OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

Trial application of the OSPAR JAMP Integrated Guidelines for the Integrated Monitoring and Assessment of Contaminants

Hazardous Substances and Eutrophication Series

2016

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l'Allemagne, la Belgique, le Danemark, l’Espagne, la Finlande, la France, l’Irlande, l’Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d’Irlande du Nord, la Suède, la Suisse et l’Union européenne.

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Table A: Summary of biological effects application by Contracting Parties

SGIMC, Study Group for Integrated Monitoring of Contaminants

* CORESET data already submitted to the ICES format 3.2, but not regularly and only partially

** Only PAH metabolites already submitted to the ICES format

*** all data already submitted to the ICES format 3.2

Contracting Parties	**Biological effects application**	**Data identified for the trial application**	**Simplified ICES process for dataset submission**	**Integrated guidelines application (SGIMC)**
United Kingdom	Yes Imposex, MN, liver histopathology, EROD, PAH metabolites, LMS, imposex/intersex fish disease	Yes	Yes*	Yes
Ireland	Yes Imposex	Yes	Yes***	No
Norway	Yes Imposex, PAH metabolite, EROD, CYP1A, ALA-D	Yes	Yes*	Yes
France	Yes Comet, MN, LMS, EROD, AChE, Fish disease, oyster embryotoxicity, intersex, Imposex	Yes	Yes*	Yes
Spain	Yes LMS, AChE, SFG, MN, PAH metabolites, sea urchin embryo	Yes	Yes***	Yes
Sweden	Yes EROD, catalase, GST, GR (glutathione reductase), DNA adducts and MT for some years, vitellogenin Reproductive success	Yes	Yes	Yes
Netherland	Yes Imposex, PAH metabolites, fish disease	No	No***	No
Germany	No Fish disease, PAH metabolites, imposex	No	No**	No

Contracting Parties	Biological effects application	Data identified for the trial application	Simplified ICES process for dataset submission	Integrated guidelines application (SGIMC)
Belgium	Yes EROD, fish disease	No	Yes	Yes
Denmark	No Imposex, reproductive success, PAH metabolites	No	Yes	Yes

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Introduction

The interest of Contracting Parties in operational effectiveness of biological effects monitoring was first demonstrated through the ICES-organised workshop in Bremerhaven in 1991 (Stebbing, 1991). Since then, Contracting Parties have put considerable effort and resources into inclusion of biological effects monitoring methods and the standardisation of monitoring techniques, partly through national experts in the ICES Working Group on Biological Effects of Contaminants (WGBEC).

In order to be coherent, the collection of data and the assessment integration must be based on a minimum number of biomarkers and contaminants analysed in biota (the same species, fish or mussel) and a minimum number of sediment bioassay measurements. An example of system coverage is presented in Figure 1.

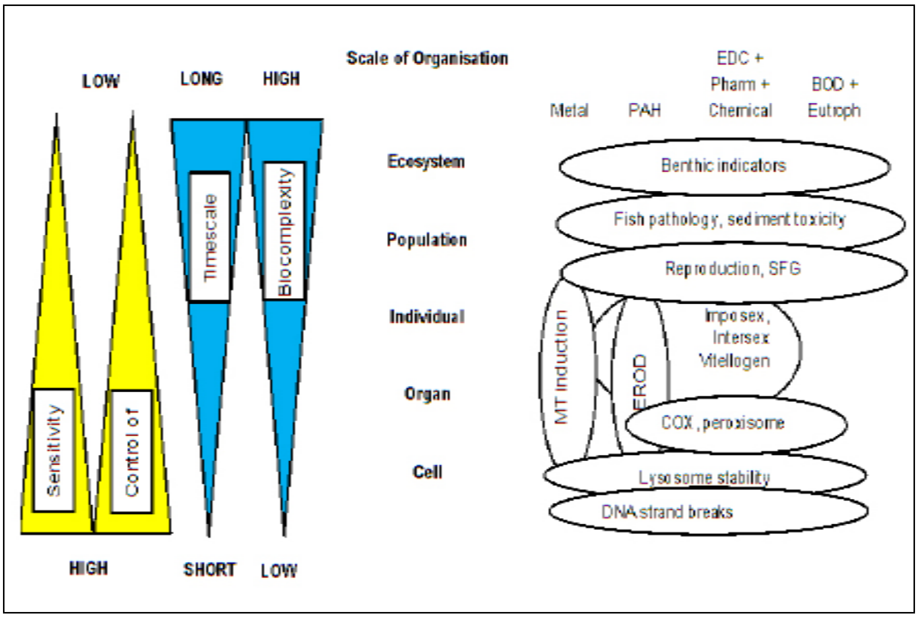

Figure 1: Example of coverage of system and contaminant spectrum by selected biomakers (Giltrap et al., 2014)[1]. The different scales of biological organisation illustrate why the CORESET requires multiple endpoints (SGIMC 2012).

Further to the expansive spectrum of measurements three requirements are essential for the incorporation into and in the implementation of appropriate methods within the CEMP CORESET of techniques, namely the:

- ongoing development of monitoring guidelines,
- availability of relevant quality assurance tools,

[1] Giltrap M., McHugh B., Ronan J. 2014. Biological effects and chemical measurements in Irish Marine Waters. Marine Research Sub-Programme (2007-2013). 108 pp.

- development of appropriate assessment tools.

