# integrated chemical and biological monitoring of the marine environment – the OSPAR approach

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# acknowledgement

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ICES working group on biological effects of contaminants (WGBEC)

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# issues

- contaminants in marine ecosystems
- chemical analyses can not be used surrogates for effects
- limitations
  - environmental chemistry
  - biological effects
- integration?
  - a range of analyses in the same individual (JAMP, NO)
  - co-ordinated sampling (EFFSTAT, DE)
  - co-ordinated sampling, analyses and assessment (fullmonti, UK; WKIMON)
- quality assurance

find what you look for ..

bioavailability, etc

specificity

natural processes

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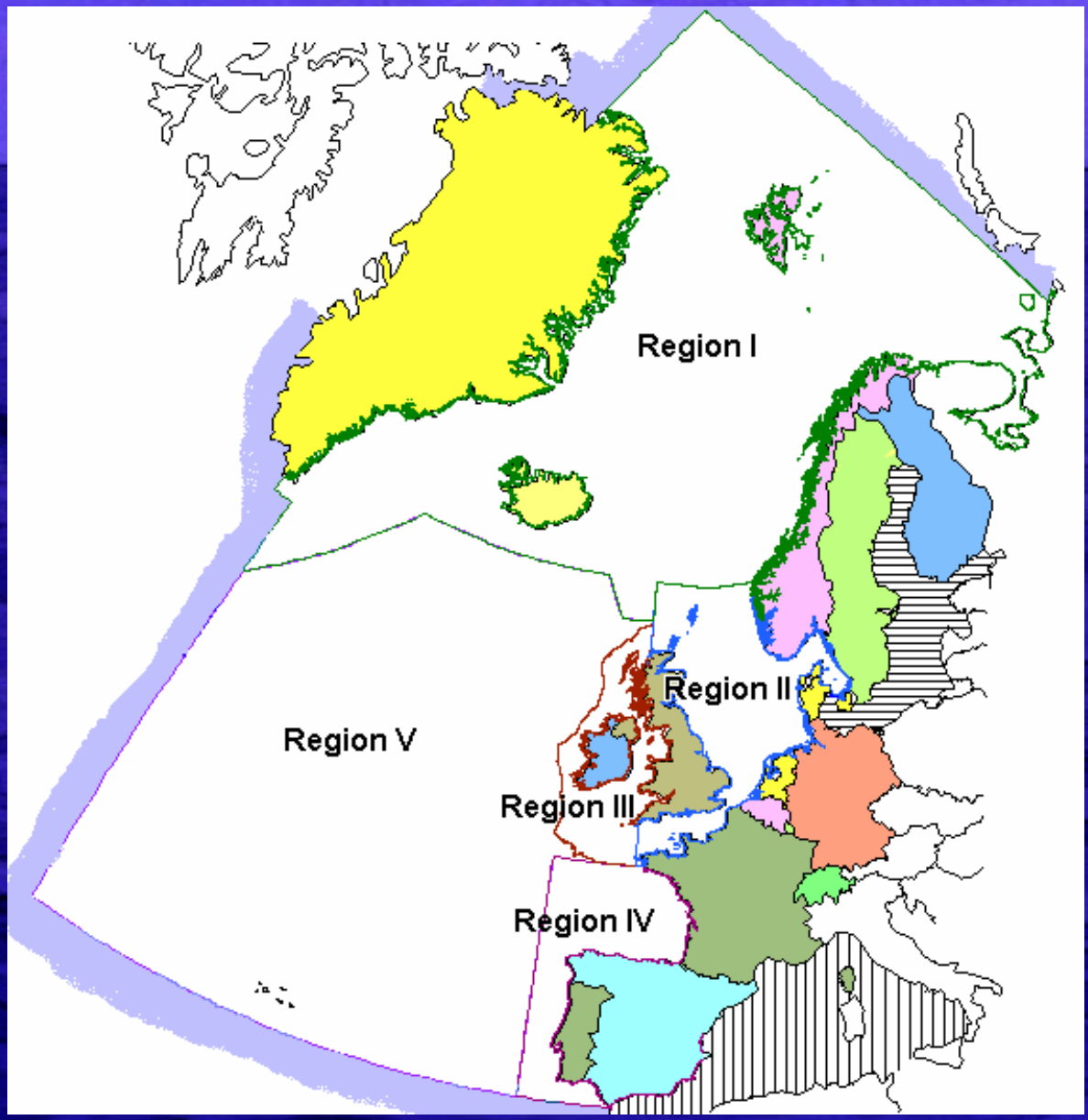
# OSPAR agreement

