MARINE CHEMISTRY WORKING GROUP (MCWG; outcomes from 2021 meeting)

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Contents

i Executive summary

The Marine Chemistry Working Group (MCWG) concentrates its work around the status and fate of pollutants (organic substances and trace metals) in marine ecosystems and chemical oceanography (nutrients and ocean acidification). The remit of the group includes analytical challenges encountered in determining, evaluating and reporting chemicals in marine compartments from sample preparation to the final result, as well as crucial steps to achieve satisfactory Quality Assurance.

Contaminants of emerging concern (CECs) are highlighted as a major topic in this report, in terms of their identification, the collection of information on their presence, concentrations in marine compartments across the ICES area, their ecotoxicological potential, and the exchange of information on how to monitor these compounds. The occurrence of microplastics in sediments, current limitations with collection methods and the potential for these to act as vectors for pollutants was reviewed.

During this reporting period, particular attention was given to human activities at sea (e.g. offshore windfarms, shipping, fishing) as a source of chemical pollution and the rapidly evolving regulations associated with these activities in order to anticipate their impact. MCWG also undertook a comprehensive review of national assessments completed prior to disposal of dredge materials at sea, including the comparison of regulated substances and thresholds used in the management of dredging activities, as well as monitoring approaches at disposal sites.

MCWG was interested in discussing advances and application in passive sampling techniques, particularly with regards to compliance monitoring, and continues updating on developments on passive sampling by informing on on-going projects from ICES area.

MCWG reviewed techniques for the analysis of discrete water samples for nutrient analysis and outcomes are presented. Quality Assurance of Information on Marine Environmental Monitoring (QUASIMEME) assessments of chlorophyll data in relation to analytical methods was analysed, which provided the rationale for an update of the existing ICES Techniques in Marine Environmental Science (TIMES) 30 guidelines on chlorophyll determination.

A spreadsheet-based database on the occurrence of CECs in European waters corresponding to selected contaminant families was developed and is being maintained. New ICES TIMES Guidelines for the use of Diffusive Gradients in Thin Films for measuring metal fluxes in sediment were published, and MCWG members also contributed to an ICES Viewpoint with the Working Group on Shipping Impacts in the Marine Environment (WGSHIP) on scrubber discharge water from ships considering risks to the marine environment and recommendations to reduce impacts.

Further publication are being finalised, notably an update of the TIMES 30 guideline on Chlorophyll determination, the review on national and regional legislation for contaminants in seafood. The review of data on CECs will also be developed into a publication.

ii Expert group information

Expert group name	Marine Chemistry Working Group and Working Group on Marine Sediments in Relation to Pollution (MCWG and WGMS)
Expert group cycle	Multiannual
Year cycle started	2018 (WGMS) and 2019 (MCWG)
Reporting year in cycle	3/3
Chair(s)	Koen Parmentier, Belgium
	Maria Jesus Belzunce Segarra, Spain
	Claire Mason, United Kingdom
Meeting venue(s) and dates	5–9 March 2018, San Pedro del Pinatar, Murcia, Spain, 12 participants (WGMS)
	4–8 March 2019, Evora, Portugal, 26 participants (WGMS and MCWG)
	2–6 March 2020, Lisbon, Portugal, 24 participants (WGMS and MCWG)
	1–5 March & 15–19 March 2021, online, 50 participants (WGMS and MCWG)

1 Introduction

The Marine Chemistry Working Group (MCWG) concentrates its work around the status and fate of pollutants (organic substances and trace metals) in marine ecosystems and chemical oceanography (nutrients and ocean acidification). The Working Group on Marine Sediments in Relation to Pollution (WGMS) has held joint meetings with MCWG since 2019 and will merge together as of 2022.

MCWG looks at emerging substances of concern for the marine environment, passive sampling techniques, and chemical aspects of ocean acidification. A significant part of its effort is linked to ICES advisory process, which includes answering to requests from regional sea conventions and providing technical advice in support of the EU Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD). The group has developed numerous guidelines for monitoring and assessment tools in support of harmonized monitoring under OSPAR's Joint Assessment and Monitoring Programme. More recently, the group has been active in the field of application of passive sampling devices in the marine environment.

During its early years MCWG played a key role in improving the quality and comparability of chemical substance measurements in the marine environment through intercalibration exercises and development of monitoring protocols for OSPAR and HELCOM. These intercalibrations were the genesis of the QUASIMEME (Quality Assurance of Information on Marine Environmental Monitoring) programme, which now supports global marine environmental monitoring activities. WGMS has played a key role in the advancement of sediment related science and has provided advice on normalization of contaminant data from sediments, sediment dynamics, and sediment quality guidelines.

The group works closely with many other expert groups such as: Working Group on Biological Effects of Contaminants (WGBEC), Working Group on Marine Litter (WGML), Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL), Working Group on Shipping Impacts in the Marine Environment (WGSHIP), Working Group on Phytoplankton and Microbial Ecology (WGPME), Ocean Acidification (SGOA), Working Group on Crangon Fisheries and Life History (WGCRAN) as well as the ICES Data Centre.

2 Contaminants of emerging concern (CECs)

2.1 Introduction

Contaminants of emerging concern (CECs) are substances that have been detected in the environment, but which are currently not included in routine monitoring programmes and whose fate, behaviour and ecotoxicological effects are not well understood (as defined by the Network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances (NORMAN), https://www.norman-network.net). In order to identify the potential risk of contaminants in the marine environment, the characterization of the main sources/inputs and the study of occurrence and distribution in the marine environment are necessary. Regarding the sources, both land and sea-based sources can be considered. Some of the land sources can be domestic and industrial Waste Water Treatment Plant (WWTP) effluents, river discharges, air deposition, etc. In the case of sea-based sources, a review has been published (Tornero and Hanke, 2016) which list 276 substances from different sea-based sources such as shipping, mariculture, offshore activities, dredging, etc. There are many potential sources of contaminants which can help to identify their origin and potential distribution: urban development, touristic activities, industry and transport, intensive agriculture, navigation and nautical activities, mining and other activities.

In the last decades, many studies have been developed to characterize the occurrence and distribution of different groups of contaminants of emerging concern, covering seawater, sediment and biota. Sediments can play an important role because they are a sink of many of these contaminants and consequently a potential source for marine organisms. It is also necessary to take into account that pressures and impacts are not continuous for many contaminants because of significant seasonal changes, as for example in coastal areas for Current Use Pesticides (CUPs), pharmaceuticals etc. (i.e.: sources, temperature and sunlight variations), and the heterogeneous distribution of sources in coastal areas (sources distance, hydrodynamic currents, dilution capacity, suspended solids sedimentation, etc.); (Munaron *et al.*, 2012; Gaw *et al.*, 2014 and references therein; Moreno-González *et al.*, 2015; Pintado-Herrera *et al.*, 2017). Thus less information is available from continental shelf and deep sea areas (Azaroff *et al.*, 2020; León *et al.*, 2020). Although some CECs can be present in sediments from many areas, specific contaminants in every subregion should probably be considered depending on predominant anthropogenic activities.

Thousands of substances enter the environment but only few of them are included in monitoring programs, and many of these substances are known to accumulate in sediments and biota, with some of them provoking adverse effects on the marine environment. The information gathered in this ToR is therefore crucial in order to improve the assessment of the marine environment for Marine Strategy Framework Directive, Regional Conventions, and for national requirements.

2.2 Project studies

The characterisation and occurrence of CECs in marine compartments is a dynamic and growing field of work, which is key in understanding the fate and transport of these compounds but also their ecotoxicological impacts. Project studies undertaken by various member countries were presented and discussed during this reporting cycle. Examples of such studies are presented below.

2.2.1 Contaminants of emerging concern in sediments from the Spanish continental shelf.

Víctor M. León, Estefania Concha-Graña, Juan A. Campillo, Victoria Besada and Soledad Muniategui-Lorenzo (Centro Oceanográfico de Murcia, ES)

The occurrence and distribution of personal care products (PCPs: synthetic musks, UV filters and antimicrobial agents) and CUPs (organophosphorus, triazines, etc.) were characterized in surface sediments from 12 areas along the Spanish Mediterranean continental shelf through the IMPACTA project (CTM2013-48194-C3). The distribution of CUPs and PCPs was heterogeneous and depended on the predominant activities in each coastal area (industrial, touristic, agricultural, etc.) and other factors, such as the distance to main pollutant sources, the hydrodynamic currents, the dilution from sources, the suspended solids deposition rates, etc. Only 20 of 49 considered contaminants were found in some of the sediment samples. PCPs were found at the highest concentrations in nine of the studied areas and triazines were the most abundant ones in three areas. Considering individual compounds, the synthetic musks (tonalide and musk ketone), the plastic additive tributylphosphate and the insecticide chlorpyrifos were found in all studied Mediterranean continental shelf sediments. However, other compounds were found only in some areas at high concentrations (i.e.: triclosan, galaxolide) showing the influence of specific human activities in these cases. Then, the influence of recreational, urban development and agriculture activities has been evidenced along the Spanish Mediterranean continental shelf, but further studies will be required in order to assess the bioavailability and the potential impact of the contaminants found in sediments on marine organisms. The results obtained in this study were published in 2020 (León *et al.*, 2020).

2.2.2 Technology Critical Elements (TCEs)

Juan Santos Echeandía, Antonio Cobelo García, Clara Almécija Pereda, Patricia Neira del Río (Centro Oceanográfico de Murcia, ES)

Technology critical element concentrations (Ga, Ge, In, Nb, Ta, Te, Tl, the platinum group elements (Ir, Os, Pd, Pt, Rh and Ru), and most of the rare earth elements (REEs: Ce, Dy, Er, Eu, Gd, Ho, La, Lu, Nd, Pr, Sm, Tb, Y and Yb)) are increasing in the environment during the last years as seen both in biota and sedimentary compartments. The analyses carried out in mussel tissues from the IEO (Instituto Español de Oceanografía) pollution monitoring program showed an increase trend of Pt concentrations after 1995. In contrast, this study showed concomitant decreased levels of Pb concentrations. These trends are related with the use of Pt in the catalytic converters of the cars. Therefore these results pointed out that more attention should be paid in the next years in order to check if TCE levels continue to increase and can pose an ecological risk for the environment. However, TCEs are currently not regulated under different Directives but may need to be considered in the future.

2.2.3 Presence of asbestos in sediments

Claire Mason (CEFAS, England)

The presence of asbestos in sediments was considered as another form of pollution in sediments. While this is naturally occurring and of low risk to the environment, it is an important consideration when marine sediments are dried, for example, in laboratory analyses.

Low levels of asbestos have been found in ~20% of marine sediments tested, mainly from ports and harbours, in England and Wales. The main risk of asbestos exposure is when samples are dry, and the asbestos fibres can become airborne. EU regulations (Directive 2009/148/EC) impose a Control Limit for airborne asbestos, but there are no safe levels of asbestos, and so although levels are low (<0.1% hazardous waste limit), awareness of this potential risk is important, particularly in relation to laboratory processes where samples are dried. This was confirmed by a study undertaken by QUASIMEME, most of their samples were very low in asbestos, but based upon results, they banned several harbour areas for sampling. Especially their own staff, processing the samples, was in risk of exposure. They enhanced personal protection equipment for themselves and advised everybody working with samples always to be careful and treat them as potentially dangerous.

Individual laboratories are encouraged to risk assess laboratory procedures in relation to presence of low levels of asbestos in samples and train staff as required.

2.2.4 Arctic Monitoring and Assessment Programme (AMAP)

Kine Baek (NIVA, Norway)

A recent report from the Arctic Monitoring and Assessment Programme (AMAP)[1], identified 25 compounds with physiochemical properties that raised concerns with respect to Arctic environments. These compounds, and an additional set of PFAS (perfluoroalkyl substances), CUPs, UV-filters, bisphenols, chlorinated paraffins, and dechloranes, were included in a part of the Norwegian screening program of 2012. The samples included air samples from an Arctic station, Arctic species of different trophic levels, and a few hot-spot samples to elucidate emission levels (wastewater effluent, marine plastic and urban air)[2]. Of the 25 selected AMAP compounds, five volatile fluoroorganic and related compounds were detected in Arctic air for the first time. A new siloxane compound was found in urban air. Seven of the eight selected UV-filters were found in both Arctic and urban biota samples. Dacthal was the only compound of the 6 selected currently used pesticides detected in Arctic air samples from the Zeppelin Mountain. Dechloranes and chlorinated paraffins were detected in all samples of Arctic biota.

The focus of the presentation was on the results of UV filters and dechloranes and the results were compared with some results from the Norwegian monitoring program for an Urban fjord[3]. Also, some preliminary results from the screening program for 2018, was presented. This was mainly the results for UV filters, including a new compound, homosalate (not published yet).

2.2.5 Contamination levels of selected CECs in shellfish from the French coast

Catherine Munschy (ILFREMER, FR)

Since 2010, the levels and profiles of contamination of the coastal marine environment by persistent and bioaccumulative organic contaminants of emerging concern using sentinel organisms used as integrator species of contamination, namely mussels and oysters, were determined. The geographical distribution of the contamination has been studied yearly on 20 sites distributed along the three mainland coastlines (English Channel, Atlantic and Mediterranean).

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[1] https://www.amap.no/documents/doc/amap-assessment-2016-chemicals-of-emerging-arctic-concern/1624

[2] https://www.miljodirektoratet.no/publikasjoner/2018/oktober-2018/screening-programme-2017---amap-assessment-compounds/

[3] https://www.miljodirektoratet.no/publikasjoner/2019/januar-2019/environmental-contaminants-in-an-urban-fjord-2017/

The general objectives of the project are to acquire new knowledge on the state of the contamination of the metropolitan coastal marine environment by contaminants for which there is little data. The data obtained will also make it possible, in the long term, to record this knowledge over time and to evaluate the temporal evolution of the contamination.

The specific objectives of this action are mainly to:

- Determine the levels and profiles of contamination of the coastal environment by organic contaminants of emerging interest (BFRs including alternative ones, PFASs, synthetic musks, OPEs) using intertidal marine molluscs;
- Determine the geographical distribution of contamination on the coast of Metropolitan France;
- Provide recurrent data for the purpose of monitoring contamination over time;
- Evaluate the levels of contamination on the French coast in relation to European levels.

