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An ICES workshop on biological effects in pelagic ecosystems (BECPELAG): overview of the programme

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Abstract

The ICES biological effects monitoring in pelagic ecosystems workshop (BECPELAG) is a multi-national, multi-dicipline workshop aimed at establishing suitable techniques for monitoring the effects of contaminants on pelagic ecosystems. During seven research cruises in 2001, pelagic organisms were collected and caged deployed at four sites in the German Bight and at four sites in a downsteam transect from an oil platform in the North Sea.

The workshop has involved more than 30 research groups in 12 European countries. The studied systems and organisms include different components of the pelagic ecosystem, from bacteria and microzooplankton through zooplankton and fish larvae to juvenile and adult pelagic fish. In addition to field-collected specimens, cod, blue mussels and passive samplers (DGTs, SPMDs) were caged at the 8 selected locations. SPMDs (semi-permeable membrane devices) were extracted and the extracts tested for biological activity. The biological methods range from bacterial diversity and microzooplankton grazing to physiological and immunological responses in caged blue mussels, biomarkers in fish and responses in genetically modified cell cultures. A summary overview of the techniques will be given; for a full overview of methods, see http://www.niva.no/pelagic/web.

Chemical analyses were carried out in water and biota for a range of determinands. The strategy used for making biological and chemical analyses in an integrated manner in order to assess effects in the two pollution gradients will be presented.

Introduction and objectives

There is a widely recognised need for methods to detect and quantify effects of contaminants in pelagic ecosystems, not least in relation to offshore oil- and gas-production activities. In the past few decades, the main focus of biological effect methods development has been on benthic organisms and systems. Progess with such methods has been advanced as the result of practical workshops. The first was held in Oslo/Langesund/Solbergstrand (Bayne et al., 1988), the second at Bermuda (Addison & Clarke, 1990) and the third in Bremerhaven (Stebbing & Dethlefsen, 1992). These three workshops stimulated research into the use of biological effects methods to monitor pollution impacts in marine ecosystems and contributed towards a framework for general and contaminant-specific monitoring (JAMP, 1998a,b).

Whereas there has been substantial progress in developing methods to assess pollution effects in benthic systems, there is still a lack of agreed methods to evaluate biological effects in the water column. There are many sources of contaminants to pelagic ecosystems including coastal inputs, dumping and long-range transport by ocean currents and the atmosphere. In areas of oil- or gas-production, there will be inputs of large volumes of produced water. The composition of produced water varies considerably from well to well, but generally contains mono- and polycyclic aromatic hydrocarbons, other organic contaminants and trace metals.

The objective of BECPELAG was to bring together scientists involved in relevant work in a practical workshop in order to assess the ability of selected methods to detect biological effects of contaminants in pelagic ecosystems under uniform and standardised conditions. The methods are being assessed for their applicability in monitoring programmes and the results from the BECPELAG workshop are currently being used to develop the water column monitoring programme for Norwegian offshore activities.

A more extensive background for the workshop can be found in Hylland (2000) or at the project web-site (http://www.niva.no/pelagic/web).

Workshop structure

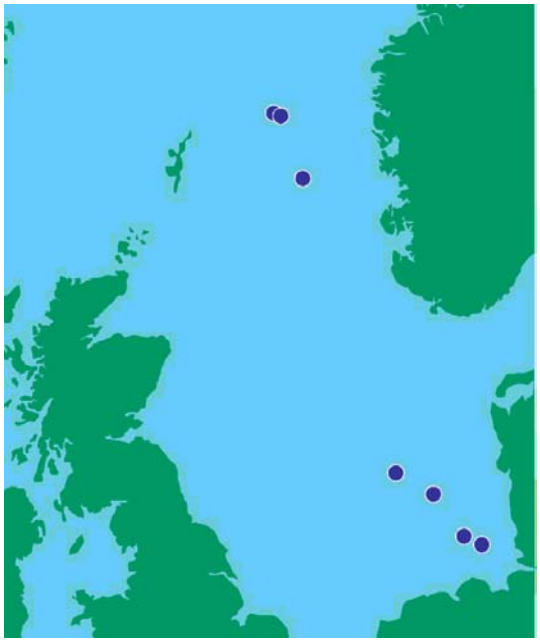
The initiative for this workshop stemmed from the ICES working group on biological effects of contaminants (WGBEC). BECPELAG has been co-ordinated through a scientific steering committee with the following members: Gerd Becker (BSH, Germany), Alistair McIntosh (FRS, UK), Ketil Hylland (NIVA, Norway), John Thain (CEFAS, UK), Kevin Thomas (CEFAS, UK), Thomas Lang (BFA-Fi, Germany), Bjørn Serigstad (IMR/Ocean Climate, Norway), Toril Inga Røe Utvik (Norsk Hydro, Norway), Dick Vethaak (RIKZ, Netherlands) and Werner Wosniok (University of Bremen, Germany). The steering group was chaired by Ketil Hylland. Progress with the workshop can be found below (Table 1).

