Blue mussels (*Mytilus edulis* spp.) as environmental bioindicator

Jonny Beyer, Merete Schøyen, Steven Brooks, Ian J. Allan, Anders Ruus, Tânia Gomes, Inger Lise N. Bråte, Jarle Håvardstun, Dag Ø. Hjermann, Norman W. Green

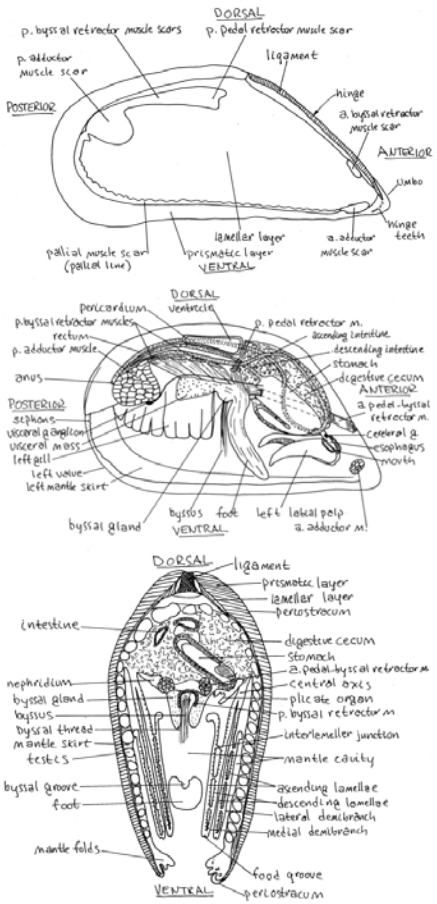
Two manuscripts coming in Marine Environmental Research:

Blue mussels (*Mytilus edulis* spp.) as sentinel organisms in coastal pollution monitoring: A review. (Submitted/accepted) Jonny Beyer, Norman W. Green, Steven Brooks, Ian J. Allan, Anders Ruus, Tânia Gomes, Inger Lise N. Bråte, Merete Schøyen

Comparison of caged and native blue mussels (*Mytilus edulis* spp.) for environmental monitoring of PAH, PCB and trace metals. (Submitted/accepted) Merete Schøyen, Ian J. Allan, Anders Ruus, Jarle Håvardstun, Dag Ø. Hjermann, Jonny Beyer

Norwegian Institute for Water Research (NIVA)