The results have been published in various scientific papers (Aminot *et al.* 2021; Munschy *et al.* 2013; Munschy *et al.* 2015; Munschy *et al.* 2019).

2.3 Future plans

An ICES MCWG review of the recently available data (i.e., 2010 onward) in relation to the occurrence and distribution of CECs in the European marine environment is being made in collaboration with 17 researchers from European countries. The available information about the occurrence of CECs in seawater, sediment, biota and air is being included in a dedicated Microsoft® Excel® spreadsheet, in order to get the most exhaustive overview of available data on CECs occurrence in ICES area and to identify knowledge gaps. Currently, data were received from 11 countries and most of them relate to PFASs and Pharmaceuticals. Other chemical contaminant families such as OPEs (Organic Phosphate Esters), alternative BFRs, CUPs and REEs are also reported. Further work is required to get a homogeneous format, correct errors and to get additional data of CECs through bibliographic literature searches, focussing on PFASs, OPEs, a-BFRS, Dechloranes, Pharmaceuticals, CUPs and PCPs, published after 2010. Catherine Munschy and Víctor M. León will continue organizing the work for completion of this task with the final aim to produce a review article in 2022. The main goal of this task is the identification of CECs occurrence data (for example, geographical distribution and concentrations) in order to give an overview of what is available and highlight gaps in our current knowledge.

Future work will be focused on assembling and the synthesis of new information on chemical substances of emerging concern in ICES area and beyond, including microplastics (additives for plastics) and the platinum group of metals:

i. CECs Publication based on information gathered in previous term.
ii. Evaluate and complete risk assessment of CECs using tox data – WGBEC
iii. Link with EQSs being developed
iv. Working with ICES data centre to progress CECs in appropriate databases and determining best way of achieving accessibility of data going forward
v. Collect information on how best to interpret data from suspect and non-targeted screening of CECs for monitoring purposes.

3 Passive sampling

3.1 Introduction

Since the publication of the Water Framework Directive (WFD; Directive 2000/60/EC) and the Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC) that regulate the protection of the aquatic systems and the marine environment, establishing a list of priority substances that are mandatory to determine the Chemical Status of a water body, the need for emerging tools to overcome the limitations of the traditional monitoring has been more evident.

Currently, the chemical status of water bodies is assessed based on the collection of water samples (spot sampling), the pre-treatment of the samples in the laboratory (e.g. filtration, preconcentration) and the determination of the chemical concentrations. However, this methodology presents several drawbacks such as the potential contamination of the samples , including preparation of passive sampling samples, as well as during at the different steps of the analysis process, the low temporal representativeness (especially in highly dynamic systems), the analytical limitations due to the low concentration of some chemicals (sometimes below the detection limit of the analytical techniques) and the low ecotoxicological relevance of the obtained results.

Passive sampling devices (PS) were proposed as alternative method to overcome the limitations of the spot sampling. PS improves limits of quantification (LOQ) by accumulating and pre-concentrating contaminants over long-term exposure. Moreover, when used in the integrative phase of uptake (i.e. integrative samplers), time-weighted average (TWA) concentrations over the expo-sure period can be derived, leading to a better representativeness of measurements (Miège *et al.* 2015), and PS measurements allow to perform in situ speciation analysis that are relevant for ecotoxicological and bioavailability assessments (link with biological effects).

Closer links between chemical and biological effect monitoring into an integrated approach might support data interpretation and provide better assessment of the marine environment.

In particular, MCWG draws attention to the use of passive samplers for measuring the bio-available fraction of organic contaminants in sediments. The group believes this is a promising technique for linking sediments contamination to biological effects.

Lately, the interest on passive samplers was focussed on searching their applicability in compliance monitoring under the WFD. In this respect, the need to develop Environmental Quality Standards (EQS) for the contaminant concentration obtained by means of passive samplers was discussed in the last years. These EQS must have at least the same level of protection as the EQS defined in the WFD. An approach was proposed to work together with NORMAN and this work was presented at the NORMAN Workshop in June 2021.

Moreover, there is currently a large body of research indicating that Diffusive Gradients in Thin films (DGT) is a promising technique for the monitoring of metal contamination (e.g. Monitool project, in section 3.2).

Resolutions for ICES publications were approved at the 2017 Annual Science Conference. Good progress was made towards the completion of a Techniques in Marine Environmental Science (TIMES) paper on passive sampling of metals in sediments and a second paper on hydrophobic contaminants. The passive sampling guidelines for metals TIMES paper was finished intersessionally and published in December 2019 (Amato *et al.* 2019).

Furthermore, resolution for a Cooperative Research Report (CRR) on passive sampling for sediments was approved at the 2017 Annual Science Conference. Good progress was made towards the completion of a paper on the use of passive samplers for metals and some work still needs to be done for organics. This implies changes in the initial content of the CRR paper (possibly to split in two CRR papers review) and the need to ask for a new resolution for CRR paper.

The WG continues reviewing and updating on developments on passive sampling by presenting and informing on ongoing projects (section 3.2).

3.2 Project studies

3.2.1 MONITOOL

Maria J Belzunce Segarra (AZTI, ES)

MONITOOL is a European project consisting of 16 Partners covering the Atlantic region from the Canary Islands to the Scottish Highlands and Islands, which aims to respond to European Directive demands for the assessment of the chemical status of transitional and coastal waters. Diffusive Gradient in Thin Films (DGT), and passive samplers (PS), in general, are already widely used in investigative monitoring and there is an increasing interest in their use for the environmental assessment of water bodies, within European policies requirements. The main barrier hindering the regulatory acceptance of PS for compliance checking is the lack of appropriate Environmental Quality Standards (EQS). EQSs for metals are defined in the dissolved fraction, preventing the use of DGT-labile concentrations for the establishment of the chemical status of water bodies. Thus, the main objective of MONITOOL is to adapt the existing EQSs to DGTs, enabling the use of DGTs for regulatory monitoring. The fulfilment of the overall objective will be achieved by organizing two different campaigns, in winter and summer, which consist in the simultaneous deployment of DGTs and the high-frequency collection of spot water samples. The first sampling campaigns were performed during winter 2017/2018 in 4 selected sites (transitional and coastal sites) in each consortium region (8 regions). All partners followed the same protocol for sampling and analysis to minimize the operational variability. Priority metals (Cd, Ni, Pb) and other specific metals (Al, Ag, Cu, Cr, Co, Fe, Mn, Zn) will be analysed in waters and in the DGT resins. Statistical analysis will be applied to study relationships between metal concentrations in DGT and in spot water samples. In a final step, suitable EQS for DGTs will be calculated on the basis of the statistical relationships obtained previously. This will permit a better implementation of the Water Framework Directive in high variable systems like transitional and coastal waters. The advantages of this implementation will be analysed in terms of cost/effectiveness of the sampling programs, representativeness, and reliability of the results.

3.2.2 A novel active-passive sampling approach for the monitoring of a wide range of pollutants in water

Elvio Amato (University of Antwerpen, BE)

A new sampling device combining active and passive sampling (APS) was developed for the measurement of time-averaged concentrations of metal and organic contaminants in water. By coupling a diffusion cell (loaded with a set of sorbents selective for different substances) with a small pump and a flow meter, the APS device is able to perform *in situ* measurements that are independent of the hydro-dynamic conditions in the exposure medium. The diffusion layer thickness (δ) at the sorbent/solution interface within the diffusion cell was characterised under controlled flow conditions. Laboratory tests indicated that, in the range of flow rates investigated, δ varied from ~60 to ~110 μm, depending on the type of substance measured and the position of the sorbent with respect to the flow direction. Due to its ability to accurately estimate δ, good to excellent agreement was found between measurements performed with the APS device in non-complexing media and concentrations measured in discrete water samples for all the substances investigated. These results suggest that the APS device could overcome issues affecting the quantitative interpretation of measurements by conventional passive sampling devices and serve as a useful tool for monitoring a wide range of contaminants (simultaneously) in water.

3.2.3 SEDRIPORT (SEdiment, Dredging and PORT RIsk assessment)

Maria J Belzunce Segarra (AZTI, ES) on behalf Natalia Montero (University of Cagliari)

The SEDRIPORT project aims to develop, in the cross-border area a shared system for the constant monitoring of silting, weather conditions, physical parameters of waters and sediments in ports and adjacent coastal areas and to define common strategies for seabed restoration.

By capitalizing the contribution of previous projects, existing legislation and good practice directions, SEDRIPORT has the objective of drawing up guidelines to be jointly implemented in cross-border area in order to improve the management of dredging and sediment handling.

SEDRIPORT applies and integrated assessment using several lines of evidence in the water column and in sediments: passive samplers (Diffusive Gradient in Thin Films – DGTs-, silicone rubber and Polar Organic Chemical Integrative Samplers –POCIS-) in the water column, physico-chemical characterization of sediments and toxicity tests in water and sediments. Results obtained show that the integrated assessment provides a useful tool to know the origin and risk of contamination, facilitating the decisions making on prevention and management.

3.2.4 GACR project

Foppe Smedes (RECETOX, Czech Republic)

Investigation of accumulation of persistent, bio-accumulating and toxic organic substances into aquatic organisms. This project studies how aqueous passive sampling relates to trophic magnification of hydrophobic organic compounds (HOC) in fish. Passive sampling indicates the thermodynamic exposure level but does not include the effect of processes as biomagnification or biotransformation. Hence, this research investigated the relation between the thermodynamic exposure level indicated by passive samplers and levels in fish (both lipid based).

3.3 Future plans

Whilst some passive sampling techniques are still being developped, others more established are increasingly being applied within the different regional areas, and future plans include:

i. Publish TIMES guidelines for passive sampling of organics in sediments
ii. Publish a CRR review on passive sampling techniques. MCWG is still discussing whether it is recommended to split into two CRR reviews to address organic and inorganic contaminants separately.
iii. Review and update on developments including working with regulators to utilise passive sampling more widely for monitoring of contaminants in harbour water bodies, for temporal trend monitoring and in general for using passive samplers in the context of WFD compliance purposes.
iv. Continue to develop a database to provide information of use in developing assessment criteria for passive sampling techniques. Initially, plan to evaluate methods to score PS against other matrices (biota, sediments, water) and how to then use these for converting

EQSs between matrices. This will define what is needed in the database and will involve ICES data centre. conversion

v. Continue to build evidence base for use of passive sampling as a method to help understanding of trophic magnification in the marine environment.

4 Chemical emissions from Offshore Renewables Developments

4.1 Introduction

Offshore wind energy is one of the emerging technologies in the transition to renewable energies in many European countries. To date, a power capacity of more than 25 GW (actual data from https://windeurope.org) is already installed. As of now, 1500 wind turbines (~ 7,8 GW) and about 30 offshore substations (OSS) and converter platforms for power transmission in Germany alone were installed during the last decade (majority in the EEZ of North and Baltic Sea). Based on Germany’s goals of renewable energy development (40 GW in 2040) more wind turbines are expected in the future, as in other European countries and worldwide. Moreover, the possible production of hydrogen utilizing offshore wind energy will further increase this development.

4.2 Possible environmental impact of chemical emissions (corrosion protection systems)

While environmental impact studies mainly focus on ecological topics such as benthos, birds, mammals, ecosystem services, and noise emissions during pile driving, chemical emissions from offshore windfarms cannot be properly assessed due to the lack of data. To date, one of the most likely candidates potentially causing an environmental impact are corrosion protection systems.

The marine environment is a highly corrosive environment for steel constructions such as offshore wind turbines or platforms. Corrosion affects all parts of offshore wind turbines, especially in the submerged and in the tidal- and wave-affected splash zones. These zones are often protected by a combination of different corrosion protection systems to ensure a lifetime of at least 25 years under offshore conditions. Typically, those systems can consist of (organic) coatings (e.g. epoxy resins and polyurethane), thicker steel to compensate the material losses through corrosion, and galvanic anode cathodic protection systems (GACP, the so called “sacrificial anodes”) or impressed current cationic protection systems (ICCP) for the submerged zones of foundations. Being in direct contact with seawater, all systems have different pathways for chemical emissions into the marine environment. Galvanic anodes emit high amounts of aluminum, zinc and other metals during their consumption (e.g. 150–700 kg anode material per wind turbine and year; data from German windfarm approvals). However, ICCP systems only emit negligible amounts (e.g. in the order of grams per wind turbine/year).

4.3 Project studies

4.3.1 Scientific review on corrosion protection systems and their potential environmental impact (desktop study)

Torben Kirchgeorg (BSH, GER)

To assess potential environmental effects caused by offshore windfarms, a scientific review on corrosion protection systems was performed (Kirchgeorg *et al.* 2018). Beside a detailed description on the systems predominantly applied and their potential chemical emissions, a first evaluation of the environmental impact based on this desktop study was conducted. Current assumptions suggest a low environmental impact, but monitoring data is currently not sufficient to assess the environmental impact of this new source of emissions. Moreover, the review provides some technical recommendations on how to reduce chemical emissions.

4.3.2 OffChEm project 2017–2021 (Germany)

In this project funded by the Federal Maritime and Hydrographic Agency (BSH, Germany)- the Helmholz Centre in Geesthacht investigates the following aspects in collaboration with the BSH:

- Identification of potential inorganic (harmful) substances which could have a relevant impact on the marine environment through the corrosion protection of offshore wind farms.
- Development of analytical methods and suitable sampling strategies to determine the emissions of the potential substances in the various compartments in the vicinity of offshore farms.
- Evaluation of the relevance of the identified potential pollutants on the basis of their material emissions from offshore wind farms and their influence on the local and regional marine environment.