To take all possible steps to prevent and eliminate pollution and to take the necessary measures to protect the maritime area against adverse effects of human activities so as to safe guard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

# objectives

- spatial monitoring
- temporal monitoring
- novel substances


Region I
Region II
Region III
Region IV
Region V

# same individual

- general factors
  - year, station
- physiology
  - sex, maturation, length (size), condition, LSI, fat
- contaminants
  - OH-pyrene (bile)
  - OCs: HCB, PCB-153, mono-ortho PCBs, p.p'-DDE (liver)
  - metals: Cd, Cu, Pb, Zn (liver); Hg (muscle)
- effects
  - cytochrome P4501A activity (EROD)
  - metallothionein, ALA-D
- multiple regression with effect as dependent factor

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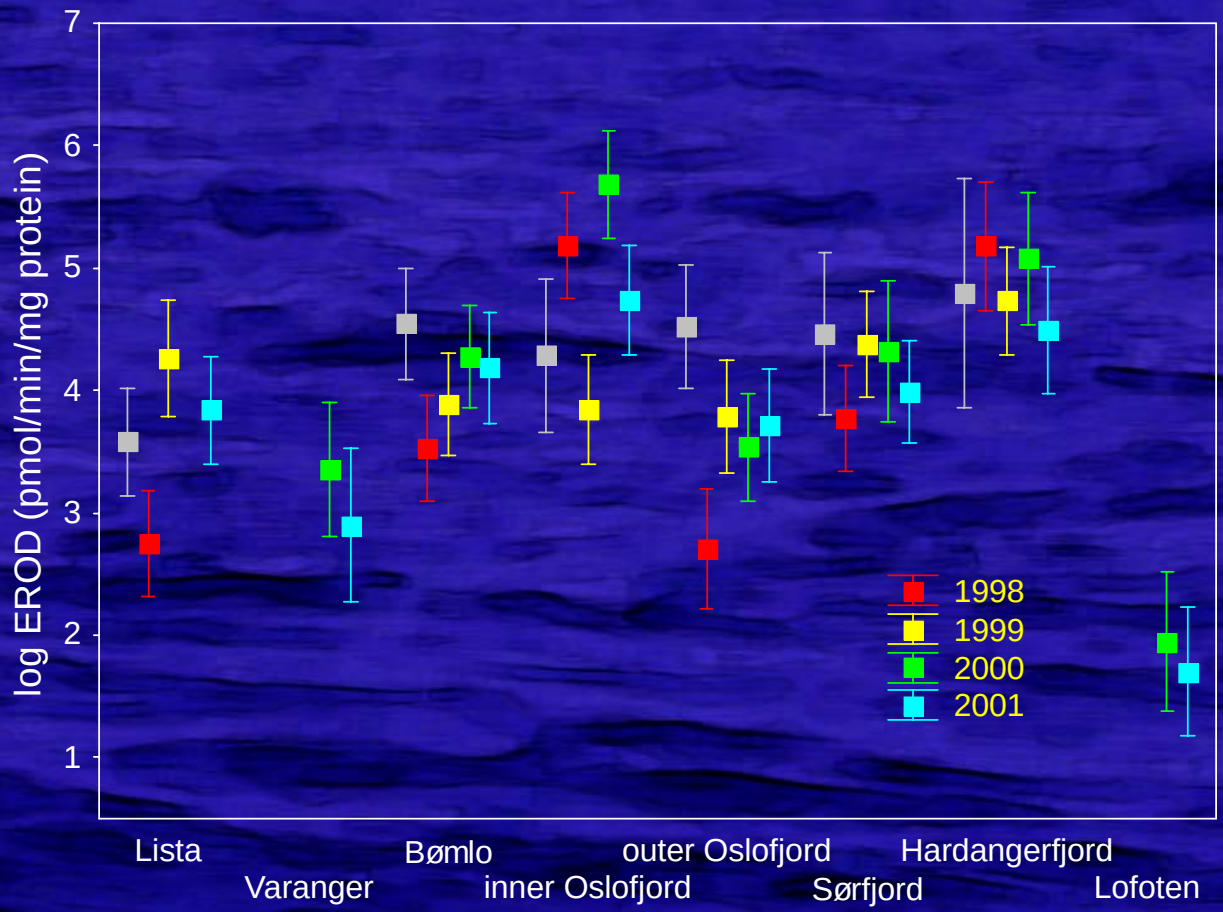
# hepatic EROD