It is now clear that for a wide range of relevant biological effects techniques that each of these elements have been sufficiently developed or facilitated by WGBEC. Guidelines are published in the ICES TIMES Series, a biological effect quality assurance programme BEQUALM has been established and assessment criteria (BAC/EAC) have been developed for a recommended techniques. The development of guidelines for the Integrated Monitoring and Assessment of Contaminants and Biological Effects by the ICES/OSPAR Study Group for Integrated Monitoring of Contaminants (SGIMC) can therefore be applied to integrate existing datasets.

As noted above, MIME 2014 reviewed the extent of data currently reported to the ICES database and concluded that insufficient data was available to make a full integrated assessment of contaminants and biological effects. It became clear that several datasets from Contracting Parties had yet to be reported to the database despite repeated requests from ICES, WGBEC, MIME and the Chair. Several reasons were presented as being instrumental in the non-reporting of data, some relevant ones being:

- The submission process is arduous/complicated and costly,
- National/local datasets are not in the specified ICES format,
- Accompanying AQC information is not always readily available Data sets are not in the right format and if they do not have accompanying AQC then the data is unlikely to be used in assessments, therefore no data submissions are made,
- Some OSPAR contracting parties will not implement biological effects methods until AQC is in place, but without laboratories conducting the assays there is insufficient numbers of laboratories for joining the AQC scheme,
- No data are submitted since there are currently no assessments.

In order to further investigate the potential for progress, MIME2014 agreed that the integrated guidelines would be tested with whatever data could be made available by Contracting Parties between MIME 2014 and HASEC2015. To assist this process, a standardised excel template was provided to Contracting Parties and other experts (e.g. WGBEC) to facilitate data reporting for the purposes of this trial exercise. This simplified datasheet, with less stringent requirements, allowed the capture of biological effects data that was not previously available, the application of the integrated approach to that data and the presentation of it to HASEC 2015. MIME 2014 proposed the following steps to arrive at the final product:

(a) analyse short- and long-term datasets from local/national studies and apply BACs and EACs,

(b) conduct a simple assessment of the SGIMC approach to integrate biological effect and chemical data

For the MIME report 2015, newly available datasets from Spain and Sweden were subject to the integrated assessment procedure. A short-term local study was integrated (Figure 4), with biological effects and chemical contaminants analysed in mussels collected on the North Iberian coast, and a long-term time series was integrated with biological effects and chemical contaminants analysed in eelpout *Zoarces viviparus* sampled in Sweden*.* These two datasets complement the analyses of short- and long-term datasets from local/national studies.

This paper details activity completed to summarise the current status of available datasets and further trials the application of biological effects tools to assess pollution effects, in line with the Oslo and Paris Commission (OSPAR) recommended approach on integrated monitoring.

a) Analyse short- and long-term datasets from local/national studies and apply BACs and EACs

Despite repeated SGIMC recommendations (Davies *et al*., 2012)[2] to submit all available biological effect data to ICES, only partial datasets from some Contracting Parties have been submitted. A list of core biological effect techniques and bioassays was recommended by SGIMC, but the available data indicates that this advice was not totally taken up by all Contracting Parties, with only part of the core biomarkers and bioassays recommended by SGIMC being utilised by those Contracting Parties investing in biological effects. The selection by Contracting Parties was influenced by a number of factors including, available expertise, costs and the voluntary nature of the pre-CEMP elements. As a result, there is a highly diverse range of biological effects data available across the OSPAR region and the focus to develop certain aspects of core techniques has, to some extent, been lost. The local diversity of biomarkers and bioassays are also influenced by inherent biological responses, the physiology of the sentinel species, the typology of the sites and local scientific purposes. Because of a voluntary approach to the use of biological effects techniques during the pre-CEMP period, a variety of strategies and different suites of biomarkers and bioassays have often been utilised by Contracting Parties; this being based on the scientific question of concern requiring specific case studies or investigations of diffuse contamination events for either inshore or offshore environments.

In the past there have been good examples (e.g. imposex) of how the above issues can be addressed by moving methods from being voluntary pre-CEMP determinants to mandatory CEMP parameters. The example of imposex clearly demonstrates that harmonisation quickly follows when techniques are made mandatory. Increased flexibility in reporting commitments and increased uptake by Contracting Parties are also important steps to move the process forward

Several Contracting Parties expressed concern in relation to data transmissions and the complexity of the ICES format 3.2. This format requires specific expertise and time investment, which are not considered as a priority whilst biological effects are voluntary determinants. A simplification of the ICES format 3.2 during the initial phase of the integrated approach would allow for increased data submission. As recommended by MIME 2014, a simplified biological effects data reporting spreadsheet was populated by Contracting Parties in the period between November 2014 and January 2015 in order to obtain data (mussel, fish and sediment) for a “quick and dirty” assessment. Six countries: Ireland, Norway, Spain, Sweden, United Kingdom and France submitted data for use in this report using the simplified spreadsheet. The result was more efficient than during the three years of trial application, probably because of the simplified spreadsheet. The newly available, extended, dataset (for the MIME 2015) corresponded to 35 local and/or short-term studies from a

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[2] Davies, I.M., Gubbins, M., Hylland, K., Maes, T., Martínez-Gómez, C., Moffat, C., Burgeot, T., Thain, J. and Vethaak, D. 2012. Guidelines for the integrated monitoring and assessment of contaminants and their effects. IN: Davies, I.M. and Vethaak, A.D. (eds). Integrated marine environmental monitoring and their effects. ICES Cooperative Research Report No. 315: 5-16.

total of 29 stations sampled between 2003 and 2014. Spain sent new data for mussels collected in four stations (Vigo, Coruña, Arosa, Raxo) from 2007-2012 (Bellas *et al.,* 2014[3]) and Sweden sent a dataset for eelpout from two stations (Kvädöfjärden and Fjällbacka) from 2003 to 2014