As a first step, 40 target metals from a suit of different Al-based and Zn-based anodes were analysed to determine the elemental mass fractions (Reese *et al.* 2020). While in general the major composition fell into the technical specifications provided by the suppliers, the results suggest that a variety of other metals are incorporated in the anodes (26 and 16 different metals were found in Al-anodes and Zn-anodes, respectively). Among these impurities, also toxicologically relevant elements such as Cd and Pb have been detected (in rather low mass fractions). Mass fractions of Cd and Pb were found to be higher in Zn-anodes than in Al-anodes. Based on these analytical results, by applying Pb isotope ratios, and taking into account the marine background values, a combined tracer approach was developed. This approach aimed at linking compounds emitted by galvanic anodes (Al, Zn, Ga, Cd, In and Pb) to a specific source and thus differentiate them from other potential sources into the marine environment.

Secondly, a suit of analytical methods and sampling strategies was developed including sensitive determination of trace metals in seawater (low ng/L), sediment, and blue mussels. For example, Indium (In), a compound characteristic for Al-based anodes, can now be analysed in seawater (LOQ: 0,01 ng/L) and sediments for the first time.

To evaluate the potential impact of offshore windfarms on the environment, three ship-based campaigns in windfarms were performed in the German North Sea (2018-2020). High resolution water and sediment sampling was conducted to get information on the spatial and temporal trends in the respective areas representing a unique dataset for further evaluation. Furthermore, blue mussels from wind turbines were gained and also analysed for their trace metal content. Since the project is still in progress and field data not fully assessed, only preliminary results can be presented here:

- Trace metals in and around windfarms are within the regional variability if compared to BSH long-term monitoring data
- However, data for e.g. zinc suggest an increase along residual current from windfarms in the Western German Bight to the windfarms further northwards (further evaluation is needed)
- Local increases of specific metals in windfarms were occasionally detected (further evaluation is needed)
- First measurements of the tracer compound Indium (In) in seawater and sediments in the North Sea

- Tracer elements were also detected in blues mussels from wind turbines (further evaluation is needed)

Overall, OffChEm will deliver the first comprehensive data set on metal distribution in windfarm areas to assess the potential environmental impact of corrosion protection measures. First results from the desktop study (Kirchgeorg *et al.* 2018) and the study on elemental composition of galvanic anodes (Reese *et al.* 2020) revealed that trace metals are emitted from corrosion protection systems in considerable amounts into the marine environment throughout the lifetime of offshore windfarms. Among those are also ecotoxicologically critical metals such as Cd, Pb, and Zn. Therefore wind farms represent an additional source for trace metals, but the environmental impact still needs further evaluation and should be monitored.

Thus, further steps in the OffChEm project include:

- Evaluation of field data by e.g. isotope ratio determination of trace metals, statistical assessment of data, hydrodynamics, further comparison with long-term monitoring data
- Assessment of data using environmental assessment criteria given e.g. by OSPAR, if applicable
- Scientific publications on the results from field campaigns
- Recommendation for monitoring programs
- In a second project phase (2021-2023) further field studies are planned in the German Baltic Sea windfarms as well as further analysis of galvanic anodes composition from different suppliers, and blue mussels from offshore structures.

4.3.3 ANODE project (France)

Catherine Munschy and Javier Castro Jimenez (ILFREMER, FR)

The ANODE project, funded by the French National Research Agency and by France Energies Marines, developed a methodology for assessing the chemical risk of wind farms linked to chemicals released from GACP by combining a hydrodynamic model with available hazard data. Three offshore wind farms subject to different hydrodynamic conditions and designs (i.e. fixed or floating foundations) were selected. One fixed foundation farm was selected on the English Channel (Courseulles-sur-Mer) coast and two with floating structures were selected on the Atlan-tic coast (Groix & Belle-île) and in the Mediterranean Sea (Leucate). Among these sites, Courseulles-sur-Mer is the only one considered as a future commercial farm (75 wind turbines). The two others are pilot farms (3 to 4 wind turbines).

The project objectives were as follows:

- Perform a literature review of the different cathodic protection systems used in the offshore industry with a focus on GACP and current knowledge of its potential impact on the marine environment.
- Draw up an overview of the data required for the numerical simulation and the availability of these data in the study areas.
- Model the hydrodynamics of the selected areas and simulate the metal releases and the evolution over time of their concentrations in the various case studies.
- Conduct a risk assessment by comparing the results obtained using the model with existing toxicity thresholds (in the water column).

The literature review revealed that, in the offshore industries, the main composition of galvanic anodes is an aluminium alloy which contains a large share of aluminium (about 95%), as well as zinc (about 5%) and other trace metals (‹ 1%): copper, iron, indium or cadmium. This project focussed on aluminium, although an assessment is also offered for other metallic elements. It has been reported that in natural seawater (pH close to 8.1), the aluminium dissolved form (Al(OH)4) is predominant, representing almost 67% of the solution (Millero *et al.* 2009). In the ANODE project, only the dissolved form was considered as it is the most abundant and readily assimilated by marine organisms. The worst-case scenario was tested assuming that 100% of each metal dissolves into the seawater.

The dispersion simulations of each element were performed over a 5-year period for the sites dominated by the tidal flow (Courseulles-sur-Mer and Groix & Belle-Île) and a 1-year period for the Leucate site where the hydrodynamic conditions are driven by the atmospheric forcing. Globally, the results show that an upper bound value of the concentration of each metal emerges in each point of the domain but strong variations around a median value were observed over short time periods. For example, the model predicted that the maximum aluminium point concentration reached during the 5 years of the simulation in Courseulles-sur-Mer (1 µg L-1) was located in the middle of the farm and that this maximum concentration registered was only reached for a period of 24h (1 record). In addition, the results of these simulations showed that where the aluminium anodes contribution is at its highest, the natural River Seine contribution of this element could be around ten times higher (10 µg L-1); (Michelet *et al.,* 2020). In spite of the large variability and the influence of natural sources of aluminium in the area, the study performed in this project is considered sufficient to obtain a first estimation of exposure associated with the metals released by the galvanic anodes. However, it is necessary to improve this approach with in situ chemical measurements. Several measurements are recommended in order to determine the initial condition of the metal concentrations at the study site location and to estimate the contribution of the galvanic anode to the environment. These measurements should be performed before the installation, one and five years after it and at different locations. However, it is also recommended to perform measurements during different hydrodynamic scenarios such as low tidal currents or strong wind which could be identified by the hydrodynamic model. Passive sampling techniques could represent a good approach to perform the measurements of target metals.

The risk assessment was performed in accordance with the REACH (Registration, Evaluation, Authorisation, and Restriction of Chemicals) technical guidance described by ECHA (European Chemicals Agency, 2008; 2016). However, seawater was the only compartment used for this evaluation, first because exposure modelling could only be conducted on this compartment and second, because this compartment is considered to be the main diffusion vector of the bioavailable forms of the elements released by the anodes. The available data to perform the risk assessment was not entirely satisfactory. For example, existing Predicted No Effect Concentrations (PNEC) for aluminium were judged to be not enough representative for the aluminium species studied and/or they covered few taxa for example (Michelet *et al.,* 2020). In spite of this limitations and based on available data, the chemical risk assessment performed identifies a risk for aluminium for the species living in the water column. However, the PNEC seawater needs to be refined by conducting standardised experimental studies in laboratory conditions for the acquisition of ecotoxicity data for aluminium on marine organisms, especially on algae, fish and crustaceans. In addition, a field study could be planned in order to measure the metal concentration associated with anode dissolution in the seawater, sediment and biota (exposed caged organisms) and to measure the bioaccumulation of aluminium and biomarkers/bioassays of effects. The final risk assessment for aluminium can only be achieved once these detailed data are acquired. Finally, the work begun should be pursued by assessing the risk for environmental compartments not considered within the ANODE project: sediment (for the protection of benthic organisms) and biota (for the protection of top predators).

A complete overview of the ANODE project, including details on methodological approaches and all results can be consulted in Michelet *et al.*, 2020. A summary, mostly based on that report, was provided above.

4.3.4 UK

There are limited contaminant data available from muddy sediments by request from the UK Marine Management Organisation (MMO) public register which may be useful for determining marine environmental impacts, although generally contaminant analysis of seabed samples are not requested for licensing applications related to wind farm developments. This is because the sediment is not being removed from the environment. Copping *et al.* 2016 look at environmental effects of marine renewable energy development around the world. This report uses numerical models to predict impact of chemicals of Marine Renewable Devices (MRDs). The results suggest that MRDs will have minimal effects on hydrodynamics locally, as well as for larger scale developments. However, validation of models is recommended with real data, particularly for larger scale developments. The report also predicts that chemical effects of MRDs are relatively low risk as the chemicals used are commercially available paints/coatings that have already undergone rigorous testing, and any releases are likely to be short term, for example, as result of a spill.

There are hydrodynamic assessments being completed at a few test sites in England and Wales to determine potential changes that may occur as a result of tidal and wave devices.

4.4 Future plans

Continue to share evidence and promote this work to Working Group on Offshore Renewable Energy (WGORE).

5 Microplastics

5.1 Introduction

In the last decades, the increasing accumulation of plastic microlitter in the aquatic environments has triggered the attention of both the scientific community and the public opinion. Governmental bodies, both at national and international level, have recently started to face such issue demanding scientists to develop effective tools to characterize levels and distribution of plastic debris in the environment (ICES, 2015). Over the last years scientists across Europe have focused on the development of standardized methods for sample collection, processing and detection of microplastics in several different environmental matrices, including marine sediments (Dehaut *et al.,* 2016; Imhof *et al.,* 2012; Löder *et al.,* 2015; Hidalgo-Ruz *et al.,* 2012; Van Cauwenberghe *et al.,* 2013; Karlsson *et al.,* 2017).

The activities and the main outcomes of some relevant EU projects for this topic, such as JPI-O "Baseman", JPI-O "Ephemare" and JPI-O "Plastox", have been introduced within two lectures. To date, a range of different methods have been suggested to estimate the abundance, distribution and composition of microplastic in the marine environment showing different application limits, sensitivity and interval of applicability.

There is a general agreement among all members about a substantial lack of standardized and unified collection of methods to support a comprehensive and reliable assessment of microplastics distribution in the benthic as well as all others environmental compartments. The assembly further agreed on the limited knowledge about the interrelated biological and chemical-physical consequences of the increasing accumulation of microplastics in sedimentary environment. Several recent findings have addressed that micrometric scaled plastic fragments can potentially act as vectors for pollutants enhancing both the accumulation on marine organisms as well as their physical dispersion from coastal to marine areas, as well as increase the bioavailability of hydrophobic pollutants co-occurring in the aquatic environment (Da Costa *et al.,* 2016; Gomiero *et al.,* 2018; Leon *et al.,* 2018; Pellini *et al.,* 2018).

5.2 Project studies and updates given

5.2.1 Microplastics in the aquatic environments: current efforts and future challenges

Alessio Gomiero, M. Arnberg, R.K. Beckmann, G. Skogerbø, K. Birger Øysæd

Plastic waste is of increasing concern in the aquatic environment. A large portion of the plastic waste is produced onshore and reaches the marine environment, which is considered the main sink of plastic debris. Floating plastic particles accumulate in pelagic habitats. However, due to the biofilm formation they eventually sink and accumulate on the seafloor together with non-buoyant by design plastic particles posing risk to the benthic communities. There is, however, a considerable lack of standardized methods for microplastic particles occurrence and composition characterization. In the presentation, a benchmark among the best available extraction and detection technologies is introduced and a multitiered approach combining fast screening low resolution methods (tier 1) and sensitive analytical techniques (tier 2) is performed on a case study.

5.2.2 LIFE-LEMA, Intelligent marine litter removal and management for local authorities

Oihane C. Basurko, Igor Granado, Luis Ferrer, Anna Rubio, Irati Epelde, Julien Mader, Jose Luis Asensio, Ivan Saez. 2018 (AZTI, ES). Presented by Maria J. Belzunce Segarra

The Life LEMA project is part of the Environment and Climate Action LIFE European Program and aims to provide a methodological guidance and intelligent tools to the local authorities for the effective management of floating marine litter in the southeast of the Bay of Biscay.

Life LEMA was approved in September 2016 and the project's tasks run until September 2019. The project is made up by an international working group and has 6 partners led by the Deputy of Environment and Hydraulic works. The research centres AZTI and Rivages Pro Tech - Suez, the public organizations Syndicat Mixte Kosta Garbia and the town hall of Biarritz and the NGO Surfrider Foundation Europe complete the work team.

In order to achieve the project’s objective, a modelling of the technical, environmental and socio-economic aspects will be realized related to the floating marine litter of the Bay of Biscay. To achieve this goal, Life LEMA has a small fleet of ships that sample and collect floating marine litter, a floating barrier that will be placed at the river Deba (Gipuzkoa) to retain waste, drones, and thermal and video cameras located in the estuaries of the rivers Adour (Pyrenees Atlantiques) and Orio (Gipuzkoa) for the remote detection of floating marine litter, drift buoys and high frequency radars.

Life LEMA also wants to promote the search of common solutions for the management of marine litter in transboundary waters. Groups of experts from the cross-border geographic scope of the project (France and Spain) have been created, and through their participation in dynamic sessions, they’ll contribute to the improvement and monitoring of the European directives related to Life LEMA.

5.2.3 Seafloor macrolitter monitoring guidelines and data reporting

In support to existing guidelines on seafloor macrolitter monitoring (JRC, 2013; OSPAR, 2017), ICES WGML developed a guideline document providing detailed information on seafloor litter monitoring with the aim to increase harmonisation. These guidelines include for example the categorization of mixed materials, the counting of pieces originating from the same original item or instructions on how to weigh macrolitter. All are encouraged to report macrolitter and microplastic data to the DATRAS and DOME portal.