| effect | DF | F | p |
|---|---|---|---|
| intercept | 1 | 56.1 | <0.000001 |
| year | 4 | 5.8 | 0.0001 |
| station | 7 | 24.5 | <0.000001 |
| year*station | 21 | 4.4 | <0.000001 |
| LSI | 1 | 7.0 | 0.008 |
| HCB | 1 | 74.5 | <0.000001 |
| Hg (muscle) | 1 | 29.1 | <0.000001 |
| error | 640 | | |

adjusted $R^2$ : 0.41. $p < 0.001$


log EROD (pmol/min/mg protein)
7
6
5
4
3
2
1
1998
1999
2000
2001
Lista
Varanger
Bømlo
inner Oslofjord
outer Oslofjord
Sørfjord
Hardangerfjord
Lofoten

# integrated assessment

- appropriate compartments and methods
- develop criteria for each parameter/endpoint
- weigh and combine results for methods
- simplify results to generate indicators (traffic light)

# fullmonti

- UK monitoring data
- three components
  - chemistry
  - individual biological effects
  - benthic community
- traffic light indicators for UK coastal areas and estuaries

| Location | fullmonti Index for benthic community / individual effects / chemistry ~ B / E / C | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1999 | | | 2000 | | | 2001 | | | 2002 | | | 2003 | | |
| | B | E | C | B | E | C | B | E | C | B | E | C | B | E | C |
| Amble | | | 5.0 | | | 10.0 | | | 5.0 | | | 10.0 | | | 10.0 |
| Tyne Hebburn | 20.5 | | 12.7 | 23.0 | 15.2 | 13.6 | 18.5 | 12.1 | 13.2 | 22.0 | | 13.5 | | 14.8 | 18.5 |
| Tyne Ferry | 18.5 | | 16.7 | 25.3 | | 11.0 | 18.0 | | 10.7 | 20.5 | | 11.3 | | | 9.5 |
| Off Tyne | 8.0 | 10.1 | 16.9 | 5.8 | 8.8 | 12.7 | | 9.1 | 11.7 | 8.0 | | 14.5 | | 11.7 | 16.9 |
| Off Tees | 4.3 | 8.7 | 5.2 | | 6.4 | 10.0 | | 7.3 | | | 4.2 | | | 6.2 | |
| Firth of Forth | | | | | | 7.8 | 12.5 | | 8.4 | | | 4.4 | | | 5.3 |
| Clyde CMT 5 | 7.3 | | 20.1 | 7.3 | | 19.3 | 7.3 | | 16.2 | 7.3 | | 13.1 | 6.3 | 21.4 | 22.5 |
| Clyde CMT 7 | 3.8 | | 24.1 | 3.5 | | 24.1 | 5.3 | | 18.7 | 4.3 | | 14.6 | 5.3 | | 22.1 |
| Irvine Bay | 5.3 | | 14.4 | 7.3 | | 14.4 | 6.0 | | 19.1 | 4.3 | | 14.6 | 8.0 | 0.0 | 16.5 |
| Loch Linnie | 12.3 | | 3.8 | 14.0 | | 3.8 | 15.5 | | 10.3 | 12.0 | | 12.5 | 12.5 | | 15.0 |
| Liverpool Bay | | 9.0 | 8.0 | 10.0 | 10.1 | 14.4 | | 7.4 | 5.5 | | 6.4 | 5.3 | | 9.6 | 13.4 |
| Isle of Man | 5.3 | 8.7 | 16.9 | 6.5 | 6.2 | 5.0 | 14.5 | 9.3 | 10.0 | | 5.7 | 3.3 | 10.8 | 8.9 | 10.0 |
| Belfast Lough | 3.3 | | 12.5 | 3.8 | | 6.3 | 6.3 | | 1.3 | 6.6 | | 2.3 | 6.0 | | 7.5 |
| Belfast Lough | 7.0 | | 10.0 | 4.3 | | 17.5 | 10.0 | | 13.4 | 4.3 | | 5.3 | 4.3 | 11.0 | 9.2 |
| Cardigan Bay | | | | 4.8 | 10.4 | 0.0 | | 8.8 | 1.9 | | 12.3 | 1.9 | | 11.5 | |
| Tees Philips Buoy | 15.0 | | | 11.5 | | 0.0 | 13.5 | | | 11.5 | | | | | |
| Tees Bramlets | 20.5 | | | 14.5 | | | 15.5 | | | 16.0 | | | | | |
| Tees No 23 Buoy | 16.0 | | | 14.4 | | | 17.3 | | | 15.0 | | | | | |