The core set of determinants (Table 1) was proposed as the minimum list of determinants required to undertake an assessment using the integrated approach, reducing the core set to one or two methods would be impractical and reduce the value of the assessment. A study was done in France in bivalves (personal data) with the widely used Integrated Biomarker Response index (IBR) (Beliaeff and Burgeot, 2002[4], Devin et al., 2013[5]). Three to ten biomarkers are mathematically pertinent with IBR, but the core set of biological effects techniques of HELCOM and SGIMC recommends ten biomarkers (ICES 2012[6]). The majority of the studies applied between by the Contracting Parties integrated four to eight biomarkers and this strategy must be harmonised in future. To indicate this, IBR covariance is significantly reduced when the numbers of biomarkers increase. The covariance of 45% for four biomarkers is reduced to 24% with eight biomarkers.

Because the SGIMC recommendation (Davies and Vethaak, 2012) was produced only recently, long term time-series including biomarkers and chemical contaminants are more limited in number than short term studies.

[3] Bellas J., Albentosa M., Vidal-Liñán, Besada V., Franco M. Angeles, Fumega J ., González-Quijano, Lucìa Vinas 2014. Combined use of chemical biochemical and physiological variables in mussels for the assessment of marine pollution along the N-NW Spanish coast. Mar. Environ. Res. 96 : 105-117.

[4] Beliaeff B. and T. Burgeot, (2002). Integrated biomarker response (IBR) a useful graphical tool for ecological risk assessment. *Environmental Toxicology and Chemistry.*1316-1322.

[5] Devin S., T. Burgeot, L. Giambérini, Minguez L., S. Pain-Devin (2013). The integrated biomarker response revisited: optimisation to avoid misuse. *Environmental Sciences and Pollution Research.216:7685*

[6] ICES 2012. Report of the Working Group on Biological Effects of Contaminats (WGBEC). ICES CM 2012/SSGHIE:04, Ref ACOM, SCICOM. 12-16 March 2012, Porto, Portugal. 131pp.

Table 1: Core set of biological effects techniques used in the SGIMC Scheme (WGBEC 2012). The biomarker scope for growth was added to the SGIMC scheme (Davies and Vethaak, 2012).

Biological effects Techniques **OSPAR/ICES SGIMC scheme**
Biomarkers
PAH bile metabolite (Fish)
EROD (Fish)
VTG (Fish)
Intersex (Fish)
Fish disease
Micronuclei (Fish and mussel)
Comet (Fish and mussel)
AChE (Fish and mussel)
LMS (Fish and mussel)
SFG (mussel)
Bioassays
% mortality: sediment/Corophium and Arenicolma and water/copepod
% abnormality: water oyster, mussel embryo and sea urchin
% growth: water sea urchin embryo

Table 2: Core Biomarkers of exposure and effects, bioassays and core chemical contaminants received from the UK CPs (n= 28 stations). The number of individual measurements available for each technique/parameter at each station is reported (e.g. 8 measurements of metals in fish for the station HWOpenSeaS_fi02_2013)

		HWOpenSeaS_fi02_2013	UK HWOpenSeaS_fi02_2011	UK HWOpenSeaNE_fi02_2011	UK HWOpenSeaNE_fi02_2013	TyneTees_TTInter_fi03 (2011)	Tyne Tees TTInter_fi03_(2013)	Anglia_AnOpenSea_fi04 (2013)	Anglia_AnOpenSea_fi03 (2011)	IrishSea_IrSIntermediateE_fi02 (2012	IrishSea_IrSIntermediateE_fi02 (2010	IrishSea_IrSIntermediateE_fi04 (2010	UK IrSIntE_Fi04_(2012)	Outer Clyde Estuary	Inner Firth of Clyde	Montrose Bank	E Scotland coast - inshore	Wexford	Cork	Dublin	Shannon	Egersund Bank	Southern North Sea	Bressay Bank	Viking Bank	Tampen - Gullfaks	Tampen - Statfjord	Honfleur	Moulard	Farfond	Seine estuary	Fjällbacka	Kvadofjarden	Raxo 2010	Coruna 2010	Arosa	VIGO 2010
EXPOSURE	EROD		2	2		2			2	2	4		4	1	1	1	1	2	2	6	2										2						
	PAH metabolites													1	1	1	1	1		1	1	2	2	2	2	2	2			4	4	1	1				
	AChE	2			1		1											2	2	2	2							1	1		2			1	1	1	1
	NRR LMS													1	1		1											1	1								
	SFG																	1		1	1													1	1	1	1
	GST (candidates)																															1	1	1	1	1	1
	CAT (candidates)																															1	1				
EFFECTS	Comet													1	1		1														2						
	DNA adduct																					1	1	1	1	1	1										
	Micronuclei MN													1	1	1	1														1						
	Vitellogenin Vtg																															1	1				
	Intersex																														1						
	liver pathology															1																					
	Macroscopic liver neoplasm															1																					
	Imposex														1		1			1								1									
	Stress on stress													1	1		1	1	1	1	1							1	1								
	LSI													2	1	2	2					1	1	1	1	1	1										
	GSI													2	1	2	2																				
	Age													1	1	1	1																				
	Size													2	2	1	2					1	1	1	1	1	1										
	DR Luc																											1									
	% mortality polychaete (Arenicola marina)																	1	1		1																
	% mortality amphipod (Corophium volutator)																	1	1	1	1							1									
	% mortality arenicola																	1	1	1	1																
	% mortality corophium																		1	1	1																
	% abnormality oyster embryo																											1									
CONTAMINANTS	Metals (sediments)														8	8	8	7	7	6	7							8									
	TBT (sediments)														1																						
	PAH (sediments)													11	11	11	11		10	10								8									
	CBs (sediments)													9	9	9	9	7	7	7	7																
	OCs (sediments)																	3	3	3	3																
	Metals (fish)	8	4	4	4	4	4	3	4	4	4	4	4	14	12	16	14	3	3	3	3								7			7	7				
	PAH (fish not applicable)																					11				11	11										
	CBs (fish)	9	9	9	9	9	9	9		9	9	9	9	9	9	9	9														9	7	7				
	OCs (fish)																															4	4				
	Metals (mussels)													8	8	0	8	5	5	5	5							7	7					6	6	6	6
	TBT (mussels)																											1									
	PAH (mussels)													11	11		11	9	9	9								10	5					4	4	4	4
	CBs (mussels)													9	9		9	9	8	9	9							9	9					7	7	7	7
	OCs (mussels)																	4	4	4	4							3	2								
	Lipid	1	1	1	1	1	1	1		1	1	1	1	2	2	1	2														2						