5.2.4 BASEMAN JPI Oceans project

Lucía Viñas

BASEMAN was one of the projects funded by the 2014 JPI-Oceans Pilot call on ecological aspects of microplastics. Standardised protocols for monitoring microplastics in seawater and sediments are freely accessible and downloadable (links below) and include general guidelines for the main aspects that have to be taken into account when designing a monitoring programme focused on microplastics.

https://www.researchgate.net/publication/330931801_Standardised_protocol_for_monitoring_microplastics_in_seawater

https://www.researchgate.net/publication/326552185_Standardised_protocol_for_monitoring_microplastics_in_sediments

5.3 Future plans

The MCWG and WGML are harmonizing their contribution toward the assessment of plastic litter in good dialog with other relevant ICES working group such as the Working Group on Biological Effects of Contaminants (WGBEC). After some joint MCWG/ WGBEC meetings it has emerged that there is common interest of the different working groups on issues related to the release of plastic-related contaminants, the equilibrium between environmental contaminants and plastics and the effects of microplastics and plastic-related contaminants on the marine environment. It is acknowledged that ICES umbrella holds a lot of expertise in monitoring and should play a role in setting guidelines for microplastics monitoring in sediment and other matrices. However, the topic of marine litter pollution is relatively new and the rising number of different alternative sampling, analysis and data handling protocols has stimulated the European commission through the Task Group Marine Litter (EU TGML) and other international coordinating bodies (JPI) to support harmonisation exercises of the existing protocols. Avoiding to double efforts and come up with harmonisation advice ourselves the MCWG in co-operation with WGML should focus on stressing the needs, strengths and limitations of plastic monitoring rather than to write own protocols to be applied as sampling and analytical approaches may significantly change in the incoming years. It is acknowledged that within the general trend toward harmonization dictated by the EU, ICES should impact and advise on the harmonization process from that side. The members of the MCWG/WGBEC recognize a knowledge gap in the migration, release, fate and environmental impact including biological effects of plastics additives, chemical substances contained in all plastic products for enhancing polymer properties and prolonging their life. Planning of a review and/or ICES viewpoint document on this topic is ongoing. This document should be scientifically based, providing different opinions in the field, but with a clear added value compared to existing reviews in its perspectives and recommendations. MCWG believes this output document should include both inorganic as well as organic additives and discuss their leaching, sorption and effects linked to the relative importance of plastics as an environmental source of additives in the marine eco-system, also related to the region-specific characteristics (e.g. sedimentology). Discussing the different characteristics of microplastics compared to natural particles might be an interesting subtopic.

6 Sediment Quality Guidelines and Assessment Criteria

6.1 Dredge sediment assessment using chemical action levels (ALs)

6.1.1 Background

Regulated substances and thresholds used in management of dredging activities have been reviewed, looking at what substances are regulated by licensing authorities in different European countries, and what ALs are in use. This has highlighted significant differences in each of these approaches between different countries.

Initially, differences in action levels were summarised from the MMO (2015) report which included a comparison of UK action levels compared with other countries. This review showed that different national guidelines are in use for the management of dredged material in the countries of EU. The framework for these guidelines is given by international conventions, like the London Convention (LC) 1972,) the Convention for the Protection of the North-East Atlantic (the OSPAR Convention) and Helsinki Convention (HELCOM). The implementation and the setting of assessment criteria are within the custody of each country. Hence, there are differences concerning the assessment criteria for the material to be disposed at sea. All countries make use of guidance levels and/or threshold levels for the characterization of dredged material. Thus, it is difficult to compare the guidelines adopted by the different European countries because they have adopted distinct: (1) elements and organic compounds which should be necessarily analysed, (2) threshold values, (3) action levels, (4) grain size fractions where metals and organic compounds are analysed.

The Netherlands is the only country who has adapted 1 action level for each element or compound. These values are given as threshold or guidance levels. Threshold values are given for priority substances which are mostly organic contaminants but also selected metals. These values are treated as strict limit values without exceptions. For non-priority substances an exceedance of up to 50% is tolerable as long as it only concerns two substances.

The action levels, besides being different among the several countries, are derived on distinct physical and chemical bases:

1. Background concentrations (the Netherlands).
2. Average sediment contaminant concentration of the respective seas (North Sea and Baltic Sea) for AL1 and the triple concentration of AL1 for AL2 (Germany).
3. Ecotoxicological bases. These values have been evaluated using bioaccumulation functions for seabirds and humans (Belgium, Norway).
4. Background concentrations for AL1 and global toxicity of sediments for AL2 (France, UK, Ireland, Denmark).

In relation to the list of elements to be analysed, there is uniformity with respect to the metal and metalloid elements that are to be analysed (As, Cd, Cr, Cu, Ni, Pb, Zn, and Hg). However, the regulations in a few countries adopt a high number of organic compounds, separating some organic groups (e.g. PAHs) into a higher number of components. This is the case of Norway who analyse 16 PAHs compounds and 7 PCBs, along with a list of less common organics, following the OSPAR list of chemicals for priority action, which are not analysed by the other European countries. Most countries prioritise the monitoring of 10 PAHs and 7 PCBs.

One of the greatest differences between the values adopted by each country is that in the most countries these values are referring to dry solids and apply to total samples in the grain size fraction < 2 mm (Netherland, Belgium, France, UK, Ireland, Denmark, Norway, Spain, Portugal), while in Germany the selected fractions depends on the nature of the elements/compounds: metal standards are referring to the grain size fraction < 20 µm (measured in < 20 µm), organic parameters are referring to the fraction < 63 µm (measured in < 2 mm and normalised to < 63 µm), except TBT which is applied to the total fraction (all referring to dry solids). This finer, higher surface area, clay-rich fraction often has a higher proportion of both anthropogenic and natural metals, and organic matter, so these values may not be directly comparable to those based on the coarser fraction.

Also the extraction procedures are quite different which invalidates the comparison between the concentrations obtained for each element. There exist three different extractions for the metals analysis which, obligatory, have different meanings: a few countries adopted a total extraction using a tri-acid digestion (HF-HNO3-HCl), for example Belgium, France and Ireland, while others use partial digestions for the metals release: HCl-HNO3, or HNO3.

An updated table of different action levels for European countries from the OSPAR and HELCOM regions are summarized in Table 6.1.

Table 6.1. Action level values for European countries from the OSPAR and HELCOM regions.

a/ Overview table showing country, analytical method summary and references

Abbreviation	Country	Analytical methods summary	Reference
BEL	Belgium	Total fraction, analyses following OSPAR guidelines.	BS/2021/AMT/S1; Ministerieel besluit houdende machtiging tot het storten in zee van baggerspecie door de Vlaamse overheid, Departement Mobiliteit en Openbare Werken, afdeling Maritieme Toegang.
ENG, NI and WALES	England, Northern Ireland and Wales	<2mm (whole sediment partial digest for metals). Other methods follow OSPAR guidelines. Exact methodology requirements are defined by the Marine Management Organisation (MMO).	MMO. (2015). High Level Review of Current UK Action Level Guidance. A report produced for the Marine Management Organisation, pp 73. MMO Project No: 1053. ISBN: 978-1-909452-350. MMO Marine licensing: physical and chemical determinands for sediment sampling (last accessed on 14/2/2002): https://www.gov.uk/government/publications/marine-licensing-physical-and-chemical-determinands-for-sediment-sampling
ENG Proposed	England proposed	as for ENG, NI and WALES	Mason, C., Lonsdale, J., Vivian, C., Griffith, A., Warford, L., Hynes, C., Barber, J., Sheahan, D., Bersuder, P. & Bakir, A., (2020) Review of Action Levels used for assessing dredging and disposal marine licences. Report ME5226/C7590 for the Department of the Environment, Food and Rural Affairs. 113pp.
SCOT	Scotland	<2mm (CSEMP Green book)	Marine Scotland Pre-disposal Sampling Guidance, Version 2, November 2017, Scottish government, 5pp
IRE	Ireland	<2mm Total HF digest for metals.	Cronin, M., McGovern, E., McMahon, T. & Boelens, R., "Guidelines for the Assessment of Dredge Material for Disposal in Irish Waters", Marine Environment and Health Series No. 24, Marine Institute 2006 Available at https://www.epa.ie/publications/licensing--permitting/freshwater--marine/Guidelines-for-Assessment-of-Dredge-Material-(2006).pdf (accessed on 14/2/2022).
FIN	Finland	<2mm partial nitric acid digest for metals. Normalisation as used in the Netherlands. Standard sediment is defined to contain 10% dry matter and 25% of clay (< 2 µm fraction). Accredited methods/laboratories should be used. Organic compounds: Accredited methods/laboratories should be used.	Ympäristöministeriö. 2015. Sedimenttien ruoppaus- ja läjitysohje. Ympäristöhallinnon ohjeita 1. 72 pp. Edita Publishing Oy. ISBN 978-952-11-4449-3 (pdf). In Finnish and Swedish. Concentrations at boundary level between two classes fall into lower concentration category. The publication is a recommendation, i.e. not fully obligatory.
FR	France	<2mm. Laboratories follow certified methods.	GEODE, 2016. Bonnes pratiques pour la caractérisation des matériaux en vue d'une opération de dragage et d'immersion en milieu marin et estuarien. EGIS Eau, Novembre 2016, 118 p. https://www.cerema.fr/system/files/documents/2018/02/guide_GEODE_Bonnes%20pratiques%20analyse%20s%C3%A9diments_14112016-1.pdf

Abbreviation	**Country**	**Analytical methods summary**	**Reference**
GER	Germany	Metals < 20 um; TBT in < 2000 µm, OCPs, PAHs, PCBs measured in < 2000 µm, normalised to < 63 µm, partial digest for metals	Joint Transitional Arrangements for the Handling of Dredged Material in German Federal Coastal Waterways (GÜBAK-WSV) (2009)Carmen add reference (between the Federal authorities and Federal States Bremen, Hamburg, Mecklenburg-Western Pomerania, Lower Saxonia and Schleswig Holstein) – current under review
NOR	Norway	<63µm. HNO_3 digest for metals.	Norwegian Environment Agency (Miljødirektoratet) Guideline for classification of water, sediment and biota M-608, 2016, revised 30 October 2020. Available at https://www.miljodirektoratet.no/publikasjoner/2016/september-2016/grenseverdier-for-klassifisering-av-vann-sediment-og-biota/
SP	Spain	<2mm. Metals: Sediments pretreated with hydrogen peroxide in cases where high amount of organic matter is present. Concentrated nitric acid digest used. PAHs: Determination of PAHs and PCBs in sediments from JAMP guidelines. Biological classification also included.	Spanish guidelines (2021): Directrices para la caracterización del material dragado y su reubicación en aguas del dominio público marítimo. Comisión Interministerial de Estrategias Marinas (CIEM), 2021. 59 pp. + Anexes. JAMP Guidelines for Monitoring Contaminants in Sediments. OSPAR Commission, Monitoring guidelines, Ref. No: 2002-16 (OSPAR, 2002. JAMP Guidelines for Monitoring Contaminants in Sediments (Agreement 2002-16). OSPAR Guidelines for the Management of Dredged Material at Sea OSPAR Agreement 2014-6.
POR	Portugal	<2mm. Although not mandatory, partial digest for metals usually applied.	National legislation - Portaria nº 1450/2007 from 12th November 2007

Tables are split into b/ Trace metals (including arsenic which although is a non-metal is analysed alongside trace metals); c/ Organotins; d/ Polychlorinated biphenyls (PCBs); e1/ Polycyclic Aromatic Hydrocarbons (PAHs) – Total and Summed hydrocarbons; e2/ Polycyclic Aromatic Hydrocarbons (PAHs) Individual PAHs; f/ Organochlorine Pesticides (OCPs) and g/ Polybrominated diphenyl ether (PBDEs) and Dioxins and furans.

Lower action levels and upper action levels are presented. Some countries (FIN, SP and PORT) have more than 2 ALs so these have been split into lower and upper ALs within the table.

AL1 = Action Level 1; AL2 = Action Level 2; if different numbering systems are used then these are reflected, for example PORT A which is the lowest of the five ALs in use for dredge assessment in Portugal.

b/ Trace metals – Units mg/kg (dry weight). Sediment fraction analysed and analysis methods summarised in Table 6.1a.

	Lower Action Level (s)																	Upper Action Level (s)														
	BEL AL1	ENG, NI, WALES AL1	ENG Proposed AL1	SCOT AL1	IRE AL1	FIN AL1	FIN AL1A	FIN AL1B	FIN AL1C	FR AL1	GER_North Sea AL1	GER_Baltic Sea AL1	NOR AL1	SP ALA	SP ALB	POR AL1	POR AL2	BEL AL2	ENG, NI, WALES AL1	ENG Proposed AL2	SCOT AL2	IRE AL2	FIN AL2	FR AL2	GER_North Sea AL2	GER_Baltic Sea AL2	NOR AL2	SP ALC	SP AL Dangerous	POR AL3	PORT AL4	PORT AL5
Arsenic (As)	20	20	20	20	9	<15	15-50	50-70		25	40	20	18	35	70	20	50	100	100	70	70	70	>70	50	120	60	71	280	1000	100	500	>500
Cadmium (Cd)	2.5	0.4	0.4	0.4	0.7	<0.5	0.5-2.5			1.2	1.5	2	2.5	1.2	2.4	1	3	7	5	4	4	4.2	>2.5	2.4	4.5	6	16	9.6	72	5	10	>10
Chromium (Cr)	60	40	50	50	120	<65	65-270			90	120	90	620	140	340	50	100	220	400	370	370	370	>270	180	360	270	6000	1000		400	1000	>1000
Chromium (Cr)VI																								-					1000			
Copper (Cu)	20	40	30	30	40	<35	35-50	50-70	70-90	45	30	70	84	70	168	35	150	100	400	300	300	110	>90	90	90	210	84	675	2500	300	500	>500
Mercury (Hg)	0.3	0.3	0.25	0.25	0.2	<0.1	0.1-0.6	0.6-0.8	0.8-1	0.4	0.7	0.4	0.52	0.35	0.71	0.5	1.5	1.5	3	1.5	1.5	0.7	>1	0.8	2.1	1.2	0.75	2.84	17	3	10	>10
Nickel (Ni)	70	20	30	30	21	<45	45-50	50-60		37	70	70	42	30	63	30	75	280	200	150	150	60	>60	74	210	210	271	234	1000	125	250	>250
Lead (Pb)	70	50	50	50	60	<40	40-80	80-100	100-200	100	90	100	150	80	218	50	150	350	500	400	400	218	>200	200	270	300	1480	600	1000	500	1000	>1000
Zinc (Zn)	160	130	130	130	160	<170	170-360	360-500		276	300	250	139	205	410	100	600	500	800	600	600	410	>500	552	900	750	750	1640	2500	1500	5000	>5000

c/ Organotins –Units mg/kg (dry weight). For GER_North Sea[1] 0.1 (National Park of the Wadden Sea)/0.3 (outside the National Park). Sediment fraction analysed and analysis methods summarised in Table 6.1a.