Table 1. Time table for activities within BECPELAG.

activity	**scheduled**
prospectus distributed	15.Feb 2000
deadline for proposals	15.Apr 2000
final programme established	mid-May 2000
kick-off meeting (ICES HQ)	Jan 2001
cruises	Feb-Sept 2001
samples sent to participating labs	Sept-Dec 2001
wrap-up conference	19-21.Aug 2002
ICES ASC theme session X	Oct 2002
publication of papers (SETAC volume)	late 2003

The practical work within BECPELAG focussed on two areas with inputs of contaminants into the pelagic ecosystem: a coastal area (German Bight) and an offshore oil-production area (Statfjord). In both areas, four locations were identified, three within a contaminantion gradient and a fourth outside the most strongly affected area (Figure 1). In Statfjord, stations were located at distances of 500 m, 2000 m and 10 000 m from the platform. At each of the eight sites, water and pelagic organisms were sampled on multiple occasions in 2001. In addition, buoys with SPMDs[1], DGTs[2], cages with blue mussels and fish (Atlantic cod, 3-spined stickleback) were deployed at each of the eight sites for a 5-6 week period in 2001.

Figure 1. Locations used in BECPELAG.



Work programme

There has been four main components in the programme: biological effect techniques, chemical analyses, hydrography/modelling and design/integrated assessment. The biological effect techniques can be divided into three categories: those applied on field-collected samples, those used for caged organisms and, finally, those used on extracts from SPMDs, the sea surface microlayer, seawater or produced water.

Field collected organisms

In each of the two main areas (Statfjord and German Bight), samples were taken at the four selected sites. The projects ranged from studies on bacterial diversity to biomarkers in pelagic fish species (Table 2).

[1] SPMD – semipermeable membrane device; used to estimate integrated accumulation of hydrophobic contaminants from water

[2] DGT – diffusive gradient in thin films; used to estimate integrated accumulation of metals from water

Table 2. An overview of methods used for field collected samples; EROD – cytochrome P4501A activity, vtg – vitellogenin, CYP – cytochrome P4501A protein.

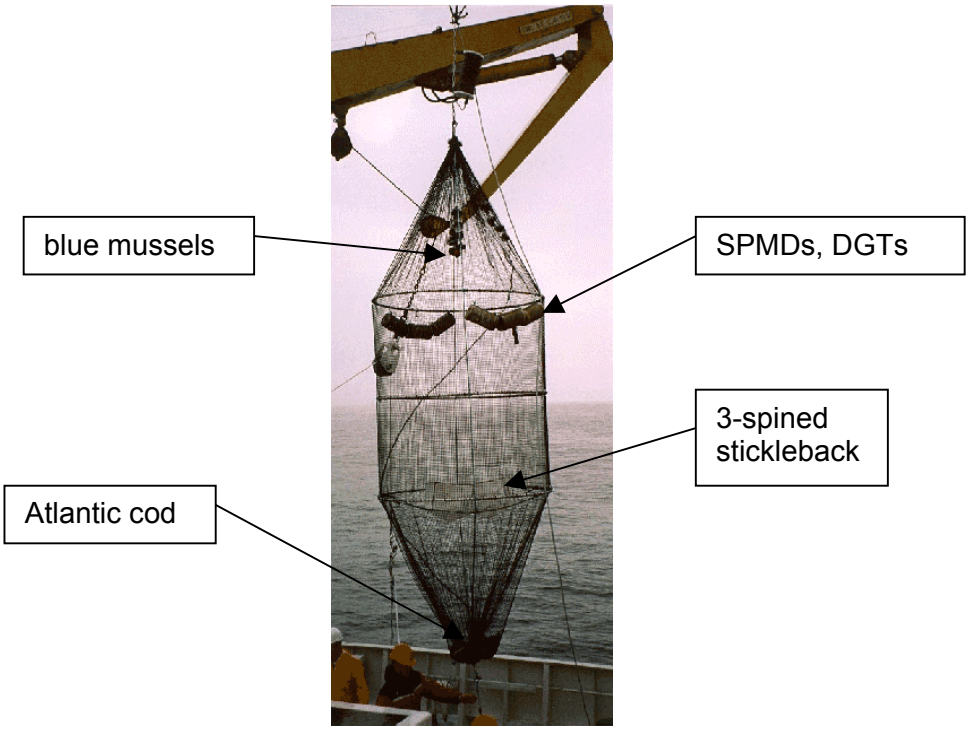
organism(s), endpoint(s)	**comment**
bacteria; genetic diversity, degradation	whole water sample
phytoplankton, photosynthesis	whole water sample
microzooplankton; grazing	whole water sample
zooplankton; biomarkers	whole Calanus
fish embryos; aberrations	embryos
fish larvae; histopathology	larvae
fish larvae; DNA damage	
juvenile herring, saithe; EROD	liver
juvenile herring, saithe; vtg, CYP	plasma, liver
herring, saithe, mackerel: PAH-metabolites	bile
juvenile herring; histopathology	liver