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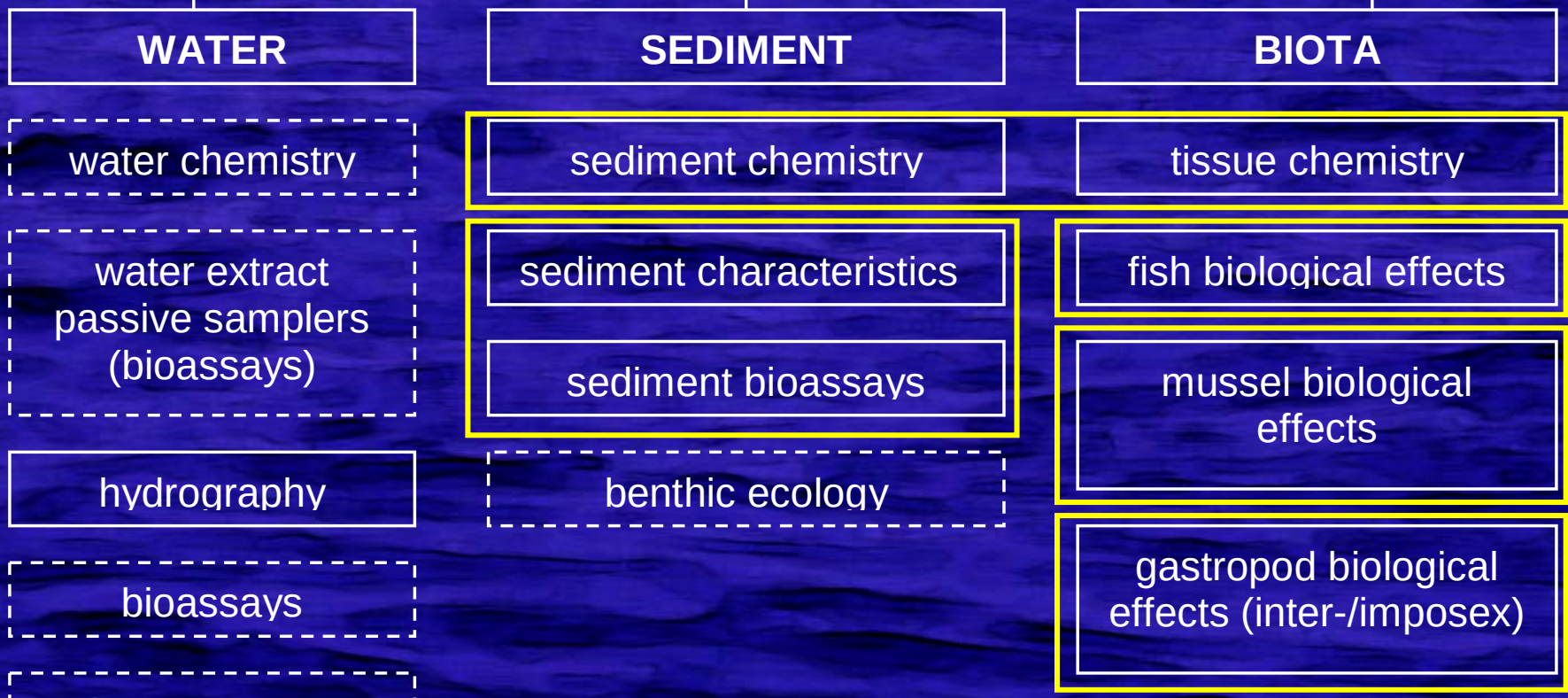
# ECOSYSTEM integration