	Lower Action Level (s)															Upper Action Level (s)											
	BEL AL1	ENG, NI, WALES AL1	ENG Proposed AL1	SCOT AL1	IRE AL1	FIN AL1	FIN AL1A	FIN AL1B	FIN AL1C	FR AL1	GER_North Sea AL1	GER_Baltic Sea AL1	NOR AL1	SP ALA	SP ALB	BEL AL2	ENG, NI, WALES AL2	ENG Proposed AL2	SCOT AL2	IRE AL2	FIN AL2	FR AL2	GER_North Sea[1] AL2	GER_Baltic Sea AL2	NOR AL2	SP ALC	SP AL Dangerous
Dibutyltin (DBT)		0.1	0.1														1	0.5				-					
Tributyltin (TBT)	0.003	0.1	0.1	0.1		<0.005	0.005-	0.03-0.1	0.1-0.15	0.1	0.02	0.02	0.000002			0.007	1	0.5	0.5		>0.15	0.4	0.1 (0.3)	0.3	0.000016		
ΣDBT and TBT					0.1															0.5							
Tributyltin (TBT)/MBT														0.05	0.2							-				1	3
Triphenyltin						<0.002	0.002-	0.01-0.02	0.02-0.03												>0.03						

d/ Polychlorinated biphenyls (PCBs) Units µg/kg (dry weight) except **ΣICES7_PCB[1] =** µg/goc (dry weight). For FIN * = HELCOM guideline 2015A substances. Sediment fraction analysed and analysis methods summarised in Table 6.1a. Σ25_PCBs is the sum of measured PCBs: PCB101, PCB105, PCB110, PCB118, PCB128, PCB138, PCB141, PCB149, PCB151, PCB153, PCB156, PCB158, PCB170, PCB18, PCB180, PCB183, PCB187, PCB194, PCB28, PCB31, PCB44, PCB47, PCB49, PCB52 and PCB66; ΣICES7 is the sum of ICES7 PCBs (ICES, 1990): PCB28, PCB52, PCB101, PCB118, PCB138 and PCB180.

	Lower Action Level (s)																	Upper Action Level (s)														
	BEL AL1	ENG, NI, WALES AL1	ENG Proposed AL1	SCOT AL1	IRE AL1	FIN AL1	FIN AL1A	FIN AL1B	FIN AL1C	FR AL1	GER_North Sea AL1	GER_Baltic Sea AL1	NOR AL1	SP ALA	SP ALB	POR AL1	POR AL2	BEL AL2	ENG, NI, WALES AL2	ENG Proposed AL2	SCOT AL2	IRE AL2	FIN AL2	FR AL2	GER_North Sea AL2	GER_Baltic Sea AL2	NOR AL2	SP ALC	SP AL Dangerous	POR AL3	PORT AL4	PORT AL5
Σ25_PCBs		20	20	20															200	180	180											
ΣICES7_PCB		10	10		7						13	40	4.1	50	180	5	25			90		1260			40	120	43	540	4000	10	50	>50
ΣICES7_PCB[1]	2																	2														
PCB28			0.6		1	*<2	2-4	4-10	10-30	5										1.7		180	>30	10								
PCB52			0.9		1	*<2	2-4	4-10	10-30	5										2.7		180	>30	10								
PCB101			1		1	*<2	2-4	4-10	10-30	10										3		180	>30	20								
PCB118			0.2		1	*<2	2-4	4-10	10-30	10										0.6		180	>30	20								
PCB138			2.6		1	*<2	2-4	4-10	10-30	20										7.9		180	>30	40								
PCB153			13		1	*<2	2-4	4-10	10-30	20										40		180	>30	40								
PCB180			4		1	*<2	2-4	4-10	10-30	10										12		180	>30	20								

e1/ Polycyclic Aromatic Hydrocarbons (PAHs) – Total and Summed hydrocarbons. Units mg/kg (dry weight) except Mineral oil (C10-C40)[1] = mg/OC (dry weight); LMW[2] and HMW[2] = µg/kg (dry weight); and Σ16PAH_BEL[3] = µg/goc (dry weight). No total or summed PAHs ALs set for FIN, or FR (see individual PAHs (d2)). Sediment fraction analysed and analysis methods summarised in Table 6.1a. LMW is the Sum of Naphthalene, Acenaphthene, Fluorene, Anthracene, C1- naphthalenes, Acenaphthylene, Phenanthrene; HMW is the Sum of Fluoranthene, Pyrene, Benz[a]anthracene, Chrysene, Benzo[a]pyrene, Dibenz[a,h]anthracene; Σ9PAH_SP = Sum of Anthracene, Benz[a]anthracene, Benzo[g,h,i]perylene, Benzo[a]pyrene, Chrysene, Fluoranthene, Indeno[1,2,3-cd]pyrene, Pyrene, and Phenanthrene; Σ16PAH is the Sum of Acenaphthylene, Acenaphthene, Anthracene, Benz[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[g,h,i]perylene, Benzo[k]fluoranthene, Chrysene, Dibenz[a,h]anthracene, Fluoranthene, Fluorene, Indeno[1,2,3-cd]pyrene, Naphthalene, Phenanthrene, Pyrene; Total PAHs_POR = Sum of all PAHs measured. This is usually Phenanatrene; Anthracene; Fluoranthene; Pyrene; Benzo(a)anthracene; Chrysene; Benzo(b)fluoranthene; Benzo(k)fluoranthene; Benzo(ghi)pyrene; Benzo(a)pyrene; Benzo(ghi)perylene.

	Lower Action Level (s)												Upper Action Level (s)												
	BEL AL1	ENG, NI, WALES AL1	ENG Proposed AL1	SCOT AL1	IRE AL1	GER_North Sea AL1	GER_Baltic Sea AL1	NOR AL1	SP ALA	SP ALB	POR AL1	POR AL2	BEL AL2	ENG, NI, WALES AL2	ENG Proposed AL2	SCOT AL2	IRE AL2	GER_North Sea AL2	GER_Baltic Sea AL2	NOR AL2	SP ALC	SP AL Dangerous	POR AL3	PORT AL4	PORT AL5
Total hydrocarbons (THC)		(100)		100																					
Mineral oil (C10-C40)[1]	14					200	250						36					600	750						
LMW[2]			552												3160										
HMW[2]			1700												9600										
Σ9PAH_SP									1.88	3.76											18.8	110			
Σ16PAH_BEL[3]	70												180												
Σ16PAH					4	1.8	3	2										5.5	9	6					
Total PAHs_POR											300	2000											6000	20000	>20000

e2/ Polycyclic Aromatic Hydrocarbons (PAHs) Individual PAHs - Units mg/kg (dry weight) – No individual ALs set for BEL, ENG, NI, WALES, IRE, GER, SP or POR (see summed PAHs). Sediment fraction analysed and analysis methods summarised in Table 6.1a.

	Lower Action Level (s)							Upper Action Level (s)			
	SCOT AL1	FIN AL1	FIN AL1A	FIN AL1B	FIN AL1C	FR AL1	NOR AL1	SCOT AL2	FIN AL2	FR AL2	NOR AL2
Acenaphthene	0.1					0.015				0.26	
Acenaphthylene	0.1					0.04	0.033			0.34	0.085
Anthracene	0.1	<0.02	0.02-0.5			0.085	0.0048		>0.5	0.59	0.03
Benz[a]anthracene	0.1	<0.02	0.02-0.1	0.1-1		0.26	0.06		>1	0.93	0.501
Benzo[a]pyrene	0.1	<0.02	0.02-0.45	0.45-4.5		0.43	0.183		>4.5	1.01	0.23
Benzo[a,h] anthracene (Dibenz[a,h]anthracene)	0.1					0.06	0.027			0.16	0.273
Benzo[b]fluoranthene	0.1					0.4	0.14			0.9	0.14
Benzo[g,h,i]perylene	0.1	<0.02	0.02-0.1	0.1-1		1.7	0.084		>1	5.65	0.084
Benzo[k]fluoranthene	0.1	<0.02	0.02-0.25	0.25-2.5		0.2	0.135		>2.5	0.4	0.135
Chrysene	0.1	<0.02	0.02-0.3	0.3-3		0.38	0.28		>3	1.59	0.28
Fluoranthene	0.1	<0.02	0.02-0.2	0.2-2		0.6	0.4		>2	2.85	0.4
Fluorene	0.1					0.02	0.15			0.28	0.694
Indeno[1,2,3-cd]pyrene	0.1	<0.02	0.02-0.1	0.1-1		1.7	0.063		>1	5.65	0.063
Naphthalene	0.1	<0.02	0.02-0.25	0.25-2.5		0.16	0.027		>2.5	1.13	1.754
Phenanthrene	0.1	<0.02	0.02-0.5	0.5-5		0.24	0.78		>5	0.87	2.5
Pyrene	0.1	<0.02	0.02-0.28	0.28-2.8		0.5	0.084		>2.8	1.5	0.84

f/ Organochlorine Pesticides (OCPs) – Units µg/kg (dry weight). No OCPs ALs set for BEL, SCOT, FIN, or SP. Sediment fraction analysed and analysis methods summarised in Table 6.1a.

	Lower Action Level (s)																
	BELAL1	ENG, NI, WALES AL1	ENG Proposed AL1	SCOT AL1	IRE AL1	FIN AL1	FIN AL1A	FIN AL1B	FIN AL1C	FR AL1	GER_North Sea AL1	GER_Baltic Sea AL1	NOR AL1	SP ALA	SP ALB	POR AL1	POR AL2
α-HCH					0.3						0.5	1					
γ-HCH(Linda											0.5	6	0.074				
Dieldrin		5	5										0				
HCB					0.3						1.8	2	17			0.5	2.5
Pentachloro benzene											1		400				
DDT (p,p'-DDT)		1	1								1	7	6				
DDE (p,p´-DDE)											1	8	0				
DDD (p,p´-DDD)											2	7	0				
ΣDDT, DDE, DDD													16				

	Upper Action Level (s)														
	BELAL2	ENG, NI, WALES AL2	ENG Proposed AL2	SCOT AL2	IRE AL2	FIN AL2	FR AL2	GER_North Sea AL2	GER_Baltic Sea AL2	NOR AL2	SP ALC	SP AL Dangerous	POR AL3	PORT AL4	PORT AL5
α-HCH					1		-	1.5	3						
γ-HCH(Linda							-	1.5	18	0.74					
Dieldrin		-	-				-			0					
HCB					1		-	5.5	6	61			10	50	>50
Pentachloro benzene							-	3		800					
DDT (p,p'-DDT)		-	-				-	3	21	-					
DDE (p,p´-DDE)							-	3	24	0					
DDD (p,p´-DDD)							-	6	21	0					
ΣDDT, DDE, DDD							-			165					

g/ Polybrominated diphenyl ether (PBDEs) and Dioxins and furans– Units µg/kg (dry weight) except for PCDDs (polychlorinated dibenzo p-dioxins) and PCDFs (polychlorinated dibenzofurans)[1] = µg/kg WHO-TEQ (dry weight). No PBDEs ALs set for any country. Proposed ALs put forward for England based on FESG (Canadian Federal Environmental Sediment Guidelines) as used for OSPAR MIME assessments. Scotland indicate ALs for PBDEs are being investigated. Sediment fraction analysed and analysis methods summarised in Table 6.1a.

	Lower Action Level (s)					Upper Action Level (s)	
	ENG Proposed AL1	FIN AL1	FIN AL1A	FIN AL1B	FIN AL1C	ENG Proposed AL2	FIN AL2
BDE28	38					110	
BDE47	33					97.5	
BDE66	33					97.5	
BDE85	0.3					1	
BDE99	0.3					1	
BDE100	0.3					1	
BDE153	367					1100	
BDE154	367					1100	
BDE183	4666					14000	
BDE209	16					47.5	
PCDDs (polychlorinated dibenzo p-dioxins) and PCDFs (polycholorinated dibenzofurans)[1]		<0.005	0.005-0.01	0.01-0.03	0.03-0.06		

Given these considerations it is obvious that all these differences have the potential to affect the threshold levels for the characterization of dredged material and it is clear that it is difficult to compare different national values for the same parameter and any comparisons between them must be viewed with caution. In a strict sense a direct comparison of national action levels / standards between different countries cannot be made.

6.1.2 Project studies

6.1.2.1 Conceptual and software assisted weight of evidence approach for sediment quality assessment

Francesco Regoli (UNIVPM, IT)

Introduction of sediment quality assessment for dredged material using a new risk based, weight of evidence approach, integrating chemical and ecotoxicological results into a software algorithm. Originally, if only one parameter falls above set threshold, for chemical or ecotoxicological tests, the dredge material was defined as failing the overall required sediment quality assessment. Now chemical and ecotoxicological thresholds are weighted to risk, based on relative hazard and magnitude, and an overall weight of evidence is used to provide a sediment quality index (HQ) based on 5 categories (A absent - negligible; B - slight; C - moderate; D - major and E - severe risk). The software developed is flexible, allowing for input of different references. Tests have been completed comparing the old approach with this new approach and show that for extremes the same result is achieved, but the new approach enables better assessment for interim sediment quality categories (B, C and D). Highlighted that industry liked this approach, as although sampling and analyses costs are relatively high, this approach allows better evidence base, potentially allowing different management options.

6.1.3 Future plans

Awareness of these differences in ALs of the pollutants of the dredged sediments is important, and in order to allow comparisons between different countries, it is suggested that countries align the following as much as possible:

1. priority elements and organic compounds
2. the threshold values
3. number of divisions of action levels (3-5)
4. analytical methods and fractions for metals and organic compounds

Considering that the different countries have distinct geological settings which affect natural sediment metal and metalloid concentrations, equal concentrations found in distinct geological settings do not have the same significance. For example, the Norwegian chromium values appear extremely high compared to all other countries possibly due to high chromium mineralisation in Norwegian rocks. Awareness of regional variations to allow sensible comparisons of anthropogenic contamination, for example using normalisation methods, is encouraged. Use of enrichment factors which has to be tested in different countries in order to find a general formula adapted to all geological conditions could be one method to utilise here.