Mytilus edulis anatomy

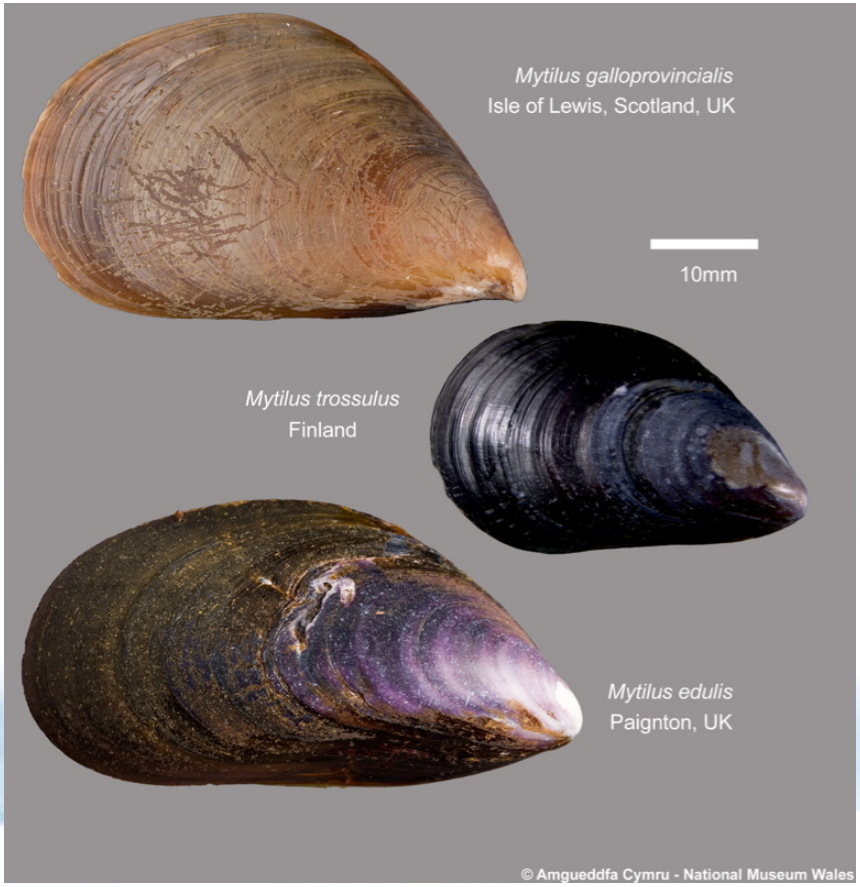


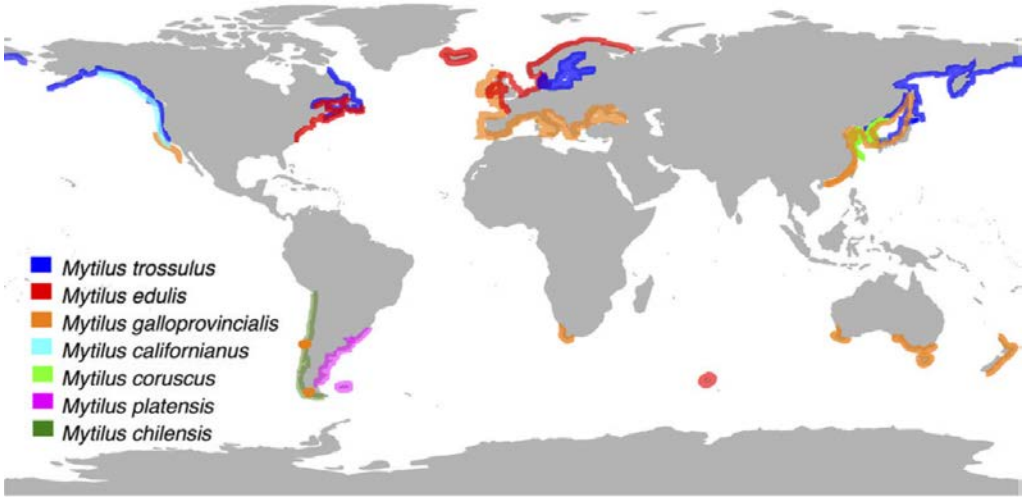
Source: Wikispecies

Original drawings: White, K. M. (1937). "Mytilus." Liverpool Marine Biology Committee **Memoir 31**: 117.

The *Mytilus edulis* complex

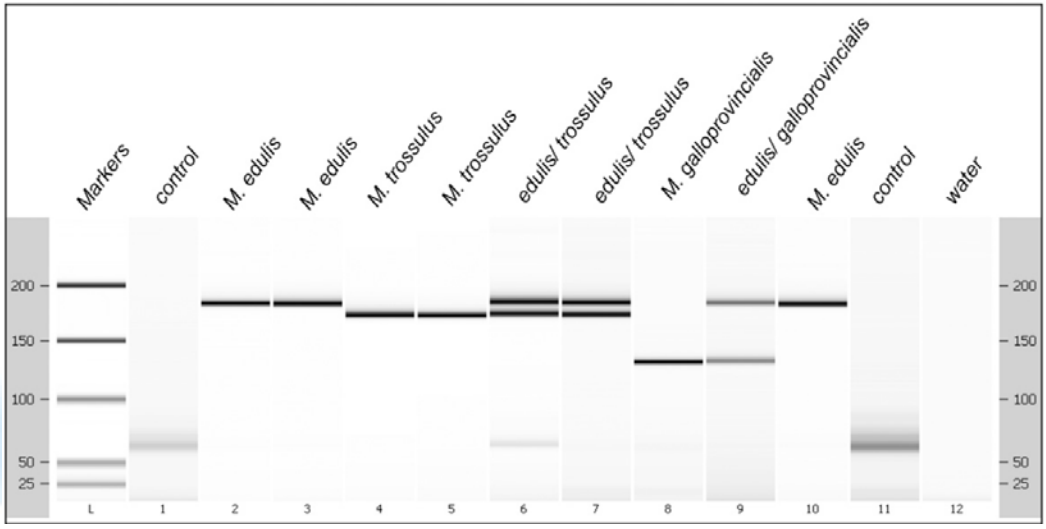
- Widely used as environmental sentinel, several thousand published studies.
- 5-7 congeneric species globally, three along North Sea coasts and the Norwegian coastline.
- Genetic hybrids develop in zones of secondary contact.