According to the SGIMC recommendations for the comparison between stations, the same number and set (core) of biomarkers, bioassays and contaminants must be selected in the same species (mussels or fish). However, this summary shows that Contracting Parties select biological effect techniques from the SGIMC list according to their local expertise and affordability (Davies and Vethaak, 2012). EROD, PAH metabolites, LMS and MN are the most commonly analysed biomarkers and have been selected as candidate indicators by MIME previously (Table 2). A number of other biomarkers like SOS (Stress On Stress), AChE, DNA adducts and the comet assay are widely applied in different Contracting Parties. Specific biomarkers of genotoxicity are mainly applied in cases of diffuse and coastal contamination or around offshore platforms. The availability of data on chemical contaminants analysed in fish, mussels and sediment are also heterogeneous. Metals and CBs are the chemical determinants most regularly analysed in fish. Supporting parameters such as lipid content, LSI, GSI, sex size and age have also generally been made available.

a-1) Examples of integrated assessments with data collected in 2014 and 2015

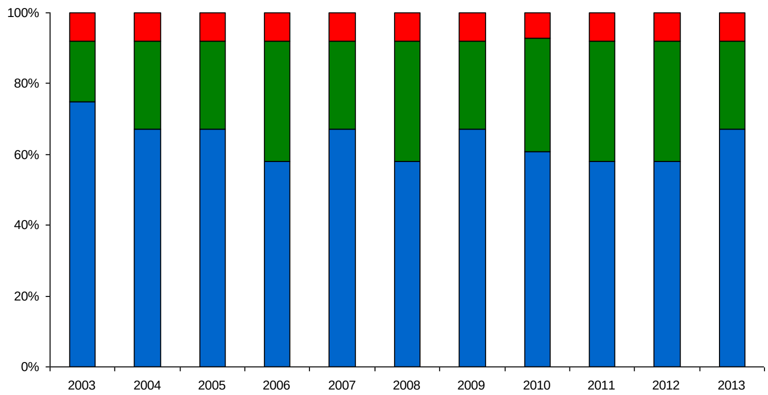
A set of biomarkers (15) and supporting parameters (LSI, GSI, size, age) were analysed in fish, mussel and gastropods (imposex). Data from 6 sediment bioassays were also reported.

Example (i) - integrated assessment of a short-term Spanish dataset

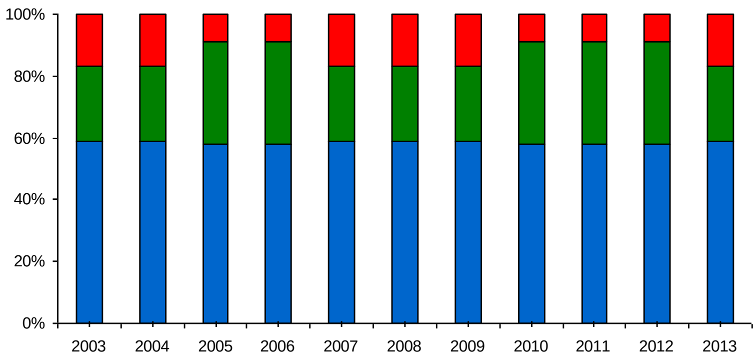
Spain submitted in 2014, a three-year study with only EROD data in fish and a five years study with SFG (already sent to the ICES database) in mussel in different stations, but this alone is insufficient data for an integrated analysis. Only the dataset of biological effects and contaminants sampled in mussels in 2010 and received in 2015 was used for the trial application (Figure 4).

Example (ii) - integrated assessment of a long-term Swedish dataset

Sweden submitted a new long-term (2003-2014) dataset, including a marker of exposure to planar organics (EROD activity), two markers of oxidative stress status (glutathione S-transferase, GST, and catalase, CAT) and a marker of oestrogenic exposure (vitellogenin, VTG) data in eelpout. Because of a lack of assessment criteria (EAC/BAC) for some biomarkers**,** candidates such as GST and CAT were not included in the core assessment. A long-term series from 2003 to 2013 with EROD and VTG analysis, three heavy metals and seven PCBs analysed in eelpout were used for the trial application (Figure 2). Here, the perch BAC for VTG was applied to eelpout in order to make value of the long-term time series. Two biomarkers (EROD and VTG) and two families of contaminants (Cd, Pb, Hg, and seven PCBs) analysed in eelpout were used for this trial application. The integration of three colour classifications of measurements of contaminants concentrations and their effects illustrate the annual variation in the proportion of results in each assessment class for two stations in Sweden (Kvädödfjärden and Fjällbacka) from 2003 to 2014. The annual assessment variation was mainly due to variability of the two biomarkers (EROD and VTG), with the highest variation being at Kvädödfjärden. The relevance of this exercise would be enhanced by adding the recommended CORE SET of biomarkers (SGIMC 2012) and also by developing assessment criteria (BAC/EAC) for candidate effects such as GST and CAT.