In reality, the differences in ALs is countered by the different overall approaches and processes being used in different countries so further work to understand the combined influence of these is required.

6.2 Problems of the metals solubility in dredging operations

6.2.1 Background

Sediments are the ultimate reservoirs of contaminants originating from urban, agricultural, and industrial lands and recreational activities and contaminated sediments in rivers and streams, lakes, coastal harbours and estuaries have the potential to pose ecological and human health risks.

Over time, dredger operations have developed containment, treatment and disposal technologies to handle these wastes, and thus clever engineering solutions have been developed and applied. However, costs became higher and options were restricted (Apitz, 2006).

Contaminants transfer between all environmental media and to reduce risk, we must assess and manage them holistically and at all the scales. Sediment is part of the hydrodynamic continuum and any action on a sediment unit can affect other parcels, resulting in conflicting, counterproductive or inefficient management actions if not coordinated.

Metals present in sediments can be strongly retained in the structure of silicate minerals, oxides or sulphides, or they may be weakly bound to the surface of clay minerals and organic particles by adsorption or fixation; they can also exist as soluble phases in pore water. The latter forms have a high mobility and, although a few metals do not have their most toxic forms in the soluble phase, they generally represent the most hazardous forms of metals in the environment due to their easy transfer to the water column and hence their bioavailability. Metals associated to silicate and oxides are the least mobile and represent the most part of metals with lithogenic origin and the most immobile forms. Metals in sulphides are often insoluble, but still represent an environmental risk since they can easily oxidize if they are disturbed, releasing metals to the water column.

The main measures for the remediation of contaminated sediments undergo joint control strategies at source and recovery or containment through the application of in situ or ex situ removal, containment and treatment measures, the applicability of which depends not only on the nature of the contaminants, but also the intrinsic characteristics of the sediments. Knowledge of the complexity involved in processes that stimulate the mobilization of heavy metals is the basis for the design of remediation methodologies. Mobilisation of metals is influenced by many factors; some physicochemical conditions may be effective for the release of certain metals from binding phases but result in the immobilization of other metals. The response of metal elements to these factors should be taken into account during the planning of a remediation project (Fonseca *et al.*, 2015).

Dredging is considered to be one of the most efficient techniques with permanent or long lasting results in terms of increasing the assimilation capacity of a water body, being the only technique able to remove all or part of the sediments, a preferred site of accumulation and retention of metallic elements, nutrients and other organic pollutants (MACTEC Project, 2008). One of the great advantages for chemical or biological remediation methods is that it does not contribute to the introduction into the system of foreign substances (U.S. EPA, 1981; Alan Plummer Associates, 2005). However, their effectiveness depends on prior control of the material being leached from the basin by implementing efficient techniques for minimizing the transport of particulates and soluble elements to the water lines.

No remediation method can remove, contain or treat contaminated sediment materials without any disturbance and consequent release of contaminants. In the case of dredging, even using the most environmentally correct methodologies there is always a re-suspension of sediments in the water column. In addition to the dredging processes, also the transport of these contaminated sediments can lead to some losses and dispersion of material, introducing contaminants in previously decontaminated areas. The risk associated with this resuspended material depends on the physicochemical characteristics of the sediments, the nature of the metals and their geochemical behaviour when modifications of the chemical conditions of the environment occur, namely modifications of pH and redox conditions (Fonseca *et al.*, 2015). Many of the metals accumulated in sedimentary materials increase their mobility under oxidizing conditions. These elements are generally associated with the mineral particles of the sediments at their deposition sites in the reduced state. Any reclosing of the material caused by the dredging leads to an increase in oxidizing conditions, increasing the solubility of metals and consequently increasing their concentration in the water column.

European guidelines for the management of dredged material in the countries of the EU do not include assessments of the major binding phases (e.g. oxyhydroxides, sulphides, organic matter) which influence the partitioning, mobility, and bioavailability of metals in sediment. Threshold or guiding levels are based on total concentrations, and thus do not take into account factors influencing metal bioavailability in sediments. During dredging operations, there is often high levels of resuspension of the smaller and less dense particles, in parallel with the release of the most soluble or la-bile species, which can pose numerous environmental problems. Thus, these action levels do not represent the real environmental hazard of the metals in the sediments and, especially, the problems that may arise due to their possible release during dredging operations.

6.2.2 Conclusions

An improved understanding of which contaminants, including contaminants of emerging concern (CECs) that may be present in the sediments and be remobilised when dredging and subsequently affect water quality, including those that increase their solubility under oxidizing conditions or are present within sediments in more soluble phases, is required. In order to avoid any problems that may occur during dredging operations, to reduce or minimise the resuspension of sediments and associated contaminants, the commonly used dredging mechanisms should be reviewed by using more environmentally friendly dredge methods. It is also noted that some types of dredging, such as water-injection dredging, aim to minimise overall impact and aim to keep sediment movement within the local system.

In summary, the following suggestions may be useful, depending on case specifics:

1. The dredging operation should be minimised and the cutting edge of the equipment should be monitored, in order to avoid high levels of sediment resuspension.
2. In the case of fine-grained sediments, the dredging operation, could be accomplish using silt curtains which are floating barriers, made in PVC or geotextiles, designed for in-water control of turbidity during dredging activities.
3. Development of a greater knowledge base about the chemical behaviour of contaminants and the possibility of being released to the water column during the dredging activities. Considering that the ability to solubilize depends on the nature of the organic and mineral compounds where they are associated, it is useful for any guidance and threshold values to include the total concentrations, as well as the concentrations of its available forms.
4. Review of monitoring strategies and how these are scheduled, with periodic and complete checks of the water quality before, during and after the dredging operation (as already regulated) could be completed. These programs should include all contaminants that may be remobilised and affect water quality, and potential for use of novel methods such as non-targetted screening and passive samples.

6.3 Reuse of dredged sediments

6.3.1 Background

Sediments act as a sink and also as a source of many hazard substances, including heavy metals and organic compounds with anthropogenic origin. However they also represent a reservoir for many other elements and compounds coming from the weathering of rocks and soils from the drainage areas which could be useful if correctly extracted and reused. Among these elements/compounds it could be found phosphorus and nitrogen in high levels that may be harmful to the water quality considering their role as key elements for eutrophication. However, once the sediments are extracted, they may represent a good option for the fertilization of agricultural soils, if they don't have potentially toxic elements above critical levels and if they are extracted in fresh-water systems or in coastal area under the influence of river waters.

Other elements which can be accumulated in sediments are the emerging elements, with great demand worldwide, due to its high economic value, their occurrence with very low levels in the nature, even in mineralized zones and the multiple uses in the industry. The most in-demand emerging elements include those from the platinum group (Au, Pt, Pd, Ru, Os, Ir), indium (In) and the REEs. Among these elements, the majority of REEs and In have lithogenic origin, and can be release from the host-minerals by chemical and physical weathering and due to their chemical resistance they can be transport to long distances without any significant alteration. This is the reason why rare earth elements are commonly used to study the sediments provenance. Elements from the platinum group has as their main source mineralization as sulphides, but they also have an anthropogenic origin, from automotive catalysts and the effluents from a few industries. These emerging elements subsequently reach the ocean and they can be found in sediments accumulated in rivers, estuaries and coastal areas.

6.3.2 Conclusions

During the phase of the recognition of the area and evaluation of the pollutants levels, it could be included analysis of the contents of the emerging elements, especially if the area to be dredge is feed by an ore mining zone or an intensely populated area, in order of evaluating the possibility of reuse those elements from the dredged sediments.

If the concentrations of these elements are significant and if a study of the evaluation of their extraction from the dredged sediments shows its reuse to be economically advantageous, it may be possible to reduce the costs inherent of dredging processes which are always very high.

6.4 Dredge disposal site monitoring approaches

6.4.1 Introduction

Birgit Schubert attended the Dredging in Europe (DGE) meeting "Special session on monitoring of aquatic deposit sites for dredged material – Consideration of the requirements of international regulations and practical implementation" on 20 February 2018.

In summary, in terms of legislation, the Marine Strategic Framework Directive (MSFD) mentions dredge disposal activity in Annex 3, Table 2: Pressure and Impacts under physical loss (smothering) and physical damage (changes in siltation). It does not include specific requirements related to monitoring of deposit sites. No other EU directives address monitoring of disposal sites specifically. Nevertheless, as the EU regulations aim at achieving a good environmental status, they may influence the handling of dredged material. The non-deterioration principle or the request for improvement of water quality in the Water Framework Directive, for example, might have implications for dredge material disposal.

The Dredged Material Guidelines of OSPAR and HELCOM, however, stipulate monitoring at selected deposit sites and its surroundings. There is no obligation to monitor all deposit sites and monitoring results may be transferred to disposal activities with similar conditions.

DGE members agreed that the main objectives of monitoring are to check whether dredge material disposal complies with the license requirements, and whether the observed effects are within the predicted range. Furthermore, monitoring results may answer wider questions and improve the understanding of (natural) processes.

Some examples of monitoring programmes at disposal sites were presented. The projects varied greatly, from small projects depositing non-contaminated sediments to larger projects, depositing large volumes of contaminated dredged material. In addition, the characteristics of deposit sites varied greatly. There were disposal sites used in areas with high hydrodynamics, as well as an example of disposal of dredged material in gravel pits.

Usually, monitoring is restricted to selected disposal sites where problems are expected or when there is a change in the intensity of dredging activities. Furthermore, monitoring is mostly restricted to critical issues where effects are expected or have to be excluded. The monitoring issues are often derived from an environmental impact assessment.

For some projects, there was no obligation to monitor. However for other projects, requirements on monitoring were fixed in the license.

The main elements of monitoring are baseline studies, compliance monitoring to check whether effects are within the expected ranges, monitoring of reference sites and monitoring at the disposal site and the surrounding area. Occasionally, results from sediment transport modelling sup-ported the design of the monitoring programme. There were also differences in the number of disposal sites monitored, as well as the frequency and extent of monitoring between the monitoring programmes of different countries. All projects had a baseline study in common, either including new investigations or based on existing knowledge. Sometimes monitoring was performed during the period when dredge disposal at the disposal sites was on-going, sometimes after disposal activity.

It is quite common to monitor bathymetry. Furthermore, sediment composition often is monitored. If contaminated dredged material is deposited, contamination at the disposal site and its surroundings usually is monitored. When fine dredged material is deposited, turbidity may be monitored, and measurements may be carried out during a disposal campaign. In some projects benthic communities or generally faunistic communities were investigated. If disposal sites are within or close to Natura 2000 areas or other protected areas, investigations are more comprehensive. There was some concern on the application of biotests in monitoring, as sometimes results for one sample analysed in two different laboratories strongly differed and made assessment difficult.

The most comprehensive monitoring programme presented had been performed for depositing of contaminated sediments at a site with lower contamination. Requirements for monitoring are included in the licence as well as some threshold values. Physical impacts only had to be monitored for non-contaminated dredged material in beneficial use schemes.

From the Italian presentation under ToR B(1) above, it was noted that if dredged material was classified as Grade B or above (i.e. all but the cleanest material), then post-disposal monitoring is required under Italian law. This would be site-specific depending upon the pressure(s).

6.4.2 Project studies

6.4.2.1 Presentation: How England monitors disposal sites

Jemma Lonsdale and Stefan Bolam Presented by Claire Mason. Originally presented at 24th DGE conference, Ministry of Environment and Food of Denmark, Copenhagen, 20 February

There are 246 disposal sites in England, of which 173 are open. Trials alongside monitoring requirements are completed when new disposal sites are created. A monitoring programme, dating back to the 1980s, aims to ensure environmental conditions at newly designated sites are suitable for the commencement of disposal activities, predictions concerning environmental impacts continue to be met and disposal operations conform with licence conditions. Generally, 5–6 sites are targeted for monitoring within any one year. They are selected based on the relative magnitude of the issues pertaining to the site, such as a significant increase in the quantity of material dis-posed; the material to be disposed is a very different sediment type to that of the receiving environment; and/or there is the potential for the occurrence of elevated contaminant concentrations. A wide range of parameters are measured, dependant on the specific issues being assessed, taking into account the site variability with respect to their physical setting, their disposal regime and the nature of their issues. Results from survey work contribute directly to the licensing pro-cess by ensuring that any evidence of unacceptable changes or practices is rapidly communicated to the Marine Management Organisation (MMO). Dissemination of results occurs by an annual project report (downloadable from the www.Defra.gov.uk website); direct communication with the MMO; and through peer-review publications on site-specific or non-site-specific impacts.

6.4.2.2 Belgium disposal site monitoring approach

Bavo De Witte - Belgium

The Belgian part of the North Sea currently has 5 dredge disposal sites, but this number may increase in the near future since studies are ongoing to add new disposal sites or change location of existing dredge disposal sites.

The monitoring program consist of 3 parts, including: (1) physico-chemical follow-up of the disposal site; (2) biological follow-up and (3) study on the dispersion of suspended matter. For the physico-chemical and biological measurements, analysis are done routinely following a BACI-design (Before – After – Control – Impact). Physico-chemical parameters are measured on a yearly basis on each sludge disposal site on sediment samples, while chemical contaminants are measured in biota samples (swimming crab, shrimp, starfish), twice a year. The biodiversity is measured based on the BEQI (Benthic ecosystem quality index). Macrobenthos and epibenthos/demersal fish samples are taken on a yearly basis for sludge disposal sites which are intensively used, while less intensively used sludge disposal sites are monitored each 3 years.

