c] ≤ BAC (i.e. concentrations near background)

BACs should be both low enough to reflect near background concentrations and high enough that we are likely to conclude that concentrations are near background when [c] = BC. In the absence of other objective means of setting the BAC, the observed precision of the CEMP data can be used to set a provisional BAC. Specifically, the BAC can be set to give a 90% probability of concluding that concentrations are near background when [c] = BC.

Technically, the BAC can be constructed as follows. Under the current OSPAR methodology[4], the mean log-concentration in the final year of a time series with at least ten years of data and residual standard deviation ψ will be estimated with a standard deviation

$$\text{s.d.} = \psi\sqrt{(SS')_{TT}} = 0.727\psi$$

where S is the smoothing matrix and the subscript TT denotes the elements corresponding to the final monitoring year. Given this precision, setting the BAC to satisfy

[4] time series of annual median log-concentrations, LOESS smoother, and a seven-year fixed window.

$$\log BAC - \log BC = 3.18 \text{ s.d.} = 2.31\psi$$

will ensure that a one-tailed t-test of size 5% will have 90% probability of concluding that the mean log-concentration is below log BAC when the true mean log-concentration is log BC. Ignoring the philosophical difficulties of moving from mean log-concentrations to mean concentrations, this suggests that if one can find a value of ψ that is typical of data collected under the CEMP, the provisional BAC should be

$$BAC = BC \exp(3.18 \text{ s.d.}) = BC \exp(2.31\psi).$$

The subsequent test of field monitoring data against the BAC uses the upper confidence limit of the monitoring data (typically the upper confidence limit of the fitted value in the final year of a time series). Concentrations considered to be above background if the upper confidence limit is above the BAC. Concentrations are considered to be near background if the upper confidence limit is below the BAC. To illustrate, we conclude that concentrations at site 1 in the figure here below are near background, but that concentrations at sites 2 and 3 are above background.

Further details of the method of derivation of BACs and the associated statistical tests are available in the OSPAR CEMP Assessment Manual.

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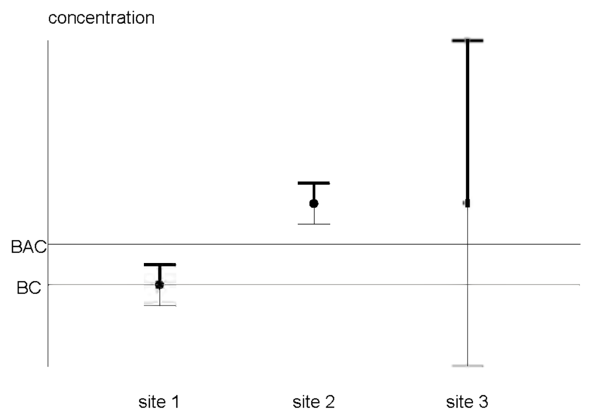


Illustration of the modified green test; the dots indicate the estimated mean concentration and the bold bars indicate the upper confidence limit. We conclude that concentrations are above background at sites 2 and 3 and near background at site 1.

ANNEX 12. TEMPORAL TREND ANALYSIS

OSPAR has developed automated procedures to fit weighted LOESS smoothers to time series data and to assess the data for significant (5%) linear and non-linear trends. Compliance with a "no deterioration" objective could be considered to be the absence of a significant upward trend over the assessment period. The potential to detect statistically significant trends will increase as the length of time series increases. There could therefore be scope to take advantage of existing time series of data, for example data already collected in response to other national or international drivers, and to maintain these time series and use the data in MSFD context. Some details of the OSPAR experience is presented below.

Statistical analyses prior to trend analysis

The main purpose of statistical analysis prior to trend analysis is to develop appropriate weightings to be applied to individual data points in the subsequent weighted LOESS smoother and trend analysis. The procedures that have been used for biota differ from those applied to sediment. The objective for field data for biota and sediment is to obtain estimates of the uncertainty in each data point. The purpose of obtaining estimates of the uncertainty in data points in time series is to allow the use of weighted smoothing functions to describe the trend. If data are not available to allow estimation of these uncertainties, trend analysis can be undertaken giving each data point the same weight. In practice, the available QA information has been used to construct an *analytical weight* for each data point, ranging from 0 (totally unacceptable) through to 1 (totally acceptable). An iterative procedure is then used to convert these analytical weights into statistical weights that account for the relative magnitudes of the environmental and analytical variances. The approach has been applied routinely to data in the ICES databank to contribute to OSPAR MON CEMP data assessments. Further details are available in the OSPAR CEMP Assessment Manual.

Method used for trend analysis of time series

Fitting a weighted smoother is straightforward if the statistical weights are known beforehand (e.g. Hastie & Tibshirani, 1990; Nicholson & Fryer, 2001; Uhlig, 2001). The statistical weights should be inversely related to the total environmental and analytical variance each year. Appropriate methods for estimating them will depend on the QA information available. For example, Nicholson & Fryer (2001) show how the EM algorithm can be used to estimate the environmental variance and hence the statistical weights when the analytical variance is known each year (e.g. from control chart information). However, most time series in the ICES databank do not have a complete record of analytical variances over time. Nicholson & Fryer (2002) extend the methodology to estimate missing analytical variances. However, they recognise that, for routine trend assessments, the method is too complex and makes too many assumptions that are difficult to substantiate.

An alternative (Nicholson & Fryer, 2002) is to use the available QA information to categorise the analytical quality of data as *Good*, *Poor*, *Unknown* and *Unacceptable* and allocate statistical weights $1 > W_{poor} > W_{unknown} > 0$ accordingly. This approach is simple and intuitively appealing. However, the choice of statistical weights is arbitrary and takes no account of the relative importance of the analytical variance to the total environmental and analytical variance. For example, all data with 'poor' analytical quality will have the same statistical weight, even though such data should be down-weighted less when the environmental variance dominates the analytical variance (when poor analytical quality doesn't matter so much).

This document presents a third approach that provides a compromise between the two methods described above. It is assumed that available QA information can be used to construct an *analytical weight* for each datum, ranging from 0 (totally unacceptable) through to 1 (totally acceptable). An iterative procedure is then used to convert these analytical weights into statistical weights that account for the relative magnitudes of the environmental and analytical variances. The approach has been applied routinely to data in the ICES databank to contribute to OSPAR MON CEMP data assessments.

Theory

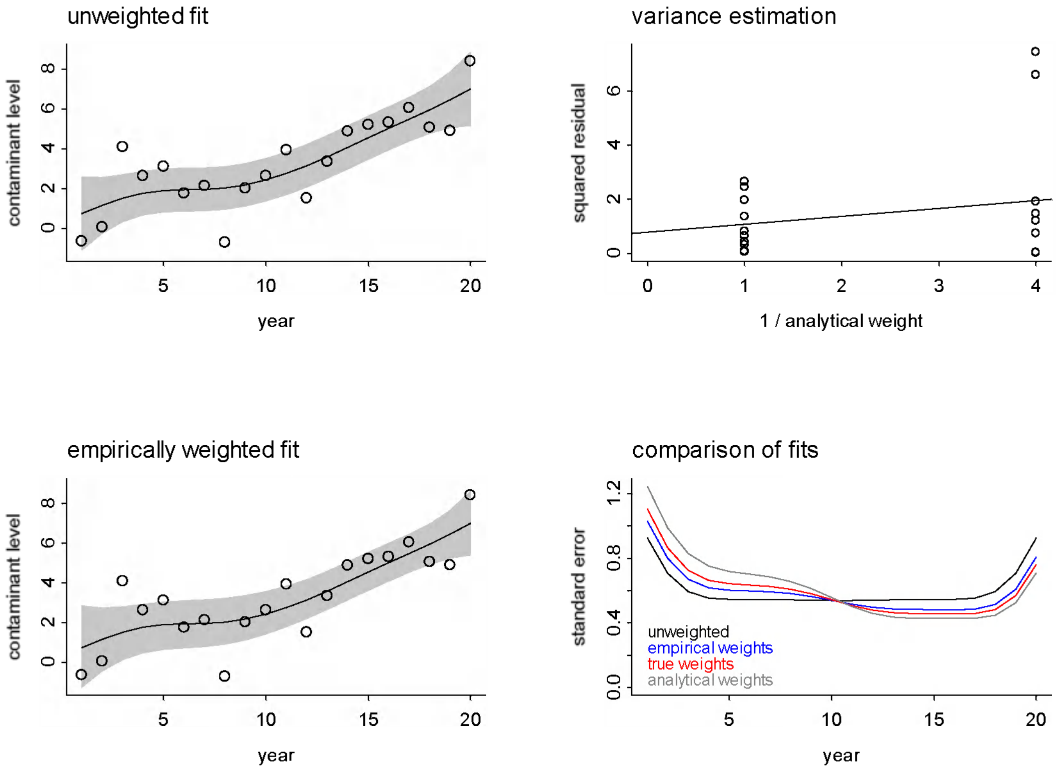
Assume that a contaminant time series can be described by the model:

$$y_t = f(t) + \varepsilon_t$$

where y_t is the annual contaminant index in year t, $f(t)$ is a smooth function of time describing the underlying trend in contaminant levels, and ε_t is the 'noise' in year t from both environmental (i.e. field) and analytical variation. Further, assume that the noise can be decomposed into two terms:

$$\varepsilon_t = \delta_t + \tau_t$$

where δ_t is the noise due to environmental variation (both between- and within-years) and τ_t is the noise due to analytical variation. Finally, assume that the noise terms are mutually independent and normally distributed:



Presentation of temporal trend assessments

In the initial output from the trend analysis software, the assessments of each parameter are summarised in two pages, one each for sediment and biota, preceded by an explanatory text. Each page contains regionalized tabulations and graphical representations of detected trends.

Firstly, contaminant data are tabulated by OSPAR region and, for biota, by species group. The number of time series, the number of significant linear trends and the number of time series where the mean concentration in the final year is significantly below the BAC (or BRC) are graphically presented.

Secondly, mean concentrations in the final year of each time series are tabulated, by OSPAR region. Time series for which the mean concentration is significantly below the BAC (BRC) are shown by filled circles; open circles indicate mean concentrations that are not significantly below the BAC (BRC).