A: Fjällbacka



B: Kvädöfjärden

Figure 2: Integrated assessment of a long term time series analysed in eelpout from two Swedish monitoring stations A) Fjällbacka and B) Kvädöfjärden. The colours represent the proportion of determinants assessed as at background (blue), above background (green) and as exceeding environmental harm thresholds (red).

Example (iii) - Localised application of the Integrated Approach in two sentinel species (fish and mussels) to the Outer Clyde Estuary, UK.

As previously discussed, several Contracting Parties completed application of the SGIMC approach on a localised scale and, as a result, data availability (chemistry and biological effects) is highly heterogeneous (Table 2). The integrated approach can, however, still be applied, albeit with less certainty. Upon application of the integrated approach it is evident that the selection of the core biomarkers and chemical contaminants can differ between the species analysed. As a consequence of the BAC and EAC application, differences in bioaccumulation, exposure biomarkers and effects biomarkers can be observed between fish and mussels from the same station (see example for Outer Clyde Estuary, Figure 3). In this example, in order to account for seasonal physiological differences in the life cycle of fish and mussels, the station was sampled in November 2012 for fish and February 2013 for mussels. Harmonisation could be undertaken according to the OSPAR guidelines on sampling strategy for the chemical contaminants and biological effects. It should be noted that the same physiological status for fish and mussels must be considered in each country for biological effects and evaluation of chemical bioaccumulation.

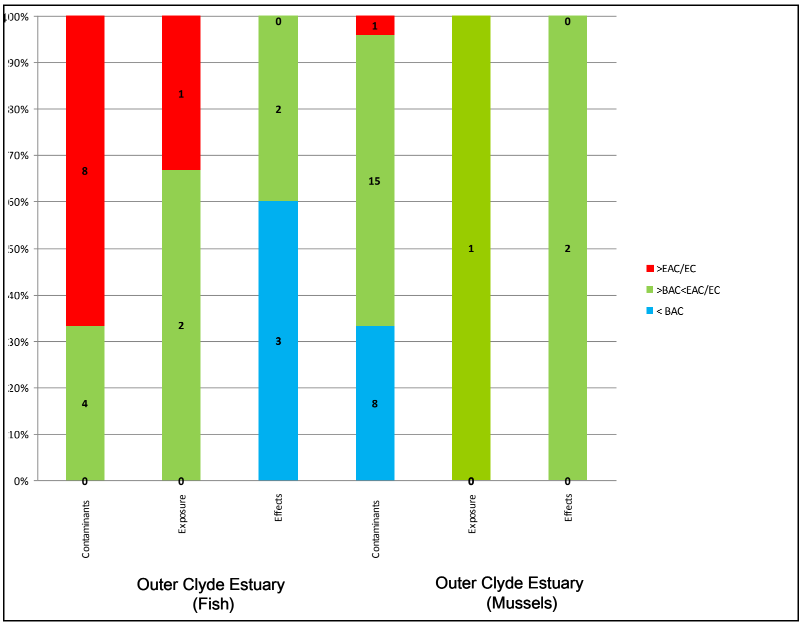


Figure 3: Example of the integrated approach applied in both fish and mussel in the Outer Clyde Estuary, UK. The integrated approach illustrates the difference of contamination, exposure and effects in fish and mussel collected respectively between November 2012 and February 2013 at the same station.

a-2) Station based assessment of analytical measurements relative to criteria (BAC and EAC):

Analytical measurements in fish, mussels and sediment can readily be assessed against BAC and EAC as reported in Davies *et al*., 2012. Overall it was evident that the majority of measurements completed were found to be either below BAC or to lie between BAC and EAC (see summary in Table 3). Several Contracting Parties (Ireland, United Kingdom, Norway, France) applied the integrated approach in either local and/or short-term studies (WGBEC 2013[7], Green et al., 2013[8], Giltrap et al., 2014[9], 2014, Brooks et al., 2014[10],). The ICON programme (2008-2009) is now well recognised as a

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[7] ICES report WGBEC 2013. Report of the working group of the biological effects of contaminants. 10-15 march 2013 San Pedro Del Pinatar. ICES CM 2013. SSGHI04. 37pp.

[8] Green N. W., Schøyen M., Øxnevad S., Ruus A., Allan I., Høg\a asen T., … Tveiten L. A. (2013). Contaminants in coastal waters of Norway 2012. NIVA-report 6582.

[9] Giltrap M., McHugh B., Ronan J., Wilson J., McGovern E. 2014. Biological effects and chemical measurements in Irish marine waters. Marine Institute 2014. Project based award, final report. 108pp

[10] Brooks S., Pampanin D., Harman C., Dunaevskava E. 2013. The Water Column Monitoring Programme 2013: Determining the biological effects of two offshore platforms on local fish populations. NIVA-report 6595

good collaborative demonstration of the integrated approach on a large geographical scale, from Iceland to Spain (MIME 2013[11], Vethaak *et al*., 2015[14]).