Additional studies are incorporated in the monitoring of sludge disposal sites. This may be related to e.g. the search for new sludge disposal site locations, the occurrence of emerging contaminants, the use of new monitoring techniques such as sediment profile imaging, etc. Reporting is related to a 5-year cycle, with a larger synthesis report at the end of the cycle, an intermediate progress report at 2.5 years and smaller progress reports that are written on a half-year basis. Synthesis and intermediate progress reports are sent to the Minister who has the North Sea under his/her competences.

6.5 Sediment Quality Guidelines

6.5.1 Introduction

Sediment quality guidelines are used to assess the state of the marine environment. For sediments, there are two types of assessment criteria used by OSPAR: Background Assessment Concentrations (BACs) and Environmental Assessment Criteria (EACs). However, BACs and EACs are only available for a limited suite of contaminants. There are no existing criteria for some priority substances, e.g. PBDEs, hexabromocyclododecanes (HBCDs or sometimes abbreviated HBCDDs); dioxins (PCDD/Fs) and dioxin-like PCBs; and PFOS and other polyfluorinated alkyl substances (PFAS)) for use in Marine Strategy Framework Directive (MSFD) and OSPAR status assessments.

6.5.1.1 BC values for PAHs in marine sediments in the Atlantic coast of Spain

Lucia Viñas (IEO, ES)

Five areas in the Atlantic Spanish coast were sampled (including the Gulf of Cadiz), where sediment cores were collected to study their PAHs concentration. The analytical procedure involved pressurized liquid extraction (PLE) and gas chromatography coupled to mass spectrometry (GC/MS). The results obtained for the deepest layers of the cores provided adequate values to calculate BC. These values were determined, following ICES/WGMS 2005 Report, as the median value of the median concentrations from each of the five areas.

As a conclusion, 35 new BC values for 22 parental PAHs and 13 alkylated PAHs were presented that can be useful to improve environmental assessment criteria and that will be published in the next few months. A PhD on BC values for parent and alkylated PAHs in sediments for the Atlantic Spanish coast has been presented recently.

6.5.1.2 BC values for PAHs in marine sediments from Norwegian marine areas in the Norwegian and the Barents Sea

Stepan Boitsov (IMR, NOR)

Geochemical studies of 174 sediment cores collected by the MAREANO mapping program in Norwegian waters of the North Atlantic Ocean give new sets of values of background concentrations (BCs) for polycyclic aromatic hydrocarbons (PAHs) for the studied regions. The study is based on deep core sediment samples representing background levels of PAHs. The samples selected were only from the deeper parts of undisturbed sediment cores with low, stable concentrations of petrogenic and pyrogenic PAHs, with low variation for individual PAH compounds between the samples within the same core, and from below the parts of the cores dated with ^{210}Pb to approximately the last 100–150 years. The results show that the main part of the studied area has BCs different from those previously established by OSPAR Commission (OSPAR) for the North-East Atlantic. Another area in central Barents Sea has a separate set of BCs of pyrogenic PAHs, apparently due to the influence from marginal ice zone mechanisms. A third area with its own set of BCs has been established for north-western Barents Sea off the coast of Svalbard, due to high natural contents of PAHs in this area. BCs for several PAHs not included in the present OSPAR list are also provided.

6.5.2 Conclusions

The work of Pérez-Fernández *et al.*, 2019 and Boitsov *et al.*, 2020 was presented at OSPAR MIME in November 2021. MIME was invited to take knowledge of the proposed BC-values, evaluate whether they are appropriate for application in (a part of) the OSPAR area and, if deemed appropriate, recommend the BCs for adoption by HASEC.

In view of the deadlines posed by the QSR2023, the application of these BC-values could not be done, as that would make the QSR run out of time. Portugal will also make available, in the first half of 2022, new data on deep cores, so in future these could be used for the Iberian Coast. For the Norwegian coast, they could also be implemented. For OSPAR Region I, the effect is difficult to assess, as there are currently no data.

6.6 Combined Future plans for Sediment Quality Guidelines

Sediment toxicity tests for use in dredge sediment assessments and Environmental quality standard (EQS) derivation is planned as joint work with WGBEC, as well as use of passive sampling in dredge material assessment and dredge disposal site monitoring (and derivation of EQSs).

Further work is required under dredging activities:

- How management apply ALs – different approaches notes (1 out, all out), weight of evidence, 3 exceedances before stop dredging), etc.
- Use of ecotox testing and derivation of EQSs – joint work with WGBEC (and SedNet Sediment Quality) – include looking at mixtures, and also how Action Level 2 thresholds are derived.
- Use of passive sampling in dredge material assessment, including effects on water quality caused by resuspension of sediment by different dredging methods and dredge disposal site monitoring (and derivation of EQSs) (linked with ToR b)
- Use of modelling to determine regional thresholds
- Laboratory analysis – problems with different analytical methods/laboratories not attaining equable detection limits. If <detection limit, then detection limit should be used, not zero. Link to Limit of Quantification (LOQ) and including measurement uncertainty with data submitted.
- Harmonisation – has been tried before and tricky but awareness of differences at least a start.
- Review how biological effects is assessed as part of disposal site monitoring assessments – joint work with WGBEC

7 Nutrients and Chlorophylls

MCWG reviewed techniques for the analysis of discrete water samples for nutrient analysis. Molecular Absorption Spectrometry, associated to Continuous flow analysis techniques, remains the standard method for (in-lab) nutrient analysis with no major advances identified in recent years. Marine Scotland Science (MSS) and RBINS reported the use of fluorometric method for the analysis of Ammonia. MSS analyse seawater samples on a SEAL Analytical QuAAtro coupled to a Jasco FP2020 fluorometer. The method is based on the reaction of ammonia with orthophtaldialdehyde (OPA) and sulphite in the presence of borate buffer to form a fluorescent species. The fluorescence is measured at 460 nm following excitation at 370 nm and quantified using standard solutions. RBINS follows broadly the same procedure, but measures the fluorescence at 425 nm and uses a Skalar auto-analyzer with SA6310 Fluorometer.

Field measurements of nutrients in the marine environment are increasingly being used as a means to obtain continuous near-real time data, monitor daily processes, trends and events. Currently, sensors for nitrate and phosphate are available which cover concentration ranges for both estuarine and open seawater regions. However, there are concerns as to their susceptibility to biofouling affecting long-term accuracy and precision. ICES DOME does not accept nutrient sensor data.

Eutrophication is still a problem in the ICES area, in spite of existing legislation like the US Clean Water Act or EU WFD and MSFD. A recent assessment (EAA, 2019, https://www.eea.europa.eu/highlights/eutrophication-remains-a-major-problem) shows that eutrophication still remains a large scale problem in some of Europe’s marine areas, particularly in estuarine and coastal areas, although some signs of improvement have been identified.

Recent improvements in techniques allow better QA for low values. Sampling and its associated uncertainty has also been the subject of recent developments, with impacts currently being felt mostly by accredited laboratories. With the publication of ISO/IEC 17025:2017 (ISO, 2017) the estimate of the total uncertainty must incorporate the uncertainty arising from sampling, and several studies point out that this uncertainty component can be the main contribution to the total uncertainty (e.g., Borges *et al.* 2019, Botta *et al.* 2012). Although several techniques are available to estimate the uncertainty arising from sampling (Ramsey *et al.,* 2019), their application to the marine environment may not be adequate since they not consider the natural heterogeneity of these systems or the error arising from positioning (Borges, 2019) and may overestimate the uncertainty associated to measurement. The use of modelling strategies, such as Kriging Interpolation or the Monte Carlo Method, have proven to be useful in the definition of sampling strategies and optimization of sampling uncertainty in the marine environment (Nelson and Grubesica, 2017, Borges *et al.,* 2021).

Joakim Ahlgren noted that the interaction of humic acids on measured concentrations is to be discussed in the upcoming meetings, as they are important in certain water bodies like the Baltic Sea. Another analytical challenge is posed by turbidity, mainly in coastal waters, and the effect they have on the measurements. Additionally, the centrifugation of water samples instead of filtration is by far superior for detection of volatile compounds like ammonia.

MCWG also reviewed the information regarding chlorophyll analysis and produced a new document that was presented to ICES to be published as a new TIMES paper. The paper acknowledges that spectrometric methods are still the most common but other alternatives are becoming increasingly used. Among these are the detection by remote sensing devices such as satellites or the use of in situ sensors, like field fluorometers.

While field fluorometers have the advantage of being able to provide measurements at a high rate, the effect of biofouling for long term deployment of these instruments is still an issue that needs some attention and frequent maintenance is advisable; as for remote sensing using satellites, although it allows the coverage of large areas of the sea, cloud coverage and need of daylight, as well as the depth penetration capability are still limiting factors.

7.1 Project studies

7.1.1 AQUIMAR and AQUASADO projects

Carlos Borges -Portugal

AQUIMAR and AQUASADO are two monitoring projects that intend to establish good environmental conditions to the establishment of aquaculture infrastructures in Portuguese oceanic and estuarine waters. Both of these projects are interdisciplinary and includes knowledge from different fields of marine science, e.g., physical and chemical oceanography, biology and sedimentary dynamics. The first of these projects, AQUIMAR, main goal is to define the most suitable areas in the Portuguese coast to set aquaculture and to establish the best species (fish and/mollusc) to be grown in each area and to which amount, while promoting good environmental status; the second one, dedicated exclusively to the Sado estuary, is more focused on defining the necessary conditions for the promotion of the sustainable production of molluscs, particularly the oyster *Crassostrea angulata*.

Preliminary results were presented for AQUASADO project, showing that, although it exhibits the general behaviour of an estuarine system in terms of several chemical parameters, like nutrients, chlorophyll and oxygen, a shift of about 1 month in the phytoplankton bloom was identified, when the data collected was compared with historical data obtained since mid-1980s to 2010.

7.2 Future plans

Continue to review and analyse QUASIMEME assessment of chlorophyll data, in particular, regarding comparability of data and potential implications for existing measurement guidance.

Update and summarise on recent advances in nutrient analysis technique and observed nutrients trends in the marine environment - Determining potential influence of SPM and humic substances on nutrient analysis.

Follow-up on the outcome of relevant projects, like NewSTHEPS, and getting the full feedback of the outcome. This project focused on CECs and their detectability by both traditional spot sampling and passive sampling with different materials used as a sorbent.

8 Ocean Acidification

Problems with the use of mercuric chloride as a biocide in the standard procedure for preservation of samples for Total Alkalinity (TA) and Dissolved Inorganic Carbon (DIC) analysis (Dickson *et al.*, 2007) were evaluated. The main issue identified with alternatives is the alteration of alkalinity within the sample. In regions where use of mercuric chloride is banned, storage of samples is not recommended and samples should be analysed at sea or as soon after collection as possible. Recently, QUASIMEME offered a proficiency testing round for DIC and TA, with samples stabilised by autoclaving (and so avoiding toxic chemicals from being in-troduced in the samples) for evaluation by the participants. Outcomes of this approach to sample preservation will be evaluated by the Group.

9 International, national and regional activities with relevance to contaminants in biota

9.1 Trophic Magnification Factors

OSPAR OMMEG is leading the development of threshold levels of polychlorinated biphenyls (PCBs) in marine mammals as a candidate indicator. The Netherlands supplied a report on a study carried out on contaminants on seabird eggs. IFREMER is currently conducting a project (EMERTROPH) on the determination of trophic magnification factors (TMFs) in European seabass (*Dicentrarchus labrax*) and common sole (*Solea solea*) trophic networks (from zooplankton to fish) in the English Channel. The target contaminants are PFASs (long chain PFCAs in particular) and alternative Brominated Flame Retardants (a-BFRs); CB-153 will be investigated as a benchmark. Enrichment of stable isotopes ($\delta^{13}C$ and $\delta^{15}N$) will be determined as well. Results are expected to be available in two years.

Recent information on trophic magnification in a freshwater system, presented by Foppe Smedes, pointed out that higher trophic level (TL), typically TL4, is more or less in equilibrium with the surrounding environment, and that the lower TLs are actually "diluting" the contaminants (especially the hydrophobic compounds) because the production of fresh organic material is much faster than the uptake rate of these compounds, suggesting a completely new approach with regard to TMF (Smedes *et al.*, 2020). In addition, the magnification in higher levels tends to lower as a function of time to reach equilibrium with the environment.

9.2 Contaminants and biotoxins in seafood

Reviewing emerging issues, and international and national regulations related to contaminants and biotoxins in seafood. Information on contaminants and toxins in seafood and algae was compiled, including input from 19 out of 20 ICES countries. A sub-group started have produced a draft writing a review paper on this topic. The publication will focuses on national and regional difference in legislation, focused on (1) contaminants in seafood, (2) contaminants in algae and (3) toxins.

9.3 Future plans

i. Continue the collection of national and regional-level information concerned with contaminants in biota, including seafood.
ii. Publish review on national and regional difference in legislation for contaminants, including biotoxins, in seafood and algae.

10 Conclusions

The workplan of MCWG and WGMS, as a merged Working Group, is ambitious, and the ToRs cover a wide range of topics. The Expert Group tries to cover the diversity within the field of marine chemistry by attracting new people, in or outside the ICES community, through personal contact, e.g. inviting as co-author in proposed publications, collaboration with other Expert Groups (like WGBEC, WGML, WGSHIP), by consulting the ICES SCICOM through the HAPISG Chair, or using the broad network of the participants. Furthermore, the MCWG will continue the work done for OSPAR and ICES with regard to requests of the Data Center, informing and advising on recent achievements in R&D, and what the implications can be for the Data Center, (as well as receiving information on how to search ICES Data), reviewing OSPAR guidelines to make sure they are up-to-date.

During the last years, people volunteered to specifically address a ToR and gather relevant information and build a network to increase progress and divert the workload from the Chairs. As such, the group was able to publish several TIMES papers and Viewpoints, and has a clear way forward leading to more publications and to keep up with the interesting developments taking place in the diverse fields that are constituting the world of Marine Chemistry. The new ToRs for another 3-years term are an illustration of the group's ambition.