Finally, selected time series are graphically illustrated. Time series can be selected where they showed a significant change in concentration over the full period of the time series, or over some subset of the data, for example for the preceding ten years or where the upper confidence limit on the mean concentration in the final year exceeded the BAC (BRC). When it is not possible to plot all time series, a selection can be made, for example to include only those which were most significant or showed the highest levels were given.

In the explanatory texts on the assessment, the following phrases have been used to explain statistical results:

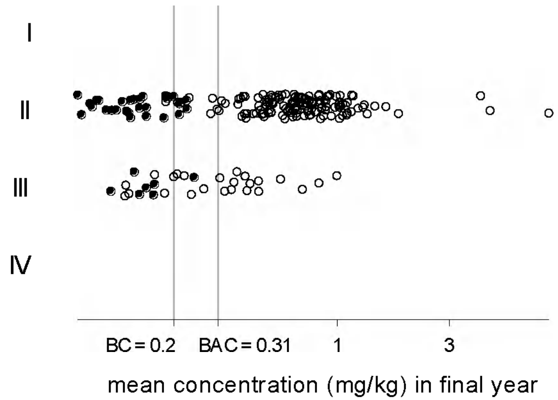
a. "*trends*" refer to linear trends, significant at the 5% level,

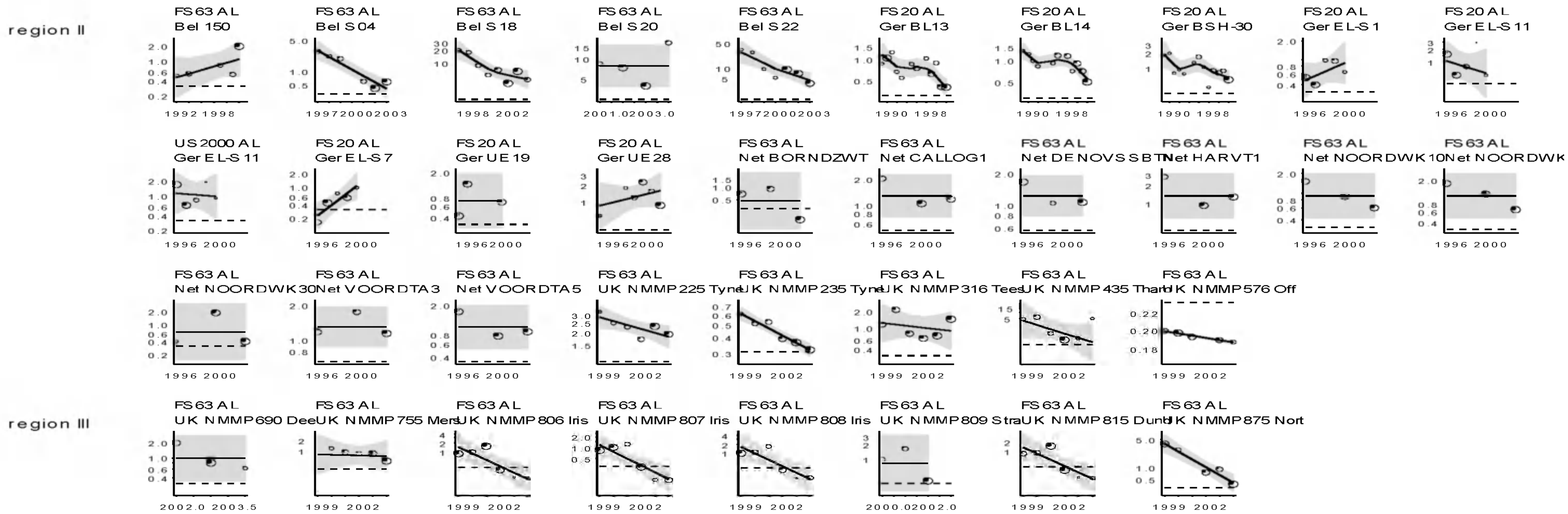
b. "*mean concentrations are at background*" or "*mean concentrations are close to zero*" means that the upper confidence limit on the fitted mean concentration in the last year of monitoring is below the BAC.

An example of the approach is given overleaf

Cadmium in sediment

Normaliser	OSPAR Region	Number of time series				Trends		UCL<
		3-4	5-6	7+	total	up	down	BAC
Aluminium	II	98	48	24	170	1	13	31
	III	13	18	0	31	0	5	7
		111	**66**	**24**	**201**	**1**	**18**	**38**





Statistical analysis of trends in relation to a "no-deterioration" objective - A practical approach

In 2007, OSPAR MON was asked to advise on the applicability of the temporal trend analysis procedures that were routinely applied in the assessment of CEMP data to the assessment of trends in relation to a "no-deterioration" objective. The advice was that the fundamentals of the CEMP methods could be applied, with some modifications to the final assessment. Some preliminary work would be required to agree an appropriate statistical power, and to establish appropriate values for a maximum 'acceptable' small upwards trend (termed β_{small}) for each contaminant in each matrix that was to be assessed. A mechanism would be required whereby it could be agreed that these values are indeed acceptably small. The detail of the advice is presented in the following

(Ref. § 5.7) OSPAR CONVENTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT OF THE NORTH EAST ATLANTIC MEETING OF THE WORKING GROUP ON MONITORING (MON) COPENHAGEN: 4-7 DECEMBER 2007

Assessing a no deterioration Objective

1. The statistical procedures currently used by MON for trend detection in assessment of CEMP data on contaminant concentrations in biota and sediment are described in the "CEMP Assessment Manual for contaminants in sediment and biota". The procedures test for statistically significant trends, up or down, based upon a null hypothesis of there being no trend:

$H_0 : \beta = 0$

$H_1 : \beta \neq 0$

2. An initial possibility of addressing a no deterioration objective would be to consider all significant downwards trends and all non-significant trends as meeting the objective. However, this would not be a precautionary approach as highly variable or short time series would typically meet the no deterioration objective, even if there was a large increase in concentration at that station, as the trend would be non-significant.

3. In making comparisons of data against assessment criteria such as BACs, MON has adopted a precautionary approach. The procedures are also described in the "CEMP Assessment Manual for contaminants in sediment and biota". It would therefore be logical to adopt a similar precautionary approach for assessments against a no deterioration objective. One might first consider writing the hypotheses as

$H_0 : \beta \geq 0$

$H_1 : \beta < 0$

but this actually constitutes a test of improvement, rather than a test of no deterioration, since $\beta = 0$ (i.e. no deterioration) is included in the null hypothesis that we are trying to reject.

4 A solution is to accept that a small upwards trend is compatible with the no deterioration objective by writing the null hypothesis as

$H_0 : \beta \geq \beta_{small}$

$H_1 : \beta < \beta_{small}$

where β_{small} is the maximum 'acceptable' small upwards trend. This is analogous to defining the BAC as a small but acceptable concentration above the BC. Choosing β_{small} involves all the same problems as choosing a BAC. A simple solution is to choose β_{small} so that there is a defined power, for example 90%, of rejecting H_0 when $\beta = 0$.

5. It would be possible to build assessments against objectives formulated in this way into the routine MON CEMP assessment process. However, some preliminary work would be required to

agree an appropriate power, to establish appropriate values for β_{small} for each contaminant in each matrix that was to be assessed, and to agree that these values are indeed acceptably small.

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ANNEX 13. SHORT DESCRIPTIONS OF SOME RELEVANT EU RESEARCH PROJECTS FOR DESCRIPTOR 8

BEAST

The pan-Baltic BEAST project is targeted at developing integrated measures of chemical pollution and tools needed to detect and understand human-induced pressure on the Baltic Sea ecosystem. We will test and validate integrated monitoring and assessment approaches for their applicability in the Baltic Sea, taking carefully into account the specific abiotic and biotic characteristics of the sea area. Using sub-regional assessments we will provide scientifically based recommendations for the implementation of an integrated chemical-biological effects monitoring strategy for the assessment of ecosystem health. This supports ecosystem-based management to safeguard the sustainable use of ecosystem's goods and services. To establish links between responses related to chemical pollution within the individuals and effects observed at higher biological levels we will generate an integrated "multi-level toolbox" including biomarkers as sensitive diagnostic tools. Capacity building, networking, exchange and intercalibration of methodologies, and training are another integral part of the project. Sixteen partners from all Baltic Sea countries are involved in BEAST; the work consists of field and experimental research using both established and novel methods on 5 Baltic Sea sub-regions so far with limited information on biological effects of hazardous substances. The outcome will be communicated to national and regional stakeholders and co-operation with HELCOM MONAS will be established. For more info see http://www.bonusportal.org/research_projects/research_projects/beast/

BONUS

BONUS started in 2003, with the goal of forming a network of research funding agencies supporting science-based management of environmental issues in the Baltic Sea (BONUS ERA-NET). The project brought together agencies from all MS around the Baltic Sea and Russia, and built a Joint Baltic Sea Research Programme under the Article-169 of the EU treaty to fund Baltic Sea research (BONUS-169). A legal structure (BONUS EEIG) was established in 2007 to implement BONUS-169 and the first call funded in total 16 projects for the period 2008-2011 (see below). Between 2010-2016, a new programme will be launched, divided into two phases: a strategic phase during 2010-2011, followed by an implementation phase during 2012-2016. At least three calls for proposals will be published, targeting multi-partner and trans-national projects, and including research, technological development, training and dissemination activities.