The expertise acquired with the integrated approach in the OSPAR zone is unique to Europe and has already been adopted in the MSFD monitoring plan in several countries (e.g. France 2012[12]). Four important scientific and regulatory advances result from the integrated approaches referred to above:

- pre-CEMP and ICES/WGBEC methodological development and the integrated approach are relevant in the context of Descriptor 8 of the MSFD
- both levels of contaminants and effects contribute to an environmental assessment in a transparent manner,
- as shown with ICON (Hylland *et al*., in press) the approach can be applied in any marine system as long as appropriate BAC/EACs are in place,
- the framework has been developed by and will be maintained by a group of experts meeting annually, through ICES (WGBEC).

[11] MIME 2013. Report of the Working Group on Monitoring and on Trends and Effects of Substances in the Marine Environment (MIME). Copenhagen: 25–29 November 2013

[12] France, 2012: French national order of the good environmental status in the MSFD. 17.12.2012.

Table 3: Assessment of the number of individual measurements at individual stations relative to the appropriate assessment criteria. Number of data below, between or above BAC and EAC for all three matrices: fish, mussel and sediment at 29 stations. Some stations were sampled several years in UK. In some stations (e.g.: UK outer Clyde estuary) the fish were sampled in November and mussels were sampled in February

b) Conduct a simple assessment of the integrated approach for biological and chemical

Location		Total measurements			FISH			MUSSELS			SEDIMENTS		
		< BAC	>BAC<EAC/EC	>EAC/ EC	< BAC	>BAC<EAC/EC	>EAC/EC	< BAC	>BAC<EAC/EC	>EAC/EC	< BAC	>BAC<EAC/EC	>EAC/EC
HWOpenSeaS_fi02_2013	UK	10	4	0	10	4	0						
UK HWOpenSeaS_fi02_2011		2	9	3	2	9	3						
UK HWOpenSeaNE_fi02_2011		4	8	2	4	8	2						
UK HWOpenSeaNE_fi02_2013		10	3	0	10	3	0						
TyneTees_TTInter_fi03 (2011)		2	10	2	2	10	2						
Tyne Tees TTInter_fi03_(2013)		10	3	0	10	3	0						
Anglia_AnOpenSea_fi04 (2013)		9	2	0	9	2	0						
Anglia_AnOpenSea_fi03 (2011)		1	3	1	1	3	1						
IrishSea_IrSIntermediateE_fi02 (2012)		1	9	4	1	9	4						
IrishSea_IrSIntermediateE_fi02 (2010)		3	9	4	3	9	4						
IrishSea_IrSIntermediateE_fi04 (2010)		0	8	4	0	8	4						
UK IrSIntE_Fi04_(2012)		1	12	3	1	12	3						
Outer Clyde Estuary		11	42	12	3	8	9	8	17	2	0	17	1
Inner Firth of Clyde		15	36	21	1	8	9	13	15	0	1	13	12
Montrose Bank		13	19	12	1	11	6	0	0	0	12	8	6
E Scotland coast - inshore		30	39	4	4	14	1	16	11	1	10	14	2
Wexford	Ireland	38	16	5	6	1	0	15	11	4	17	4	1
Cork		39	18	9	5	1	0	10	10	8	24	7	1
Dublin		32	32	10	10	1	1	9	14	8	13	17	1
Shannon		41	6	3	5	1	1	16	3	2	20	2	0
Egersund Bank	Norway	0	3	0	0	3	0						
Southern North Sea		1	2	0	1	2	0						
Bresssay Bank		0	3	0	0	3	0						
Viking Bank		0	2	1	0	2	1						
Tampen - Gullfaks		0	3	0	0	3	0						
Tampen - Statfjord		0	2	1	0	2	1						
Honfleur	France	22	13	15				7	11	13	15	2	2
Moulard		15	8	6	0	2	1	15	6	5			
Parfond		4	0	0	4	0	0						
Seine estuary		9	11	14	9	10	14	0	1	0			
Vigo	Spain	9	8	1				9	8	1			
Raxo		4	11	3				4	11	3			
Arosa		9	5	4				9	5	4			
Coruña		5	10	3				5	10	3			
Fjällbacka	Sweden	11	2	1	11	2	1						
Kvädöfjärden		10	3	1	10	3	1						

data

The SGIMC integrated approach was applied to suitable data reported post MIME 2014 (from 7 Contracting Parties at 15 (mussels)-24 (fish) stations). Two separate maps of the OSPAR zones illustrate the spatial distribution of the mussel (Figure 4) and fish (Figure 5) data. The feasibility of an integrated approach had already been demonstrated on a wider geographical scale in the Northeast Atlantic ICON project (WGBEC 2014[13], Vethaak *et al*, 2015[14]), which also included the Mediterranean coast of SE Spain (Martínez-Gómez, 2014[15]). The primary conclusions from these simple assessments are that it is clear that biological effects and associated contaminants datasets exist, are accessible and sufficiently homogeneous for the completion of an integrated assessment. Contracting Parties should be invited to implement harmonised biomarkers/bioassays/contaminant analyses suggested by SGIMC and accepted by all Contracting Parties. Such harmonisation is already under way and is required for a spatial comparison of contaminant impacts in marine areas.

[13] ICES report WGBEC 2014. report of the working group of the biological effects of contaminants. 3-7 March 2014 Copenhagen. ICES CM 2014. SSGHI03. 39pp

[14] Vethaak A.D., Davies I.M., Thain J., Gubbins M.J., Martinez-Gomez C., Robinson C., Moffat C.F., Burgeot T., Maes T., Wosniok W., Giltrap M., Lang T., Hylland K. (2015). Integrated indicator framework and methodology for monitoring and assessement of hazardous substances and their effects in the marine environment. *Mar. Environ. Res. In press*

[15] Martínez-Gómez, C., Fernández, B., Valdés, J., Navarro, C., Albentosa, M., Campillo, J.A., León, V.M, Benedicto, J., Burgeot, T., Vethaak, A.D. 2014. Integrated assessment of the chemical environmental status of Cartagena Bay (NW Mediterranean) using contaminant and biomarker data. Poster SETAC Bale May 2014.