Gaitan-Espitia, J. D., et al. (2016). *Scientific Reports* ***6.***

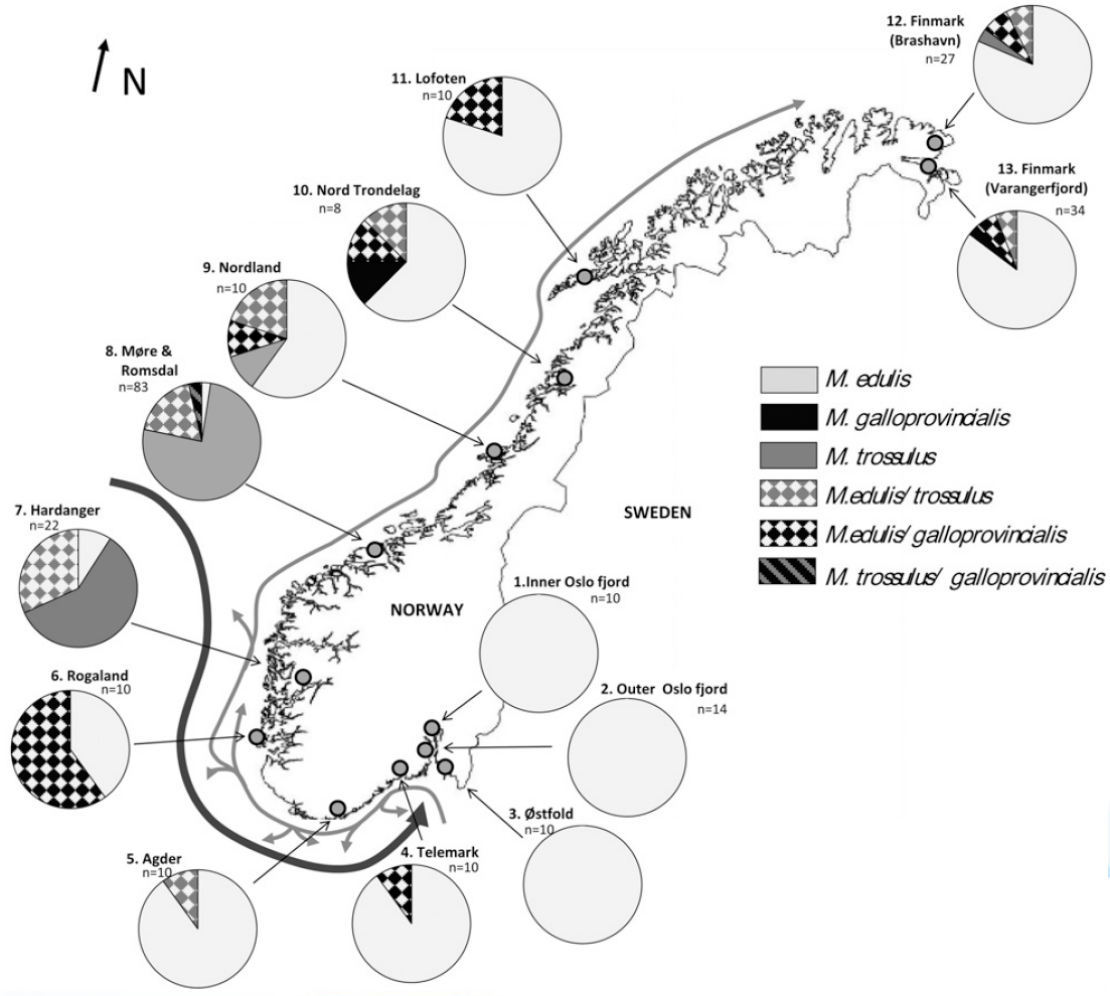
Only diagnostic genetic markers provide a certain species identification

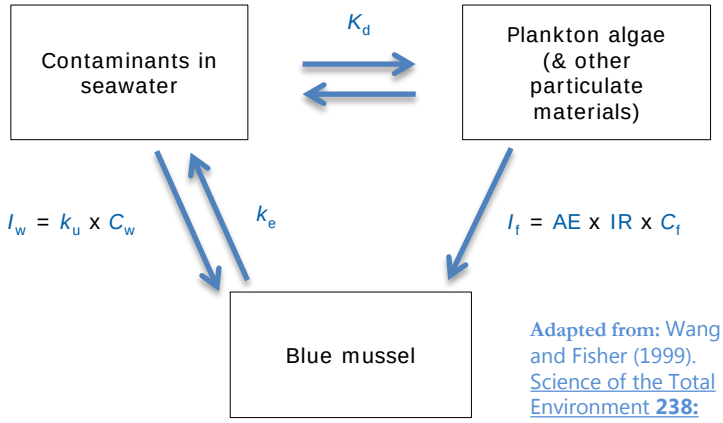


Brooks, S. J. and E. Farmen (2013). *JOURNAL OF SHELLFISH RESEARCH* ***32(2): 265-270.***