Caged organisms

Cages constructed by Ocean Climate (Bergen, Norway) were deployed at each of the eight locations. As mentioned above, Atlantic cod (*Gadus morhua*), blue mussel (*Mytilus edulis*) and 3-spined stickleback (*Gasterosteus aculeatus*) were caged. In addition, SPMDs and DGTs were deployed.

Blue mussels were collected from southern Ireland (post-spawned) and Trøndelag in Norway (spawning) for cage deployment. Hatchery-reared Atlantic cod was also deployed (50 in each cage). Stickleback was collected on the Swedish west coast and adapted to full-strength seawater at IMR (Bergen, Norway). Specially made cages with stickleback were be deployed with cod and blue mussels (see Figure 2). The cages were deployed at 12-15 m depth, one at each location except the two reference locations, which had two cages each.

Figure 2. Cages used for deployment of blue mussels, cod, stickleback, SPMDs and DGTs.



Both cod and blue mussels survived the deployment well, but all stickleback died. Later work has shown that the cage construction was not optimal for the stickleback. For an overview of methods see Table 3.

Table 3. An overview of methods used for caged organisms. All stickleback died during the exposure period. Abbreviations, see table 2; additional: BPH – benzo(a)pyrene hydroxylase, GST- glutathione *S*-transferase, AChE – acetyl cholinesterase, CEA – cellular energy allocation.

organism	**tissue**	**endpoint**
blue mussel (*Mytilus edulis*)	gills	MT induction
	hepatopancreas	MT induction, histochemistry, AChE, BPH, oxidative damage, antioxidant enzymes, DNA damage
	haemolymph	immunotoxicity, lysosomal stability (platereader), 2D-electrophoresis
	whole mussel	genotoxicity, histopathology, scope for growth, CEA
Atlantic cod (*Gadus morhua*)	liver	EROD, DNA adducts, CYP, GST, histopathology
	bile	PAH-metabolites
	plasma	vtg
	muscle	AChE

Bioassays

Extracts were made from seawater, the sea surface microlayer (SSML) and SPMDs deployed at each site. The extracts were distributed to participants for testing in *in vitro* assays. An extract of produced water directly (from Statfjord C) was used as a positive control. See Table 4 for an overview of methods.

Table 4. Overview of bioassays used for extracts. Abbreviations, see tables 2 and 3.

test system	**endpoint**
pure enzyme	AChE inhibition
primary fish hepatocytes	viability, vtg, CYP induction
modified cell lines with reporter genes	dioxin, estrogen, androgen receptor
bacteria	microtox
modified yeast with reporter gene	estrogen receptor
juvenile salmon, i.p. injection	vtg, CYP induction
early life stage *Danio rerio*	embryonal development
oyster embryo, Tisbe *sp,* algae	toxicity
invertebrate larvae	toxicity; UV-exposure
Acartia tonsa	survival, reproduction
mussel larvae	survival
Daphnia magna	toxicity in bile

Chemistry programme

The chemistry programme for the workshop focussed on biological matrices in support of the biological effects techniques. Metals were analysed in all biological matrices, PAHs (polycyclic aromatic hydrocarbons) in extracts, blue mussels and zooplankton (PAH metabolites in bile for fish), alkylphenols and PBDEs (polybrominated diphenyl ethers) were analysed in selected samples, organotin and organochlorine compounds were analysed in a

range of samples, mainly fish. An overview of the analytical programme can be found at the BECPELAG web-site.

Conclusions

The workshop has attained the main aim of investigating the usefulness of biological effects methods in marine pelagic ecosystems. There is currently an ongoing process to develop a water column monitoring programme using the results from BECPELAG.

Some lessons were learnt during the workshop, both concerning caging technology for different species, extraction techniques and the logistics for managing samples. A summary of results and recommendations can be found in Hylland *et al.* (2002).

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