Several research projects have sofar been implemented:

AMBER, Assessment and Modelling Baltic Ecosystem Response

BALCOFISH, Integration of pollutant gene responses and fish ecology in Baltic coastal fisheries and management

BaltGene, Baltic Sea Genetic Biodiversity

BALTIC GAS, Baltic Sea Genetic Biodiversity

Baltic-C, Building predictive capability regarding the Baltic Sea organic/inorganic carbon and oxygen systems

BalticWay, The potential of currents for environmental management of the Baltic Sea maritime industry

BAZOOCA, Baltic zooplankton cascades

BEAST, Biological Effects of Anthropogenic Chemical Stress: Tools for the Assessment of Ecosystem Health

ECOSUPPORT, Advanced modeling tool for scenarios of the Baltic Sea ecosystem to support decision making

HYPER, HYPoxia mitigation for Baltic Sea Ecosystem Restoration

IBAM, HYPoxia mitigation for Baltic Sea Ecosystem Restoration

INFLOW, Holocene saline water inflow changes into the Baltic Sea, ecosystem responses and future scenarios

PREHAB, Spatial PREdiction of Baltic benthic HABitats: incorporating human pressures and economic evaluation
PROBALT, Improving Societal Conditions for the Baltic Sea Protection,
RECOCA, Reduction of Baltic Sea Nutrient Inputs and Cost Allocation within the Baltic Sea Catchment
RISKGOV, Environmental Risk Governance of the Baltic Sea

EUROSITES

EuroSITES is a FP7 Collaborative Project which aims to form an integrated European network of 9 deep-ocean (>1000m) observatories. With the deep-sea being a final sink for contaminants, the project can link to ways for in situ long-term time-series ocean observations.

http://www.eurosites.info

HARBASINS

HARBASINS is a European project and stands for Harmonised River Basins Strategies North Sea. The aim of the HARBASINS project is to enhance the compatibility of management strategies and international cooperation for the North Sea's coastal waters, estuaries and river basins. The focus is on harmonisation of the WFD and the international cooperation on integrated management of estuaries and coastal waters in the North Sea Region, ultimately leading to ecosystem restoration and compatible instruments which ensure sound environmental management of interconnected coastal zones. The project is co-funded by the European Regional Development Fund (ERDF) Interreg IIIB North Sea Programme which is a Community Initiative concerning Transnational Cooperation.

HERMIONE

The HERMIONE (Hotspot Ecosystem Research and Man's Impact on European Seas) project http://www.eu-hermione.net/ is a Collaborative Project funded under the European Commission's Framework 7 programme. HERMIONE is the successor to the highly successful HERMES project, which finished in March 2009. It is designed to make a major advance in our knowledge of the functioning of deep-sea ecosystems and their contribution to the production of goods and services. This will be achieved through a highly interdisciplinary approach (including biologists, ecologists, microbiologists, biogeochemists, sedimentologists, physical oceanographers, modelers and socio-economists) that will integrate biodiversity, specific adaptions and biological capacity in the context of a wide range of highly vulnerable deep-sea habitats. HERMIONE study sites include the Arctic, North Atlantic and Mediterranean and cover a range of ecosystems including cold-water corals, canyons, cold and hot seeps, seamounts and open slopes and deep basins. The project will make strong connections between deep-sea science and user needs. HERMIONE started work on 1 April 2009 and will continue for the next 3 years. The consortium comprises 38 partners across Europe, and includes leading experts in the fields of marine research and environmental socio-economics.

ICON

Following the development of a framework for integrated chemical and biological monitoring for contaminant impacts in marine ecosystems (ICES and OSPAR working group WKIMON), a need was identified to test the suggested methods in a practical exercise, i.e. ICON. ICON (Integrated assessment of contaminant impacts on the North Sea) includes research groups from 10 European countries and is based on material sampled during research cruises and campaigns in 2008 and 2009. The sampling locations included offshore and inshore reference locations on Iceland as well as estuarine, coastal and offshore locations in the North Sea, Wadden See, Seine bay and Mediterranean. Mussels, dab, haddock and flounder is currently being analysed for concentrations of selected contaminants and a range of biological effects responses. Sediment samples from the same locations were tested for toxicity and extracted for further in vitro testing using bioassays. The results from the project will be summarised and published in 2010.

KEYBIOEFFECTS

KEYBIOEFFECTS research training network is aiming to provide the elements required to train the new generations of researchers skills needed to solve problems surrounding biodiversity conservation and water pollution in European rivers and to transfer this knowledge to different stakeholder groups. The scientific objective of this project is to provide a better understanding of the causes of ecological quality loss and the cause-effect relationships of pollution and to derive from this knowledge practical tools for water quality assessment. The development of complementary tools is crucial to achieving this objective: the identification of key toxicants, the quantification of the influence of environmental conditions on toxicant bioavailability, the assessment of these effects at the organism, on populations, on communities and ecosystems, and testing in micro- and mesocosms will result in the description of cause-effect relationships and allow the modelling of toxicant effects on the biota.

MERMEX

The French community working in marine biogeochemistry and biological ecosystems is currently structured to initiate the MERMEX project (Marine Ecosystems Response in the Mediterranean Experiment). This programme is associated to other programmes related to the study of the hydrological cycle (HyMeX) and atmospheric chemistry (ChArMEx) in the Mediterranean basin. MERMEX aims to deepen the current understanding of the Mediterranean marine ecosystems to better anticipate their upcoming evolution. It will focus on the response of ecosystems to modifications of physico-chemical forcing at various scales, both in time and space, linked to changing environmental conditions and increasing human pressure. We propose a comprehensive, integrated approach considering the continuum between the coastal zone and the open sea and its interfaces, including ocean-continent, ocean-atmosphere and water-sediment to precisely describe and model the current state of the Mediterranean ecosystems and the complex interactions existing between the environmental and human factors. Only a coordinated and ambitious strategy, addressing simultaneously the physics and biogeochemistry of these systems will permit to explore and analyse the present sensibility of marine ecosystems, and to validate the tools used to forecast their changes. We present the French initiative MERMEX for a large biogeochemical program in the Mediterranean and call for international collaboration.

MODELKEY

Models for Assessing and Forecasting the Impact of Environmental Key Pollutants onMarine and Freshwater Ecosystems and Biodiversity. MODELKEY comprises a multidisciplinary approach aiming at developing interlinked and verified predictive modelling tools as well as state-of-the-art effect-assessment and analytical methods generally applicable to European freshwater and marine ecosystems:

- to assess, forecast, and mitigate the risks of traditional and recently evolving pollutants on fresh water and marine ecosystems and their biodiversity at a river basin and adjacent marine environment scale,
- to provide early warning strategies on the basis of sub-lethal effects in vitro and in vivo,

- to provide a better understanding of cause-effect-relationships between changes in biodiversity and the ecological status, as addressed by the WFD, and the impact of environmental pollution as causative factor,
- to provide methods for state-of-the-art risk assessment and decision support systems for the selection of the most efficient management options to prevent effects on biodiversity and to prioritise contamination sources and contaminated sites,
- to strengthen the scientific knowledge on an European level in the field of impact assessment of environmental pollution on aquatic ecosystems and their biodiversity by extensive training activities and knowledge dissemination to stakeholders and the scientific community.

One of the subprojects focuses on the transfer of key-contaminants in the marine and fresh water food chains in three basins in Europe (Scheldt, Elbe, and Lljobregat).

MYTILOS

The purpose of the Mytilos project is the development of an interregional costal water quality monitoring network through biological integrators (mussels *Mytilus galloprovincialis*), for the sustainable protection of the Western Mediterranean Sea.

This evaluation and monitoring network of the coastal contamination carries out an active biomonitoring through caged mussels. This caging method has been implemented on the French coasts since 1996 (100 cages).

This goal will be achieved through

- setting up a network of partners with the same methodology,
- implementing a standard protocol in the Western Mediterranean, including its dissemination among the Maghreb partners,
- evaluating the chemical quality of the Mediterranean Sea as identified in the Framework Directive in the field of water policy (directive 2000/60/CE).

NORMAN

The NORMAN network, a former 6th EU Framework Programme project, is a permanent self-sustaining network of reference laboratories, research centres and related organisations for the monitoring and biomonitoring of emerging environmental substances. Its mission is to: enhance the exchange of information and collection of data on emerging environmental substances; encourage the validation and harmonisation of common measurement methods and monitoring tools so that the demands of risk assessors can be better met; ensure that knowledge on emerging pollutants is maintained and developed by stimulating coordinated, interdisciplinary projects on collaborative, problem-oriented research and knowledge transfer to address identified needs. NORMAN operates via the organisation of a number of activities, including expert group meetings, workshops, databases and methods validation exercises. (For more info see http://www.norman-network.net/.) Many of these activities, including chemical and biological effects methods, calibration of methods, and data storage, can play a role in the implementation of future monitoring activities related to the MSFD.

REBECCA

The objective of REBECCA is to provide underpinning for one of the key scientific principles on which the WFD is based, i.e. that relationships between the biological state and physical and chemical properties of surface waters are sufficiently well understood to enable the management of catchments and rivers to achieve ecological objectives. Historically, there has been great success in maintaining and improving the quality of surface waters by developing an understanding of the links between anthropogenic pressures (e.g. water abstraction, agriculture, and effluent discharges) and the chemical status of waters, although there remain many challenges in reliably designing and implementing the necessary programmes of measures. Our present understanding of the link between chemical properties and ecological state, while good in some instances, is generally not adequate to support management intervention against ecological objectives.

THRESHOLDS

The Thresholds Project took place within the FP6 EU framework, and more than twenty partners from all europe participated in several of its streams. The objectives of the thresholds project was to advance in the understanding of the points of no return, or "thresholds" of ecosystems due to anthropogenic pressures, mainly, nutrients and pollutants. While there is a long tradition of field studies on the influence of nutrients and eutrophication on ecosystems, the stream dealing with pollutants clearly started from a lower knowledge of how pollutants affect ecosystems, which was centered in planktonic food web. The project did contributions in the modeling of POPs in the marine environment and by generating new data sets of POPs (for the Mediterranean) in order to fill gaps. The project did important contributions on the the knowledge of the processes affecting bioconcentration of POPs in plankton, the major variables affecting the effects of POPs in phytoplankton, and provided evidence that pollutants may already be affecting phytoplankton populations in some oceanic/marine regions. Concerning bioaccumulation, the assessment of plankton samples from all the Mediterranean has allowed to determine the trophic controls on PAH, PCB, HCH and HCB concentrations in the lower levels of the food web. The concentrations of these pollutants decrease at higher biomass following a power law, being the effect more pronounced for those chemicals that are more biodegraded in the water column. Indeed, lighter PAHs and HCH show a more pronounced effect. Conversely, for persistent POPs, the trends are those predicted from interactions between atmospheric deposition and bioconcentration in plankton, thus a depletion of water column levels due to higher settling fluxes of organic matter in some regions.