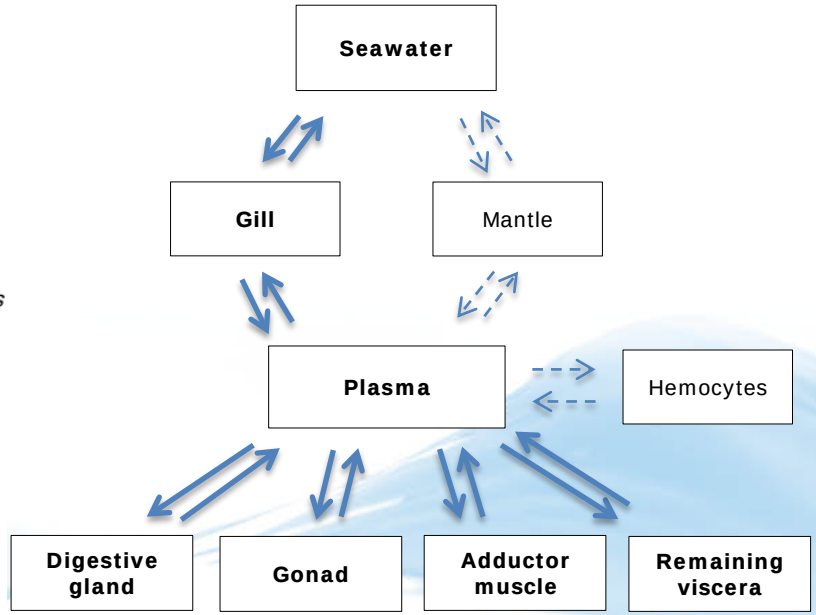
Mytilus hybridization – relevance to bioaccumulation?

Map source: Brooks, S. J. and E. Farmen (2013). *JOURNAL OF SHELLFISH RESEARCH* ***32(2): 265-270.***



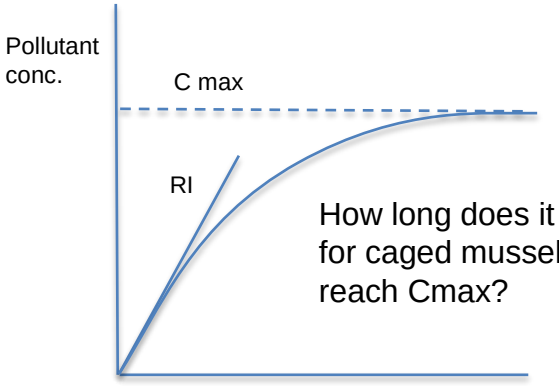


Adapted from: Wang and Fisher (1999). Science of the Total Environment **238: 459-472.**