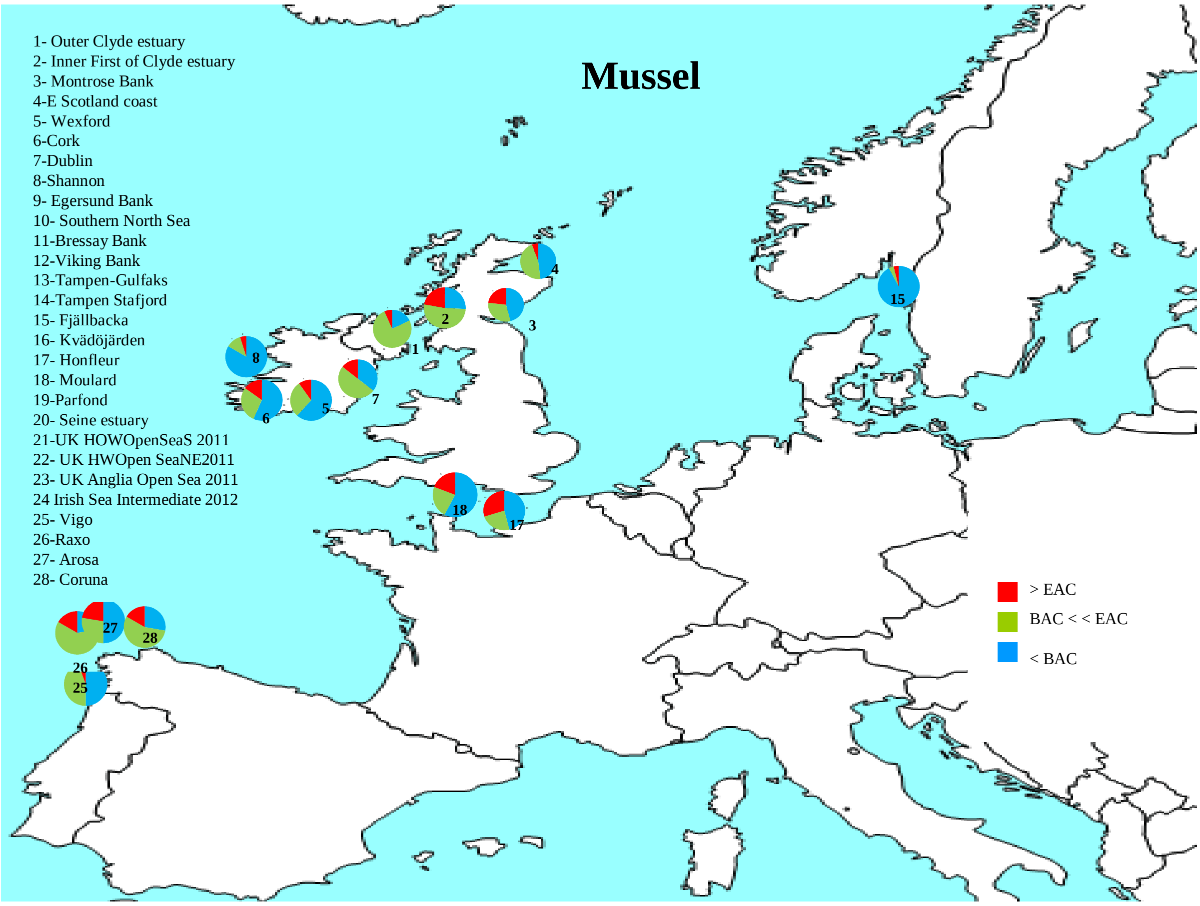

Figure 4: Biological effects and chemical contaminants integrated approach applied for mussel.