Concerning the study of the effects of pollutants on phytoplankton and zooplankton, work has been done using mesocosmos and microcosmos in the field. The results have shown that individual and mixtures of PAH affect phytoplankton and zooplankton but at concentrations 3 to four orders of magnitude higher than those found in the field. Conversely, the application of a novel approach allowed to determine the influence of complex mixtures of organic pollutants on oceanic phytoplankton populations. The results of these experiments suggests that current levels of POPs are close, only 20 times below, the levels at which significant influence on ecosystem function (primary productivity) is found. These experiments were performed at open sea, since concentrations in coastal areas are higher, it is possible that this is already occurring in some regions.

ANNEX 14. BALTIC SEA SUBREGIONS

This paper presents a suggestion of the division of European marine waters as regards the assessment of the environmental status of the marine waters in the Marine Strategy Framework Directive (MSFD). The simple division method combines three different approaches: national boundaries, coastal and offshore waters, and physico-chemical and biological division of the sea area.

The marine coastal and offshore waters have significant differences as regards human pressures, biological components and physico-chemical characteristics and processes. The WFD distinguishes coastal waters as a transition zone from inland waters to marine waters. In WFD, the coastal waters are defined as the coastal baseline + 1 nautical mile. However, according to WFD, the chemical status of coastal waters is assessed for a larger area, defined as coastal baseline + 12 nm (territorial waters).

The marine waters have other differences which arise from oceanographic processes and seabed geomorphology, such as up-welling or down-welling zones, different stratification, salinity gradients, bathymetry, etc. Such differences result in differences in biological diversity and biological processes. The basis of the division is mainly the salinity gradient and bathymetry (and the resulting biological differences), but management point of view has also been included to the division.

The combination of all the three approaches mentioned above results assessment units, which are small enough to take into account a wide array of differences in the characteristics of the marine waters (Fig. 3). However, the assessment units are large enough to be feasible in the long-run: (1) assessments of separate units do not fail do to lack of detailed data and (2) national assessment do not pose too great workload to the MS. The cartographic combination of the three layers may produce small areas, which should be considered case by case and merged to neighboring areas. Also, the common approach may fail to show some significant features in the marine waters, and a Member State may want define more detailed areas in addition to the common approach. These assessment units (Figure 3) are used in the on-going HELCOM HOLAS project. See more information on assessment units from the HELCOM Document 2/14 - Towards a Holistic Assessment of Environmental Status in the Baltic Sea – HOLAS ROADMAP, HELCOM 30/2009 Meeting. This document includes the names of assessment units shown in Figure 3. Although the overarching goal of HOLAS is to assist the harmonized implementation of the HELCOM BSAP, it also proactively paves the way for the harmonized implementation of the EU Marine Strategy Framework Directive (MSFD).

The national boundaries is to be incorporated to Figure 3, because all EU MS shall assess their own marine waters in MSFD. The division will therefore follow the border of Exclusive Economic Zones (EEZ, not shown in Figure 3).

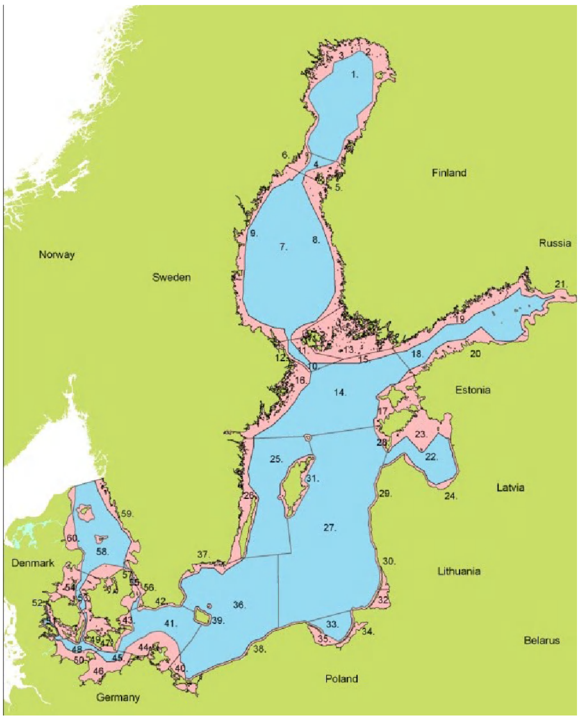

Figure 3. The proposal on the Baltic Sea sub-regions (assessment units) to be used in MSFD. The overlay map of the three delineations: coastal/offshore waters, national boundaries concerning the coastal waters and natural characteristics of the sea area.

By: Division of marine waters to assessment units in Marine Strategy Framework Directive, HELCOM Secretariat 9th December 2009.

ANNEX 15. DATA AGGREGATION, INTEGRATION AND ASSESSMENT: EXPERIENCE FROM THE OSPAR CEMP ASSESSMENT FOR QSR 2010 AND COMMENTS ON APPLICATION TO GES

Background

In preparing an assessment of CEMP monitoring data on contaminant concentrations in fish, shellfish and sediment for the OSPAR QSR 2010 project, there was a requirement to produce very succinct graphical presentations of assessments against OSPAR objectives for hazardous substances, i.e. that concentrations should be at, or approaching, background levels for naturally occurring substances and close to zero for manmade substances, and that there should be no unintended/unacceptable biological responses, or unintended/unacceptable levels of such responses, being caused by exposure to hazardous substances. Data should be integrated to provide assessments/summaries at OSPAR Region level.

Data

The monitoring data available to the assessment group consisted primarily of time series data (annual) for contaminant concentrations in sediment, fish and shellfish from national programmes. These were supported by various amounts of spot samples from stations that had been sampled less regularly. The assessment was carried out by OSPAR MON, who made extensive use of the OSPAR CEMP Assessment Manual, which provided methodological guidance, including normalisation methods for concentrations in sediments, and the statistical analysis of data for temporal trends. All the data were held by the ICES Data Centre, and included QA information to allow assessments of the relative quality of data. Preparatory work had included the development of assessment (BACs, EACs) for priority hazardous substances. Work under previous assessments had provided automation of core parts of the data assessment method. The data included in the assessment covered analyses of sediment, fish and shellfish for mercury, lead, cadmium, CBs (7 off), and PAHs (6 off) from a large number of stations throughout the OSPAR Convention area.

Steps in the data assessment and integrations

a) Step 1:

The first step in the data assessment was to undertake assessments of the data for temporal trends, by fitting LOESS smoothers to the data. This identified those data series for individual contaminants, in individual matrices, at individual stations in which significant linear or non-linear trends had occurred. The process also returned the fitted values in the final year of each time series, and the uncertainty in these values. These values were then compared to assessment criteria (EACs and BACs), and the outcomes of these assessments were expressed in a traffic light system. In turn, this information was presented in maps showing the results of assessment for each station by contaminant, and by matrix (e.g. Fig. 1). These maps were used to show both significant trends and comparisons of concentrations with assessment criteria.

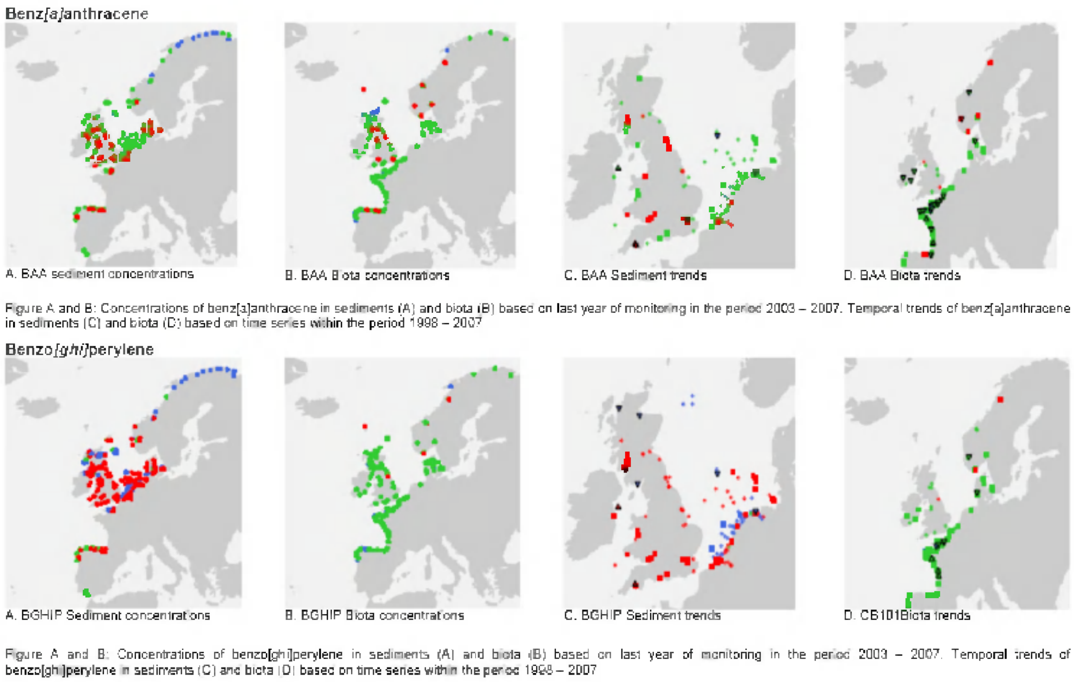

Figure 1.

b) Step 2

While the priority metals, Hg, Cd and Pb are treated as individual hazardous substances in OSPAR, the CBs and PAHs are considered as groups. The initial data analysis provided assessments for each CB congener and each PAH separately. To provide a balanced basis for further integration of data, it was necessary to summarise the assessments for CBs and PAHs down to single assessment, by matrix, by station. A "one out all out" approach was considered for this, burt was rejected as it was thought to be too susceptible to possible uncertainties in either the data or the assessment criteria, and a "two out all out" approach was used, and found to be more satisfactory and less easily influenced by uncertainties in data.

This step had the benefit if ensuring that subsequent data presentations would not be distorted by the multiple determinands used in the CB and PAH groups. The data were now structured by stations, contaminants and matrices. All have been summarised as traffic light scheme assessments. The traffic light assessments against BAC and EAC were taken forward into a summarising/ integration process.

c) Step 3

The next step was to define geographical sub-areas for which integrated assessments would be made. It was recognized that there were differences in environmental quality within OSPAR Regions. The most consistent pattern within OSPAR Regions was between near shore and offshore areas, with generally higher levels of contamination being found in near shore waters. Therefore, an assessment framework of subdivisions for each OSPAR Region was based upon a large offshore area, and a small number (up to 4) of inshore areas consisting of coastal sea waters within the 12 nautical mile boundary (Fig. 2).