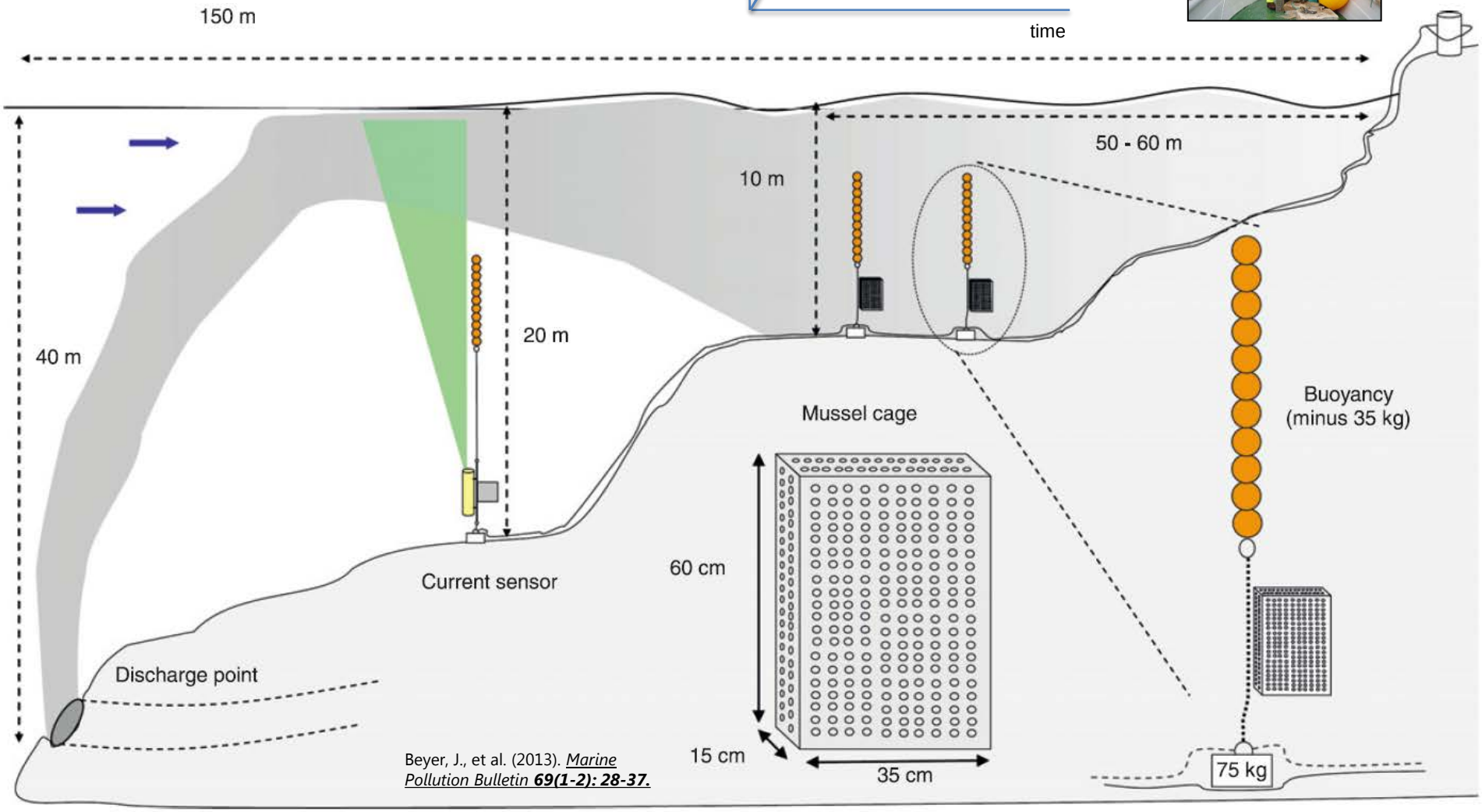


Adapted from: Ricciardi et al. (2016). Environmental Toxicology and Chemistry 35(4): 863-873.

Is caged *Mytilus a fully* comparable alternative to native mussels when the latter are missing?

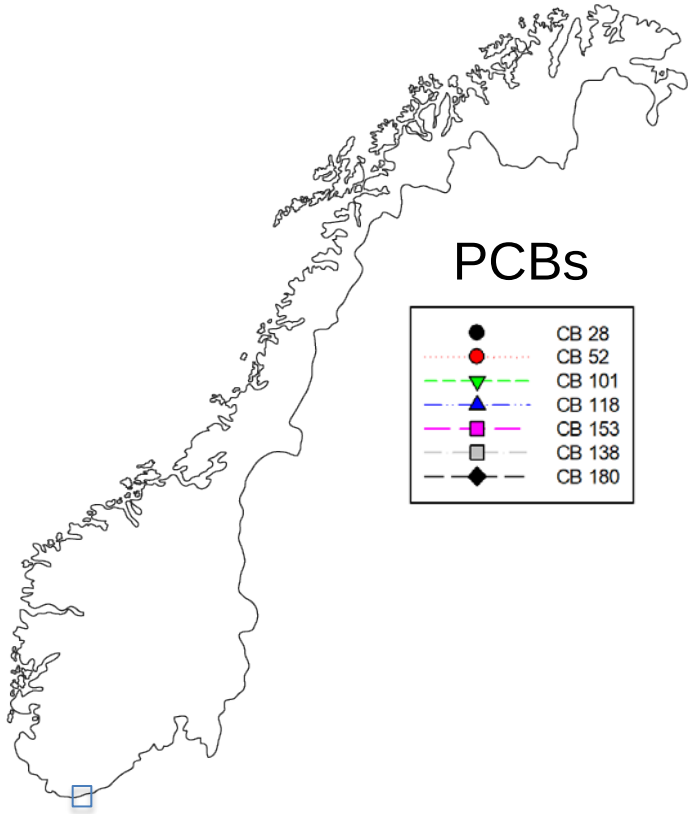


How long does it take for caged mussels to reach Cmax?