**OSPAR WKIMON**

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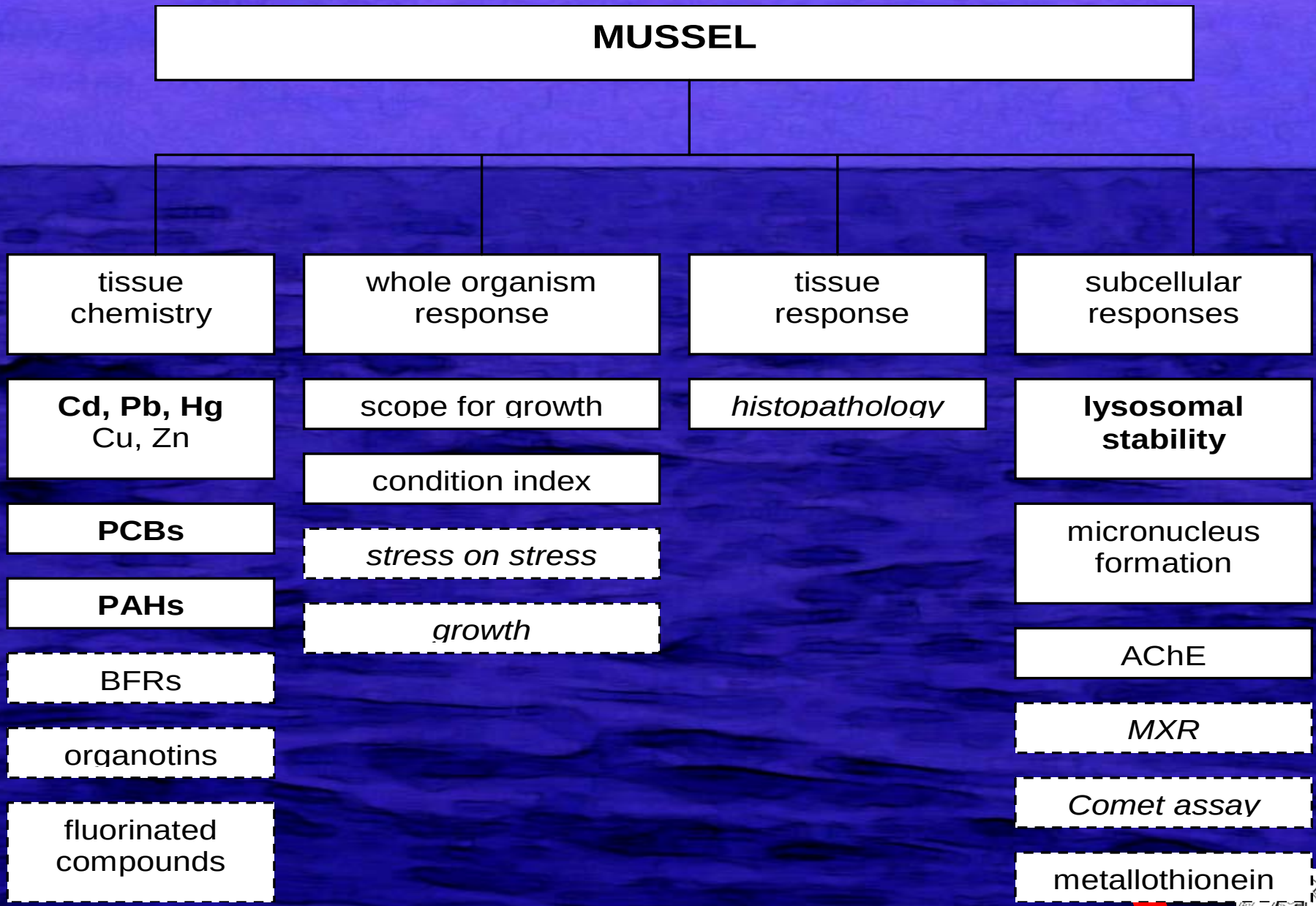
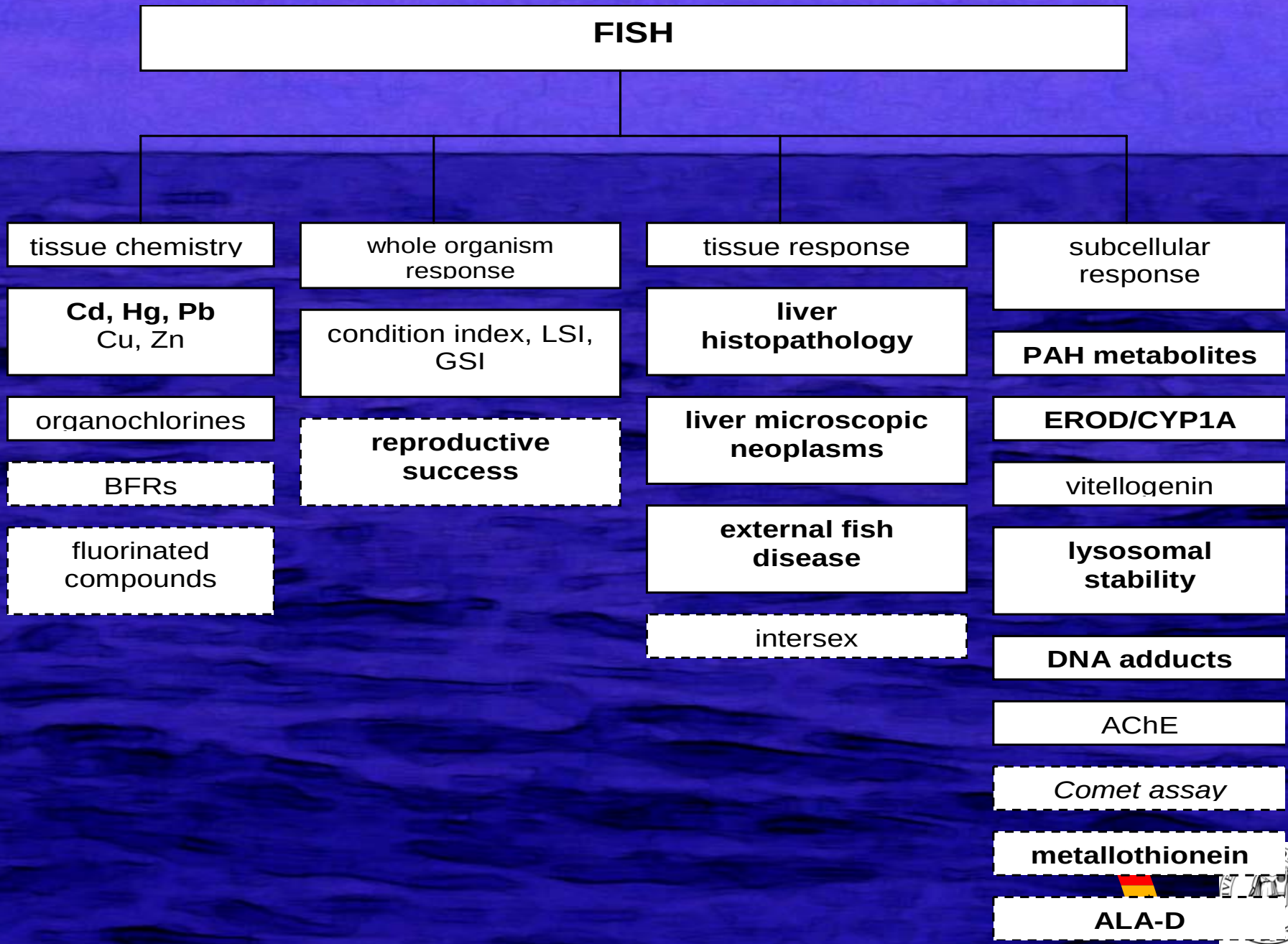