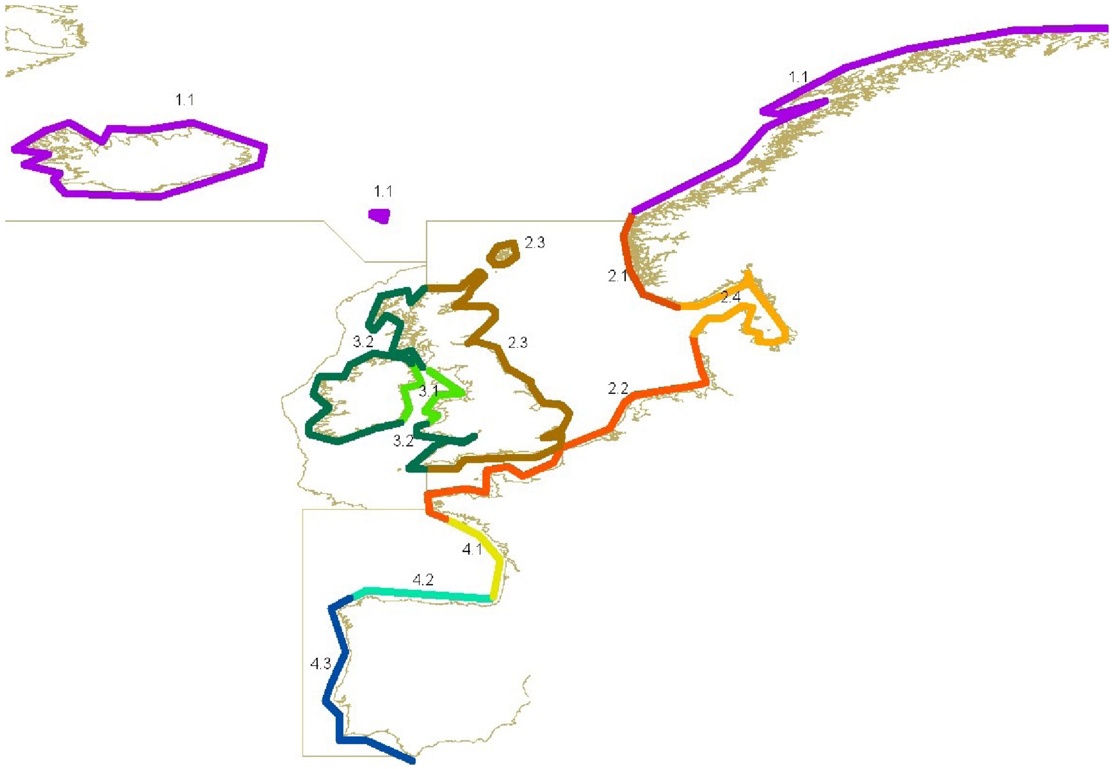

Figure 2. Subdivisions of the OSPAR area used in contaminant data assessment for the QSR 2010, showing offshore areas, and coastal waters defined by the 12 nautical mile limit, in OSPAR Regions I-IV. The colours are of no significance, but are included to improve clarity of the map.

d) Step 4

The next stage in the integration process was to combine data within contaminants, across stations within assessment sub-areas. This was done by calculating the percentages of blue, green and red station assessments, by contaminant, in each sub-area. Assessments based on time series were given twice the weight of spot samples.

These results were displayed as histograms superimposed in maps of each OSPAR Region. Various different presentations can be envisaged. The version shown in Fig. 3 shows proportions of blue, green and red assessments, for each contaminant, in each sub-area. It therefore integrates across stations and across matrices. The upper horizontal bar for each sub-area integrates across contaminants as well to give an overall expression of environmental quality for each sub-area for the five priority contaminants or groups of contaminants used in the assessment.

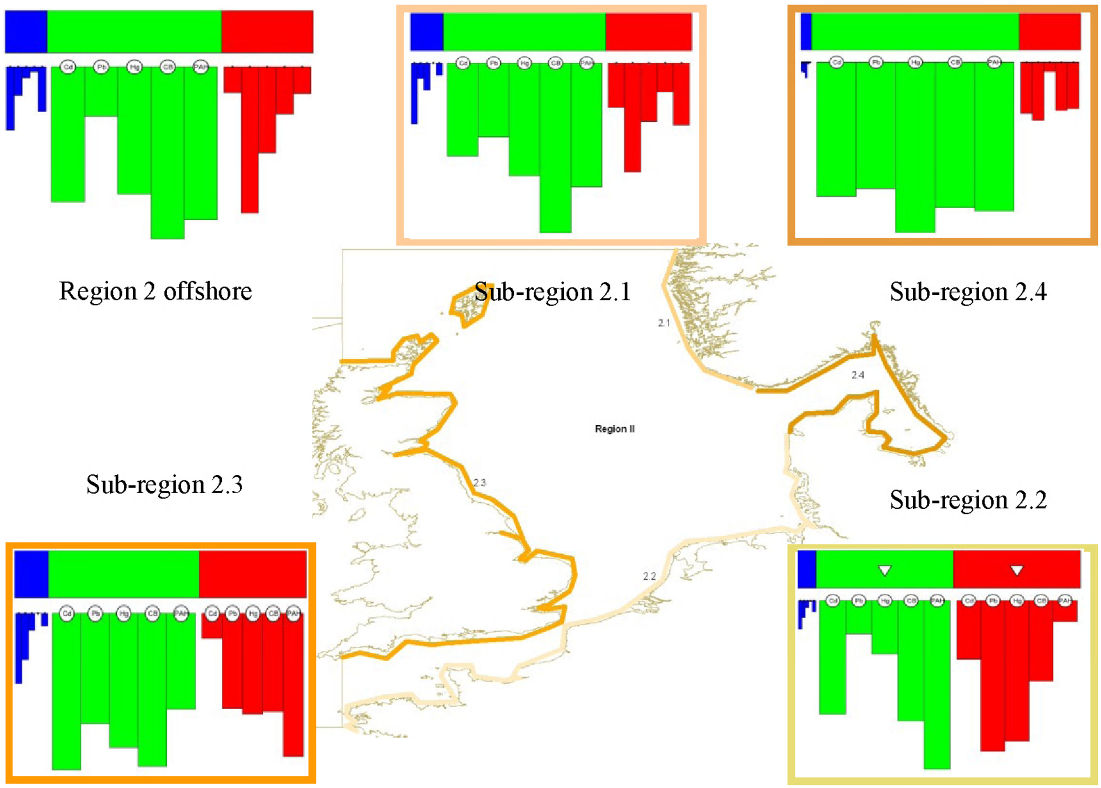

Figure 3. Display of data integration across sub-areas.

e) Step 5

The final step was to combine data across across sub-areas within Regions to obtain Region-scale assessments. This was done by averaging the sub-area assessments within each Region. The final presentation used in the draft QSR document (Fig. 4) allows comparisons to be made of environmental quality for each contaminant within a Region, and also individual contaminants across Regions.

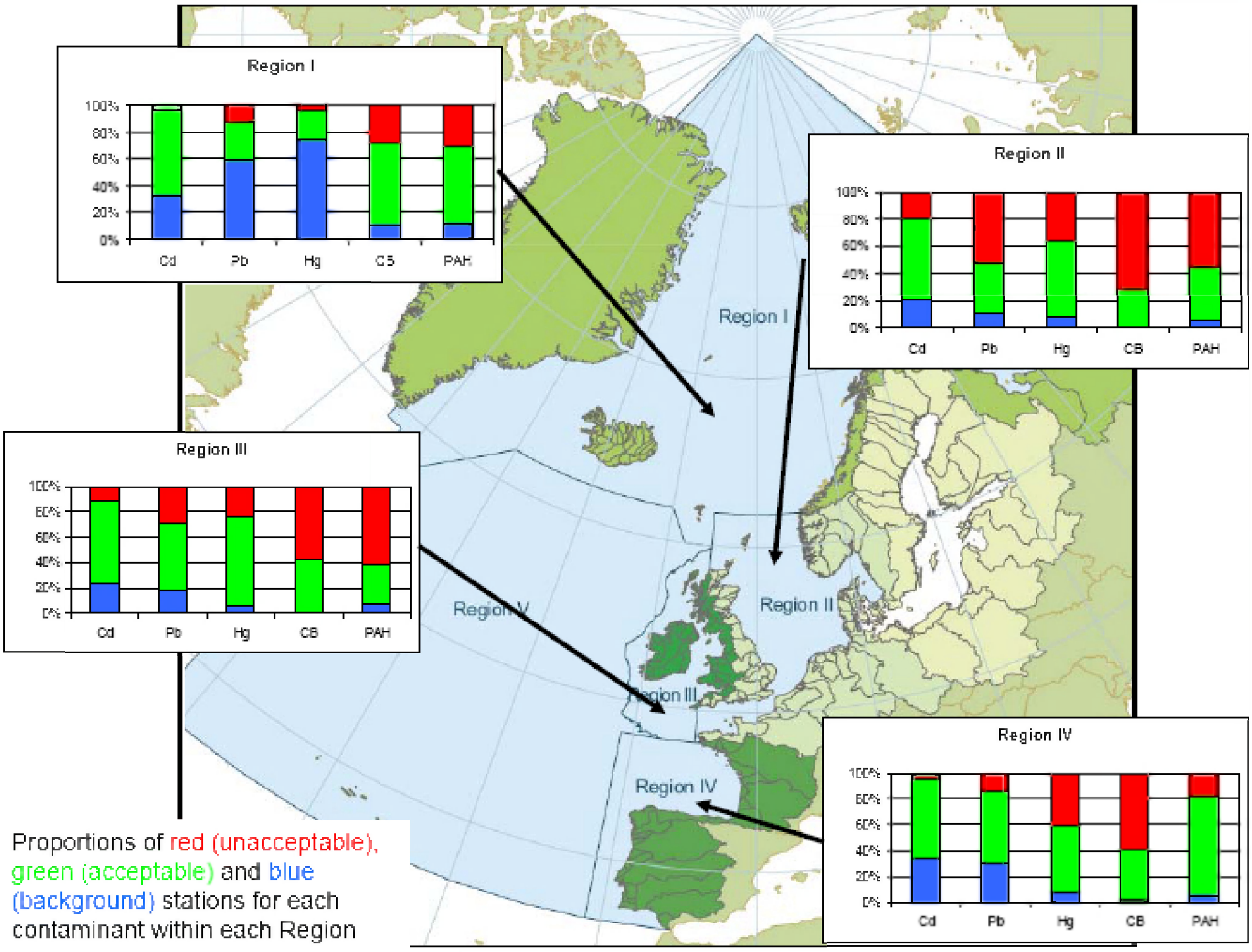

Figure 4. Integrated data presentation used in the draft OSPAR QSR 2010

It is important to recognise that the progressive integration or summarising of data is inevitably accompanied by a progressive loss of the detail present in the underlying data. The higher levels of integration allow an overview of the data to be made. The presentation in Figure DDD was suitable for the OSPAR in that it allowed rapid visual assessment of the degree to which OSPAR objectives had been met for each contaminant in each Region. Outputs from all the preceding levels of data integration are available in the supporting documents for the QSR, allowing the reasons for particular assessments to be explored, and effective targeting of potential control measures.