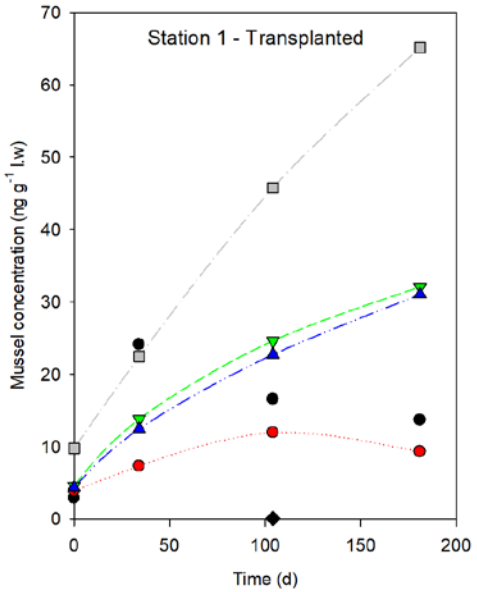
Beyer, J., et al. (2013). *Marine Pollution Bulletin* ***69(1-2): 28-37.***

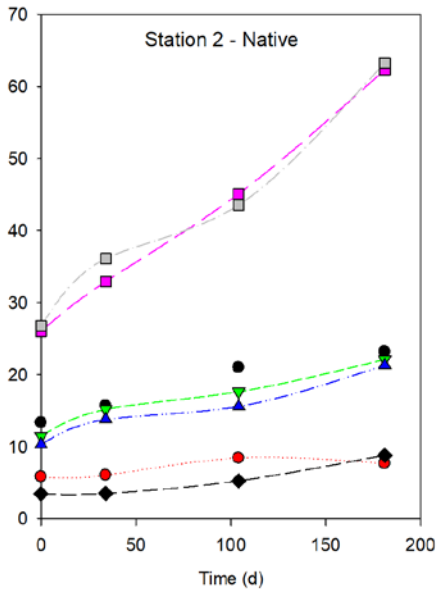
Comparison of bioaccumulation in caged and native *Mytilus*