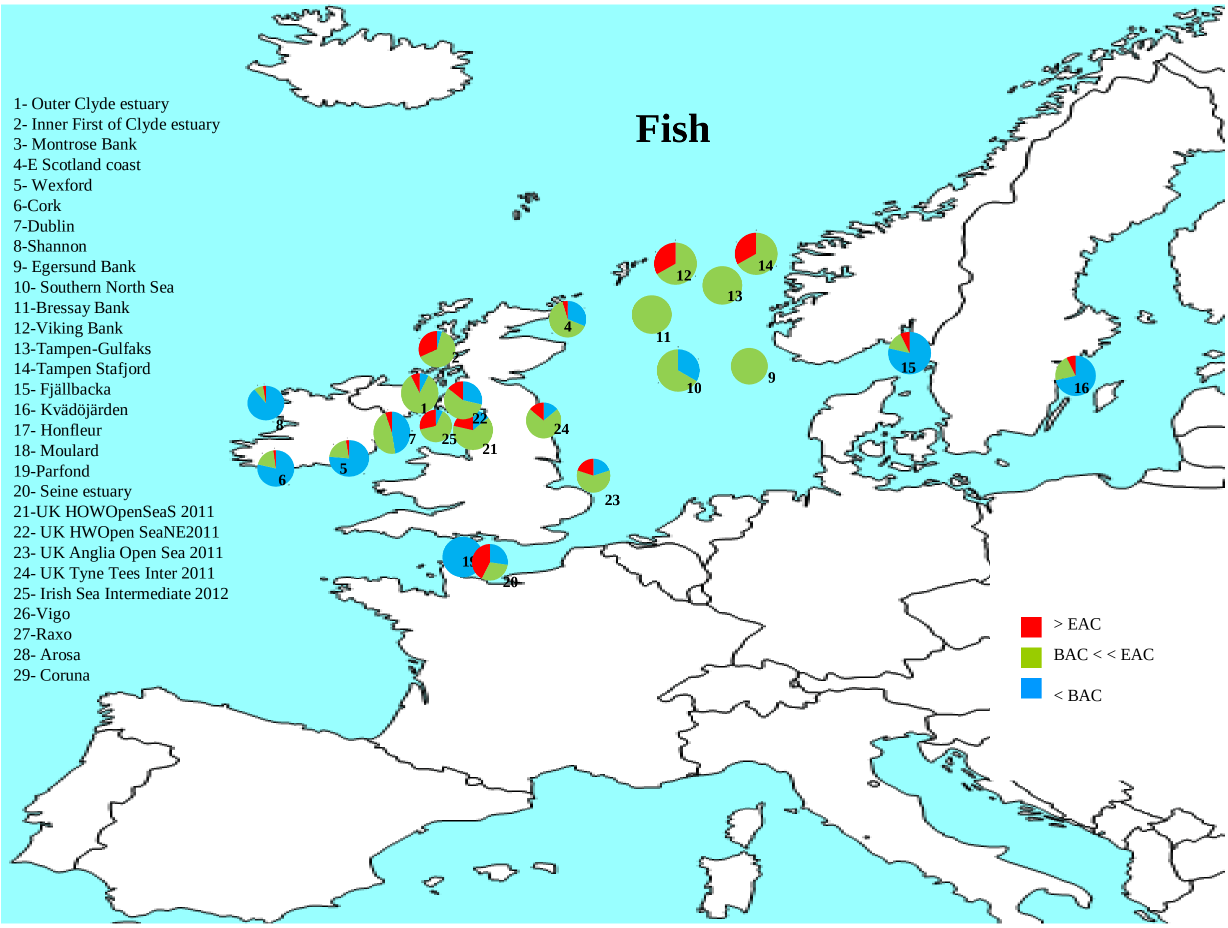

Figure 5: Biological effects and chemical contaminants integrated approach applied for fish.

c) Conclusions

A number of summary conclusions/ recommendations can now be identified:

- While the need to integrate biological effects and contaminant concentrations has been identified by OSPAR in previous Quality Status Reports, there is a specific need to include biological effects in any assessment of contaminant impacts, as has been reinforced by the EU MSFD, Descriptor 8.2.2. This requires data on biological effects in order to evaluate whether harm is occurring when assessing environmental status of contaminants.
- A core set of biological effect techniques has been recommended by SGIMC following a comprehensive process. These recommendations were taken forward by the HELCOM CORESET Programme (an almost identical process).
- Although not all biological effect data can be uploaded to the ICES database due to issues with reporting formats, a wide range (spatial plus inshore versus offshore) of data exist and can be included in an integrated approach.
- A simplification of the ICES format 3.2 during the initial phase of the integrated approach would presumably facilitate improved data submission. Since HASEC 2015, WGBEC contact

the Sjur Ringheim Lid from the Norwegian Marine Data Centre (NMD) in IMR in order to initiate the simplification of the ICES format.

- While a variety of data exist, not all core contaminants, biomarkers and bioassays suggested by SGIMC are included in the monitoring programmes in different Contracting Parties.
- The SGIMC integrated approach can provide an overall ecological assessment based on a selection of contaminants, biomarkers and bioassays.
- Appropriate guidelines, AQC and assessment criteria are available for some contaminants and all core biological effects techniques.
- Continued focus on harmonisation of the selection of a minimum and appropriate contaminant and biomarkers/bioassay analysis programme, the on-going ecological validation of the chemical and biological EAC and BAC applied in all areas of monitoring and the continued development of new EAC and BAC for contaminants and biomarkers/bioassays are also key to the further enhancement/application of integrated approaches within CEMP and in support of D8 of the MSFD.
- Moving biological effects techniques from pre-CEMP to a mandatory CEMP basis would be expected to further facilitate uptake of these methodologies and would likely allow for an integrated assessment of contaminants and biological effects on (sub)regional or specific scale. The example of imposex demonstrates clearly that when techniques are made mandatory harmonisation quickly follows.
- The development of a metric to quantifying contaminant-related effects in marine ecosystems is a key deliverable of this approach.
- The weight-of-evidence approach is appropriate in the most common field scenario with chronic and diffuse contamination. In this case, the dynamic response of the core biomarkers illustrate a stress which can integrate the combined effects of a mixture of contaminants
- The efforts undertaken by OSPAR Contracting Parties has allowed the development of a comprehensive suite of assessment criteria (BAC/EAC) which is unique in Europe and OSPAR has the scientific legitimacy to propose an integrated approach with a standardised interpretation based on assessment criteria in biology and chemistry
- This paper only reflects an assessment of “Integrated” data acquired through the standardised spread sheet and is reflective of data that Contracting Parties consider as having been collected in an integrated manner.
- The paper does not include all data existing in the database as this needs to be further screened to evaluate if there are contaminants data associated with these sites and, if so, whether these series can then be considered as being suitable for integrated assessment.

OSPAR COMMISSION

Victoria House
37-63 Southampton Row
London WC1B 4DA
United Kingdom

t: +44 (0)20 7430 5200
f: +44 (0)20 7242 3737
e: secretariat@ospar.org
www.ospar.org

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