Inclusion of biological effects measurements in the presentation:

The availability of assessment criteria corresponding to background levels of response and also to levels of response that indicate pollution effects, or unacceptable levels of risk, opens the opportunity to adopt a similar approach to the assessment of biological effects data to that described above for contaminant concentrations. A simple presentation would be to include various effects measurements in the Regional histograms shown in Figure 4.

Assessment under OSPAR and view on possible application to GES assessment:

Considerable effort has been made during the preparation of the QSR 2010 to develop effective summaries and presentations of the large amount of chemical monitoring data available for the OSPAR Convention area. The bulk of the data are concerned with OSPAR priority contaminants, such as mercury, cadmium, lead, PCBs and PAHs, with lesser amounts for a wide range of other contaminants. Monitoring matrices are sediment, fish tissue (muscle and liver) and shellfish tissue (mainly mussels and oysters). As described before, data have been assessed against thresholds (EAC) and a colour coding (traffic light system) was applied.

In relation to MSFD GES, the green-red transition point may be considered to correspond to the boundary between achieving and not achieving GES. It is clear that conditions vary considerable within both OSPAR regions and assessment sub-areas. Generally, the data are not all red or all green/blue. It will therefore be necessary to consider whether it is necessary to develop environmental target levels, for example a maximum percentage of red assessments that would be consistent with GES. Alternatively, it may be more appropriate to present data as a two or three colour traffic light scheme to represent degrees of achievement of GES.

The assessment for the QSR involved the agreement of a full set of assessment criteria for these priority contaminants and monitoring matrices. A subsequent step was the development of procedures for integrating the results of comparisons with assessment criteria across stations and/or contaminants to derive numerical and graphical summarised presentations of the data for inclusion in the QSR and its feeder documents.

A core aspect of this integration was the achievement of a coherent classification system that categorized concentrations in a consistent way in relation to a consistent set of assessment criteria. The use of BACs and EACs for all data was essential to this process. The purpose of chemical and biological effects monitoring data collected for MSFD purposes is to contribute to the determination of whether assessment areas have achieved GES. Contaminant concentrations should be such that pollution effects do not occur, and biological effects measurements should indicate whether pollution effects are occurring.

Chemical concentrations and almost all biological effects measurements are continuous variables. Therefore some targets (standards or thresholds) are necessary to distinguish between a range of environmental situations:

a) situations where no significant difference form natural conditions is occurring,

b) situations where some difference is occurring, and where the difference is currently not sufficient to cause pollution effects, or some biological response can be measured but is not appropriate to be termed a pollution effect

c) situations where concentrations are sufficiently high that pollution effects might be expected, or biological effects data indicate that pollution effects are occurring.

Situations in Category c) would be considered to fail to reflect GES. Situations in Categories a) and b) would be considered to meet the requirements of GES. The threshold between categories b) and c) is therefore of primary importance to classification of areas against GES under MSFD.

The additional threshold between Categories a) and b) is not necessary for GES classification. However, the additional degree of discrimination that that threshold gives is likely to be of considerable value in interpreting the potential causative agents of pollution effects. The high level biological effects that most directly inform on the presence of pollution effects are generally much less contaminant specific than biological effects that can be termed biomarkers of exposure. They are likely to respond to a wide range of contaminants (and perhaps also other features if the environment). Information on those contaminants which show concentrations above natural background will be helpful in assessing the likelihood of mixtures of contaminants exerting combined effects, or indicate where chemical analysis has failed to detect a likely causative agent.

For a system of environmental target levels to be effective and allow reliable interpretation, it is important that the assessment criteria are derived using a consistent set underlying principles. A good example of this is the WFD TGD on the derivation of EQSs which ensures that risk to the environment is handled consistently across all contaminants. The EACs used in OSPAR to interpret chemical data are being developed in a manner that is consistent with the WFD EQSs. The upper assessment criteria for biological effects being developed by ICES/OSPAR are also designed to reflect a similar level of risk to organisms. The result is that monitoring data can be assessed using EQSs, EACs for sediment or biota, and upper assessment criteria for biological effects in an integrated way, using this set of assessment criteria.

Similarly, ICES/OSPAR have developed/adopted a standard definition of background concentrations and standard approaches to determining background concentrations of contaminants. This has been transferred to biological effects measurements to allow a consistent and integrated assessment of chemical and biological effects data against background.

Using background and EQS/EAC assessment criteria meets the needs for assessment against Descriptor 8 and also makes effective use of monitoring data in targeting actions/measures to bring about improvements in environmental quality where they may be necessary. For additional information on experience from the OSPAR CEMP assessment for QSR 2010 and comments on application to GES see Annex 10.

ANNEX 16. LIST OF DOCUMENTS IN THE ICES TIMES SERIES

Biological effects analysis methods

No.41 Sundelin, B., Eriksson Wiklund, A-K., and Ford, A. T. 2008. Biological effects of contaminants: the use of embryo aberrations in amphipod crustaceans for measuring effects of environmental stressors. 21 pp. DKK 70.00. View TIMES 41

No.40 Widdows, J. and Staff, F. 2006. Biological effects of contaminants: Measurement of scope for growth in mussels. 30 pp. DKK 60.00. View TIMES 40

No.39 Ariese, F., Beyer, J., Jonsson, G., Visa, C.P., Krahn, and M.M. 2005. Review of analytical methods for determining metabolites of polycyclic aromatic compounds (PACs) in fish bile. 41 pp. View TIMES 39

No.38 Feist, S.W., Lang, T., Stentiford, G.D., and Köhler,A. 2004. Biological effects of contaminants: Use of liver pathology of the European flatfish dab (*Limanda limanda* L.) and flounder (*Platichthys flesus* L.) for monitoring. 42pp. View TIMES 38

No.37 Oehlmann, J. 2004. Biological effects of contaminants: Use of intersex in the periwinkle (*Littorina littorea*) as a biomarker of tributyltin pollution. 22pp. View TIMES 37

No.36 Moore, M.N. and Lowe, D. 2004. Biological effects of contaminants: Measurement of Lysosomal membrane stability. 31pp. View TIMES 36

No.34 Hylland, K. 2004. Biological effects of contaminants: Quantification of d-aminolevulinic acid dehydratase (ALA-D) activity in fish blood. ICES Techniques in Marine Environmental Sciences. 9pp. View TIMES 34

No.31 Scott, A.P., and Hylland, K. 2002. Biological effects of contaminants: Radioimmunoassay (RIA) and enzyme-linked immunosorbent assay (ELISA) techniques for the measurement of marine fish vitellogenins. 21pp.

No.29 Thain, J., and Bifield, S. 2001. Biological effects of contaminants: Sediment bioassay using the polychaete Arenicola marina. 16 pp.
View TIMES 29

No.28 Thain, J., and Roddie, B. 2001. Biological effects of contaminants: Corophium sp. sediment bioassay and toxicity test. 21 pp.

No.26 Hylland, K. 1999. Biological effects of contaminants: Quantification of metallothionein (MT) in fish liver tissue. 18 pp. View TIMES 26

No.25 Reichert, W.L., French, B.L., and Stein, J.E. 1999. Biological effects of contaminants: Measurement of DNA adducts in fish by 32P-post-labelling. 45 pp. View TIMES 25

No.24 Gibbs, P.E. 1999. Biological effects of contaminants: Use of imposex in the dogwhelk, (*Nucella lapillus*) as a bioindicator of tributyltin (TBT) pollution. 29 pp. View TIMES 24

No.23 Stagg, R., and McIntosh, A. 1998. Biological effects of contaminants: Determination of CYP1A-dependent mono-oxygenase activity in dab by fluorimetric measurement of EROD activity. 16 pp. View TIMES 23

No.22 Bocquené, G., and Galgani, F. 1998. Biological effects of contaminants: Cholinesterase inhibition by organophosphate and carbamate compounds. 12 pp. View TIMES 22

No.19 Bucke, D., Vethaak, D., Lang, T., and Mellergaard, S. 1996. Common diseases and parasites of fish in the North Atlantic: training guide for identification. 27 pp. View TIMES 19

No.13 Galgani, F., and Payne, J.F. 1991. Biological effects of contaminants: microplate method for measurement of ethoxyresorufin-O-deethylase (EROD) in fish. 11 pp.
View TIMES 13

No.11 Thain, J.E. 1991. Biological effects of contaminants: oyster (*Crassostrea gigas*) embryo bioassay. 12 pp.
View TIMES 11

Chemical analysis methods

No.46 Webster, L., Tronczynski, J., Bersuder, P. Vorkamp, K., and Lepom, P. 2009. Determination of polybrominated diphenyl ethers (PBDEs) in sediment and biota. ICES Techniques in Marine Environmental Sciences No. 46. 16 pp. DKK 40.00. View TIMES 46

No.45 Webster, L., Tronczynski, J., Korytar, P., Booij, K., and Law, R. 2009. Determination of parent and alkylated polycyclic aromatic hydrocarbons (PAHs) in biota and sediment. ICES Techniques in Marine Environmental Sciences. No. 45. 26 pp. DKK 50.00. View TIMES 45

No.44 Webster, L., Bersuder, P., Tronczynski, J., Vorkamp, K., and Lepom, P. 2009. Determination of Hexabromocyclododecane (HBCD) in sediment and biota. ICES Techniques in Marine Environmental Sciences No. 44. 15 pp. DKK 40.00. View TIMES 44

No.30 Aminot, A. and Rey, F. 2001. Chlorophyll a: Determination by spectroscopic methods. 18 pp.