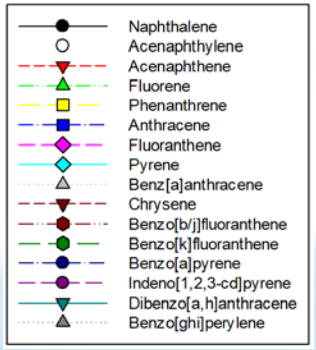
Kristiansand harbour

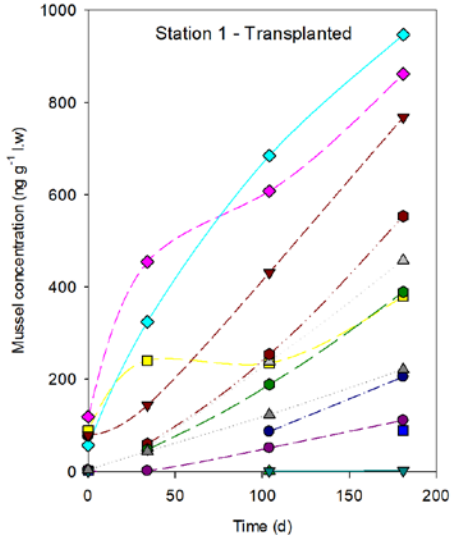
PCBs

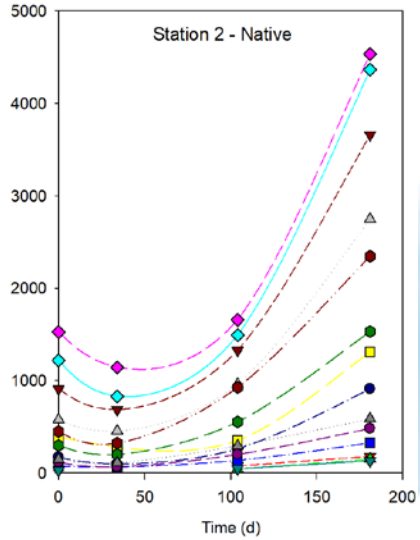




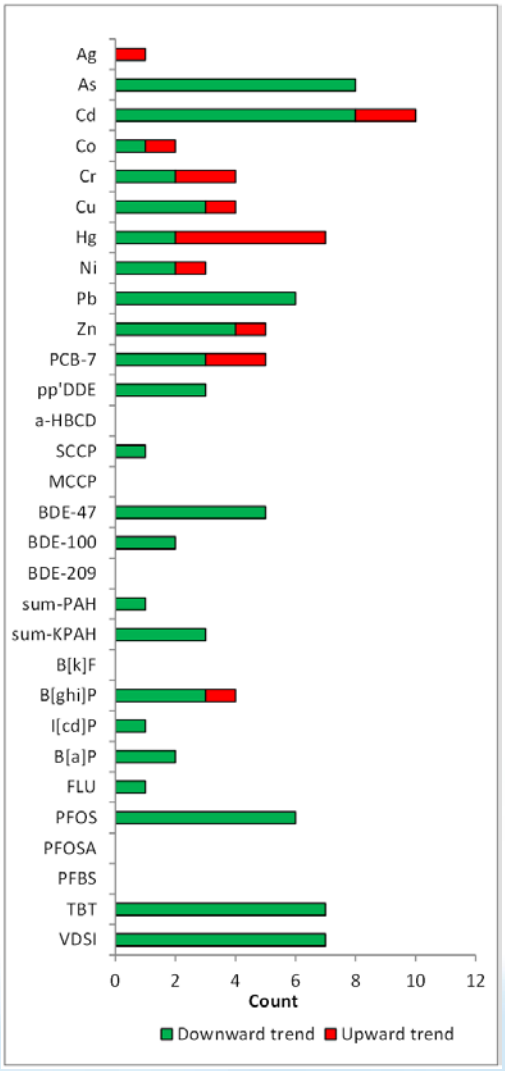
PAHs







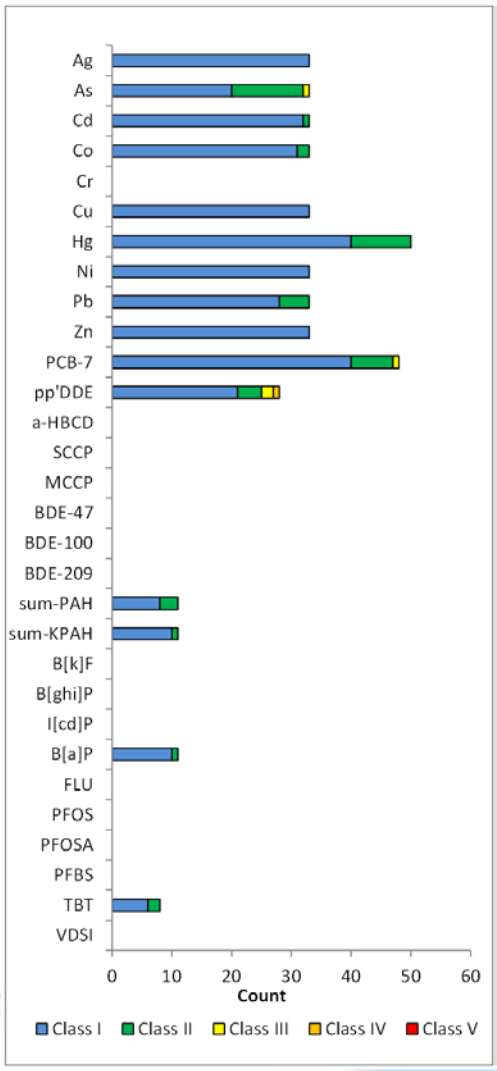
Background contamination data and temporal trends in Norwegian mussel watch monitoring



Summary of 829 recent trends (left) and classification of levels (right) of 30 key contaminants in Norwegian mussel watch activities.

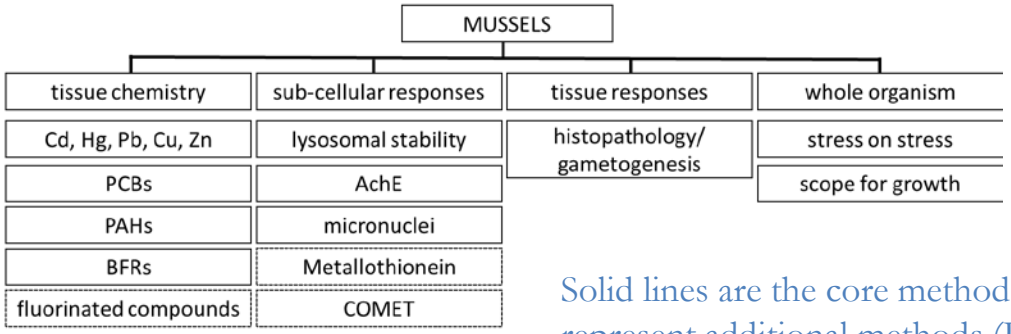
Data source: MILKYS trends report (Green et al., 2016).