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Annex 2: Resolutions

Marine Chemistry Working Group (MCWG)

2018/MA2/HAPISG05 The **Working Group on Marine Chemistry** (MCWG), chaired by Koen Parmentier, Belgium, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	4–8 March	Evora, Portugal		Meeting in association with WG on Marine Sediments (WGMS)
Year 2020	2–6 March	Lisbon, Portugal		Joint meeting with WGMS and WGBEC
Year 2021	1–5 March; 15–19 March	Online meeting	Final report (joint with MCWG) by 15 April to SCICOM	WGMS and MCWG combine to form one Expert Group as of 2022

ToR descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
a	Assemble and synthesise new information on chemical substances of emerging concern in ICES area and beyond, including residuals in higher trophic level marine species.	Provide new data – link to WGBEC- Eco-toxicology and analytical methods – sampling, extraction, detection, issues, Quality Assurance (QA/QC). Check of EU Water Framework Directive (WFD) watch list and identify substances because of increasing international awareness. This includes toxins from algae blooms.	2.1; 4.1; 6.1	3 years	Reporting to ICES, including: - synthesizing new evidence, - identification of gaps, - emphasis on concern for monitoring, - non-target screening, especially for endocrine disruptors.
b	Develop novel monitoring strategy for compliance and screening tools.	The use of passive samplers (PS) increases, and sensors are in use e.g. in Ferrybox systems, and The EU GRACE project has generated comparison and validation data regarding in situ fluorescence detection of dissolved oil.	3.1; 3.3; 6.1	3 years	Reporting to ICES on use and development of PS (compliance monitoring in relation to Environmental Quality Standards (EQS)). Collect QA/QC and validation for in-situ sensors, (incl. oil, pH, CO_2 and nutrients) and screening methods.
c	Report new developments in	Availability of high quality proficiency	3.1; 3.3	3 years	Reporting to ICES:

	QUASIMEME (Quality Assurance of Information on Marine Environmental Monitoring), and provide information on other proficiency testing schemes with relevance to MCWG.	testing is vital to produce reliable results.			- provide guidance for proficiency testing, - development of test materials for new compounds.
d	Review and report of availability of new data, analytical methods and QA/QC on Ocean Acidification (OA) in coastal/shelf seas and establish link with eutrophication.	OA and understanding its importance, quantification of its impact is crucial for a variety of scientific disciplines, and for ocean health. OA is a voluntary paremeter in OSPAR CEMP but developments in QC supports are required.	1.2; 2.1; 3.2; 4.1, 6.1	3 years	Reporting to ICES: - technical guidance document on sampling, sample handling and storage, - preparation of in-house reference material for testing and validation.
e	Review and analyse QUASIMEME assessment of chlorophyll data, in particular, regarding comparability of data and potential implications for existing measurement guidance.	Solve problems for data comparability that exist for decades concerning chlorophyll measurements.	1.3; 2.1	Year 1	Publication in TIMES: manuscript on chlorophyll determination methods.
f	Review emerging issues, and international and national regulations related to contaminants and biotxons in seafood.	Seafood is an important dietary source of many contamminants. Several EQS are derived from human health risks. Although this is not ideal for marine environmental monitoring, follow-up is imperative.	2.1; 5.6; 6.1; 6.3	3 years	Reporting to ICES: - reference document on food and feed regulations, - overview on biotoxins, - monitoring emerging issues with respect to contaminants in seafood.
g	Review of the evidence of of man-made structures (such as platforms, wind farms, buoys, pipelines, cables and ship wrecks) and shipping (such as exhaust gases, spills and scrubbles) on the marine environment as a source of chemical pollution.	Amount of constructions is ever increasing. Some protective compounds used are new to the marine environment. Application is directly into the marine systems and requires follow-up and identification of knowledge gaps.	2.1; 4.5; 6.1	3 years	Review manuscript
h	Summarise and synthesise relevant information from relevant ICES expert groups on the interface with MCWG: WGMS, WGBEC, WGEEL,	MCWG is active in trying to interconnect different WGs. The intention is to have joint meetings with WGMS, there is a direct link	2.2; 2.5; 4.1	3 years	Publication in TIMES, contributing to WGMS dredge spoil report.

	JWGBird, WGOH, WGPME, WGML.	concerning dredging activities.			
i	Review and report developments in international legislative acts (incl. Marine Strategy Framework Directive (MSFD) and WFD), in particular regarding emerging and high-priority hazardous substances and associated EQS values, conversion factors and other closely related issues.	Follow-up on this matter is key in order to guide the development process for consistent application of environmental quality criteria in monitoring prgrammes. Follow-up on JRC list of chemicals that are being monitored by different countries.	3.2; 6.1	3 years, on a year by year basis.	Reporting to ICES: - setting EQS or Environmental Assessment Criteria (EAC) and conversion factors, - review manusript on emerging contaminants and risks involved.
j	Collect regional-level information to determine Trophic Magnification Factor (TMF) and Trophic Level (TL)	The use of generic TMF and TL, as required by MSFD to calculate concentrations to compare with EQS_{biota} gives rise to unacceptable inflation of uncertainty.	2.1; 6.1; 6.3	3 years	Reporting to ICES: overview of region-specific TMF, TL for target organisms and determination of highest TL.
k	Update and summarise on recent advances in nutrient analysis technique and observed nutrients trends in the marine environment.	Eutrophication reductive measures need to be followed; recent improves in techniques allow better QA for low values.	1.2; 1.3; 2.1; 3.3	3 years	Reporting to ICES
l	Respond to potentially incoming advisory requests	Science or advisory requirements.	3.1; 6.1; 6.5; 6.6	3 years, on a year by year basis.	Advice products, as appropriate

Summary of the Work Plan

Year 1	Complete ToR e). Respond to requests under ToRs i), l). Progress work towards completion of the remaining ToRs.
Year 2	Respond to requests under ToRs i), l). Progress work towards completion of the remaining ToRs.
Year 3	Respond to requests under ToRs i), l). Report on the remaining ToRs.

Supporting information

Priority	This group maintains an overview of key issues in relation to marine chemistry, both with regard to chemical oceanography and contaminants. MCWG provides input across the field of marine chemistry, which underpins the advice given by ICES, and also supports the work of national and international collaborative monitoring programmes, e.g. within OSPAR.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 15-20 members and guests.
Secretariat facilities	Participation using electronic means should be examined and encouraged.
Financial	No financial implications.

Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	WGMS (the aim is to have joint meetings), WGBEC, WGML. OSPAR ICG-OA, from 2019 on (first meeting Jan 2019, Aberdeeen, UK) replacing the OSPAR/ICES study group on Ocean Acidification (SGOA) ICES Data Centre
Linkages to other organizations	The work of this group is closely aligned with EU working groups under the Water Framework Directive (e.g. Working Group on Chemicals) and EU expert networks with regard to contaminants under the MSFD. Specific agenda points will be directly relevant for QUASIMEME. The group provides the basis for some advice to OSPAR.

Working Group on Marine Sediment (WGMS)

2017/MA2/HAPISG01 The **Working Group on Marine Sediments with respect to pollution** (WGMS), chaired by Claire Mason, UK, and Maria Belzunce, Spain, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2018	5–9 March	San Pedro del Pinatar, Murcia, Spain	Interim report by 1 June	
Year 2019	4–8 March	Évora, Portugal		Change in Chairs Outgoing: Craig Robinson, UK Incoming: Claire Mason, UK
Year 2020	2–6 March	Lisbon, Portugal	Final report by 15 April (suspended following decision to combine with MCWG)	Joint meeting with MCWG and WGBEC
Year 2021	1–5 March; 15–19 March	Online meeting	Final report (joint with MCWG) by 15 April to SCICOM	WGMS and MCWG combine to form one Expert Group as of 2022

ToR descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
A	Respond to potential requests for advice as required.		2.1; 2.2	3 years	Advice
B	Dredging activities 1) Review the regulated substances and thresholds used in management of dredging activities 2) Review and recommend monitoring approaches to disposal sites	A major source of contaminants in marine sediments, the substances considered, their thresholds and management approaches are different in each country.	2.1; 6.1 2.1; 3.1; 6.4	3 years 3 years	Review document & recommendation, if required Review document & recommendation, if required

C	Sediment Quality Guidelines Review recent publications that may contain data to refine existing sediment assessment criteria	More data may be available to refine existing BACs / EACs; there are no existing criteria for some prioirity substances (e.g. PBDEs) for use in MSFD / OSPAR status assesments.	2.1; 3.2; 6.1	3 years	Annual updates and final report.
D	Plastic litter: To assess the relevance and the potential risk impact of (micro-) plastics in sediments and follow up of outcomes of other expert groups	(Micro-)plastics are included in MSFD Descriptor 10, are of emerging concern and can be a vector for contaminant transfer to sediments, or from sediments to biota	2.1; 2.2; 2.5	3 years	Annual updates and final report.
E	Emerging issues 1. To review and inform on the occurrence of substances of emerging concern in sediments, including platinum group and rare earth elements, as well as organic contaminants 2. To consider other forms of pollution, e.g. microbiological	Sediments are a sink for many of these pollutants, but may also be a source.	2.1; 4.5 2.1; 2.2	3 years	Annual updates and final report.
F	Impact of renewable energy devices To explore the potential risk impact in terms of inputs (corrosion, anti-corrosion agents…) and release of contaminants due to sediment scouring	Changes in hydrodynamics may release sediment-bound contaminants; there may be inputs of contaminants during installation, operation and decommissioning. This is under active research by a member of the group.	2.1; 2.2; 2.7	3 years	Report (with recommendations, as appropriate)
G	Passive sampling 1) To publish guidelines on passive sampling of sediments	Documents are in advanced drafts and will be completed	2.3; 3.3; 4.4; 6.1	1 year	Two ICES TIMES papers
	2) To publish a review on passive sampling techniques	A review document is at an advanced stage of drafting and will be completed	2.3; 3.3; 4.4; 6.1	1 year	Cooperative Research Report
	3) Review and update on developments	Passive sampling is an advancing area of research that could improve on existing monitoring techniques	2.3; 3.3; 4.4; 6.1	3 years	Annual updates and final report.
	4) continue to develop a database to provide information of use in developing assessment criteria for passive sampling techniques		2.3; 2.5; 3.2; 6.1	3 years	Dataset and advice to OSPAR on progress

H	Coordinate with MCWG members to form one group (merge WGMS and MCWG into new Expert Group)	WGMS and MCWG to combine into one expert group and produce a joint final report in 2021. Members to decide name, and future ToRs for next term 2022-2024.	1 year	Resolution proposing new Expert Group with associated ToRs for next 3 years.

Summary of the Work Plan

Year 1	Completion of the different draft documents on Passive Sampling (PS) and submission as two ICES TIMES papers (Guidelines on PS in sedimens) and one Cooperative Research Report on the techniques for passive sampling of marine sedments. Progress work towards completion of the remaining ToRs.
Year 2	Progress work towards completion of the remaining ToRs.
Year 3	Final Report (suspended as now combining with MCWG). Continued work towards completion of all the ToRs.
Year 4	Final Report jointly with MCWG.

Supporting information

Priority	This Group handles key issues regarding monitoring and assessment of contaminants in sediments. The current activities of this Group will lead ICES into issues related to the understanding of the relationship between human activties and marine ecosystems (estimation of pressure and impact, …). Consequently, these activities are considered to have a high priority.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 10-15 members and guests.
Secretariat facilities	The normal secretarial support to an ICES Expert Group is required.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There are close working relationships with Marine Chemistry Working Group (MCWG) and Working Group on Biological Effects of Contaminants (WGBEC); some members of WGMS are also members of these. The work of WGMS is also relevant to the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) and to the OSPAR Intersessional Correspondence Group on Marine Litter (ICG ML).
Linkages to other organizations	OSPAR, HELCOM, MEDPOL, EU/JRC Expert Network on Contaminants.

MCWG and WGMS ToR alignment

MCWG ToR	WGMS ToR
a. Assemble and synthesise new information on chemical substances of emerging concern in ICES area and beyond, including residuals in higher trophic level marine species.	e. Emerging issues 1. To review and inform on the occurrence of contaminants of emerging concern (CEC) in sediments, including platinum group and rare earth elements, as well as organic contaminants 2. To consider other forms of pollution, e.g. microbiological (not addressed).
b. Develop novel monitoring strategy for compliance and screening tools.	g. Passive sampling 1) To publish guidelines on passive sampling of sediments 2) To publish a review on passive sampling techniques 3) Review and update on developments 4) continue to develop a database to provide information of use in developing assessment criteria for passive sampling techniques
c. Report new developments in QUASIMEME (Quality Assurance of Information on Marine Environmental Monitoring), and provide information on other proficiency testing schemes with relevance to MCWG.	-
d. Review and report of availability of new data, analytical methods and QA/QC on Ocean Acidification (OA) in coastal/shelf seas and establish link with eutrophication.	-
e. Review and analyse QUASIMEME assessment of chlorophyll data, in particular, regarding comparability of data and potential implications for existing measurement guidance.	-
f. Review emerging issues, and international and national regulations related to contaminants and biotoxins in seafood.	-
g. Review of the evidence of man-made structures (such as platforms, wind farms, buoys, pipelines, cables and ship wrecks) and shipping (such as exhaust gases, spills and scrubbers) on the marine environment as a source of chemical pollution.	f. Impact of renewable energy devices To explore the potential risk impact in terms of inputs (corrosion, anti-corrosion agents…) and release of contaminants due
h. Summarise and synthesise relevant information from relevant ICES expert groups on the interface with MCWG: WGMS, WGBEC, WGEEL, JWGBIRD, WGOH, WGPME, WGML.	d. Plastic litter: To assess the relevance and the potential risk impact of (micro-) plastics in sediments and follow up of outcomes of other expert groups

i. Review and report developments in international legislative acts (incl. Marine Strategy Framework Directive (MSFD) and WFD), in particular regarding emerging and high-priority hazardous substances and associated EQS values, conversion factors and other closely related issues.	b. Dredging activities 1) Review the regulated substances and thresholds used in management of dredging activities 2) Review and recommend monitoring approaches to disposal sites c. Sediment Quality Guidelines Review recent publications that may contain data to refine existing sediment assessment criteria
j. Collect regional-level information to determine Trophic Magnification Factor (TMF) and Trophic Level (TL) b	-