No.21 Smedes, F., and de Boer, J. 1998. Chlorobiphenyls in marine sediments: Guidelines for determination. 24 pp. View TIMES 21

No.12 Ehrhardt, M., Klungsøyr, J., and Law, R.J. 1991. Hydrocarbons: review of methods for analysis in sea water, biota, and sediments. 47 pp. View TIMES 12

No.10 Grøn, C. 1990. Organic halogens: determination in marine media of adsorbable, volaltile, or extractable compund totals. 19 pp. View TIMES 10

No.9 Loring, D.H., and Rantala, R.T.T. 1990. Sediments and suspended particulate matter: total and partial methods of digestion (*videotape available*). 14 pp. View TIMES 9

No.5 Richardson, K. 1987. Primary production: guidelines for measurement by 14C incorporation. 21 pp. View TIMES 5

No.4 Ehrhardt, M. 1987. Lipophilic organic material: an apparatus for extracting solids used for their concentration from sea water. 14 pp. View TIMES 4

No.3 Rantala, R.T.T., and Loring, D.H. 1987. Cadmium in marine sediments: determination by graphite furnace atomic absorption spectroscopy. 9 pp. View TIMES 3

No.2 Yeats, P.A. 1987. Trace metals in sea water: sampling and storage methods. 8 pp. View TIMES 2

No.1 Harms, U. 1987. Cadmium and lead: determination in organic matrices with electrothermal furnace atomic absorption spectrophotometry. 10 pp. View TIMES 1

Benthic faunal community analysis methods

No.43 Rumohr, H. 2009. Soft-bottom macrofauna: Collection, treatment, and quality assurance of samples. 24 pp. DKK 40.00
View TIMES 43

No.42 Rees, H. L. (ed). 2009. Guidelines for the study of the epibenthos of subtidal environments. 88 pp. DKK 70.00 View TIMES 42

No.27 Rumohr, H. 1999. Soft bottom macrofauna: Collection, treatment, and quality assurance of samples (Revision of No. 8). 19 pp. View TIMES 27

No.16 Rees, H.L., Heip, C., Vincx, M., and Parker, M.M. 1991. Benthic communities: use in monitoring point-source discharges. 70 pp. View TIMES 16

No.8 Rumohr, H. 1990. Soft bottom macrofauna: collection and treatment of samples. 18 pp. View TIMES 8

Quality assurance advice

No.35 Lysiak-Pastuszak, E. and Krysell, M.2004. Chemical measurements in the Baltic Sea: Guidelines on Quality assurance. 149pp. View TIMES 35

No.32 Rees, H. 2004. Biological monitoring: General guidelines for quality assurance. 45pp. View TIMES 32

No.6 Vijverberg, F.A.J.M., and Cofino, W.P. 1987. Control procedures: good laboratory practice and quality assurance. 33 pp. View TIMES 6

Sampling and statistics

No.20 Nicholson, M.D., Fryer, R.J., and Larsen, J.R. 1998. Temporal trend monitoring: Robust method for analysing contaminant trend monitoring data. 22 pp. View TIMES 20

No.18 Nicholson, M.D., and Fryer, R.J. 1996. Contaminants in marine organisms: pooling strategies for monitoring mean concentrations. 30 pp. View TIMES 18

No.15 Uthe, J.F., Misra, R.K., Chou, C.L., Scott, D.P., and Musial, C.J. 1991. Temporal trend monitoring: contaminant levels in tissues of Atlantic cod. 11 pp. View TIMES 15

No.14 Uthe, J.F., Chou, C.L., Misra, R.K., Yeates, P.A., Loring, D.H., Musial, C.J., and Cofino, W. 1991. Temporal trend monitoring: introduction to the study of contaminant levels in marine biota. 18 pp. View TIMES 14

No.7 Yeats, P.A., and Brügmann, L. 1990. Suspended particulate matter: collection methods for gravimetric and trace metal analysis. 9 pp. View TIMES 7

Further TIMES series documents are in preparation:

Biological Effects of Contaminants: Oyster (*Crassostrea gigas*) Embryo Bioassay by J. E. Thain

Statistical Methods for the Analysis of Fish Disease Data by W. Wosniok, T. Lang, A. D. Vethaak, S. des Clers, S. Mellergaard, S. W. Feist, A. H. McVicar, and V. Dethlefsen

The Protocol for Measuring Multi-Drug / Multi-Xenobiotic Resistance (MDR/MXR) in Blue Mussels by Calcein Am Efflux.

The Protocol for Extraction Methods for Bioassays.

The protocol for conducting EROD determinations in flatfish.

Histopathology of mussels Mytilus spp. for health assessment in biological effects monitoring' by S. W. Feist, J. Bignell, M. P. Cajaraville, I Marigomez, A. Villalba and D. Lowe.

Protocol for measuring dioxin-like and estrogenic activity in environmental samples using CALUX assays. Dick Vethaak

Protocols for measuring micronucleus formation in cells as an indicator of toxicant induced genetic damage. Brett Lyons

Protocol for measuring estrogen/androgen activity in environmental samples using YES/YAS yeast screen assays. J Thain, Kevin Thomas

The protocol for gonadal histology in flounder. S. Feist *et al.*

ANNEX 17. OSPAR GUIDELINES FOR MONITORING OF HAZARDOUS SUBSTANCES

JAMP Guidelines for Monitoring Contaminants in Biota (agreement 1999-2)

Technical Annex 1: Organic contaminants
Technical Annex 2: Metals
Technical Annex 3: PAHs in biological materials
Technical Annex 4: PBDEs in biota
Technical Annex 5: HBCD in biota
Technical annexes on monitoring of PFOS, TBT, alkylated PAHs, co-planar CBs and dioxins in biota are currently under development

JAMP Guidelines for Monitoring Contaminants in Sediments (agreement 2002-16)

Technical Annex 1: Statistical aspects of sediment monitoring
Technical Annex 2: Determination of chlorobiphenyls in sediments - analytical method
Technical Annex 3: Determination of PAHs in sediments *(under revision)*
Technical Annex 4: Determination of mono-, di- and tributyltin in sediments - Analytical methods
Technical Annex 5: Normalisation of contaminant concentrations in sediments
Technical Annex 6: Determination of metals in sediments
Technical Annex 7: Determination of PBDEs in sediment
Technical Annex 8: Determination of HBCD in sediment
Technical annexes on monitoring of PFOS, alkylated PAHs, co-planar CBs and dioxins in sediment are currently under development

Guidelines have also been agreed relating to the monitoring of the biological effects of contaminants. These are conceptually divided between contaminant-specific biological effects, and general biological effects, and indicated below:

Guidelines for monitoring the biological effects of hazardous substances

JAMP Guidelines for Contaminant-specific Biological Effects Monitoring (agreement 2008-9)

Technical Annex 1: Metal-specific biological effects monitoring
Metallothionein
δ-amino levulinic acid dehydratase inhibition in blood (ALA-D)
Oxidative stress
Technical Annex 2: PAH-specific biological effects monitoring
Cytochrome P4501A
Bulky DNA adducts
PAH metabolites
Liver pathology
Macroscopic liver neoplasms
Technical Annex 3: TBT-specific biological effects monitoring
Imposex
Intersex
Technical Annex 4: Oestrogen-specific biological monitoring
Bile estrogenicity
Vtg induction
Gonadal intersex

JAMP Guidelines for General Biological Effects Monitoring (agreement 1997-7)

Technical Annex 1: Whole sediment bioassays
Technical Annex 2: Sediment pore-water bioassays
Technical Annex 3: Sediment sea water elutriates
Technical Annex 4: Water bioassays
Technical Annex 5: CYP1A9

Technical Annex 6: Lysosomal stability
Technical Annex 7: Liver histopathology
Technical Annex 8: Macroscopic liver neoplasms
Technical Annex 9: Externally visible fish diseases
Technical Annex 10: Reproductive success in fish

JAMP Guidelines for the Integrated Monitoring and Assessment of Contaminants and their effects (in preparation)

A large number of Background Documents have been prepared on compounds that showed some potential for inclusion in the CEMP. These provide useful preliminary assessments of risk to the environment, and of the availability of monitoring and analytical methods

Background documents

Background document on Octylphenol, 2006, No. 273,1-905859-00-7
Background document on 4-(dimethylbutylamino)diphenylamine (6PPD), 2006,No. 271, 1-905859-05-8
Background document on Phthalates, 2006, No. 270, 1-905859-04-X
Background document on Perfluorooctane Sulphonate (PFOS), 2006, No. 269, 1-905859-03-1
Background document on clotrimazole (2005 Update), 2005, No. 199, 1-904426-38-7
Background document on Hexachlorocyclopentadiene (HCCP) (update 2005), 2004 No. 204, 1-904426-40-9
Background document on trifluralin (2005 Update), 2004, No. 203, 1-904426-37-9
Background document on tetrabromobisphenol-A (TBBPA) (2005 Update), 2004, No. 202, 1-904426-39-5
Background document on Hexamethyldisiloxane (HMDS), 2004, No. 201, 1-904426-41-7
Background document on musk xylene and other musks, 2004, No. 200, 1-904426-36-0
Background document on 2,4,6–tri-tert-butylphenol (update 2006), 2003, No. 274, 1-905859-01-5
OSPAR background document on 4-tert-butyltoluene (2005 Update), 2003, No. 172, 1-904426-17-4
OSPAR background document on trichlorobenzenes (2005 Update), 2003, No. 170, 1-904426-10-7
OSPAR background document on triphenylphosphine (2005 Update), 2003, No. 169, 1-904426-18-2
OSPAR Background Document on Lindane (2004 update), 2002, No. 153, 0 94695694 4
Background document on cadmium (2004 update), 2002, No. 151, 0 946956 93 6,English
OSPAR Background Document on Dicofol (update 2004), 2002, No. 150, 0 946956 97 9
OSPAR Background Document on Endosulphan (update 2004), 2002, No. 149, 0 946956 98 7
OSPAR Background Document on Lead including (1) OSPAR Background document on possibilities of reducing lead in paints (published 2003), and (2) OSPAR Background document on possibilities of reducing lead in PVC (published 2003) (update 2004), 2002, No. 148, 1-904426-00-X
OSPAR Background Document on Methoxychlor (update 2004), 2002, No. 147, 0 946956 99 5
OSPAR Background Document on Short Chain Chlorinated Paraffins (update 2004), 2001 No. 141, 0 946956 77 4
OSPAR Background Document on Pentachlorophenol, Update 2004, 2001, No. 138, 0 946956 74 X
OSPAR Background Document on Polycyclic Aromatic Hydrocarbons (PAHs), update 2004, 2001, No. 137, 0 946956 73 1
OSPAR Background Document on Nonylphenol/Nonylphenolethoxylates, update 2004, 2001 No. 136, 0 946956 79 0
OSPAR Background Document on Certain Brominated Flame Retardants – Polybrominated Diphenylethers, Polybrominated Biphenyls, Hexabromo Cyclododecane, 2004 Update, 2001 No. 135, 0 946956 70 7
OSPAR Background Document on Polychlorinated Biphenyls (PCBs), 2004 Update, 2001 No. 134, 0 946956 78 2
OSPAR Background Document on Organic Tin Compounds (update 2004), 2000, No. 103,0 946956 56 1
OSPAR Background Document on Mercury and Organic Mercury Compounds First published 2000, Updated in 2004, 2000, No. 100,0 946956 54 5