There is a need for quality standards for specially adapted for pollutant monitoring with *Mytilus* (e.g. in connection with WFD EQS_{biota})



Biomarkers in blue mussels in monitoring

ICES has established a set of recommended biological effects methods which is included in the mussel component of the ICES integrated ecosystem assessment.



Solid lines are the core methods, whilst dotted lines represent additional methods (Davies and Vethaak (2012), ICES report no. 315).

In Norway, a set of biomarkers in caged blue mussels measured according to ICES recommendations have for years been part of the offshore water column monitoring targeting possible ecotoxicants in produced water streams discharged from offshore oil and gas production platforms.

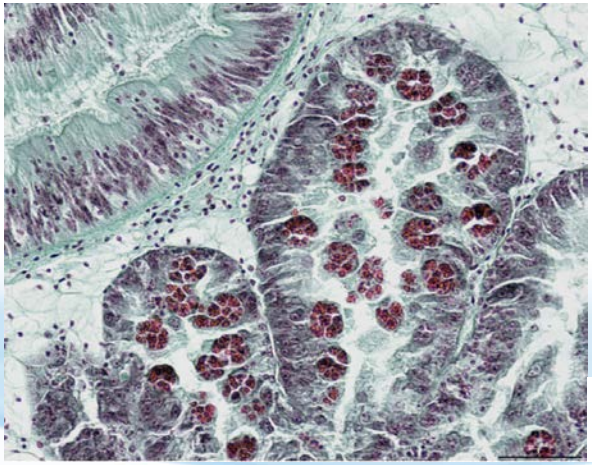
A key challenge with the use of a multi-biomarker approach is the often complex response data that are difficult to integrate in environmental policy frameworks. To encompass this problem, several ways for simplifying complex data have been developed, among which the so-called *Integrated Biomarker Response* (IBR) index.

Emerging issues in blue mussel monitoring

- PARTICLE CONTAMINANTS: ICES has suggested blue mussels as suitable sentinels for monitoring of microplastic contamination but this field is associated with many unknowns.

- CLIMATE CHANGE: Ongoing warming of the seas is apparently modifying the natural distribution range of blue mussels, generally shifting the distribution closer to the poles, and also causing the more warm-water tolerant *M. galloprovincialis* to invade regions which earlier have been dominated by *M. edulis*, *M. trossulus* or other more cold-water tolerant mussel tax

- PARASITES: The Institute of Marine Research (Bergen, Norway), recently reported that the unicellular parasite *Marteilia refringens*, which is lethal to *Mytilus* and other mussels, has been detected for the first time in Norway.



Marteilia refringens in mussel digestive gland epithelium. Refringent granules staining bright red are clearly visible. Gridley stain. Scale bar = 25um, source: CEFAS

Summary

- Blue mussels play a crucial role as bioindicators in regional and local trend monitoring of key pollutants and in compliance monitoring of industries that release hazardous chemicals into coastal water bodies.
- This calls for a development of internationally harmonized and environmentally realistic assessment criteria for prioritized contaminants specially adapted for blue mussel sentinels.
- The toxicokinetic features of a broad range of key anthropogenic contaminants are well described in blue mussel taxa, but there are still knowledge gaps for substances whose mode of uptake and accumulation deviate from general partitioning and when there could be a concentration dependency of the uptake (e.g. for PFCs).
- There is apparently an issue for several key PSs targeted by the WFD EQS regulations in Europe (i.e. brominated diphenyl ethers, mercury, TBT and PCB7), and these need urgent attention.
- Progress has been made for development and use of biomarkers in blue mussel, and for emerging issues, such as micro- and nano-scale particulate contaminants, climate change and ecotoxicity of mixed pollution situations. Continued progress in this knowledge is expected in the years to come.
- It is important to clarify and minimize the influence of confounding non-target factors in mussel monitoring, e.g. by adopting international harmonization and standardization of study conditions and program designs. Such developments could call for an increased use of mussel transplant caging.

NIVA