MUSSEL
tissue chemistry
whole organism response
tissue response
subcellular responses
Cd, Pb, Hg
Cu, Zn
PCBs
PAHs
BFRs
organotins
fluorinated compounds
scope for growth
condition index
stress on stress
growth
histopathology
lysosomal stability
micronucleus formation
AChE
MXR
Comet assay
metallothionein


FISH
tissue chemistry
Cd, Hg, Pb
Cu, Zn
organochlorines
BFRs
fluorinated compounds
whole organism response
condition index, LSI, GSI
reproductive success
tissue response
liver histopathology
liver microscopic neoplasms
external fish disease
intersex
subcellular response
PAH metabolites
EROD/CYP1A
vitellogenin
lysosomal stability
DNA adducts
AChE
Comet assay
metallothionein
ALA-D

# ICON

| | | |
|---|---|---|
| Coastal | Spanish Med coast | mussels, sediment, gastropod |
| | Wadden See | flounder, mussels, sediment, gastropod |
| | southern England | flounder, mussels, sediment, gastropod |
| | Iceland | (flounder?), mussels, gastropod, sediment |
| | Seine Bay | dab, flounder, mussel, gastropod |
| Offshore | German Bight (JAMP) | dab, sediment, (whelk) |
| | Dogger Bank | dab, sediment (haddock, whelk) |
| | off Firth of Forth | dab, haddock, sediment, (whelk) |
| | Ekofisk | dab, haddock, sediment, (whelk) |
| | Iceland | dab, haddock, sediment, (whelk) |
| | Baltic | dab, flounder, sediment, (whelk) |
| Gradient | Firth of Forth | flounder, mussel, gastropod |

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Ísland
Açores (P)
Madeira (P)
Canarias (E)
Guadeloupe (F)
Martinique (F)
Guyane (F)
Suriname
Réunion (F)
Brasil
Suomi Finland
Norge
Sverige
Eesti
Latvija
Lietuva
R.
Rossija
Belarus'
Qazaqstan
Ireland Eire
United Kingdom
Danmark
Nederland
België Belgique
Deutschland
Polska
Ukraïna
Luxembourg
Česká republika
Slovensko
Moldova
France
Liechtenstein
Suisse Schweiz Svizzera
Österreich
Magyarország
România
Slovenija
Hrvatska
Bosna i Hercegovina
Srbija
Crna Gora
Shqipëria
Bălgarija
Sakartvelo
Azərbaycan
Hayastan
Iran
Andorra
Monaco
San Marino
Italia
Città del Vaticano
Portugal
España
Ελλάδα Ellada
Türkiye
Iraq
Souriya
Libnan
Κύπρος Kypros Kibris
El Maghreb
El Djazaïr
Tounis
Malta

# conclusions

- assessment of environmental impacts of contaminants require both chemical analyses and biological effects
- co-ordinated analyses in same individual will not provide all required information
- temporal and spatial co-ordination is essential, but not sufficient
- an integrated programme requires water, sediment and biota components
- assessment frameworks need to be transparent and include relevant ecosystem components
- lack of correspondence between effects and contaminant concentrations may indicate the presence of unknowns
- quality assurance is critical

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# challenges

- integrated assessment framework
- assess contaminant impacts in relation to other environmental stressors (fisheries, eutrophication, habitat change, etc)
- national compliance, competence and resources
- quality assurance