The interpretation of monitoring data has involved the assessment of the significance of any temporal trends in the field data, and the comparison of the data with assessment criteria reflecting the objectives of the OSPAR Hazardous Substances Strategy and the JAMP, that concentrations of contaminants should be close to background, and that no unintended or unacceptable biological effects of contaminants are occurring. The details of the processes involved in data assessment are described in the CEMP Assessment Manual: Co-ordinated Environmental Monitoring Programme Assessment Manual for contaminants in sediment and biota (OSPAR Commission, 2008, SBN 978-1-906840-20-4 Publication Number No. 379/2008). This document contains information relating to:

1. Introduction
2. Selection of bases for expressing concentrations
2.1 Introduction
2.2 Conversions of bases for field data
2.3 Conversion of assessment criteria to preferred bases
3. Methods used for the determination of Background Concentrations
3.1 Introduction
3.2 Background concentrations of contaminants in sediment
3.3 Background concentrations of lead in sediment
3.4 Background concentrations for PAHs in sediments
3.5 Background concentrations of contaminants in biota
4. Application of Background Concentrations i.e. the derivation and use of Background Assessment Concentrations (BACs)
4.1 Introduction
4.2 Testing whether concentrations are near background or close to zero
4.3 Setting Background Assessment Concentrations
4.4 Technical method for deriving of BACs
5. Methods for normalisation of contaminant concentrations in sediments
5.1 Introduction
5.2 Normalisation and required parameters
6. Trend analysis
6.1 Statistical analyses prior to trend analysis
6.2 Uncertainty in biota analysis
6.3 Uncertainties in sediment analysis
7. Method used for trend analysis of time series
8. Presentation of temporal trend assessments
9. Power of temporal trend programmes to detect changes in concentrations of
Contaminants

OSPAR has also prepared guidline documents on the Comprehensive Atmospheric Monitoring Programme (CAMP), Riverine Inputs and Direct Discharges (RID), and on the monitoring of nutrients and eutrophication effects. These are available on the OSPAr website (www.ospar.org).

ANNEX 18. SUMMARY OF THE SCOPE OF THE QUASIMEME PTS

Matrix	Compound group	Individual substances
Biota matrices (shellfish, fish muscle and fish liver)		
	Trace metals	As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn, Ash weight, Dry weight, Total lipid, Extractable lipid
	PCBs	(CBs 28, 31, 52, 101, 105, 118, 138+163, 153, 156, 180
	Organochlorine pesticides	*p,p'*-DDD, *p,p'*-DDE, *o,p'*-DDT, *p,p'*-DDT, Dieldrin, HCB, HCBD, α-, β-, γ- and □-HCH, Transnonachlor and total and extractable lipids)
	Dioxins and non-ortho PCBs	All seventeen 2,3,7,8-substituted PCDDs and PCDFs and CBs 77, 126 and 169)
	PAHs	Acenaphthene, Acenaphthylene, Anthracene, Benz[*a*]anthracene, Benzo[*a*]fluorene, Benzo[*a*]pyrene, Benzo[*b*]fluoranthene, Benzo[*e*]pyrene, Benzo[*ghi*]perylene, Benzo[*k*]fluoranthene, Chrysene, Dibenz[*a,h*]anthracene, Dibenzo[*a,i*]pyrene, Dibenzothiophene, 3,6 Dimethylphenanthrene, Fluoranthene, Fluorene, Indeno[1,2,3 *cd*]pyrene, 2 Methylphenanthrene, 1 Methylpyrene, Naphthalene, Perylene, Phenanthrene, Pyrene, Triphenylene, total and extractable lipids
	Organotins	Tributyltin, Dibutyltin, Monobutyltin, Triphenyltin, Diphenyltin and Monophenyltin
	Brominated flame retardants	BDEs 28, 47, 66, 85, 99, 100, 153, 154, 183, 209, TBBP-A, dimethyl-TBBP-A, total HBCD and α-, β- and γ-HBCD isomers
	Shellfish toxins	Amnesic shellfish poisoning toxins – domoic and epidomoic acid
	chlorobornanes / toxaphene	CHBs 26, 32, 40, 41, 44, 50, 62, total toxaphene, total and extractable lipids)
Sediment matrices:		

Matrix	Compound group	Individual substances
	Trace metals	Al, As, Cd, Cr, Cu, Fe, Hg, Li, Mn, Ni, Pb, Sc, Zn, TOC and Inorganic carbonate
	PCBs	CBs 28, 31, 52, 101, 105, 118, 138+163, 153, 156, 180
	Organochlorine pesticides	*P,p'*-DDD, *p,p'*-DDE, *o,p'*-DDT, *p,p'*-DDT, Dieldrin, HCB, HCBD, α-, β- , γ- and [illegible]HCH, Transnonachlor and TOC)
	PAHs	Acenaphthene, Acenaphthylene, Anthracene, Benz[*a*]anthracene, Benzo[*a*]fluorene, Benzo[*a*]pyrene, Benzo[*b*]fluoranthene, Benzo[*e*]pyrene, Benzo[*ghi*]perylene, Benzo[*k*]fluoranthene, Chrysene, Dibenz[*a,h*]anthracene, Dibenzo[*a,i*]pyrene, Dibenzothiophene, 3,6 Dimethylphenanthrene, Fluoranthene, Fluorene, Indeno[1,2,3 - *cd*]pyrene, 2 Methylphenanthrene, 1 Methylpyrene, Naphthalene, Perylene, Phenanthrene, Pyrene, Triphenylene, TOC
	Organotins	Tributyltin, Dibutyltin, Monobutyltin, Triphenyltin, Diphenyltin and Monophenyltin
	Brominated flame retardants	BDEs 28, 47, 66, 85, 99, 100, 153, 154, 183, 209, TBBP-A, dimethyl-TBBP-A, total HBCD and α-, β- and γ-HBCD isomers
Seawater, estuarine and low salinity open water:		
	Nutrients	Ammonia, TOxN, Nitrite, Phosphate, Silicate, Total N and Total P
	Trace metals	Ag, As, B, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Ni, Sn, V and Zn
	Chlorophyll	Chlorophyll a, b and c and pheopigments
	Pentachlorophenol	Pentachlorophenol
	Halogenated organics	Aldrin, pp'-DDD, pp'-DDE, op'-DDT, pp'-DDT, Dieldrin, Endosulphan I and II, Endrin, HCB, HCBD, [illegible]-, [illegible]-, [illegible]- and [illegible]-HCH, Isodrin, Pentabromodiphenylether, Pentachlorobenzene, 1,2,3-, 1,3,5- and 1,2,4-TCB and Trifluralin

Matrix	Compound group	Individual substances
	Volatile organic compounds	Benzene, Carbon tetrachloride, Chloroform, 1,2-dichloroethane, Dichloromethane, Trichloroethene, 1,1,1- and 1,1,2-trichloroethane, Tetrachloroethene, Trichloromethane
	Organophosphorus pesticides and triazine herbicides	Alachlor, Atrazine, Azinphos ethyl, Azinphos methyl, Chlorfenvinphos, Chlorpyriphos, Coumaphos, Demeton, Diazinon, Dichlorvos, Dimethoate, Diuron, Fenchlorphos, Fenitrothion, Fenthion, Irgarol 1051, Isoproturon, Malathion, Omethoate, Parathion ethyl, Parathion methyl, Simazine, Triazophos
	Organotins	Tributyltin, Dibutyltin, Monobutyltin, Triphenyltin, Diphenyltin and Monophenyltin
	PAHs	Acenapthene, Acenaphtylene, Anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Fluoranthene, Indeno(1,2,3-cd)pyrene, Phenanthrene, Naphtalene

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Abstract

The Marine Strategy Framework Directive (2008/56/EC) (MSFD) requires that the European Commission (by 15 July 2010) should lay down criteria and methodological standards to allow consistency in approach in evaluating the extent to which Good Environmental Status (GES) is being achieved. ICES and JRC were contracted to provide scientific support for the Commission in meeting this obligation.

A total of 10 reports have been prepared relating to the descriptors of GES listed in Annex I of the Directive. Eight reports have been prepared by groups of independent experts coordinated by JRC and ICES in response to this contract. In addition, reports for two descriptors (Contaminants in fish and other seafood and Marine Litter) were written by expert groups coordinated by DG SANCO and IFREMER respectively.

A Task Group was established for each of the qualitative Descriptors. Each Task Group consisted of selected experts providing experience related to the four marine regions (the Baltic Sea, the North-east Atlantic, the Mediterranean Sea and the Black Sea) and an appropriate scope of relevant scientific expertise. Observers from the Regional Seas Conventions were also invited to each Task Group to help ensure the inclusion of relevant work by those Conventions. This is the report of Task Group 8 Contaminants and pollution effects.

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